Maura Healey, Governor
Kimberley Driscoll, Lieutenant Governor
Phillip Eng, Interim MassDOT Secretary
Jonathan L. Gulliver, Undersecretary and Highway Administrator

MassDOT
Massachusetts Department of Transportation
Highway Division

Proposal No. 609409-133236 April 1, 2026

ADDENDUM NO. 5

To Prospective Bidders and Others on:

SPRINGFIELD
Federal Aid Project No. HIP(NGB)-003S(924)
Bridge Replacement, S-24-016, Armory Street over CSX Mainline
& S-24-026, Armory Street over Abandoned CSX

PROPOSAL TO BE OPENED AND READ: TUESDAY, APRIL 14, 2026 at 2:00 P.M.

Transmitting changes to the Contract Documents as follows:

QUESTIONS AND RESPONSES:	Twelve pages.
DOCUMENT 00010:	Revised page 2.
DOCUMENT A00801:	Revised pages 66, 108, 109, 177, and 232. Inserted new pages 110.1 through 110.10.
DOCUMENT A00802:	Revised pages 11 and 12.
DOCUMENT A00891:	Inserted new document (6 pages).
DOCUMENT A00892:	Inserted new document (664 pages).
DOCUMENT B00420:	Revised pages 4 and 7 through 27.
PLANS:	Revised plan sheets 62, 85, 91, 109, 112, 121, 130, 132, 144, 149, 154, 155, 156, 161, 176, 180, and 191 of 204.

Take note of the above, substitute the revised pages and plan sheets for the originals, insert the new documents and pages in the proper order, and acknowledge Addendum No. 5 in your Expedite Proposal file before submitting your bid.

Very truly yours,

for Slava Podluzny
Digitally signed by Slava Podluzny
Date: 2026.04.01 16:03:00 -04'00'

Eric M. Cardone, P.E.
Construction Contracts Engineer

EMC/mac
cc Anthony Christakis, Project Manager

Ten Park Plaza, Suite 4160, Boston, MA 02116
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SPRINGFIELD
Federal Aid Project No. HIP(NGB)-003S(924)
Bridge Replacement, S-24-016, Armory Street over CSX Mainline
& S-24-026, Armory Street over Abandoned CSX

Questions and Responses Addendum No. 5, April 1, 2026

Railroad Construction Company, Inc., email dated Thursday, March 5, 2026

Question 10) Reference Sheet 36 of 70 in the Bridge No. S-24-016 drawing set and Sheet 35 of 61 in the Bridge No. S-24-026 drawing set. For the structures requiring gravel borrow backfill, will any excavation outside the pay limits shown on these drawings be required to be backfilled with the same gravel borrow backfill, or would suitable excavated material be permissible to use?

Response 10) **Response 10 issued in Addendum No. 2 has been rescinded and replaced with the following:**

Gravel borrow backfill is not required outside the pay limits shown on the drawings.

Question 11) Reference Sheet 36 of 70 in the Bridge No. S-24-016 drawing set and Sheet 35 of 61 in the Bridge No. S-24-026 drawing set. For the structures requiring lightweight aggregate backfill, will any excavation outside the pay limits shown on these drawings be required to be backfilled with the same lightweight aggregate backfill, or would suitable excavated material be permissible to use?

Response 11) **Response 11 issued in Addendum No. 2 has been rescinded and replaced with the following:**

Lightweight aggregate backfill is not required outside of the pay limits shown on the drawings.

SPRINGFIELD
Federal Aid Project No. HIP(NGB)-003S(924)
Bridge Replacement, S-24-016, Armory Street over CSX Mainline
& S-24-026, Armory Street over Abandoned CSX

Railroad Construction Company, Inc., email dated Thursday, March 12, 2026

Question 22) Contract Drawings 91 and 161 note that bottom of existing abutment footing elevation can be found in a table, but it does not seem to be provided. Please confirm the depth/height of the existing abutments for both of the existing bridges.

Response 22) See pages A00888 - 57 and 58 for Bridge No. S-24-016.
See pages A00892 - 50 and 51 for Bridge No. S-24-026.

Question 23) Please confirm the elevation of the bottom of the existing wall #7 to remain.

Response 23) See pages A00892 - 52 and 53.

Question 25) Please confirm that the intended bottom elevation for all closure wall pours should match the top of the concrete socket on the adjacent pile. There are conflicting details such as the Wall No.3 elevation on drawing 85, and Wall No. 5 elevation on drawing 156 that depict the closure walls to an undetermined elevation below the top of the pile concrete socket.

Response 25) See revised plan sheets 85 and 156 of 204.

Question 26) Please confirm what specific structural concrete items are included under 904.3?

Response 26) See revised page A00802 - 12.

SPRINGFIELD
Federal Aid Project No. HIP(NGB)-003S(924)
Bridge Replacement, S-24-016, Armory Street over CSX Mainline
& S-24-026, Armory Street over Abandoned CSX

Question 27) Specification section 995.1/995.2 makes reference to a concrete abutment extension which his not included under these sections. No reference is made of that description in the contract plans. Please specifically identify which drawing or item of work that this applies to.

Response 27) The term concrete abutment extension was meant to be a general term to encompass the crashwalls, wingwalls, and returnwalls. The concrete abutment extensions are not a separate item.

Question 28) Contract drawing 156, Wall No. 5 plan seems to indicate that the sidewalk/moment slab detail extends past the last pile. Please confirm if this is the case, which section should be used and how far past the last pile will it extend.

Response 28) See revised plan sheet 156 of 204.

Question 30) Please confirm which specific structural elements are included under item 910.2.

Response 30) See revised page A00802 - 12.

MIG-C.A.C. Bridge Builders JV, LLC, email dated Monday, March 16, 2026

Question 35) There is no Special Provision for item 904.3, please clarify what 5000 PSI-3/4 Inch-685 HP Concrete is paid under item 904.3.

Response 35) See revised page A00802 - 12.

Question 38) Item 904.33 Precast Concrete Panels: is the Cast-in-Place coping shown on drawing 155 of 204 for precast panel wall #6, paid for under item 904.33 or item 904.3?

Response 38) See revised page A00802 - 12.

SPRINGFIELD
Federal Aid Project No. HIP(NGB)-003S(924)
Bridge Replacement, S-24-016, Armory Street over CSX Mainline
& S-24-026, Armory Street over Abandoned CSX

E.T.& L. Corp., email dated Wednesday, March 18, 2026

Question 41) In the special provisions under items 995.01 and 995.02, it states "Concrete abutment extensions / crashwalls and wingwalls / return walls shall be paid for separately, and are not included in this Lump Sum". The special provisions also state "Concrete shall be used to construct all concrete work, including cast-in-place deck slab, end diaphragms, abutment pile caps, backwalls, curtain walls and keeper blocks, abutment column and column footing (pile cap), approach slabs, stem walls at the gravity block/crash walls/return walls and retaining wall footings, CP-PL2 barriers, shared-use-path moment slab and sidewalk moment slab, highway guardrail transitions and at those areas as designated by the Engineer, and/or areas designated on the Plans". Please specify the payment items for the following: gravity block walls, crash walls, return walls, retaining wall footings, sidewalk moment slab on retaining walls, shared-use path moment slabs on retaining walls, and wall closure pours.

Response 41) See revised page A00802 - 12.

MAS Building & Bridge, Inc., email dated Wednesday, March 18, 2026

Question 57) Please provide a detail for the installation of the three relocated existing light poles within the moment slab.

Response 57) See revised page A00801 - 177.

Question 62) Wall #6 and GB #4 Wall details on Sheet 155/204 do not show the lightweight fill transitioning to the South from the end of the return wall, while the details for Wall #3 and GB#2 Wall on sheet 85/204 do. Is this correct?

Response 62) See revised plan sheet 155 of 204.

Question 63) What is the flow rate for the 15" VCP sewer line to be bypassed?

Response 63) See revised pages A00801 - 108 and 109.

SPRINGFIELD
Federal Aid Project No. HIP(NGB)-003S(924)
Bridge Replacement, S-24-016, Armory Street over CSX Mainline
& S-24-026, Armory Street over Abandoned CSX

Atlantic Bridge & Engineering, email dated Thursday, March 19, 2026

Question 65) For Bridge No. S-24-026 – Armory St. over CSX RR (Abandoned) please advise on the following:

a. For the Stage 1 bridge construction, the existing 4" AT&T conduit between existing girders E2 & E3 is to be temporarily supported in place while the new bridge steel is erected around it (Reference Br. Sheets 18/19 of 61). The permanent intermediate U2 diaphragms (Ref. Br. Sheet 46 of 61) in the bay with this conduit (GR5/GR6) are single piece shop welded frames which cannot be installed over/around this existing conduit. Please advise.

b. For the Stage 1C bridge construction, the Eversource Electric conduits are to be relocated from behind the traffic barrier on the existing bridge deck to below the new bridge deck on temporary supports between existing girder E4 and new girder GR6 (Ref. Br. Sheet 19 of 61). In Stage 2B these conduits are then final supported onto the new diaphragms between girders GR6 and GR7 (Ref. Br. Sheet 20 of 61). The permanent U2 diaphragms in this bay are single piece shop welded frames which cannot be installed over/around these conduits. It should also be noted that as this is the phase line bay, these diaphragm connections will not be able to be completed until after the Stage 2 deck slab has been constructed. Please advise.

c. For the Stage 2A bridge construction (Ref. Br. Sheet 20 of 61), the existing Comcast, Crown Castle and Verizon conduits are to be relocated from their existing bridge bays onto temporary supports between existing girders E8 & E9 (New girders GR11 and GR12). These conduits are then to be relocated to their final locations in the bays between new girders GR9/GR10 & GR10/GR11 once this portion of the Stage 2 bridge steel has been erected. This sequence would also require the installation of new girder GR12 in a separate mobilization once these conduits are relocated as the permanent U2 intermediate diaphragms in the bay between GR11/GR12 (which are required for the support/stability of GR12) would not be able to be installed with the existing conduits in place. Thus please confirm that this is the intended sequence for the Stage 2 erection work.

Response 65) a. See revised plan sheet 176 of 204 (Br. Sheet 46 of 61).

b. See Response 65a.

c. The sequence stated above is correct, see revised plan sheet 176 of 204 (Br. Sheet 46 of 61) for new diaphragm detail.

SPRINGFIELD
Federal Aid Project No. HIP(NGB)-003S(924)
Bridge Replacement, S-24-016, Armory Street over CSX Mainline
& S-24-026, Armory Street over Abandoned CSX

Question 66) For Bridge No. S-24-016 Armory St. over CSX RR Mainline please advise on the following:

a. For the Stage 2A bridge construction (Ref. Br. Sheet 19 of 70), the existing Comcast and Crown Castle conduits are to be relocated from their existing bridge bays onto temporary supports between existing girders E7 & E8 (New girders GR10 and GR11). The permanent intermediate U2 diaphragms (Ref. Br. Sheet 52 of 70) in the bay with these conduits are single piece shop welded frames which cannot be installed over/around these existing conduits. Please advise.

b. For Bridge No. S-24-016 Armory St. over CSX RR Mainline please advise on the following: For the Stage 1B bridge construction (Ref. Br. Sheet 18 of 70), the Eversource Electric conduits are shown to be relocated from behind the traffic barrier on the existing bridge deck to below the new bridge deck onto supports that are cantilevered off of the side of new bridge girder GR6. Then in Stage 2B (Ref. Br. Sheet 19 of 70) these conduits are shown to be final supported onto the new permanent diaphragms between girders GR6 and GR7. The permanent U2 diaphragms in this bay are single piece shop welded frames which cannot be installed over/around these existing conduits. Thus, are these Stage 1B cantilevered supports intended to be part of the new permanent diaphragms with their remaining portion to be completed during the Stage 2 erection work? Please advise. It is also be noted that as this is the phase line bay, the permanent diaphragm connections will not be able to be completed until after the Stage 2 deck slab has been constructed.

Response 66) a. See revised plan sheet 112 of 204 (Br. Sheet 52 of 70).

b. During the shop drawing review process, the Contractor may submit proposed alternative construction methods for consideration. No such alternatives shall be incorporated into the Work unless and until written approval is obtained from the District Construction Engineer's office.

SPRINGFIELD
Federal Aid Project No. HIP(NGB)-003S(924)
Bridge Replacement, S-24-016, Armory Street over CSX Mainline
& S-24-026, Armory Street over Abandoned CSX

Railroad Construction Company, Inc., email dated Thursday, March 19, 2026

Question 70) Contract drawing sheets 19 and 20 show 3 billboards that are to be removed and reset. Please provide bid item for these billboards and electrical details if lighting is to be restored.

Response 70) These billboards are labeled R&R (BO). The work will be performed by others and is not included in the Contract.

J.F. White Contracting Company, email dated Monday, March 23, 2026

Question 71) We have reviewed and compared the information in the soldier pile & lagging walls chart on sheet 34 of 70 for Bridge S-024-016 versus the elevation views of Wall #1 on sheet 23 of 70, Wall # 2 on sheet 24 of 70 and Wall #3 on sheet 25 of 70. We have found differences in the following quantities:
A.) Length of Soldier Piles.
B.) Length of the galvanized portion of the soldier piles.
C.) Square foot quantity of precast panels

Do the chart values or the elevation views of the wall govern?

Response 71) Sheets 23, 24 and 25 of 70 govern.

Question 72) We have reviewed and compared the information in the soldier pile & lagging walls chart on sheet 35 of 61 for Bridge S-024-026 versus the elevation views of Wall #4 on sheet 24 of 61, Wall # 6 on sheet 25 of 61 and Wall #5 on sheet 26 of 61.

We have found differences in the following quantities:

A.) Length of Soldier Piles.
B.) Length of the galvanized portion of the soldier piles.
C.) Square foot quantity of precast panels.

Do the chart values or the elevation views of the wall govern?

Response 72) Sheets 24, 25 and 26 of 61 govern.

SPRINGFIELD
Federal Aid Project No. HIP(NGB)-003S(924)
Bridge Replacement, S-24-016, Armory Street over CSX Mainline
& S-24-026, Armory Street over Abandoned CSX

Atlantic Bridge & Engineering, Inc., email dated Tuesday, March 24, 2026

Question 73) For Bridge No. S-24-016 Armory St. over CSX RR Mainline please confirm that Shear Stud Connectors are not required to be installed on Kicker Beams KB1, KB2, KB3A & KB3B (Ref. Br. Sheets 49, 50 & 61 of 70).

Response 73) See revised plan sheet 121 of 204 (Br. Sheet 61 of 70).

Railroad Construction Company, Inc., email dated Tuesday, March 24, 2026

Question 74) Section 100.91 Pre & Post Construction Survey state that following existing structures that will remain shall be surveyed and documented prior to construction. This includes the abandoned 30-inch sewer pipes at Armory Street over CSX Mainline. Sheet 94 of 204 under the table for Soldier Piles and Lagging Walls under Wall 1B calls for bottom of shaft to be elevation 103.93. The layout shows the proposed soldier pile shafts in direct conflict of the 30 inch sewer with an invert elevation of 117.1'. Please confirm that since this section of sewer is abandoned that it is permitted to drill through the 30 inch abandoned sewer line. If it is not permitted, please advise.

Response 74) Yes, it is permitted to drill through the 30-inch abandoned sewer line.

Railroad Construction Company, Inc., email dated Tuesday, March 24, 2026

Question 75) Please provide required qualifications for the Contractor's Public Outreach Specialist and duties that will be required for Bid Item 149.2.

Response 75) There are no specific qualifications. See Special Provision for Item 149.2.

MIG Corporation, Inc., email dated Tuesday, March 24, 2026

Question 76) Item 904.33 Precast Concrete Panels: Engineer's estimated quantity is 4,581 SF. Our takeoff indicates there is 3,600 SF. Please review/confirm the contract bid quantity for item 904.33.

Response 76) See revised page B00420 - 24.

SPRINGFIELD
Federal Aid Project No. HIP(NGB)-003S(924)
Bridge Replacement, S-24-016, Armory Street over CSX Mainline
& S-24-026, Armory Street over Abandoned CSX

Question 77) Wall line for retaining wall 5 at Bridge S-24-026, and retaining wall 2 at Bridge S-24-016 are in the same location as existing Easterly retaining walls. The existing retaining walls are not shown on the contract cross-sections. Removing existing walls will undermine the roadway above unless temporary sheeting or shoring is installed to support the road during removal and new wall construction. How does Support of Excavation get paid when removing existing wall structures?

Response 77) See detail on plan sheet 77 of 204 for temporary barrier and earth support system for staged construction. This shoring is paid under Item 953.31. See pages A00801 - 222 and 223.

Question 78) Is the removal of existing concrete retaining walls paid for under Item 127 or 127.1? How is the metal rail on same existing retaining walls paid for?

Response 78) See revised page A00801 - 66.

Question 79) Is the concrete coping on retaining wall 6 at Bridge S-24-026 paid under Item 904.33 or 904.3?

Response 79) See revised page A00802 - 12.

Railroad Construction Company, Inc., email dated Wednesday, March 25, 2026

Question 80) Pay Item #140 on the Price Proposal Form has a quantity of 2,010 cubic yards. When adding the Bridge Excavation quantities from Sheet 2 for both bridge drawing sets, the total quantity is 2,881 cubic yards. Please clarify if the pay quantity on the Price Proposal Form is correct.

Response 80) See revised page B00420 - 4.

SPRINGFIELD
Federal Aid Project No. HIP(NGB)-003S(924)
Bridge Replacement, S-24-016, Armory Street over CSX Mainline
& S-24-026, Armory Street over Abandoned CSX

Question 81) The response to RFI #10 in Addendum #2 seems to say that the Contractor is required to provide gravel borrow backfill if excavation is performed outside the gravel borrow pay limits as long as that excavation is in back of structures. Therefore, suitable excavated material cannot be placed in locations outside the gravel borrow pay limits. See the following two questions related to this:

a. Can the Authority please confirm that this is the correct interpretation of that RFI response?

b. If so, will Contractor be paid for this gravel borrow placed outside the gravel borrow pay limits shown in the bridge drawings, given that the Authority is requiring it to be gravel borrow?

Response 81) See revised Response 10 issued in this Addendum.

Question 82) The response to RFI #11 in Addendum #2 seems to say that the Contractor is required to provide either gravel borrow backfill or lightweight backfill if excavation is performed outside the lightweight backfill pay limits. Therefore, suitable excavated material cannot be placed in locations outside the lightweight backfill pay limits. See the following two questions related to this:

a. Can the Authority please confirm that this is the correct interpretation of that RFI response?

b. If so, will Contractor be paid for this gravel borrow or lightweight backfill placed outside the lightweight backfill pay limits shown in the bridge drawings, given that the Authority is requiring it to be either gravel borrow or lightweight backfill?

Response 82) See revised Response 11 issued in this Addendum.

SPRINGFIELD
Federal Aid Project No. HIP(NGB)-003S(924)
Bridge Replacement, S-24-016, Armory Street over CSX Mainline
& S-24-026, Armory Street over Abandoned CSX

Railroad Construction Company, Inc., email dated Wednesday, March 25, 2026

Question 83) Please provide the required warranty period and specific items for the project.

Response 83) All required warranty periods shall be per the MassDOT Standard Specifications.

Manafort Brothers Incorporated, email dated Tuesday, March 31, 2026

Question 84) Page 25 of the CSX Manual requires that new overhead bridges (including existing bridge replacements) clear span CSX's right-of-way and have a minimum 23'-0" vertical clearance above top of rail. The proposed clearance for Bridge S-24-016 is 21'-10 3/8". Please confirm this is acceptable.

Response 84) Yes. See plan sheet 61 of 204 for proposed vertical clearance.

Question 85) The plans call for 12" DI water pipe installed within an 18" insulated and jacketed SCH 20 steel sleeve, with the carrier pipe bare. Please confirm whether the intent is for insulation to be placed on the casing/sleeve only, or also directly on the carrier pipe. If carrier pipe insulation is also required, please identify the specified product.

Response 85) See plan sheets 16 through 18 of 204. Insulation of the 18" containment pipe is proposed for its entire length. Outside of the containment pipe, where the 12" pipe transitions to underground on the gravity blocks, the 12" pipe is proposed to be insulated. The 12" pipe is not insulated in the insulated containment pipe. See pages A00883 - 31 through 34 for material requirements and approved manufacturers.

Railroad Construction Company, Inc., email dated Tuesday, March 31, 2026

Question 86) Please provide concurrence that the rebar associated with the Gravity Walls are paid under Bid Item 910.2 – Steel Reinforcement for Structures.

Response 86) See revised page A00802 - 12.

SPRINGFIELD
Federal Aid Project No. HIP(NGB)-003S(924)
Bridge Replacement, S-24-016, Armory Street over CSX Mainline
& S-24-026, Armory Street over Abandoned CSX

Railroad Construction Company, Inc., email dated Tuesday, March 31, 2026

Question 87) Please confirm what specific structures are included in under pay items 903 and 904?

Response 87) See revised page A00802 - 11.

Question 88) Which pay item is used for the transportation and disposal of asphalt pavement removed from roadway areas?

Response 88) See MassDOT Standard Specifications Subsection 120.

⑤ Addendum No. 5, April 1, 2026
② Addendum No. 2, March 13, 2026

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⑤ Addendum No. 5, April 1, 2026

ITEM 127.1 REINFORCED CONCRETE EXCAVATION CUBIC YARD

The work under this item shall conform to the applicable provisions of Subsections 120 and 140 of the Standard Specifications.

The work includes furnishing all labor and equipment necessary to perform the demolition and proper disposal of the upper portions of the existing concrete abutment bridge seats and backwalls to faciliate the proposed "slab-over" details; and demolition of concrete portions of retaining walls as detailed on the Plans.

Prior to the start of work, the Contractor shall locate all utilities and coordinate with CSX as required by and paid for under Item 114.1 and Item 114.2.

Prior to concrete excavation, a vertical ¾" deep groove shall be sawcut at the limits shown on the plans. Concrete may be excavated by means of pneumatic hammers approved by the Engineer. Excavation shall not be undertaken until the limits have been defined by sawcutting.

The Contractor shall not damage the portions of existing structures to remain. Any areas damaged as a result of the Contractor's operations shall be repaired as required by the Engineer, and at the Contractor's expense.

After the existing concrete has been removed, all exposed surfaces shall be cleaned of all loose particles and loose rust by wire brushing, or other approved means, prior to placing the new concrete.

METHOD OF MEASUREMENT

Item 127.1 will be measured for payment by the Cublic Yard of reinforced concrete excavation to the limits shown on the plans, and as required by the Engineer.

BASIS OF PAYMENT

Item 127.1 will be paid at the Contract Bid Price per Cubic Yard, which price shall include all labor, material, equipment, tools, and incidental costs required to complete the work.

⑤ No separate payment will be made for the removal and disposal of any metal railings on existing retaining walls, but all costs in connection therewith shall be included in the Contract unit price bid.

⑤ Addendum No. 5, April 1, 2026

ITEM 210.1	**SANITARY SEWER MANHOLE MUNICIPAL STANDARD**	**EACH**
ITEM 210.11	**SANITARY SEWER MANHOLE MUNICIPAL STANDARD - DOGHOUSE**	**EACH**
ITEM 212.	**TEMPORARY SANITARY SEWER BYPASS**	**LUMP SUM**
ITEM 220.9	**SANITARY STRUCTURE ABANDONED**	**EACH**

The work under these items shall conform to the relevant provisions of Subsection 201 of the Standard Specifications and the following:

The work under these items is required to account for a conflict of an existing 15" VCP sanitary sewer pipe with proposed Wall 1 soldier pile foundations and for the earthwork that is anticipated for the Contractor to access the work area and construct the proposed abutment extension at Bridge No. S-24-016.

Manholes shall be constructed in accordance with the Springfield Water and Sewer Commission Standard Details Ver 4 – November 2020, Revised: August 12, 2021. (See Document A00884). Manholes shall be precast and conform to Standard Detail S-02.0 and associated reference details. Manhole frames and covers for the standard manholes shall conform to Standard Details S-02.55 and/or S-2.56 and S-02.62, respectively. The manhole frame and cover in Armory Street shall be lock-down conforming to Standard Detail S-02.65. The doghouse manhole in Armory Street shall be comprised of precast units with a cast in place bottom slab and the invert constructed in conformance with Standard Detail S-02.66.

Materials shall be in accordance with Springfield Water and Sewer Commission Material Specifications Version 4. (See Document A00883).

The Contractor shall submit shop drawings for all work under these items to the Springfield Water and Sewer Commission for approval.

The proposed doghouse manhole in Armory Street shall be constructed as soon as possible in Stage 1 in coordination with soldier pile foundation construction. Following completion of the manhole existing sanitary sewer flow shall be temporarily re-routed with a bypass from the new manhole to the existing sanitary sewer manhole downstream beyond the wall. The route and method of bypass shall be proposed by the Contractor to facilitate construction of Wall 1 and other work in the area. The Contractor is also responsible for providing power, protection and monitoring of the bypass to ensure that the installation safely operates. The Contractor shall submit proposed bypass plans including all provisions proposed for its operation and protection to the Springfield Water and Sewer Commission and obtain approval prior to commencing bypass work.

⑤ The Contractor shall verify flow conditions in the existing system prior to the commencement of construction. The Contractor shall have no claim for additional compensation by reason of delay or inconvenience in adapting its operations to the need for maintaining existing dry weather flows. The dry weather flow estimate for the existing 15" VCP sanitary sewer pipe is 1,650 gpm.

⑤ Addendum No. 5, April 1, 2026

ITEMS 210.1, 210.11, 212., and 220.9 (Continued)

⑤ It shall be noted that estimated dry weather flows are average flows and will require the Contractor to use a dry weather peaking factor to address the range of potential flows they may encounter. The 15" VCP is likely a combined sewer pipe and wet weather flows are anticipated to be higher than dry weather flows.

The existing sanitary sewer manhole in Armory Street labeled as EX1 in the Plans shall be abandoned by removing and disposing the frame and cover and removing the top four feet of the structure. Abandoned sanitary sewer pipe shall be bulkheaded at both ends with masonry bricks or blocks and sealed with non-shrink grout.

The disposition of sanitary sewer structure remaining shall be subject to approval by the Springfield Water and Sewer Commission. No abandonment work shall commence until SWSC approval is obtained for the means and methods of abandonment proposed by the Contractor.

METHOD OF MEASUREMENT

Items 210.1 and 210.11, Sanitary Sewer Manhole Municipal Standard and Sanitary Sewer Manhole Municipal Standard – Doghouse, respectively, will be measured for payment by the unit each, including frames, covers, and invert brickwork, complete in place and approved by SWSC.

Item 220.9, Sanitary Structure Abandoned, will be measured for payment by the unit each, complete, following approval by the Springfield Water and Sewer Commission.

BASIS OF PAYMENT

Item 210.1, Sanitary Sewer Manhole Municipal Standard and Item 210.11, Sanitary Sewer Manhole Municipal Standard – Doghouse, will be paid at the contract bid price each, which price shall be full compensation for all labor, materials, equipment, and incidental costs required to complete the work.

Item 212., Temporary Sanitary Sewer Bypass, will be paid at the contract lump sum price, with 50 percent of payment made after the bypass (or first of multiple bypasses) is functioning and 50 percent payment made after the bypass is removed. No additional payment will be made for multiple bypasses or for multiple methods of bypass. Payment shall be full compensation for all labor, materials, equipment, and incidental costs required to complete the work.

Item 220.9, Sanitary Structure Abandoned, will be paid at the contract unit bid price each, which price shall be full compensation for all labor, materials, equipment, and incidental costs required for the work.

ITEM 213. FLOW BYPASS FOR SEWER PIPE LUMP SUM

The work under this item shall conform to the relevant provisions of Subsection 230 of the Standard Specifications and the following:

The Contractor shall provide a continuous dry weather flow bypass pumping system for the existing combined sewer in the area of Armory Street and Albany Street.

The Contractor shall design the Flow Bypass for Sewer Pipe that meets the requirements outlined in this specification.

The work under this item includes the following:

- Design of the bypass pumping system;
- Pumps; suction hoses;
- Discharge pipes or hoses;
- Pump controls;
- Freeze protection if anticipating cold weather;
- Generators or electrical supply; fuel;
- Temporary plug(s) and restraint/anchoring, fittings, couplings and appurtenances;
- Backup equipment (one backup pump and one backup power supply) equipment;
- Clearing and grubbing of brush and overland areas to facilitate access for bypass pipes and equipment;
- Temporary removal and replacement of fencing for bypass piping;
- Excavation for temporary burial of bypass pipes, and hoses, or discharge location manhole access;
- Protecting existing structures to remain; transporting material to/from soil staging area; temporary excavation support;
- Preparation of subgrade;
- Assembling bypass pumping system;
- Backfill around buried pipes or hoses;
- Removal and replacement of guardrail as necessary to facilitate structural improvements and/or to facilitate buried hose;
- Temporary ramps over bypass piping/hose;
- Testing of pumping system prior to bypassing operations;
- Weather monitoring;
- Periodic bypass suspension and preparing the receiving structures and pipelines to handle wet weather flow (i.e. Temporarily removing plugs/restraints and equipment);
- Emergency service during non-work hours;
- Continuous monitoring and management of flow bypass system throughout the duration of the work;

ITEM 213. (Continued)

- Manning pumps or other bypasses as may be required;
- Protection of discharge locations; temporary plating of suction and discharge manholes when pumping operation is suspended;
- Protection of bypass measures;
- Removal of all bypass pumping system equipment at the end of the pumping operation;
- Backfill around discharge manhole and empty bypassing pipe trench;
- Compaction;
- Subbase including grading and compaction;
- Site restoration after pumping system is removed;
- All appurtenances and incidental work not specifically included for payment elsewhere.

The flow bypass alignment, including the suction and discharge manholes that shall be used for the flow bypass system are specified herein and shown in Document A00891.

The Contractor shall perform all operations associated with handling bypass flows from the existing system from the structures SMH 3812 (suction manhole) and SMH 3805 (discharge manhole) as shown in Document A00891 and in accordance with these specifications.

Discharge piping shall be routed overland between the two structures along the alignment of the existing sewer and in accordance with CSX permit requirements.

Pumps shall be staged in the vicinity of SMH 3812 on private property within an existing sewer easement.

The Contractor shall maintain dry weather flows from the main pipelines without interruption of service and maintaining dry weather flows in lateral connections with minimal interruption of service.

The section of sewer to be bypassed between SMH 3811 and SMH S17936 shall be completely free of all flows during bypass operations. Under existing conditions, SMH S17936 is not accessible.

The Contractor shall perform the work in a sequence that is the least disruptive to vehicular and pedestrian traffic and in a manner that shall protect the public from damage to persons and property.

The Contractor is responsible for maintaining continuous service in the collection system that replicates existing conditions during all dry weather conditions.

ITEM 213. (Continued)

For all wet weather occurrences, the Contractor shall take actions to protect and prepare work zones for flow reinstatement in the existing pipelines, which shall include removal of all equipment and temporary plugs, dams, walls, or other structures within the pipeline. No additional payment will be made for damages due to inadequate wet weather flow handling provisions nor inadequate work area precautionary provisions.

The Contractor is not expected to provide pumped bypass of live flows other than to facilitate the inspection and all other related work activities related to the existing sewer located in the vicinity of Armory Street and Albany Street.

The existing combined sewer is subject to heavy inflow, as modest storms can increase the flow considerably as demonstrated by the estimated flow values in Table 1.

Note: All forecasted wet weather greater than 0.1 inches shall be basis for removing the flow bypass system and reinstating the existing sewer.

The Contractor shall plug or block all flows upstream of SMH 3811 and upstream of SMH 3805 utilizing an inflatable plug, removable dam, or other temporary flow control device.

All flow control systems shall be sufficiently restrained to resist hydrostatic forces from upstream flows. The Contractor shall remove all flow control systems in advance of wet weather.

The Contractor shall not propose or use masonry weirs, sandbags, or metal plates as means of diverting flow during bypass operations unless approved by both the Springfield Water and Sewer Commission.

The Contractor shall route suction piping within SMH 3812 and the existing 30-inch sewer such that suction is within the existing 50-inch by 66-inch elliptical interceptor, as shown in Attachment 1.

The Contractor shall be required to inspect existing brick manhole structures SMH 3812 (suction manhole) and SMH 3805 (discharge manhole).

The Contractor shall maintain the condition of the structures throughout the duration of the flow bypass operation. If necessary, structures shall be modified, reconstructed and/or rehabilitated to accommodate the flow bypass equipment in advance of bypassing operation.

Any backup or discharge of sanitary sewer or combined sewer flows outside the sewer collection system. Including, ground surface, surface waters, into private property, or onto private property, is prohibited. In the event of such a discharge, the Contractor shall provide a written report to the Engineer outlining the incident and including causes and mitigation measures. Payment for mitigation resulting from such discharges shall be incidental to this Item.

ITEM 213. (Continued)

SUBMITTALS

Flow bypass shall not be started, nor materials and equipment ordered until the qualifications and submittals herein have been accepted by the Engineer.

1. A Bypass Pumping Work Plan complete with Certificate of Design Certified by a Professional Engineer registered in the Commonwealth of Massachusetts for each site in which bypass pumping is proposed which includes the following proposed items:

    a. Location, configuration, and routing of bypass flow handling pipes and hoses that aligns with the layout shown in Attachment 1 and specifications herein.

    b. Anticipated schedule and duration at bypass flow handling activities.

    c. Staging area(s) for pumps and other equipment that aligns with the layout shown in Attachment 1 and specifications herein.

    d. Manufacture's shop drawings and descriptive literature for the following materials and equipment:
        i. The proposed pump(s) indicating materials, flow curves, equipment, and accessories.
        ii. The proposed bypass pipe(s) and hose(s), suction line(s), header(s), and discharge line(s) indicating the diameter(s), material, and quantity.
        iii. The temporary plugging, damming, or other isolation measure of the upstream and downstream flow collection locations.

    e. Calculations for sizing/estimating the following:
        i. Pump(s);
        ii. Generator(s) and/or power source(s);
        iii. Suction and discharge piping;
        iv. Temporary pipe supports;
        v. Temporary pump plugging or bulkheading including the anticipated time for activating and deactivating along with the method(s) to restrain plug in the event of plug failure;
        vi. Bypass Pumping System Average and Maximum Daily Flows;
        vii. Static lift, friction losses, and flow velocity.

ITEM 213. (Continued)

f. For information, the manufacturer's literature describing the system's Testing, Start-up, and Operation and Maintenance Procedures.

g. Method of protecting structures that accept discharge flows.

h. Method of compliance with CSX right of way occupancy requirements.

i. Spill Containment Plan.

j. Noise Pollution Abatement Plan.

k. A Forecasted Weather Monitoring Plan;

l. An Emergency Response Plan addressing the following:
   i. In the event of pump failure and/or flowrate increases that result in an exceedance of pump capacity, contingency procedures to handle flows present in the combined sewer, including appropriate points of contact for notifications, and roles and responsibilities for Contractor, stakeholders, and 3rd parties (vendors) supporting mitigation steps.

2. A list of 24-hour emergency telephone numbers at which the Contractor may be reached.

3. Contractor shall submit complete documentation of qualifications as specified.

   a. Provide preliminary submittals listed in Paragraph 1.3.A of this Section 4 weeks after the Notice to Proceed, or at least 4 weeks prior to any proposed bypassing/diverting operations, whichever occurs first. The Contractor should anticipate an extended review period due to the risk of failure of the bypass, environmental and public health sensitivities, private property impacts, and Permitting Agency coordination. Resubmittals and requests for supplemental or additional information may be required. Submit any revised plans 2 weeks prior to proposed bypass/diversion.

   b. The Contractor designing and installing the bypass flow handling system shall have completed at least five projects of similar size and complexity as this project in the United States within the past three years. Contractor may employ the services of a subcontractor that specializes in this work to fulfill this requirement.

   c. Rejection of any subcontractor and/or manufacturer by the Engineer due to insufficient qualifications shall not be grounds for modifications to the Contract Documents such as change in scope, time of completion or contract amount.

ITEM 213. (Continued)

MATERIALS AND EQUIPMENT

The equipment handling the bypass flow shall be of sufficient size and material to convey existing flows from the designated suction and discharge structures SMH 3812 and SMH 3805 as shown in Document A00891 without overflow, spillage or discharge to the surrounding environment.

The Contractor shall be fully equipped to operate and respond to any repair or replacement of the continuously operating flow bypass system, 24 hours per day and 7 days per week, while the bypass flow handling system is in use.

If the system is in operation during non-working hours, then it shall be monitored by a qualified employee of the Contractor or Subcontractor.

The Contractor shall have adequate standby equipment available and ready for immediate operation and use in the event of emergency or breakdown: one (1) standby pump for each size pump utilized and backup power supply and/or source shall be provided.

The Contractor shall incorporate noise reduction equipment to minimize impact on the surrounding environment. The Contractor shall utilize sound-attenuated diesel pumps and generators, if utilized, for the bypass operation.

Noise reduction measures shall include insulated enclosures, hospital grade silencers or mufflers, equipment modifications and/or special equipment to limit noise to 80 dBA at seven feet or 60 dBA at the nearest residence or business.

ITEM 213. (Continued)

DESIGN CRITERIA

The Contractor shall verify flow conditions in the existing system prior to the commencement of construction. The Contractor shall have no claim for additional compensation by reason of delay or inconvenience in adapting its operations to the need for maintaining existing dry weather flows.

The following are flow estimates:

Table 1 - Estimated Flow Values

Location	Estimated Flow (MGD) [1]	
	ADWF	PDWF
SMH 3811	2.4	2.7

Notes:
1. Estimated Flow rounded to the nearest 0.1 MGD

ADWF = Average Dry Weather Flow
PDWF = Peak Dry Weather Flow

It shall be noted that estimated dry weather flows are average flows and will require the Contractor to use a dry weather peaking factor to address the range of potential flows they may encounter.

The proposed suction and discharge manholes for flow bypass are SMH 3812 and SMH 3805 as shown in Document A00891. Approximate invert and rim elevations for suction and discharge are indicated on the plan.

It shall be the responsibility of the Contractor to determine the total dynamic head and power requirements of the bypass pumping system, based on the equipment provided.

The necessary power and/or fuels shall be provided by the Contractor. Payment for power and/or fuels shall be incidental to this Item.

The pumping system shall be non-clog and capable of passing a 3-inch solid.

ITEM 213. (Continued)

CONSTRUCTION

The Contractor shall perform all work in accordance with municipal, state and federal requirements.

The Contractor shall obtain any City of Springfield, CSX Railroad and Springfield Water and Sewer (Owner) related permits required to perform work prior to the commencement of construction, which shall be incidental to this Item.

Prior to the commencement of construction, the Contractor shall perform all possible preparatory work and shall, always, conduct operations with minimal interference to existing flows.

The Contractor shall protect water resources, wetlands and other natural resources. Bypass of untreated or partially treated sewage to surface waters or drainage courses is prohibited during construction. In the event accidental bypassing is caused by the Contractor's operations, the Engineer shall immediately be entitled to direct others to stop the bypass. The costs incurred therefore, will be deducted from the Contractor's construction progress payment.

The Contractor shall submit for review and approval to Springfield Water and Sewer Commission through the Engineer the proposed Bypass Pumping Plan(s) prior to initiating any bypassing/diverting activities.

Plug and Restraint

Precautions. Worker safety downstream of a temporary plug is critical to the Owner. The plug/restraint mechanism must be secure and readily removable in the event of wet weather.

At minimum, three (3) days prior to the scheduled installation of the plug/restraint mechanism, the Contractor shall begin to monitor the daily weather forecast.

The Contractor will not commence if more than 0.1 inches of rainfall is predicted. If more than 0.1 inches of rainfall is predicted while the plug/restraint mechanism is installed, the work area is to be shut down, the sewer to be evacuated, and provisions shall be made for the emergency removal of the plug/restraint mechanism and reinstatement of flows within the existing pipeline. The minimum duration for reinstatement shall be 12 hours.

ITEM 213. (Continued)

Temporary plugging or blocking of service connections may only be done in a manner that does not cause an extended inconvenience (more than 4 hours), risk to the public, or damage to property. The Contractor shall submit a description/plan as described herein.

1. Design and Pre-Fabrication

    a. Engage the services of a Professional Engineer licensed in the Commonwealth of Massachusetts to design the temporary plug/restraint mechanism, to ensure that the proposed installation is structurally adequate, readily removable, and provides protection to the safety of workers located down-system from the plug/restraint mechanism.

    b. Utilize as-built information as necessary to field verify existing conditions.

    c. Submit plug/restraint mechanism design to the Engineer for review.

    d. Strictly adhere to all requirements and dimensions as indicated in the design and verify in the field prior to installation.

2. Field Preparation for Installation. Attend pre-construction meeting with the Owner and the Engineer to review procedures, responsibilities, time frames, contacts, and any other operational issues associated with the installation of the plug/restraint mechanism.

Bypass Layout

The Contractor shall design the layout and routing of the bypass flow handling system in accordance with Document A00891 to minimize disturbance to public and private land.

The Contractor shall furnish, install, maintain and operate all temporary facilities such as dams, plugs, pumping equipment, conduits and all other labor and equipment necessary to intercept the flow.

The Contractor shall protect existing facilities from damage, during pumping activities.

Plugging or blocking of flows shall incorporate a primary and secondary watertight plugging device. When plugging is no longer required, it is to be removed in a manner that permits flows to slowly return to normal without surge, surcharge or other major disturbance.

The Contractor shall be responsible for monitoring the forecasted weather as well as daily updates during days of activity.

Mitigation of any damage to public or private property caused by the Contractor by providing the flow bypass shall be the full responsibility of the Contractor.

ITEM 213. (Continued)

BASIS OF PAYMENT

Item 213. will be paid for at the contract unit price, Lump Sum. This price shall include all labor, materials, tools, equipment, and incidental costs required to establish, maintain, and remove a dry weather bypass pumping system complete as required to handle existing flows.

⑤ Addendum No. 5, April 1, 2026

ITEM 823.70 HIGHWAY LIGHTING POLE AND LUMINAIRE REMOVED AND RESET EACH

The work under this item shall conform to the relevant provisions of Subsection 820 of the Standard Specifications, Supplemental Specifications, and the following.

The existing light poles and luminaires shall be removed and temporarily stored offsite to enable other contract work to proceed. The condition of the existing lighting materials to be stored shall be documented with photographs and provided to the Engineer prior to removal. Any undocumented damage to the existing materials that are evident when the materials are brought back to the site for resetting shall be repaired if feasible or the item shall be replaced at the Contractor's expense. The existing luminaires are fully functioning and shall be photographed at night prior to removal to establish the condition prior to temporarily storing.

⑤ All materials that cannot be reused shall be new. The light poles shall be reset on new bolts and foundations (MassDOT SD3.011) that are constructed through the proposed moment slabs. The locations of the reset light poles and new conduit shall be confirmed at the site with the Engineer prior to placing the moment slab concrete to check ADA compliance.

METHOD OF MEASUREMENT

Item 823.70, Highway Lighting Pole and Luminaire Removed and Reset will be measured by each reset installation, complete in place, including foundations and all conduit, sweeps, hardware, wiring, and all miscellaneous work, tested and fully functioning.

BASIS OF PAYMENT

Item 823.70, Highway Lighting Pole and Luminaire Removed and Reset will be paid at the contract bid price per each, which price shall include all labor, materials, equipment, and incidental costs required to complete the work.

⑤ Addendum No. 5, April 1, 2026

ITEMS 995.01 and 995.02 (Continued)

SCHEDULE OF BASIS FOR PARTIAL PAYMENT

Within ten (10) days after the Notice to Proceed, the Contractor shall submit, in duplicate, for the approval of the Engineer, a schedule of unit prices for the major components of the bridge structures as listed below. The bridge structure Lump Sum breakdown quantities provided below are estimated and not guaranteed. The total of all partial payments to the Contractor shall equal the Lump Sum contract price regardless of the accuracy of the quantities furnished by the Engineer for the individual bridge components. The cost of labor and materials for any Item not listed but required to complete the work shall be considered incidental to Item 995.01 and Item 995.02 and no further compensation will be allowed.

SCHEDULE FOR ITEM 995.01					
Sub-Item	Description	Quantity	Unit	Unit Price	Total
482.31	Sawing and Sealing Joints in Asphalt Pavement at Bridges	135	FT		
904.3	5000 PSI, 3/4 INCH, 685 HP Cement Concrete	498	CY		
910.	Steel Reinforcement for Structures	12,170	LB		
910.2	Steel Reinforcement for Structures - Coated	92,265	LB		
⑤ 911.1*	Shear Connectors	4,500	EA		
922.	Laminated Elastomeric Bearing Pad without Anchor Bolts	27	EA		
960.	Structural Steel	506,836	LB		
965.	Membrane Waterproofing for Bridge Decks	7,675	SF		
970.	Damp-Proofing	2,039	SF		
975.4	Protective Screen Type II	238	FT		
975.41*	Protective Screen Type I Extension	238	FT		
Total Cost for Item 995.01 =					

⑤ Addendum No. 5, April 1, 2026

PROJECT FILE NO. 609409
- PRELIMINARY ESTIMATE OF QUANTITIES - DETAIL SHEET -
CITY/TOWN – SPRINGFIELD YEAR 2025
BRIDGE REPLACEMENTS April 11, 2025

ITEM 665. CHAIN LINK FENCE REMOVED AND STACKED

STA 31+33, 20' RT (WARWICK ST) – STA 13+14, 25' RT	165 FT
STA 14+72.37, 25.5' RT – STA 14+75, 74.4' RT	65 FT
STA 14+72.37, 25.5' RT – STA 16+27.28, 40.9' RT	130 FT
	TOTAL: 360 FT

ITEM 666. CHAIN LINK FENCE REMOVED AND RESET

STA 13+39, 44' RT – STA 13+44, 60' RT	20 FT
	TOTAL: 20 FT

ITEM 671. FENCE GATE AND GATE POST REMOVED AND STACKED

AT THE FREEDMAN DRIVEWAY

ITEM 767.121 SEDIMENT CONTROL BARRIER

PLACED AT SLOPE LIMITS OF ALL DISTURBED SOIL

STA 12+03.02, 68.1' RT – STA 13+49.12, 39.7' RT	214 FT
STA 12+87.11, 25.4' LT – STA 13+33.87, 25.2' RT	54 FT
STA 14+41.37, 54.3'RT – STA 14+75.73, 68.6' RT	44 FT
STA 14+72.44, 68.1' LT – STA 16+32.32, 29.8' LT	188 FT
STA 14+99.72, 67' RT – STA 16+29.73, 54.5' RT	163 FT
STA 16+95.02, 43.2' RT – STA 17+56.52, 87.3' RT	83 FT
STA 17+92.51, 23.5' LT – STA 18+02.69, 28.3' LT	13 FT
	TOTAL: 760 FT

ITEM 856.12 PORTABLE CHANGEABLE MESSAGE SIGN

- PORTABLE CHANGEABLE MESSAGE SIGNS SHALL BE OPERATED ON THE APPROACHES TO THE WORK ZONE 7 DAYS PRIOR TO THE APPROVED WORK SCHEDULE
- FOR DETOURS

⑤ **ITEM 903. 3000 PSI, 1.5 INCH, 470 CEMENT CONCRETE**

FOR SPRINGFIELD WATER AND SEWER COMMISSION STANDARD CONCRETE THRUST BLOCKS AND GRAVITY BLOCKS FOR WATER MAIN WITHIN ROADWAY

⑤ **ITEM 904. 4000 PSI, 3/4 INCH, 610 CEMENT CONCRETE**

FOR STREET LIGHT POLE FOUNDATIONS

Addendum No. 5, April 1, 2026

PROJECT FILE NO. 609409
- PRELIMINARY ESTIMATE OF QUANTITIES - DETAIL SHEET -
CITY/TOWN – SPRINGFIELD YEAR 2025
BRIDGE REPLACEMENTS April 11, 2025

ITEM 904.3 5000 PSI, 3/4 INCH, 685 HP CEMENT CONCRETE

WILL BE USED FOR THE FOLLOWING WHICH NOT INCLUDED IN THE LUMP SUM BRIDGE ITEMS:

FOR GRAVITY BLOCKS, CRASH WALL, RETURN WALLS, CLOSURE POURS, MOMENT SLABS, AND CONCRETE COPING.

ITEM 910.2 STEEL REINFORCEMENT FOR STRUCTURES - COATED

FOR GRAVITY BLOCKS, CRASH WALL, RETURN WALLS, CLOSURE POURS, MOMENT SLABS, AND CONCRETE COPING.

Addendum No. 5, April 1, 2026

DOCUMENT A00891

SWSC FLOW BYPASS CONCEPT PLAN

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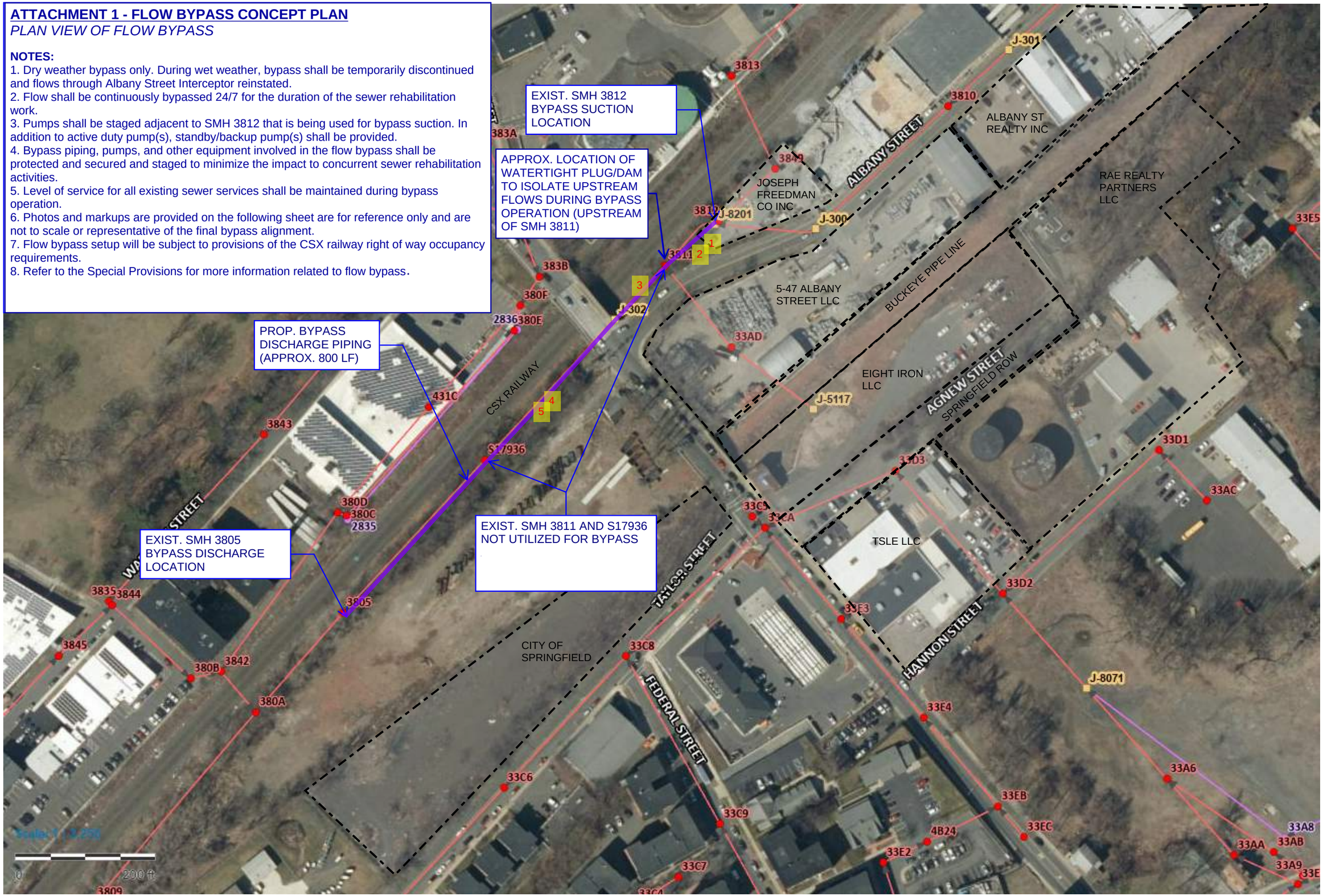
ATTACHMENT 1 - FLOW BYPASS CONCEPT PLAN

PLAN VIEW OF FLOW BYPASS

NOTES:

1. Dry weather bypass only. During wet weather, bypass shall be temporarily discontinued and flows through Albany Street Interceptor reinstated.
2. Flow shall be continuously bypassed 24/7 for the duration of the sewer rehabilitation work.
3. Pumps shall be staged adjacent to SMH 3812 that is being used for bypass suction. In addition to active duty pump(s), standby/backup pump(s) shall be provided.
4. Bypass piping, pumps, and other equipment involved in the flow bypass shall be protected and secured and staged to minimize the impact to concurrent sewer rehabilitation activities.
5. Level of service for all existing sewer services shall be maintained during bypass operation.
6. Photos and markups are provided on the following sheet are for reference only and are not to scale or representative of the final bypass alignment.
7. Flow bypass setup will be subject to provisions of the CSX railway right of way occupancy requirements.
8. Refer to the Special Provisions for more information related to flow bypass.



ATTACHMENT 1 - FLOW BYPASS CONCEPT PLAN

PHOTOS OF FLOW BYPASS ALIGNMENT

1

2

3

4

5

ATTACHMENT 1 - FLOW BYPASS CONCEPT PLAN
ANNOTATED RECORD DRAWING SHOWING SUCTION PIPING

SMH 3812 - SUCTION MANHOLE
EXIST. BRICK STRUCTURE
APPROX. RIM EL.: 135.0 FT
APPROX. INV. EL.: 121.9 FT

SOUND-ATTENUATED DIESEL BYPASS PUMPS STAGED AT GRADE

SUCTION PIPING TO BE ROUTED WITHIN SMH 3812 AND EXIST. 30-INCH RCP SEWER (APPROX. 6 LF) TO EXIST. 50-INCH BY 66-INCH RCP SEWER

R.R. RIGHT OF WAY
4+84.32
3+91.32
M.H.
A.S.T.M. C-76-60T CLASS V LOCK JOINT WALLS
PAILS 13307 13307 13307 13307
107.39' - 30" R.C.P. A.S.T.M. C-76-60T CLASS V
135.84' 30" R.C.P. A.S.T.M. C-76-60T CLASS V LOCK JOINT
356.77' 30" R.C. PIPE CLASS V ALL A.S.T.M. C-76-60T 0.80%
EXIST. 4'-2" x 5'-6"
INV. 121.90
30" CONN. TO EXIST. SEWER
INV. 118.90
INV. 122.76
INV. 123.85
INV. 125.18
INV. 125.60
INV. 126.70
INV. 127.20
INV. 128.00
NEW 12" CONN.
Base 115
+06.6
5 +92.61
4
+56.77
3
2 +90.30
+37.20
1
0 0-11
Base 115

PROFILE
SCALE: HOR. 1"=40' VERT. 1"=4'

CHANDLER ST.
NAPIER
EXIST. 24" SEWER
C.B.
O.N.E. W.G.
STREET
M.H.
New M.H.
0-11 EXIST. 12" SEWER
INV. 128.00
M.H. Abandon to M.H.
12"
24"
New Conn.
NEW M.H.
Relay to New M.H. Pole
PLUGGED
0+00
INV. 126.70
EXIST. 24" SEWER
FIELD CHECKED ON 3-22-82 VERIFIED THAT 30" SLY. OUT OF M.H. HAS BEEN PLUGGED.
F.P.O
S 43° 31' 15" W
0x00
15'
STORAGE TANK
FUTURE STORAGE TANK
30" SEWER ABANDONED
0+33.7
30" COMBINED SEWER
S 46° 28' 45" E
15'
1+37.20 M.H.
S 28° 07' 45" E
1+90.30 M.H.
POPULAR MARKETS INCORPORATED

HARRY & MELVIN HOLSTEIN
STREET
N 39° 40' 25" W
30.84
ARMORY
S 43° 29' 15" W
694+62.29
3+91.32
R.R. Sideline
SIDETRACK
BOSTON AND ALBANY RAILROAD
WEST SPRINGFIELD
694+17.45
694+83.76
4+37.82
BASE LINE
BOSTON
SIDETRACK
SMH 3811 - ACCESS MANHOLE FOR SEWER REHAB
EXIST. BRICK STRUCTURE
APPROX. RIM EL.: 127.5 FT
APPROX. INV. EL.: 116.8 FT
APPROX. LOCATION OF WATERTIGHT PLUG/DAM TO ISOLATE UPSTREAM FLOWS DURING BYPASS OPERATION
SMH 3812 - SUCTION MANHOLE
EXIST. BRICK STRUCTURE
APPROX. RIM EL.: 135.0 FT
APPROX. INV. EL.: 121.9 FT
Steel Pole
C.B.
+37
M.H.
6" Dwy
Wall
694+05.23
+11.05
4+84.32
S 43° 29' 15" W
30" COMBINED SEWER
4+92.61
M.H.
R.R. sideline
SPUR
16" Sumac
S 19° 01' 15" E
COMBINED SEWER
3+56.77 M.H.
30"
S 46° 51' 45" W
COMBINED SEWER
8' Wood Fence
M.H.
1+90.30
C.B.
ALBANY
STREET
DISCHARGE PIPING TO BE ROUTED OVERLAND ALONG ALIGNMENT OF EXISTING SEWER FROM SMH 3812 TO EXIST. SMH 3805 (APPROX. 800 LF).
1+00.89
EXIST. 4'-2" x 5'-6" CONC. SEWER
PITTSBURG PLATE GLASS COMPANY

DATE	STATION TO STATION	REVISED BY	REMARKS
			10-18-62 CITY

ACCEPTED	CONST. ORDER	ENTRY	STARTED	COMPLETED	CONST. BY	STATION TO STATION

SPRINGFIELD, MASS.
DEPARTMENT OF STREETS AND ENGINEERING
NAPIER STREET
COMBINATION SEWER OUTLET
NAPIER ST. S.E.LY - S.W.LY & W.LY ACROSS PRIVATE LANDS TO AN EXISTING SEWER

SCALE: 1" = 20'	DATE OCT. 1961
DRAWN BY E.A.P. TRACED BY	CHECKED BY
SURVEY BOOK NO. PAGE	FILE NO. 389-56

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Addendum No. 5, April 1, 2026

DOCUMENT A00892

GEOTECHNICAL REPORT
BRIDGE NO. S-24-026

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nobis

GEOTECHNICAL REPORT

ARMORY STREET BRIDGE OVER ABANDONED CSX SPUR BRIDGE NO. S-24-026

SPRINGFIELD, MASSACHUSETTS

MassDOT Project File No. 609409

MassDOT Contract No. 115796

FOR

Tetra Tech
100 Nickerson Road
Marlborough, MA 01752

BY
NOBIS GROUP®

(800) 394-4182

Nobis Project No. 094184.100

May 30, 2025

www.nobis-group.com

May 30, 2025 (revised from March 7, 2025)
File No. 094184.100

Tetra Tech
Alison Lima, P.E.
Director A-E Services
100 Nickerson Road
Marlborough, MA 01752
Alison.Lima@tetratech.com

Subject: **Revised Geotechnical Report**
Armory Street over Abandoned CSX Spur
MassDOT Bridge No. S-24-026
Springfield, Massachusetts

Dear Ms. Lima:

Nobis Group is pleased to provide this revised report to Tetra Tech in support of the 100% Design Plan Submission. The purpose of our work, and this report, is to document the data obtained and provide geotechnical recommendations for the design and construction of the above-referenced bridge replacement.

We appreciate the opportunity to assist you with this project. If you have any questions, or if we may be of further service to you, please let us know.

Sincerely,

NOBIS GROUP

Robert Clopper, PE
Senior Project Engineer

Kurt Jelinek, PE
Director of Transportation Projects

COMMONWEALTH OF MASSACHUSETTS
KURT
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BRIDGE NO. S-24-026
SPRINGFIELD, MASSACHUSETTS

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1. EXECUTIVE SUMMARY

This geotechnical report concerns the replacement of the Armory Street over the abandoned CSX spur bridge (No. S-24-026) located in Springfield, Massachusetts. We understand the existing bridge was constructed in 1934 and is approximately 200 feet southeast of the bridge over the CSX Mainline (No. S-24-016). The existing bridge is approximately 50 feet wide and 62 feet long. Retaining walls exist on both sides of the bridge approaches including along Albany Street, spanning Armory Street between the two bridges.

As part of the bridge replacements, Armory Street will be widened by approximately 20 feet to the west. New retaining walls will be required to accommodate the roadway widening.

The generalized subsurface conditions encountered in the borings observed by Nobis consist of medium dense to very loose embankment and/or urban fill, underlain by reworked silt and clay, up to 40 feet of varved silt and clay, glacial till, and bedrock. Bedrock was encountered approximately 85 to 90 feet below Armory Street. The subsurface profile at this site is representative of a seismic Site Class E and is not considered susceptible to soil liquefaction.

The existing granite block abutments do not have an acceptable bearing resistance to meet current AASHTO LRFD design guidance, and we recommend deep foundations to support the replacement bridge. New pile caps supported by 2 rows of 17 (34 piles in total) 10.75-inch outside diameter (O.D.) drilled micropiles (DMPs) will be constructed behind the existing abutments, resulting in an approximately 24-foot longer bridge.

New retaining walls will be constructed west of Armory Street to retain the soil from the roadway widening. We recommend the proposed retaining walls associated with the replacement bridge consist of a deep foundation system, because constructing walls bearing on the medium dense to very loose fill and/or varved silt and clay could result in excessive settlements and create other constructability issues. The existing retaining wall along the east side of Armory Street and north of the bridge does not meet current AASHTO LRFD design guidance regarding the resistance factor for global stability and needs to be replaced. Additionally, an existing masonry block wall is located along the east side of Armory Street due south of the existing bridge. We understand the geometry of this wall was previously unknown and as-built plans are not available. After performing coring through the wall, its geometry was estimated and interpretive cross sections were developed. Based on the estimated geometry, the existing masonry block wall, designated Wall 7, meets current AASHTO LRFD design guidance regarding the resistance factor for the global stability and provides acceptable bearing resistance. We propose the use of soldier pile and lagging (SPL) walls for the proposed retaining walls designated Walls 4 through 6 and we recommend the existing Wall 7 remain in place.

To accommodate the roadway widening to the west, the existing north and south abutments will be extended to the west to retain the proposed fill. A portion of the proposed fill should be lightweight fill to reduce lateral loads on the north and south crash walls and return walls, as well as the SPL walls. The area of the lightweight fill should be indicated on the construction drawings. The abutment extensions, referred to as North and South Crash Walls, will be supported by pile caps with micropiles having an O.D. of 10.75 inches that extend into bedrock. In addition, return walls will be required to close the space between the crash walls and the proposed retaining walls north and south of the proposed bridge. The return walls will be located just behind the crash walls and will be partially underneath the proposed abutment pile caps. Both return walls will be supported on new 13.5-foot-wide pile caps that are 11 feet long, and the pile caps will be supported by 10.75-inch O.D. micropiles that extend into bedrock.

2. INTRODUCTION

2.1 Scope of Report

Nobis Engineering, Inc., d/b/a Nobis Group® (Nobis) has prepared this report for Tetra Tech presenting geotechnical engineering recommendations for the final design of the proposed bridge replacement located along Armory Street just south of Albany Street in Springfield, Massachusetts (the Site). Our geotechnical recommendations are in support of the 100% Design Plan Submission prepared by Tetra Tech. Work was performed in accordance with the Nobis proposal originally dated July 31, 2018 and ten (10) addendums: No. 1 and No. 2 dated January 15, 2019, No. 3 dated April 23, 2019, No. 4 dated February 16, 2020, No. 5 dated March 9, 2022, No. 6 dated June 10, 2021, No. 7 dated May 10, 2022, No. 8 dated February 10, 2023, No. 9 dated July 10, 2024, and No. 10 dated December 17, 2024. All existing features relating to the above-referenced project discussed herein are based on a Topographic Survey Plan provided by Tetra Tech on January 20, 2021, Proposed Bridge and Retaining Wall Drawings provided by Tetra Tech on November 4, 2024, and on provided as-built drawings. Elevations presented in this report are in feet and are relative to the North American Vertical Datum of 1988 (NAVD88).

A separate geotechnical report was prepared for the Armory Street Bridge over the CSX Mainline (S-24-016). This report is subject to the limitations contained in **Appendix A**.

2.2 Project and Site Conditions

The Site is located along Armory Street over the abandoned CSX spur (Bridge No. S-24-026) which is approximately 200 feet south of the bridge over the active CSX Mainline. The location of the Site is depicted on the attached **Figure 1**, Site Locus Plan. Based on the as-built drawings for the approaches to Armory Street Bridge dated September 1934 and prepared by the Springfield

Department of Streets & Engineering and Google Maps images, it appears the existing bridge is approximately 50 feet wide and approximately 62 feet long.

The project also includes the Armory Street bridge approaches between Warwick Street (due north) and Taylor Street (south), and the approximately 200-foot-long approach along Albany Street which connects with Armory Street due north and east of the bridge over the abandoned CSX spur. As-built drawings for the approaches from 1934 indicate that four 21 to 159 feet long concrete gravity retaining walls were constructed on both sides of Armory Street. The present condition of the retaining walls is unknown.

An existing approximately 170-foot-long retaining wall is located on the south side of Albany Street. As-built drawings for this retaining wall are not available. The present condition and stability of this wall along Albany Street is unknown. We understand this retaining wall is not part of this project and will therefore not be addressed in this report.

Photo 1 - Armory Street Bridge over the abandoned CSX Spur.

Another existing retaining wall is located along the east side of Armory Street between Albany Street and the north bridge abutment. This retaining wall is depicted on plans dated September 1934 and appears to be a concrete gravity or semi-gravity wall. A full replacement is planned for this wall as it does not meet the required factor of safety for global stability. Additionally, an existing approximately 52-foot-long retaining wall is located along the east side of Armory Street between the south bridge abutment and Agnew Street. This retaining wall is depicted on plans dated September 1934 and appears to be a combination of masonry and concrete gravity or semi-gravity walls. Refer to **Appendix D** for the as-built drawings.

Existing roadway grades at the southern approach of the abandoned CSX spur bridge is at approximately elevation (El.) 158 feet and slopes upward to approximately El. 160 and back down to approximately El. 153 at the junction of Armory Street and Albany Street. The abandoned CSX spur beneath the bridge is at approximately El. 138 and is currently used as a scrap yard.

Site utilities include, but may not be limited to, an existing 10-inch high pressure gas main, a 12-inch water main, two 4-inch fiber optic lines, and underground electrical and telephone lines that run along Armory Street and/or Albany Street. Based on DigSafe markings, a fiber-optic line runs approximately parallel and within the abandoned CSX spur.

2.3 Proposed Construction

We understand that the bridge over the abandoned CSX spur will be a full replacement, and that the abandoned CSX spur may be used in the future as a rail layover location to support the New Haven – Hartford – Springfield railroad expansion.

Armory Street will be widened by approximately 20 feet to the west. The roadway widening will accommodate a 10-foot shared path and a 2-foot shoulder on the west side of the existing bridge. The water main along Armory Street will be relocated and supported above ground on a concrete pedestal on the western side of the bridge. New retaining walls are proposed along the northwest and southwest sides of the bridge to accommodate the roadway widening.

Photo 2 - South abutment and existing wall east of Armory Street.

The existing masonry block retaining wall along the east side of Armory Street between the existing building located north of Agnew Street and the existing south abutment will remain in place. The existing retaining wall between the north abutment and Albany Street will be removed and replaced with a new structure.

The project also includes roadway reconstruction of the Armory Street bridge approaches between Warwick Street due north and Taylor Street to the south, and roadway reconstruction for the approximately 200-foot-long approach along Albany Street.

We understand that the project will be constructed in two (2) phases with the 1st phase being the construction of the western half of Armory Street including the roadway widening while the

southbound travel lane is closed, followed by the 2nd phase being the construction of the eastern half while the northbound travel lane is closed.

Refer to **Figure 2** for the approximate location of existing conditions and the proposed construction at the Site.

3. SUBSURFACE CONDITIONS

3.1 Historic Geologic Information

Based on the USGS surficial geologic map entitled "Geologic Map of the Springfield South Quadrangle, Hampden County, Massachusetts" from 1967, the Site is mapped as embankment fill, overlying stream-terrace deposits consisting of well-bedded sand, gravel, and silt. Underlying these stream-terrace deposits are glacial lake deposits consisting of well sorted, thin layers of alternating clay and silt or thick layers of fine sand and silt deposited in glacial Lake Hitchcock. A site-focused plan view of the 1967 USGS surficial geologic map along with the corresponding descriptions of geologic units are provided on **Figure 3**. Bedrock was reportedly encountered in the vicinity of the bridge over the abandoned CSX Spur at El. +75 which is approximately 85 to 90 feet below the Armory Street level.

A 1983 USGS map entitled "Bedrock Geologic Map of Massachusetts", indicates that bedrock at the Site generally consists of sedimentary and volcanic rocks of the Hartford basin. The bedrock locally encountered are reddish brown to pale red arkose and siltstone as well as gray sandstone, siltstone, and black shale. A site-focused plan view of this 1983 USGS bedrock map is provided on **Figure 4**.

3.2 Subsurface Explorations

Two subsurface explorations programs were performed. The first exploration program was performed in April/May 2019 and the second in November 2022 and February 2023. Test borings were advanced using standard drive and wash drilling techniques with Standard Penetration Tests (SPTs) performed in general accordance with ASTM D1586 and split-barrel samples recovered at generally continuous or semi-continuous intervals through fill and at five-foot intervals until the required depth was achieved.

Borings were located using taped measurements from existing site features prior to drilling. The ground surface elevation at each boring location was estimated based on the provided Topographic Survey Plan. Descriptions of subsurface conditions encountered are presented on the boring logs attached as **Appendix B.1**, pavement core photos are attached as **Appendix B.2,**

and test pit logs are attached as **Appendix B.3.** Approximate as-drilled exploration locations are depicted on the subsurface exploration plan attached as **Figure 2**.

3.2.1 Explorations Performed in 2019

The first subsurface exploration program for the reconstruction of Armory Street and the structures associated with it included the performance of twelve (12) test borings, four (4) probe lines, and three (3) test pits. The test borings were designated BB-1 through BB-8 (BB indicating a bridge boring) as well as BB-2A, BB-8A, WB-1, and WB-3 (WB indicating a retaining wall boring). The four (4) probe lines designated as PL-1, PL-2, PL-7, and PL-8 were also performed. The test pits were designated TP-1, TP-2, and TP-2A.

Test Borings and Probe Lines

Seaboard Drilling, Inc. (Seaboard) of Chicopee, Massachusetts mobilized to the Site on April 17, 2019, to perform test boring BB-6 during daytime hours. Seaboard completed this test boring, as well as boring BB-1, on April 25, 2019, and demobilized from the Site. Seaboard returned to the Site on Sunday, May 5, 2019, to begin evening/night drilling along Armory Street. Test borings BB-7, BB-8, BB-8A, WB-1, WB-3 and probe lines PL-7, and PL-8 were completed by the evening of May 23, 2019. Test borings BB-1 through BB-4, BB-2A, and probe lines PL-1 and PL-2 were performed simultaneously and were used for the analysis of the Armory Street bridge over the CSX Mainline. Test boring BB-5 was completed during daytime hours between May 28, 2019, to May 30, 2019. An observation well was installed in boring BB-2A for subsequent groundwater readings.

Test boring WB-2 and probe lines PL-3 through PL-6 were unable to be performed due to utility conflicts including a hi-pressure gas line operated at that time by Columbia Gas. Boring WB-2 was proposed along the south side of Albany Street, probe lines PL-3 and PL-4 were proposed near the retaining wall along the north side of Albany Street, and probe lines PL-5 and PL-6 were proposed near the retaining wall along the south side of Albany Street. These probe lines were meant to help estimate the existing geometry of the retaining walls along Albany Street.

Photo 3 - Drill rig set up at BB-2.

Borings were advanced to depths ranging from 17 to 84 feet below ground surface (bgs). NX-sized bedrock cores were collected in borings BB-5 and BB-6, in general accordance with ASTM D2113 to confirm the presence of bedrock and to evaluate bedrock type and quality. The probe lines were performed to determine the approximate geometry of the existing bridge abutments. See **Table 1** for a summary of the information obtained from the probe lines as well as bridge borings:

Table 1: Summary for Probe Lines and Bridge Borings

Probe / Boring ID		Distance from Abutment Face (feet)	Description
Probe Line PL-7	7-1/6	6.0	Refusal at 19 feet bgs
	7-2	11.4	Terminated at 35 feet bgs
	7-3	8.8	Terminated at 35 feet bgs
	7-4/BB-7	6.7	Refusal at 17 feet bgs
	7-5	5.0	Refusal at 19 feet bgs
Probe Line PL-8	8-1/BB-8	8.0	Refusal at 23.5 feet bgs (refusal on probable boulder cluster)
	8-2	5.0	Refusal at 3 feet bgs (refusal on buried cobble roadway)
	8-3	9.9	Refusal at 23.5 feet bgs (refusal on probable boulder cluster)
	8-4/BB-8A	12.0	Terminated at 35 feet bgs
BB-5	BB-5	3.0	Terminated at 70.5 feet bgs
BB-6	BB-6	4.0	Terminated ay 84 feet bgs

Refer to **Figures 5A** and **5B** showing the performed probes and our estimated cross section of the existing abutments. The shown geometries are estimates based on the probe lines and the actual geometry could be different.

Asphalt Pavement Cores

Asphalt cores were taken prior to drilling at borings WB-1 and BB-8 on Armory Street and at boring WB-3 on Albany Street using a 6-inch diameter thin-wall core drill unit. The retrieved asphalt cores provide the existing pavement layers and thickness. Photographs of the pavement cores are included in **Appendix B.2**.

Test Pits

Test pits TP-1, TP-2, and TP-2A were excavated on July 8, 2019 in front of the existing abutments of the bridge over the abandoned CSX spur, using a Komatsu PC45 track-mounted excavator, and were terminated at depths between 6 and 8 feet bgs, or approximately El. 132 and 130, respectively.

Photo 4 – Test Pit Excavation of TP-2.

Subsurface conditions encountered in the test pits generally consisted of approximately 6 to 6.5 feet of urban fill materials consisting of moist, brown and red to dark brown and black, fine to coarse sand, some fine to coarse gravel, some silt, and numerous construction debris including concrete, glass, and bricks. Some of the encountered fill was interpreted as reworked silt and clay. Nobis measured the embedment depth of the existing granite block abutments which ranged from approximately 5.5 feet to 6.5 feet and logged the subsurface conditions encountered. The test pits were backfilled with excavated fill soils and compacted using the excavator bucket. Test pit logs are provided in **Appendix B.3**.

3.2.2 Explorations Performed in 2022 and 2023

Test Borings

Seaboard Drilling, Inc. (Seaboard) of Chicopee, Massachusetts mobilized to the site on the evening of November 14, 2022, to perform boring WB-6 during night hours. Seaboard completed this boring and boring WB-4 in support of the Armory Street bridge over the CSX Mainline bridge approximately 200 feet north on November 16, 2022, and demobilized from the site. Seaboard returned to the site on Friday, November 18, 2022, to complete boring WB-5 during daytime hours also in support of the Armory Street bridge over the CSX Mainline bridge. Boring WB-6 was advanced to a depth of 73 feet bgs.

Retaining Wall #7 Cores

Cores from the front of the masonry block wall designated Wall #7 were performed by Witch Enterprises of Agawam, Massachusetts and observed by Nobis on February 16 and 17, 2023. Cores performed from the front of the masonry block wall at different angles indicate a base width between 6.7 and 7 feet and an embedment of 4.4 to 5.3 feet below ground surface.

Figures 6A and **6B** show the performed cores and our estimated cross section of the existing Wall #7. The shown geometries are estimates based on the cores and the actual geometry could be different.

3.3 Laboratory Testing

Soil and rock samples were selected by Nobis and submitted to GeoTesting Express of Acton, Massachusetts for laboratory testing. Laboratory testing included:

- Two (2) moisture content tests (ASTM D2216);
- Five (5) grain size analyses (ASTM D6913);
- One (1) grain size analysis with hydrometer (ASTM D6913/D7928);
- Two (2) Atterberg Limits (ASTM D4318);
- Two (2) Incremental Consolidation tests (ASTM D2435);
- One (1) pH test (ASTM D4972);
- One (1) test for Chloride and Sulfate Ions in Water Tests (ASTM D512-12 & ASTM D516-16); and
- One (1) Uniaxial Compressive Strength of Rock test (ASTM D7012-C).

Testing was performed to help evaluate soil and rock properties as well as verify visual field classifications. Additional laboratory testing performed for on samples obtained in test borings associated with the Armory Street bridge over the CSX Mainline was used for the analysis of the varved silt and clay as well as bedrock encountered at the site. The laboratory test results are attached as **Appendix C.**

3.4 Soil Engineering Properties

Soil properties of the varved silt and clay strata are essential for estimating settlement. Three incremental one-dimensional consolidation tests were performed on collected varved silt and clay samples from test borings BB-1 and BB-5 at a depth ranging from approximately 23 feet to 38 feet bgs. Three different methods (Casagrande, Log-Log, and Strain Energy) were used to estimate the maximum past pressures for all three samples. Due to apparent disturbance of the sample collected in boring BB-1, we did not use the results from that test in our settlement analyses. The estimated maximum past pressure for the two (2) tests performed on the samples collected in boring BB-5 varied between 8,000 and 11,000 pounds per square foot (psf). The over-consolidation ratio (OCR) was estimated to be 4.7 and 4.4, respectively, and we used the lower range of 4.5 in our settlement analyses. The compression index, C_C was estimated to be 0.1 and the recompression index, C_R, was estimated to be 0.025. Refer to **Appendix E.1** for our evaluation of the effective stress with depth, maximum past pressure, and OCR.

To perform bearing resistance and global slope stability analyses, the strength parameters of the varved silt and clay were estimated based on published articles. A study performed on Connecticut Valley Varved Clay entitled “Geology and Engineering Properties of Connecticut Valley Varved Clay” (DeGroot, D.J. and Lutenegger, A.J.) was used as a guide for estimating the

cohesion and angle of internal friction of the varved silt and clay. A cohesion of 130 psf and a friction angle (phi) of 22 degrees were considered as conservative properties for the varved silt and clay as well as for the reworked silt and clay deposits.

3.5 Generalized Subsurface Conditions

The generalized conditions encountered in the borings performed by Nobis consisted of topsoil, asphalt, or concrete underlain by embankment and/or urban fill, reworked silt and clay, varved silt and clay, silt, glacial till, and bedrock.

Refer to the logs of explorations observed by Nobis, included in **Appendix B,** for more detailed subsurface conditions. A generalized interpretative subsurface profile along the bridge center line is attached as **Figure 7**. The following paragraphs provide a general description of each stratum encountered.

Note that lithology within borings, and within the interpretive subsurface profile, is approximate and is based on our review of the soil samples and knowledge of the surficial geology maps. Variations and different interpretations are likely.

Asphalt/Concrete

Asphalt was encountered at the ground surface in borings WB-3 and WB-6 and was cored at WB-1 (PC) and BB-8 (PC). Asphalt thickness ranged from 6 to 18 inches. Concrete was encountered at the ground surface of borings BB-7, BB-8, BB-8A, and WB-1, as these borings were performed in the concrete sidewalk area. The concrete sidewalk was typically 4 to 4.5 inches thick.

Fill / Urban Fill / Subsoil

Fill was encountered in all boring locations beneath the topsoil, asphalt, or concrete sidewalk. It appears fill was used to construct the approach embankments, increasing in thickness and depth approaching the bridge abutments. The fill generally consisted of brown and tan fine to coarse sand with varying amounts of silt and gravel. Fill contained urban debris (glass, asphalt, brick, etc.) in samples taken closer to the ground surface in most areas across the Site. Urban fill ranged from very loose to very dense, while the embankment fill was typically very loose to loose.

Up to 15 feet of reworked silt and clay was encountered near the bottom of the abutments and approach embankments of the bridge over the Abandoned CSX spur. The reworked silt and clay material ranged from gray to reddish-brown and contained varying amounts of sand and gravel. The density of the reworked material was typically loose to medium dense or stiff for fine deposits.

Varved Deposits

Varved silt and clay was encountered below the fill/reworked silt and clay at each boring location where the fill layer was fully penetrated. We estimate the thickness of the soil layer ranges from approximately 25 to 50 feet across the site. This soil generally consisted of clayey silt and/or silty clay with varying amounts of sand and occasional gravel. The density of the varved deposits ranged from very loose to medium dense, or soft to stiff for fine deposits.

Silt

Within the southern portion of the Site at the location of borings BB-5, BB-6, and WB-6, a layer of silt was encountered. This soil layer ranged from 11.5 to 16 feet in thickness. The silt stratum was fully penetrated around El. 83 in borings BB-5 and BB-6 and at approximately El. 105.5 in boring WB-6. The stratum generally consisted of silt with little to and fine to coarse sand and trace clay. The density of the silt ranged from loose to very dense.

Glacial Till

Dense to very dense or hard glacial till was encountered below the varved silt and clay or silt deposits. Where encountered, the thickness of the layer ranged from 5 to 20.5 feet. The glacial till was not fully penetrated in boring WB-6. Most of the till stratum was fine in nature, consisting of fine sands and silt with varying amounts of medium to coarse sand and gravel. Numerous cobbles and/or boulders were encountered within the glacial till.

Bedrock

Borings BB-5 and BB-6 were advanced into bedrock and the top of bedrock was encountered at approximately El. 78.0 and 75.4, respectively. The top approximately 0.5 to 4.4 feet of bedrock was interpreted as weathered based on drilling behavior. Competent bedrock was encountered at depths ranging from El. 77.5 to 71. A total of 10 feet of NX-size bedrock coring was performed in borings BB-5 and BB-6. The recovery ranged from 87 to 100%, and the Rock Quality Designation (RQD) ranged from 25 to 50%.

Photo 5 - Bedrock Cores from BB-2A and BB-5.

The bedrock consisted of light red to reddish-brown, hard, fresh to slightly weathered, and moderately to severely fractured argillaceous

Sandstone. The rock jointing was very close to moderately close with horizontal. Numerous horizontal mechanical breaks occurred during the coring process.

Groundwater

Groundwater measurements were attempted at each boring location where encountered. The groundwater ranged from El. 129.8 to 142.2. The variance between the measured levels is likely the result of insufficient stabilization time, the use of water during the rotary-wash drilling processes, and the low permeability of the reworked and varved silt and clay layers.

Note that fluctuations in the observed groundwater levels will occur due to variations in precipitation, temperature, and other factors different from those existing at the time the measurements were made.

3.6 Implications of Subsurface Conditions

Based on our evaluation of the subsurface conditions at the Site, we believe the primary geotechnical issues for the proposed bridge replacements are as follows:

- **Reworked / Varved Silt and Clay** – The varved silt and clay deposits are compressible and may cause excessive settlements if additional loads are applied.

- **Presence of Loose to Very Loose Fill** – No record of placement or compaction is available for the existing fill. SPTs indicate that certain fill has a loose to very loose density. Obstructions such as old foundations, railroad ties, and other building debris may be encountered in the urban fill layers.

3.7 Geotechnical Seismic Design Recommendations

The seismic parameters developed for the proposed bridge are provided below per the AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition, 2015. Based on the FHWA HEPGIS website, Armory Street is classified as part of MAP-21 NHS Principal Arterials and therefore does not fall within the "National Highway System". Therefore, the proposed bridge is not considered a critical/essential bridge, and the 1,000-year seismic event maps were referenced.

Mapped Ground and Spectral Response Coefficients (USGS 1,000-year Seismic Hazard Maps):

- Horizontal Peak Ground Acceleration (PGA): 0.059
- Horizontal Response Spectral Acceleration, 0.2 Sec (S_S): 0.13
- Horizontal Response Spectral Acceleration, 1.0 Sec (S_1): 0.038

Based on SPT N-values obtained from borings BB-1, BB-2A, BB-5, and BB-6, the seismic Site Class is a "E" according to AASHTO Table 3.4.1.1-1. Other seismic site parameters are as follows:

- Site Factors for Site Class "E" (AASHTO Tables 3.4.2.3-1, and -2):
  Zero-Period (F_{pga}) = 2.5, Short-Period, 0.2 Sec (F_a) = 2.5, and Long Period, 1.0 Sec (F_v) = 3.5.

- Design Spectral Response Parameters for Site Class "E":
  A_S = 0.148 S_{DS} = 0.325 S_{D1} = 0.133

  where:
  - A_S is the response spectral acceleration
  - S_{DS} is the design spectral acceleration coefficient at 0.2-sec period
  - S_{D1} is the design spectral acceleration coefficient at 1.0-sec period

Per AASHTO Section 3.5, the site is assigned Seismic Design Category A based on a calculated S_{D1} of 0.133. The calculations are included as **Appendix E.2**.

3.8 Liquefaction Potential

Based on the medium dense to stiff consistency of the soils encountered below the groundwater table, the existing subsurface soils at the site are not considered susceptible to soil liquefaction.

4. GEOTECHNICAL DESIGN RECOMMENDATIONS

This section presents the geotechnical recommendations for the proposed bridge replacement of the Armory Street bridge over the abandoned CSX spur, including approaches. The provided Topographic Survey Plan (AutoCAD) and Bridge Plans and Profiles were used for the development of our recommendations. Our analyses were performed in accordance with MassDOT Bridge Manual published in 2020 and AASHTO LRFD Bridge Design Specifications, 9th Edition 2020.

Nobis assumes that Tetra Tech will perform the structural checks for the existing and proposed abutments and retaining walls including the sliding and overturning checks (if applicable), as well as evaluate if deep foundations meet the structural capacity including the design of micropile connections into the pile cap based on the anticipated loads and intended structural behavior (i.e. pinned pile head condition).

4.1 Design Groundwater Elevations

Nobis recommends a design groundwater elevation of El. 131 feet for the Armory Street bridge over the abandoned CSX spur.

4.2 Existing Bridge Abutments

Based on the test borings and probe lines observed by Nobis, the following information was assumed for our geotechnical analyses to evaluate the stability of the existing abutments:

- Embedment of the granite block abutment footings are at least five (5) feet below lowest ground surface;
- The bottoms of the granite block abutment footings are at approximately El. 132.5 feet;
- The widths of the abutment footings for the bridge over the abandoned CSX spur are assumed to be approximately 7.5 feet, and the length is approximately 48 feet; and
- The granite block footings are bearing on existing fill and/or reworked silt with varying amounts of clay and fine sand.

4.2.1 Bearing Resistance of Existing Bridge Abutments

Nobis estimated the factored bearing resistance of the existing abutments using information obtained from the subsurface explorations, and the assumptions mentioned above. The estimate is based on a bearing stratum with an assumed friction angle of 22°, a cohesion of 130 psf, and a bearing resistance factor, (φ_b), of 0.45. Footing width and length were estimated based on existing conditions. The factored bearing resistance for the existing abutments of the Armory Street over the abandoned CSX spur are approximately 4.1 kips per square foot (ksf). Refer to **Appendix E.3** for the bearing resistance calculations of the existing abutments.

4.2.2 Lateral Earth Pressures for Existing Bridge Abutments

We recommend that the existing abutments be evaluated based on the following soil parameters:

- Active Earth Pressure Coefficient (K_a) = 0.26 (MassDOT Bridge Manual, 3.1.6)
- Sliding Resistance Factor (φ_τ) = 0.85 (AASHTO LRFD Bridge Design Specification, 10.5.5.2.2)
- Retained Soil Unit Weight (γ) = 115 pcf
- Retained Soil Friction Angle (ϕ) = 33 degrees

According to AASHTO LRFD Article 10.6.3.4, a sliding coefficient of friction ($\tan \phi_f = \tan 22^0$) of 0.40 is recommended for the existing abutments supported on the reworked silt and clay and a value of C=0.8 for granite block footings against soil.

The active earth pressure coefficient, above, is based on a level backslope angle (i.e., 0 degrees). The sliding coefficient of friction is for the granite block against silt and clay interface.

A 250 psf live load surcharge should be applied to account for construction equipment. A live load surcharge should also be applied to account for vehicular traffic (AASHTO LRFD Article 3.11.6.4). The live load surcharge may be estimated as a uniform horizontal earth pressure due to an equivalent height of soil in accordance with AASHTO LRFD Tables 3.11.6.4-1 and -2. The existing abutments should be analyzed assuming that hydrostatic pressure will not be applied. We recommend ignoring passive pressure. The earth pressure coefficient calculations for the existing abutments are included as **Appendix E.4**.

4.2.3 Global Stability of Existing Bridge Abutments

The 2D limit equilibrium software Slide2 by RocScience, Inc. was used to evaluate the global stability of the existing granite block abutments. The required resistance factor for global stability is 0.75 (AASHTO LRFD Section 11.6.3.7), which corresponds to a factor of safety of approximately 1.3.

Based on our analysis, we estimate a resistance factor of 0.65 (i.e., FOS = 1.5) or greater for both abutments. The global stability calculations for the existing abutments are included in **Appendix E.5**.

4.3 Proposed Micropile Supported Abutments, Crash Walls, Return Walls, and Gravity Blocks

This section provides recommendations relating to the evaluation of the north and south abutment micropiles as well as the micropiles for the North Crash Wall, North Return Wall #3, South Crash Wall, South Return Wall #4, and Gravity Blocks #3 and #4.

North and South Abutments

A new pile cap supported by drilled micropiles will be constructed behind each of the existing abutments, whereas the existing abutments will be reused as retaining crash walls. The conceptual model is that the proposed micropiles will carry the entire load from the new superstructure including pile caps, whereas the existing abutments and proposed crash walls need to be stable without these superstructure loads.

The new North and South Abutments include 8-foot-wide and approximately 70.68-foot-long pile caps supported by 34 micropiles (2 rows of 17 piles). The bottom of the pile caps will be at approximately El. 151.25 and El. 151.5 for the North and South Abutments, respectively.

The west side of each abutment was also analyzed to evaluate if the micropile design can withstand the temporary loading during the 1st phase of construction. The 1st phase of construction (west) pile caps will be approximately 36.84-foot-long, supported by 18 micropiles (2 rows of 9 piles).

North and South Crash Walls

The North Crash Wall and South Crash Wall will be supported on new pile caps constructed west of the existing abutments approximately 4 to 4.5 feet below the rail track level with the bottom at El. 129.25 to 129.50. The existing north and south abutments will be extended 20.5 feet west and will be supported on 8.5-foot-wide pile caps. Each pile cap will consist of 10 micropiles (2 rows of 5 piles).

North Return Wall #3 and South Return Wall #4

The North Return Wall #3 will be located just north of the North Crash Wall and will be partially underneath the North Abutment pile cap. The South Return Wall #4 will be located just south of the South Crash Wall and will be partially underneath the South Abutment pile cap. The return walls will be supported on new 13.5-foot-wide and 11- foot-long pile caps that will be supported by 2 rows of 2 micropiles (a total of 4 micropiles). The micropiles for the return walls will be installed around the micropiles for the proposed North and South Abutments.

Gravity Blocks #3 and #4

Two (2) micropile supported gravity blocks along the west side of the roadway are proposed to accommodate the pipe bends where the water main changes from above ground to underground or underground to above ground, or any changes in elevation. The gravity blocks will support the dead load of the walls and soil behind the walls as well as the water main and assemblies. The gravity blocks will also experience a load in the plane of the wall from the water pressure at the pipe bends of the water main. Gravity Block #3 is due south of the existing driveway and will be supported by five (5) micropiles (1 row of 3 micropiles and 1 row of 2 micropiles). Gravity Block #4 will be supported by seven (7) micropiles (1 row of 4 micropiles and 1 row of 3 micropiles).

4.3.1 General Recommendations for Micropiles

Micropile Loads and Lightweight Fill

Tetra Tech provided updated loads for the crash walls, Return Walls #3 and #4, and Gravity Block Walls #3 and #4 on December 10, 2024. Tetra Tech provided updated loads for the proposed abutment pile caps on December 27, 2024. Loads are attached as part of **Appendix E.6**.

Additionally, we understand that lightweight fill will be needed at the North and South Crash Walls, as well as the North and South Return Walls #3 and #4 to reduce lateral loads. The lightweight fill should be place from the bottom of the pile caps and extend upward at a 45-degree angle. Lightweight fill should also be placed at a 45-degree upward angle towards the north to create a transition zone between regular weight and lightweight fill. The area of the lightweight fill should be indicated on the construction drawings. We recommend the use of foamed glass aggregate with a moist unit weight of approximately 22.5 pcf and a friction angle of 41 degrees as lightweight fill.

Micropile Axial Capacity - General

Nobis assumed the micropiles will be cased down to top of bedrock (casing extending approximately 1 foot± into competent bedrock), with the uncased section socketed in the bedrock. Nobis recommends that the micropiles be supported by side resistance in the bedrock in the uncased section (a.k.a. bond zone) only, ignoring side resistance in the overlying soils (cased section). Tip resistance is typically ignored for micropiles and was therefore not considered in our preliminary analyses. Nobis recommends using a nominal presumptive grout-to-ground bond value of 11 ksf for the preliminary design of the gravity-grouted micropiles (a.k.a. Type A) socketed into bedrock.

In general, bedrock consists of moderately to severely fractured Argillaceous Sandstone. The top 0.5 to 4.4 feet of the bedrock in this area was considered weathered bedrock. Below the weathered portion the bedrock had the RQD ranging from 25 to 50%.

A summary of the axial micropile capacity analysis for each structure is provided below. The axial capacity evaluations for the micropiles are provided in **Appendices E.6**.

Micropile Lateral GROUP Analysis - General

Nobis performed three-dimensional lateral pile analyses using the software GROUP v2022 by Ensoft Inc., for the proposed structures, which are discussed below. GROUP analyses were performed based on the loads and load factors provided by Tetra Tech for the substructures with the objective of estimating the lateral deflections, moments, as well as shear and axial forces in the micropiles for different load cases. Non-linear EI was assumed in all analyses. Based on discussions with Tetra Tech, we understand that a pinned connection between the micropiles and pile cap should be evaluated for all substructures (abutments, crash walls, return walls, and gravity block walls). Steel casings shall be drilled a minimum of 12 inches into intact bedrock to prevent subsidence of overburden into the uncased and/or bond zone portion of the drill hole (i.e., the rock socket). The structural engineer should evaluate the structural resistance of the micropiles to

ensure the micropiles are adequate. A summary of the lateral GROUP analysis for each abutment is provided below. The lateral group analyses for the micropiles are provided in **Appendices E.6**.

Micropile Settlement

We estimate that the settlement of the micropiles will primarily be elastic compression based on the axial loads, provided by Tetra Tech. Settlement due to elastic compression should be estimated by the structural engineer to confirm whether it meets project requirements. The elastic compression will occur primarily during construction, soon after the superstructure loads are applied. It is assumed micropile settlement in the bedrock will be negligible.

Micropile Casing Strength and Design

We recommend 10.75-in. outside diameter casing with a wall thickness of 0.5-inches, as found in Table 3.2.4-1 of the MassDOT Bridge Manual. According to the MassDOT Bridge Manual section 3.2.4.2-4, 52 ksi steel should be considered for the casing of steel micropiles.

Based on our analyses of the proposed structures, we recommend there be no casing joints (i.e., threads) within at least the first 3 feet below the bottom of the proposed pile caps. Below the top 3 feet, however, the analysis assumes a loss of 0.25 inches of the 0.5-inch-thick micropile casings to account for threading and we believe that this more than accounts for the loss in the steel due to corrosion in our analyses.

Micropile Rebar Strength and Design

We recommend #8 sized threaded central bar be used over the entire length of the micropile. According to the MassDOT Bridge Manual section 3.2.4.2-7, Grade 60 steel should be considered for the threaded central bar.

Corrosion of Steel Micropiles

The steel micropiles may be subject to corrosion. Corrosion rates are typically a function of temperature, soil pH, access to oxygen, and chemistry of the environment surrounding the pile. Based on the laboratory test results, the tested soil samples would be classified as non-corrosive according to AASHTO LRFD Bridge Design Specifications manual - Section 10.7.5. However, according to the MassDOT Bridge Manual section 3.2.4.2-5, we recommend a 1/16-inch loss in the casing due to corrosion be considered.

Lateral Earth Pressure behind Proposed Micropile Caps

We recommend that at-rest lateral earth pressure be considered behind the micropile supported pile caps to calculate the earth pressure loading. The proposed micropile caps should be analyzed based on the following soil parameters:

- At-Rest Earth Pressure Coefficient (K_o) = 0.46 (MassDOT Bridge Manual, 3.1.6)
- Retained Soil Unit Weight (γ) = 125 pcf
- Retained Soil Friction Angle (ϕ) = 33 degrees

The at-rest earth pressure coefficient above is based on a level backslope angle (i.e., 0 degrees). The earth pressure calculations for the proposed pile caps are included as **Appendix E.7**.

4.3.2 Micropile Design for Proposed North and South Abutments

The proposed approximately 70.68-foot-long abutment pile caps will be supported by 2 rows with 17 micropiles in each row that will be socketed into bedrock. The center-to-center spacing between rows is 5 feet and the center-to-center spacing between micropiles is 4 feet. The micropiles will consist of 10.75-inch diameter with 0.5-inch-thick casings and will include a minimum #8 center bar having a yield strength of 60 ksi and 5 ksi grout. A sketch of the proposed micropile configurations is included as **Figure 8**.

Micropile Axial Capacity

Based on the loads provided by Tetra Tech, and the lateral analysis performed below, the maximum axial load per micropile is approximately 105 kips. Assuming 9.75-inch diameter grouted rock sockets, a minimum rock socket length of 8 feet is required to support the anticipated loads at the north and south abutment pile caps. An 8-foot-long rock socket will result in an allowable factored geotechnical resistance of 123 kips, with a resistance factor of 0.55 and a nominal geotechnical resistance of 225 kips.

Micropile Lateral GROUP Analysis

Four (4) load cases were analyzed, as presented below in **Table 2**:

Table 2: Lateral Analyses for North/South Abutments (per Micropile)

Structure	Load Case	Max Shear (kip)	Max Lateral Deflection[1] (in)	Max Moment Below Top 3 Feet (kip*ft)[2]	Max Axial Load (kip)	Min Axial Load (kip)
	Service I	6.6	0.23	15.8	75	60

North and South Abutments	Strength I (Max)	9.3	0.33	22.9	105	85
	Strength I (Min)	6.7	0.24	16.4	90	75
	Extreme Event I	4.3	0.15	10.2	45	35

Notes:
[1] Depth of fixity is approximately 21 feet below the bottom of the pile cap, and taken at the 2nd point of zero deflection.
[2] Maximum moment with loss of 50% outside casing thickness due to threaded connections.

4.3.3 Micropile Design for Proposed Abutments (West) – Phase 1

The proposed approximately 36.84 foot-long abutments western portions constructed during Phase 1 pile caps will be supported by 2 rows with 9 micropiles in each row that will be socketed into bedrock. The center-to-center spacing between rows is 5 feet and the center-to-center spacing between micropiles is 4 feet. The micropiles will consist of 10.75-inch diameter with 0.5-inch-thick casings and will include a minimum #8 center bar having a yield strength of 60 ksi and 5 ksi grout. A sketch of the proposed micropile configurations is included as **Figure 8**.

Micropile Axial Capacity

Based on the loads provided by Tetra Tech, and the lateral analysis performed below, the maximum axial load per micropile is approximately 105 kips. Assuming 9.75-inch diameter grouted rock sockets, a minimum rock socket length of 8 feet is required to support the anticipated loads at the north and south abutment pile caps. An 8-foot-long rock socket will result in an allowable factored geotechnical resistance of 123 kips, with a resistance factor of 0.55 and a nominal geotechnical resistance of 225 kips.

Micropile Lateral GROUP Analysis

Four (4) load cases were analyzed, as presented in the below in **Table 3**:

Table 3: Lateral Analyses for North/South Abutment - West (per Micropile)

Structure	Load Case	Max Shear (kip)	Max Lateral Deflection[1] (in)	Max Moment Below Top 3 Feet (kip*ft)[2]	Max Axial Load (kip)	Min Axial Load (kip)
North and South Abutments	Service I	7.1	0.22	16.0	75	50
	Strength I (Max)	10.0	0.31	22.9	105	75
	Strength I (Min)	7.4	0.23	16.7	90	65
	Extreme Event I	4.8	0.15	10.6	45	30

Notes:
[1] Depth of fixity is approximately 21 feet below the bottom of the pile cap, and taken at the 2nd point of zero deflection.
[2] Maximum moment with loss of 50% outside casing thickness due to threaded connections.

4.3.4 Micropile Design for North/South Crash Walls with Lightweight Fill

The crash walls will be constructed west of the existing abutments on new, approximately 8.5-foot-wide and 20.5-foot-long pile caps that will be supported by ten (10) micropiles (2 rows with 5 drilled micropiles in each row) that will be socketed into bedrock. The center-to-center spacing between rows is 5.25 feet and the center-to-center spacing between micropiles is 4.375 feet. The micropiles will consist of 10.75-inch diameter with 0.5-inch-thick casings and will include a minimum #8 center bar having a yield strength of 60 ksi and 5 ksi grout. A sketch of the proposed micropile configurations is included as **Figure 8**.

Micropile Axial Capacity

Based on the loads provided by Tetra Tech, and the performed lateral pile analysis, the maximum axial load per micropile is approximately 110 kips. The minimum axial load per micropile is approximately -30 kips, or 30 kips of uplift. Assuming 9.75-inch diameter grouted rock sockets, a minimum rock socket length of 8 feet is required to support the anticipated loads at the crash walls. An 8-foot-long rock socket will result in an allowable factored geotechnical resistance of approximately 123 kips, with a resistance factor of 0.55 and a nominal geotechnical resistance of approximately 225 kips.

Micropile Lateral GROUP Analysis

Loads provided assumed the use of lightweight fill. Five (5) load cases were analyzed as presented in the below in **Table 4**:

Table 4: Lateral Analyses for North/South Crash Walls (per Micropile)

Structure	Load Case	Max Shear (kip)	Max Lateral Deflection[1] (in)	Max Moment Below Top 3 Feet (kip*ft)[2]	Max Axial Load (kip)	Min Axial Load (kip)
North/ South Crash Walls	Service I	11.7	0.15	24.0	85	-20
	Strength I (Max)	15.8	0.22	33.0	110	-30
	Strength I (Min)	10.6	0.13	21.4	75	-20
	Extreme Event I (I)[3]	14.8	0.20	30.3	80	-20
	Extreme Event I (II)[4]	16.2	0.23	33.4	75	-15

Notes:
[1] Depth of fixity is approximately 14 feet below the bottom of the pile cap, and taken at the 2nd point of zero deflection.
[2] Maximum moment with thickness loss of 50% of casing due to threaded connections.
[3] Extreme I (I) is 50% Inertial + 100% P_{ae}.
[4] Extreme I (II) is 100% Inertial + 50% P_{ae}.

4.3.5 Micropile Design for North/South Return Walls #3 and #4 with Lightweight Fill

The North Return Wall #3 and South Return Wall #4 will be constructed on new, approximately 11-foot-long and 13.5-foot-wide pile caps that will be supported by four (4) micropiles (2 rows with 2 micropiles in each row) that will be socketed into bedrock. The center-to-center spacing between rows is 8 feet and the center-to-center spacing between micropiles is 5 feet. The micropiles will consist of 10.75-inch diameter with 0.5-inch-thick casings and will include a minimum #8 center bar having a yield strength of 60 ksi and 5 ksi grout. A sketch of the proposed micropile configurations is included as **Figure 8**.

Micropile Axial Capacity

Based on the loads provided by Tetra Tech, and the performed lateral pile analysis, the maximum axial load per micropile is approximately 140 kips. The minimum axial load per micropile is approximately -20 kips, or 20 kips of uplift. Assuming 9.75-inch diameter grouted rock sockets, a minimum rock socket length of 10 feet is required to support the anticipated loads at the return walls. A 10-foot-long rock socket will result in an allowable factored geotechnical resistance of approximately 154 kips, with a resistance factor of 0.55 and a nominal geotechnical resistance of approximately 281 kips.

Micropile Lateral GROUP Analysis

Loads provided assumed the use of lightweight fill. Five (5) load cases were analyzed as presented in the below in **Table 5**:

Table 5: Lateral Analyses for North/South Return Walls #3 and #4 (per Micropile)

Structure	Load Case	Max Shear (kip)	Max Lateral Deflection[1] (in)	Max Moment Below Top 3 Feet (kip*ft)[2]	Max Axial Load (kip)	Min Axial Load (kip)
North/ South Return Walls	Service I	17.2	0.25	37.1	110	-15
	Strength I (Max)	23.0	0.37	50.1	140	-20
	Strength I (Min)	15.5	0.22	33.3	100	-10
	Extreme Event I (I)[3]	22.7	0.37	48.8	110	-10
	Extreme Event I (II)[4]	25.7	0.45	55.7	100	-5

Notes:
1 Depth of fixity is approximately 14 feet below the bottom of the pile cap, and taken at the 2nd point of zero deflection.
2 Maximum moment with thickness loss of 50% of casing due to threaded connections.
3 Extreme I (I) is 50% Inertial + 100% P_{ae}.
4 Extreme I (II) is 100% Inertial + 50% P_{ae}.

4.3.6 Micropile Design for Gravity Block Wall #3

Gravity Block Wall #3, which is proposed near STA 15+10 will consist of a new, approximately 12.5-foot-wide and 16.82-foot-long pile cap north of the proposed retaining wall designated Wall #4 and south of the existing driveway. The pile cap will be supported by five (5) micropiles, (1 row with 3 and 1 row with 2 micropiles) that will be socketed into bedrock. The center-to-center spacing between rows is 8 feet and center-to-center spacing between micropiles is 5.5 to 5.6 feet. The micropiles will consist of 10.75-inch diameter with 0.5-inch-thick casings and will include a minimum #8 center bar having a yield strength of 60 ksi and 5 ksi grout. A sketch of the proposed micropile configurations is included as **Figure 8**.

Micropile Axial Capacity

Based on the loads and load factors provided by Tetra Tech, and the performed lateral pile analysis, the maximum axial load per micropile is approximately 135 kips. Assuming 9.75-inch diameter grouted rock sockets, a minimum rock socket length of 10 feet is required to support the anticipated loads at Gravity Block Wall #3. A 10-foot-long rock socket will result in an allowable factored geotechnical resistance of approximately 154 kips, with a resistance factor of 0.55 and a nominal geotechnical resistance of approximately 281 kips.

Micropile Lateral GROUP Analysis

Five (5) load cases were analyzed as presented in the below in **Table 6**:

Table 6: Lateral Analyses for Gravity Block Wall #3 (per Micropile)

Structure	Load Case	Max Shear (kip)	Max Lateral Deflection[1] (in)	Max Moment Below Top 3 Feet (kip*ft)[2]	Max Axial Load (kip)	Min Axial Load (kip)
Gravity Block Wall #3	Service I	28.2	0.67	58.4	95	50
	Strength I (Max)	37.6	1.09	90.3	135	60
	Strength I (Min)	25.4	0.58	51.5	110	40
	Extreme Event I (I)[3]	32.8	0.86	72.3	90	55
	Extreme Event I (II)[4]	37.9	1.10	88.9	90	65

Notes:
1 Depth of fixity is approximately 15 feet below the bottom of the pile cap, and taken at the 2nd point of zero deflection.
2 Maximum moment with thickness loss of 50% of casing due to threaded connections.
3 Extreme I (I) is 50% Inertial + 100% P_{ae}.
4 Extreme I (II) is 100% Inertial + 50% P_{ae}.

4.3.7 Micropile Design for Gravity Block Wall #4

Gravity Block Wall #4 is proposed near STA 17+15 and will consist of a new, approximately 12.5-foot-wide, 18.2-foot-long pile cap north of the proposed retaining wall designated Wall #6. The pile cap will be supported by seven (7) micropiles, (1 row with 4 and 1 row with 3 micropiles) that will be socketed into bedrock. The center-to-center spacing between rows is 8 feet and the center-to-center spacing between micropiles is 4.5 feet in the row with 4 micropiles and 6.75 feet in the row with 3 micropiles. The micropiles will consist of 10.75-inch diameter with 0.5-inch-thick casings and will include a minimum #8 center bar having a yield strength of 60 ksi and 5 ksi grout. A sketch of the proposed micropile configurations is included as **Figure 8**.

Micropile Axial Capacity

Based on the loads and load factors provided by Tetra Tech, and the performed lateral pile analysis, the maximum axial load per micropile is approximately 100 kips. Assuming 9.75-inch diameter grouted rock sockets, we recommend a minimum rock socket length 7 feet to support the anticipated loads at the Gravity Block Wall # 4. A 7-foot-long rock socket will result in an allowable factored geotechnical resistance of approximately 108 kips, with a resistance factor of 0.55 and a nominal geotechnical resistance of approximately 197 kips.

Micropile Lateral GROUP Analysis

Five (5) load cases were analyzed as presented in the below in **Table 7**:

Table 7: Lateral Analyses for Gravity Block Wall #4 (per Micropile)

Structure	Load Case	Max Shear (kip)	Max Lateral Deflection[1] (in)	Max Moment Below Top 3 Feet (kip*ft)[2]	Max Axial Load (kip)	Min Axial Load (kip)
Gravity Block Wall #3	Service I	22.0	0.49	36.9	75	35
	Strength I (Max)	28.0	0.73	54.7	100	40
	Strength I (Min)	18.9	0.43	32.9	80	25
	Extreme Event I (I)[3]	24.8	0.60	45.0	70	40
	Extreme Event I (II)[4]	27.6	0.71	52.8	65	45

Notes:
1 Depth of fixity is approximately 17 feet below the bottom of the pile cap, and taken at the 2nd point of zero deflection.
2 Maximum moment with thickness loss of 50% of casing due to threaded connections.
3 Extreme I (I) is 50% Inertial + 100% P_{ae}.
4 Extreme I (II) is 100% Inertial + 50% P_{ae}.

4.3.8 Final Design of Micropiles and Load Testing

The micropile rock socket lengths and rock socket diameter may be modified by the contractor based on the load testing results, with the approval of the engineer. Based on AASHTO LRFD Section 10.9.3.5.4, micropile load tests should be performed to validate their design. The micropile load testing recommendations are discussed in further detail in the construction considerations section of this report.

4.4 Bridge Approach Slabs

Approach slabs were not encountered during the performance of the probe lines. Approach slabs are recommended at each new abutment. The intent is to reduce the lateral earth pressure onto the abutments and to avoid abrupt changes in elevation between the proposed bridge and the approach embankment, which may result from differential settlement. The approach slabs should be structurally tied to the abutments and be free to rotate about the abutment. We recommend that the proposed approach slabs be supported by at least 12 inches of compacted Gravel Borrow.

4.5 Existing Retaining Walls

4.5.1 Retaining Wall 5

An existing retaining wall is located on the east side of Armory Street between Albany Street and the bridge over the abandoned CSX spur. As-built drawings for the existing wall were provided by Tetra Tech in July of 2018. The existing retaining wall appears to be a cast-in-place concrete gravity retaining wall. The existing wall does not meet the required bearing resistance or resistance factor against global stability. The bearing resistance and global stability analyses for the existing retaining wall are included in **Appendix E.8**. The replacement wall is referred to herein as Wall 5.

4.5.2 Retaining Wall 7

An existing masonry block wall is located between the bridge over the abandoned CSX spur and the existing building along Agnew Street along the east side of Armory Street. No as-built drawings or existing conditions reports are available for the existing wall. Coring through the existing masonry blocks was performed at different angles from the front face of the wall in 2023 by Witch Enterprises. Based on the performed cores, we estimate that the base of the wall is at El. 141.2 feet and the base width is approximately 6.7 feet. Refer to **Figures 6A** and **6B** for more details regarding the completed cores. Nobis understands this wall will remain in place and will hereafter be referred to as Wall 7.

Bearing Resistance of Existing Retaining Wall 7

Nobis estimated the factored bearing resistance of the existing wall using information obtained from the subsurface explorations. Based on the borings, there are two types of existing fill in the general area of the existing retaining wall. The upper layer consists of granular embankment fill and the lower layer consists of reworked silt and clay. The estimate is based on an upper bearing stratum with an assumed friction angle of 33°, a unit weight of 115 pcf, and a bearing resistance factor, (φ_b), of 0.55. The lower bearing stratum has an assumed friction angle of 22 and a unit weight of 120 pcf. Footing width and length were estimated based on existing conditions and results of the cores. The factored bearing resistance for the existing retaining Wall 7 is approximately 12.1 ksf. Refer to **Appendix E.8** for the bearing resistance calculations of the existing abutments.

Global Stability

The 2D limit equilibrium software, Slide2, by RocScience, Inc. was used to evaluate the global stability of the existing masonry block retaining wall. The required resistance factor for global stability is 0.75 (AASHTO Section 11.6.3.7), which corresponds to a factor of safety of approximately 1.3.

Based on our analysis, we estimate a resistance factor of 0.53 (i.e., FOS = 1.9) or greater for the existing retaining Wall 7. The global stability calculations for the existing retaining Wall 7 are included in **Appendix E.8**.

4.6 Proposed Retaining Walls

Six (6) retaining walls will be replaced and/or constructed as a part of the Armory Street bridge reconstruction and roadway widening. Proposed Walls 4 through 6 and existing Wall 7, which will remain in place, are as shown in **Figure 2**. Retaining Walls 1 through 3 are addressed in a separate report for the Armory Street bridge over the CSX Mainline.

4.6.1 General Retaining Wall Recommendations

Retaining Wall Options

Mechanically stabilized earth (MSE) or prefabricated modular gravity block (PMGB) walls could be considered if the maximum bearing pressure is less than or equal to the bearing resistance at the service limit state for an acceptable settlement. We believe that MSE walls is the wall system that could tolerate larger settlements in comparison to PMGB walls because the front wall panels of MSE wall could be installed after some of the settlement has occurred. However, there are several disadvantages using MSE and/or PMGB walls including the following:

- Utilities could likely not be installed in the area of the MSE wall reinforcement or PMGB structural elements which need to be placed up to approximately 9 to 12 feet behind the wall face;

- A temporary support of excavation (SOE) with an exposed height of up to approximately 17 feet would be required during the construction of MSE or PMGB walls. Because of the existing loose to very loose fill and varved silt and clay at the site, a temporary SOE consisting either of a sheet pile wall or soldier pile and lagging wall would likely need to be installed to depths of 40 to 60 feet below the roadway level to achieve moment and force equilibrium requirements. The embedment depth of the sheeting and/or soldier piles could be shortened, and the steel profile be reduced if temporary tiebacks are utilized. Another possible solution would be to install a temporary soil nail wall if the nails will not interfere with existing utilities and would provide sufficient resistant in the loose fill; and

- MSE and PMGB walls are proprietary wall systems, and the final design is typically performed by the manufacturer. Some manufacturers may be hesitant to provide a design with such a low allowable bearing resistance at the service limit state and estimated settlements without improving the ground underneath first.

Nobis also analyzed whether cantilever walls would be feasible for the proposed Walls 4 through 6. Based on MassDOT standard drawing E 305.5.0, we understand that cantilever walls with an exposed height of approximately 10 to 13 feet will result in a maximum soil bearing pressure of approximately 4 to 5 ksf. Based on these bearing pressures, we believe that cantilever walls will not be feasible because of inadequate bearing resistances and estimated settlements of 2 to 3 inches. Refer to **Appendix E.8** for the bearing resistance, settlement, and global stability analyses for these retaining walls. We believe that ground improvements would be necessary to increase the bearing resistance at the service limit state. A summary of our analyses is presented below in the **Table 8**:

Table 8: Summary of Cantilever Wall Analyses

Wall ID	Exposed Wall Height	Factored Bearing Resistance at the Strength Limit State	Maximum Factored Load / Estimated Settlement Based on Maximum Factored Load	Resistance Factor / Meets Global Stability Requirements?
Retaining Wall 4	13 feet	2.8 ksf	4.9 ksf / 3.2 inches	0.77 (FOS=1.3) / No
Retaining Wall 5	10 feet	3.0 ksf	4.1 ksf / 2.9 inches	0.77 (FOS=1.3) / No
Retaining Wall 6	10 feet	3.9 ksf	4.1 ksf / 2.5 inches	0.67 (FOS=1.5) / Yes

Based on the performed analysis and assessing the different retaining wall options, Nobis believes that the following 3 options are feasible and could be considered for the proposed walls:

1. Cantilever wall with ground improvement and temporary SOE;
2. MSE wall with temporary SOE (and possibly some ground improvements); and
3. Drilled soldier pile and lagging wall.

Because options 1 and 2 will require a temporary SOE and some ground improvements, these options are likely not more economical than option 3. Nobis therefore recommends that retaining Walls 1 through 3 consist of drilled soldier pile and lagging (SPL) walls without the aid of tiebacks. SPL walls with tiebacks has been considered as a possible wall option to reduce the size and length of the drilled soldiers. However, the temporary condition during construction after partially backfilling the SPL wall and prior to installing the tiebacks will control the design and would make this option only feasible if temporary rakers are installed to support the soldier piles.

4.6.2 SPL Wall Recommendations and Lightweight Fill

General

Details for the SPL configurations Nobis analyzed including estimated lateral deflections, shear forces, moments, and minimum required embedment are provided in the following sections. The selected drilled SPL configurations were based on drawings including plans and cross-sections received from Tetra Tech on October 30, and November 15, 2023., and April 11, 2024.

The presented drilled SPL walls should be detailed by Tetra Tech based on our recommended embedment depth and selected soldier pile type and spacing. The design to be performed by Tetra Tech should include, but not limited to a verification that the estimated maximum deflection, shear forces and moments presented in **Appendix E.9** are acceptable, and the design of the lagging system. The proposed walls should be evaluated in accordance with AASHTO LRFD Bridge Design Specifications and the MassDOT Bridge Manual.

Minimum Use of Lightweight Fill

At a minimum, the south portion of Wall 4 should be backfilled with lightweight fill to reduce lateral loads from STA 15+75 to 16+18. The lightweight fill should be utilized at a minimum from the back edge of the top of the drilled shaft at El. 146 at a 45-degree upward angle. Lightweight fill should also be placed at a 45-degree upward angle towards the north to create a transition zone between regular weight and lightweight fill. The area of the lightweight fill should be indicated on the construction drawings. We recommend the use of foamed glass aggregate with a moist unit weight of approximately 22.5 pcf and a friction angle of 41 degrees as lightweight fill.

Lateral Deflections, Shear Forces, and Moments

Nobis performed the lateral analyses for proposed Walls 4 through 6 using the computer program Shoring Suite V8 from CivilTech Software to evaluate deflections, shear forces, and moments along the proposed soldier piles. Analyses were performed at the perceived critical cross-sections for proposed Walls 4 through 6 and considered various SPL wall configurations (i.e., HP- and W-sections, shaft diameters) and a 250 psf live load surcharge spanning the proposed roadway and sidewalk and extending to 1.5 feet from the nearest wall face. Based on our evaluations, we estimate the most critical drilled SPL configuration is at proposed Wall 4, Station 16+00, where the unsupported wall height is approximately 13.1 feet based on drawings received from Tetra Tech.

Nobis' analyses assume an approximately 4-foot-wide bench at grade on the passive side of the wall, 36-inch diameter drilled shafts, and soldier pile spacing of 6 feet on-center. The results of our lateral analyses indicate that a W18x311 soldier pile will deflect approximately 0.7 inch at the top of proposed Wall 4 at Station 15+50 with Gravel Borrow, 2 inches at the top of proposed Wall 4 at Station 15+75 with Gravel Borrow, and 2 inches at the top of proposed Wall 4 at Station 16+00 with lightweight backfill. A W16x89 soldier pile will deflect approximately 0.9 inch at the top of proposed Wall 5 and a W18x283 will deflect approximately 1.7 inches at the top of proposed Wall 6. The maximum shear forces experienced by the proposed SPL walls based on the soldier pile configurations considered are approximately 76.7 kips, 119.1 kips, 109.8 kips, 27.2 kips, and 92.1 kips at the bottom of the proposed shafts for Wall 4 at 15+50, Wall 4 at 15+75, Wall 4 at 16+00, Wall 5, and Wall 6, respectively. The results of the analyses also indicate maximum moments of approximately 556.8 kip-feet at 32.4 feet (approximate depth from top of wall), 1052.4 kip-feet at 47.9 feet, 901.1 kip-feet at 48.4 feet, 213.5 kip-feet at 25.7 feet, and 690.9 kip-feet at 46.4 feet for Wall 4 at 15+50, Wall 4 at 15+75, Wall 4 at 16+00, Wall 5, and Wall 6, respectively. Refer to the table entitled *Summary of SPL Wall Analyses* for information.

Minimum Embedment

In accordance with AASHTO LRFD Table 3 .4.1-2, a load factor of 1.5 should be used for the active earth pressure, while a resistance factor of 0.75 (Table 11.5.7-1) should be used for passive earth pressure for non-gravity cantilever walls. Given this guidance, the soldier pile configurations evaluated, and the subsurface conditions considered at each perceived worst-case wall sections, the results of our analyses using Shoring Suite indicate the minimum embedment (moment and force equilibrium) for Wall 4 at 15+50, Wall 4 at 15+75, Wall 4 at 16+00, Wall 5, and Wall 6 are approximately 39.7 feet, 60.5 feet, 55.9 feet, 31 feet, and 55.1 feet, respectively. Refer to **Appendix E.9** for additional details, including assumptions, summary tables, methodology, figures depicting evaluated wall sections, and output from the Shoring Suite analyses.

Lateral Earth Pressures for Soldier Pile and Lagging Walls

The lagging for the soldier pile walls should be designed for lateral earth pressures and surcharge loads in accordance with AASHTO LRFD and MassDOT Bridge Manual requirements. We recommend that the retaining walls be evaluated based on a retained soil with the following values:

Proposed Compacted Backfill and Existing Embankment Fill:	
Friction angle, ϕ	= 34 degrees (average of existing and proposed fill)
Unit Weight	= 125 pcf
Active Earth pressure coefficient (K_a)	= 0.25
At-Rest Earth pressure coefficient (K_0)	= 0.44
Passive Earth pressure coefficient (K_p)	= 3.5

Per MassDOT Bridge Manual, the at-rest earth pressure coefficient (K_0) should be considered for all pile supported retaining walls (i.e., for SPL walls). Jaky's method was used to determine the at-rest earth pressure coefficient. Lateral earth pressure coefficient calculations for the proposed SPL walls are included as **Appendix E.10**.

In addition, a minimum live load surcharge of 250 psf should be applied at the location of the proposed roadway and sidewalk (assumes no traffic barrier) to account for vehicular traffic and construction equipment (AASHTO LRFD Article 3.11.6.4). The live load surcharge may be estimated as a uniform horizontal earth pressure due to an equivalent height of soil in accordance with AASHTO LRFD Tables 3.11.6.4-1 and 3.11.6.4-2. The proposed retaining walls should be designed to drain, and therefore, be analyzed assuming that hydrostatic pressure will not be applied to the retaining walls.

Summary

Based on the analyses outlined above, we recommend drilled soldier pile walls with lagging, with soldier piles consisting of W18x311 (Wall 4), W16x89 (Wall 5), and W18x283 (Wall 6), spaced a maximum of 6 feet center-to-center, within 36-inch diameter drilled shafts (minimum 4,000 psi concrete) extending from final grade to the pile tip.

A summary of our soldier pile evaluations and recommendations is provided below in **Table 9**.

Table 9: Summary of SPL Wall Analyses

Steel Section	W18x311			W16x89	W18x283
Shaft Diameter (ft)	3				
Pile Spacing (ft c-t-c)	6				
Wall Designation	WALL 4			WALL 5	WALL 6
Approx. Station	15+19 to 15+50	15+50 to 15+75	15+75 to 16+18	14+72 to 16+18	17+30 to 17+49
Approx. Wall Length (ft)	31	25	43	174	27
Approx. No. Piles	5	4	7	30	5
Max. Pile Deflection (in)	0.7	2.0	2.0	0.9	1.7
Max. Shear Force (kips)	76.7	119.1	109.8	27.2	92.1
Max. Moment (kip-ft)	556.8	1052.4	901.1	213.5	690.9
Approx. Min. Pile Embedment (ft)	39.7	60.5	55.9	31.0	55.1
Approx. Pile Total Length (ft)	48.4	70.1	69.0	37.3	65.1

4.7 Settlement Due to Proposed Roadway Widening

Settle3, by RocScience, was used to estimate settlement that will occur due to the placement of fill behind the proposed soldier pile and lagging walls to support the roadway widening to the west of Armory Street. A model was created to symbolize the additional fill load and the effect that it is likely to have on the existing fill, reworked silt and clay, and varved silt and clay. The settlement models are included in **Appendix E.11**.

Based on the settlement model, the estimated total settlement with time is as follows:

- 0.6 inch of settlement from 0 to 3 months after fill placement,
- An additional 0.5 inch of settlement from 3 months to 50 years.

Therefore, the total estimated settlement (primary and secondary) is approximately 1.1 inches over 50 years.

We recommend that fill placement at the site be performed as far in advance as possible prior to final grading and placement of asphalt pavement to limit post-construction settlements. Paving activities should take place at least 3 months after construction of the retaining wall and placement of the backfill material.

5. CONSTRUCTION CONSIDERATIONS

5.1 Construction of Micropiles and Quality Assurance

5.1.1 Drilled Micropile Installation and Observation

Observation of micropile installation should be conducted by experienced geotechnical personnel. The depths of casings and rock sockets, required grouted lengths, depth of strata changes, pile alignment, and the anticipated grout take should be verified and documented for each micropile prior to placement of grout and/or rebar. We recommend construction of the drilled micropiles be in accordance with the MassDOT Bridge Manual published in 2020, AASHTO LRFD Bridge Design Specifications, 9th Edition 2020, AASHTO LRFD Construction Specifications, 4th Edition, and FHWA Micropile Design and Construction manual, 2005. We also recommend the following construction procedures:

- We recommend that the contractor sequence pile installation such that piles within 8 feet of the pile to be installed not be grouted within the previous 12 hours (i.e., when a pile is grouted, piles within 8 feet of the grouted pile shall not be drilled for minimum 12 hours, or allow 12 hours of grout set-up prior to drilling within 8 feet); and

- Micropiles shall be grouted as soon as possible after drilling is completed.

5.1.2 Micropile Load Tests

Load testing of micropiles is required per AASHTO LRFD Section 10.9.3.5.4. We recommend that two (2) verification load tests in tension be performed according to ASTM D3689 on two (2) sacrificial micropiles during the 1st phase of construction. One (1) verification load test is recommended for micropiles with a rock socket length of 10 feet at the north or south return walls and another verification load test for micropiles with a rock socket length of 8 feet at North or South Abutments. One (1) verification test should be performed at the north side of the bridge (i.e. either North Abutment or North Return Wall #3) and one should be performed at the side of the bridge (i.e. either South Abutment or South Return Wall #4). The loading procedure should follow the Quick Load Test method. The verification load tests should be performed and evaluated such that no skin friction outside the bond zone is included in the micropile resistance. This could be performed utilizing an oversized casing to the top of the bond zone or by utilizing tell-tales/strain gauges at the top and bottom of the bearing zone. The load test should be within 10 feet of the footprint of the proposed substructures, but at least 5 feet away from any production pile. We recommend that the contractor proposes the actual location of the sacrificial piles for the verification load tests.

The AASHTO LRFD Bridge Construction Specifications, 4th Edition, 2017, Section 33.5.2 requires that verification micropile be tested to 150% of the factored design load. The maximum design load for the Return Walls #3 and #4 micropiles is 140 kips; therefore, the required micropile test load for the 10-foot-long rock sockets is 210 kips (maximum design load of 140 kips * 150%). The maximum design load for the North/South Abutment micropiles is 105 kips; therefore, the required micropile test load for the 8-foot-long rock sockets is 158 kips (maximum design load of 105 kips * 150%). These loads likely exceeds the factored structural tensile resistance of a drilled micropile with a No. 8 bar. For sacrificial micropile load testing purposes, the contractor needs to design the micropiles with a larger center bar and likely a higher yield strength (i.e., Grade 150 ksi).

In addition to the verification tests, a minimum of eight (8) proof tests of production micropiles are also recommended, of which six (6) will be performed during the 1st phase and two (2) during the 2nd phase of construction. Two (2) proof tests at the North Abutment and two (2) proof tests at the South Abutment should satisfy the requirement that a minimum of 5% of piles be proof tested in accordance with AASHTO LRFD Section 10.9.3.5.4. Additionally, we recommend that one (1) proof test be performed at each substructure; North Crash Wall, North Return Wall #3, South Crash Wall, South Return Wall #4, Gravity Block Wall #3, and Gravity Block Wall #4. The proof tests should be loaded to 100 percent of the maximum factored design load. **Table 10** below provides a summary of the recommended micropile proof tests:

Table 10: Recommended Micropile Proof Tests for Bridge No. S-24-026

Structure	Rock Socket Length	Number of Micropiles	Max. Axial Load (i.e., Factored Design Load)	Required Proof Test Load	Number of Micropiles being Proof Tested
North Abutment (West) - Phase 1	8 feet	18	105 kips [1]	105 kips	1
North Abutment (Final) - Phase 2	8 feet	34-18 = 16	105 kips	105 kips	1
South Abutment (West) - Phase 1	8 feet	18	105 kips [1]	105 kips	1
South Abutment (Final) - Phase 2	8 feet	34-18 = 16	105 kips	105 kips	1
South Crash Wall	8 feet	10	110 kips [2]	110 kips [2]	1 [2]
South Return Wall #4	10 feet	4	140 kips [2]	140 kips [2]	
North Crash Wall	8 feet	10	110 kips [2]	110 kips [2]	1 [2]
North Return Wall #3	10 feet	4	140 kips [2]	140 kips [2]	
Gravity Block Wall #3	10 feet	5	135 kips	135 kips	1
Gravity Block Wall #4	7 feet	7	100 kips	100 kips	1

Notes:

[1] Micropiles for the North and South Abutments (West) - Phase 1 should be installed and proof tested for a factored design load of 105 kips and a required proof test load of 105 kips based on the North Abutment and South Abutment final pile cap analyses.

[2] Two (2) proof tests will be required, one to 110 kips and one to 140 kips. Either one (1) proof test at the South Crash Wall and one (1) proof test at the North Return Wall #3; or one (1) proof test at the North Crash Wall and one (1) proof test at the South Return Wall #4.

Successful proof testing should be performed and completed near the beginning of production micropile installation at each phase of construction.

5.2 Construction of Drilled Soldier Piles and Observation

Obstructions may be encountered in the urban fill stratum during the construction of the drilled soldier piles. If encountered, Nobis anticipates that shallow obstructions can be excavated and removed. Following removal of the obstruction, the excavation should be backfilled with a granular fill material and compacted prior to advancing the soldier pile. The contractor also needs to be prepared to remove obstructions at greater depth and use appropriate means and methods according to the encountered obstruction.

Observation of soldier pile drilled shaft installation should be conducted by a geotechnical engineer to verify soil layering and engineering properties and assumptions made in the design analyses. The depth drilled, shaft diameter, alignment and bottom elevation should be verified and documented for each shaft prior to placement of concrete.

5.3 Subgrade Preparation Procedures for Approach Slabs

We recommend the following subgrade preparation procedures for the proposed approach slabs:

- The approach slab should bear on a minimum 6-inch-thick, ¾-inch compacted Gravel Borrow for Bridge Foundations (M1.03.0, Type a) layer placed over the compacted subgrade;
- Subgrades for the approach slab should be dewatered, as needed, so that construction is performed in the dry; and
- Protect subgrades from frost at all times during construction. Fill should not be placed over frozen soil.

5.4 Protection of Existing Structures

The abutments/retaining walls and adjacent structures that will remain should be protected from adverse impacts during construction. Deformation monitoring points and survey targets should be installed and attached to the existing abutment, retaining walls, and/or other structures for instrumentation monitoring during construction.

We also recommend that an appropriate preconstruction survey be performed for the existing abutments/retaining walls and adjacent structures within 50 feet of Armory Street that will

remain. A preconstruction survey should be conducted to document all existing cracks, existing settlement, structural displacement, spalling, deterioration, damage, or other existing adverse effects for each structure using descriptions, video, photographs, measurements, and survey techniques.

Specific instrumentation and monitoring requirements shall be based on the proposed construction sequence, duration of construction, and performance criteria. Initial measurements should be established well in advance of construction so that baseline data can be developed. This information will be invaluable for providing early warning of adverse trends and for assessing the need for mitigating measures.

5.5 Construction Dewatering and Temporary Excavation Support

We do not anticipate that dewatering will be necessary for the construction of the pile caps and soldier pile walls. However, dewatering could potentially be required for the construction of the north and south crash walls, and the north and south return walls. If dewatering is necessary, the contractor should be responsible for selecting the dewatering methods based on his proposed methods and equipment used for excavation and excavation support. The method of dewatering will depend on the time of year that the work is performed, size of the open excavation, and the duration of time the excavation remains open. Dewatering efforts must satisfy the requirements of local, state, and federal environmental and conservation authorities.

Temporary earth support and dewatering systems should be selected by the contractor and designed by a Professional Engineer registered in the Commonwealth of Massachusetts retained by the contractor. The earth support and dewatering designs are mutually inclusive and should be submitted as a single submittal for review by MassDOT. Where excavation sides are cut back and sloped, they should be in accordance with Occupational Safety and Health Administration (OSHA) Construction Industry Standards.

5.6 Earthwork and Compaction

Fill material placement should be in accordance with Sections 150 and M of the Massachusetts Department of Transportation Standard Specifications for Highways and Bridges. Reference is also made to the following Table:

Borrow Material	MassDOT Spec. No.	Use
Ordinary Borrow	M1.01.0	General Fill
Special Borrow	M1.02.0	Drainage, Stabilization Fill

Borrow Material	MassDOT Spec. No.	Use
Gravel Borrow	M1.03.0, Type b	Behind abutments and retaining walls, and as embankment fill
Gravel Borrow for Bridge Foundations	M1.03.0, Type a	Beneath pile caps and approach slabs
Sand Borrow	M1.04.0	Drainage fill
Crushed Stone for Bridge Foundations	M2.01.1	Beneath pile caps, approach slabs, and for drainage

Fill should be placed in loose layers not more than 12 inches thick and compacted to at least 95 percent of the maximum dry density as determined by the Modified Proctor Test (ASTM D-1557). In confined areas, place only 6-inch layers and compact with manually operated, powered vibratory compactor acceptable to the geotechnical engineer. Crushed Stone, where used, for any required depth of more than 12 inches, should be placed in 6-inch layers and compacted to an unyielding surface. Crushed Stone should be wrapped in non-woven geotextile fabric that is qualified for separation per MassDOT M9.50.0, such as Mirafi 180N, or equivalent. A plate compactor should be used within 5 feet of the existing abutments and proposed retaining walls to minimize additional lateral earth pressures.

The placement and compaction of the lightweight fill should be performed in accordance with the project-specific special provisions for Lightweight Foamed Glass Aggregate.

5.7 Reuse of Excavated Materials

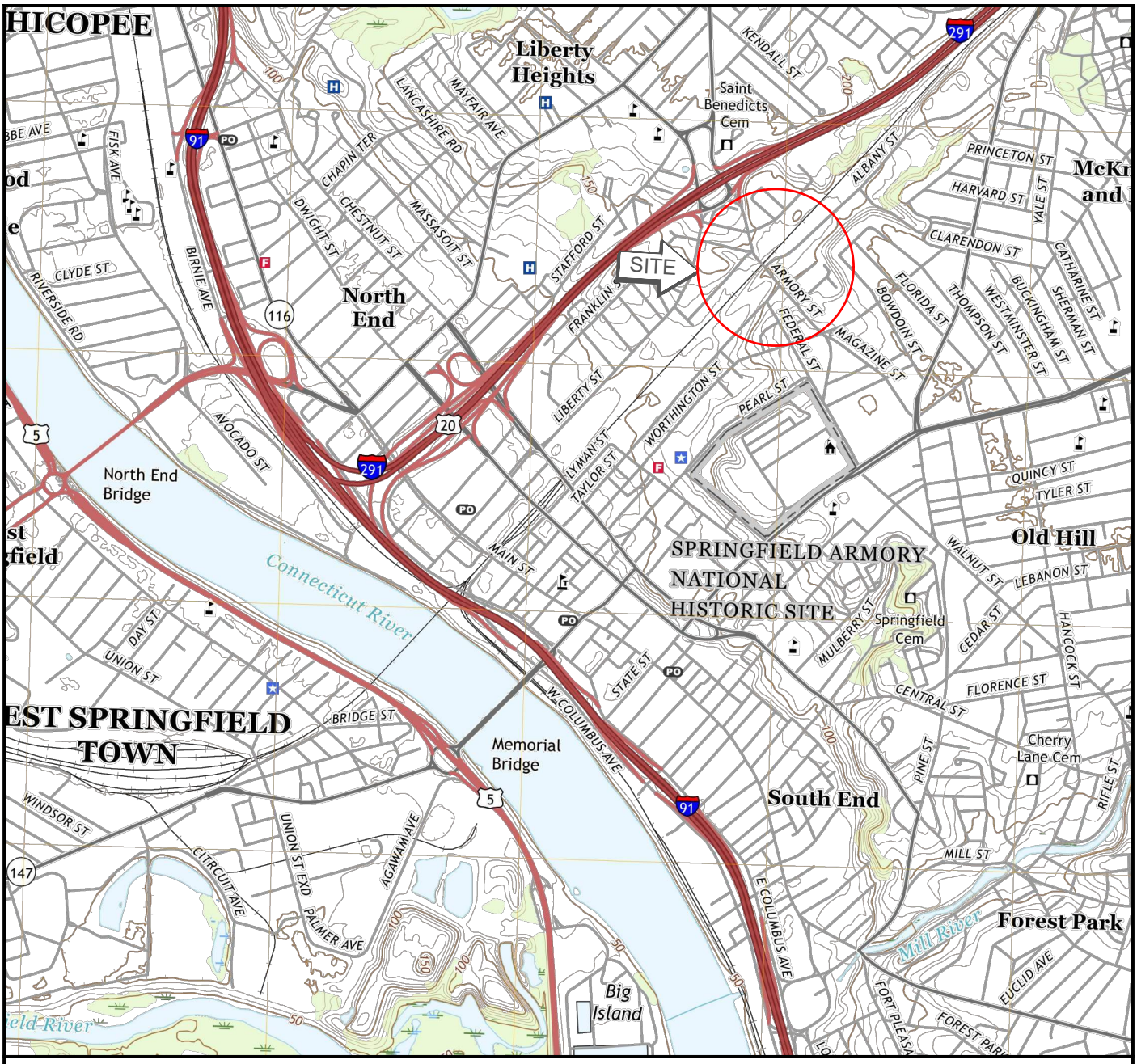
Based on the soil descriptions on the boring logs and the results of the laboratory testing, it is not anticipated that the existing on-site soils to be excavated for foundation construction may meet the gradation requirements for Gravel Borrow. Soils not meeting the Gravel Borrow specification may be reused in areas not requiring a free-draining material, provided that the moisture content can be controlled, and the material can be compacted to the required density. Re-use of on-site soils should be at the acceptance of the geotechnical engineer prior to placement. Excavated soil that cannot be reused on-site or on other portions of the project should be removed from the site in accordance with applicable local, state, and federal regulations.

5.8 Contract Documents and Construction Monitoring

We recommend that Nobis be engaged to assist with preparing the final geotechnical design recommendations, specifications, and special provisions, to review near final plans for conformance with our geotechnical recommendations, and to provide reviews of the contractor's submittals as well as for construction observation during the earthwork and foundation phases of

the project. Construction phase services may include micropile installation observations and load testing, drilled soldier pile installation observations, and observation of proof-rolling operations and placement of fill. This construction oversight is considered an important part of obtaining quality site improvements.

FIGURES



NORTH

2018 USGS TOPOGRAPHIC MAP

SPRINGFIELD SOUTH QUADRANGLE
SPRINGFIELD, MASSACHUSETTS
CONTOUR INTERVAL 10 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88)

APPROXIMATE SCALE
1 INCH = 2,000 FEET

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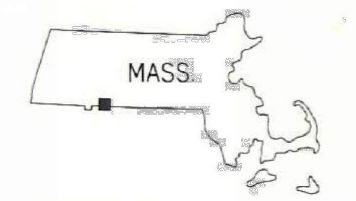


QUADRANGLE LOCATION

PROJECT FILE NO. 609409

massDOT
Massachusetts Department of Transportation
Highway Division

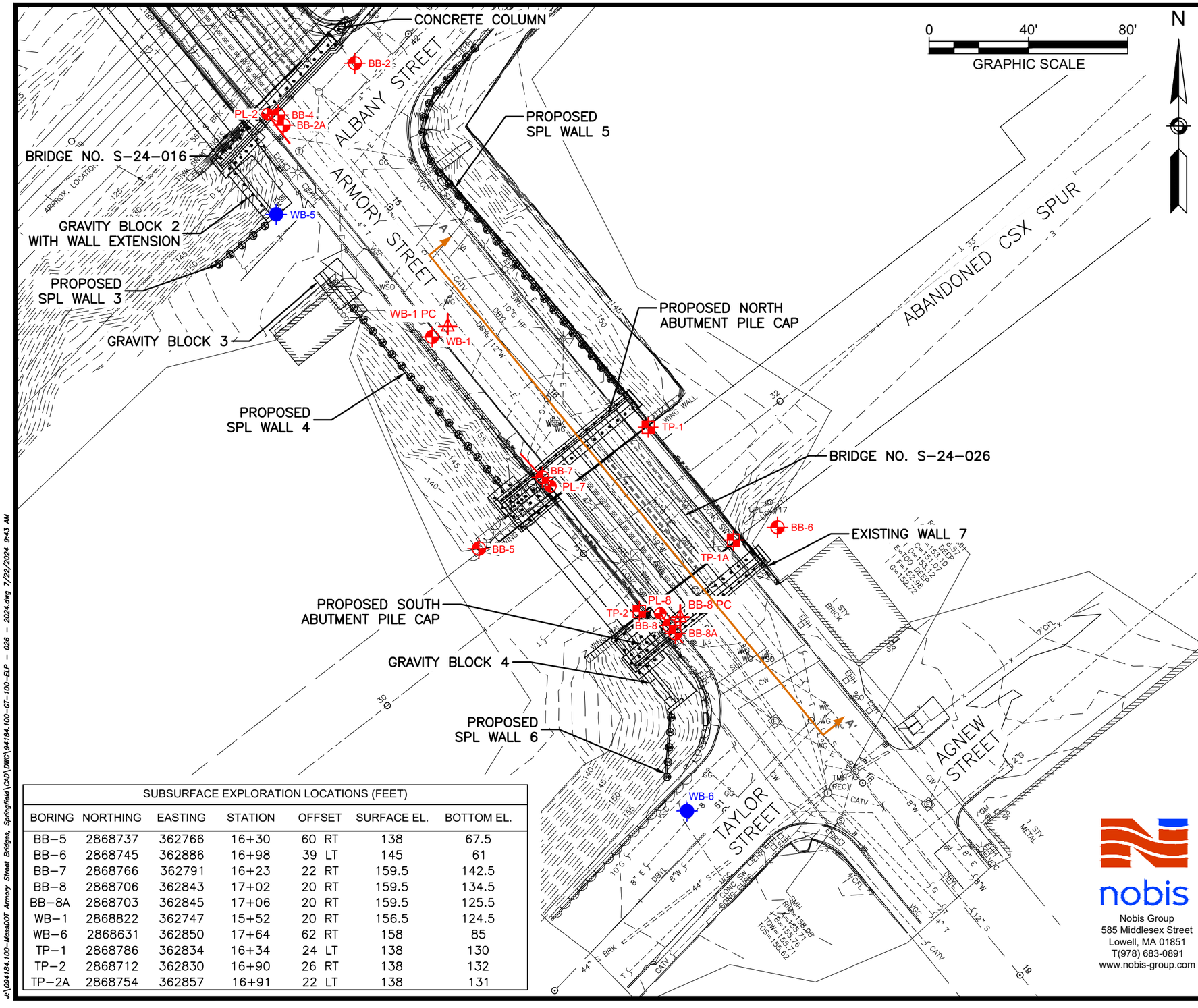
FIGURE 1
SITE LOCUS PLAN
SPRINGFIELD

ARMORY STREET OVER ABANDONED CSX SPUR

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

SHEET 1 OF 1 APRIL 2024

BRIDGE NO. S-24-026



NOTES:

1. THE BASE PLAN WAS DEVELOPED USING A TOPOGRAPHIC SURVEY DRAWING, AND PROPOSED BRIDGE AND ROADWAY LAYOUT DRAWINGS PROVIDED IN AUTOCAD FORMAT BY TETRA TECH ON JANUARY 20, 2021 AND APRIL 9, 2024, RESPECTIVELY.
2. LOCATIONS AND SITE FEATURES DEPICTED ARE APPROXIMATE AND GIVEN FOR ILLUSTRATIVE PURPOSES.
3. ELEVATIONS ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).
4. REFER TO FIGURE 6 FOR SUBSURFACE PROFILE A-A'.

LEGEND

- WB-5 — TEST BORING PERFORMED BY SEABOARD DRILLING AND OBSERVED BY NOBIS BETWEEN NOVEMBER 14 AND NOVEMBER 15, 2022.
- LOCATION OF CORING THROUGH RETAINING WALL 7 PERFORMED BY WITCH ENTERPRISES BETWEEN FEBRUARY 16 AND 17, 2023
- WB-3 — TEST BORING PERFORMED BY SEABOARD DRILLING AND OBSERVED BY NOBIS IN 2019
- PL-1 — PROBE LINE PERFORMED BY SEABOARD DRILLING AND OBSERVED BY NOBIS IN 2019
- WB-1 PC — PAVEMENT CORE PERFORMED BY SEABOARD DRILLING AND OBSERVED BY NOBIS IN 2019
- TP-1 — TEST PIT PERFORMED BY SEABOARD DRILLING AND OBSERVED BY NOBIS IN 2019
- A A' — SUBSURFACE PROFILE BASELINE

SUBSURFACE EXPLORATION LOCATIONS (FEET)

BORING	NORTHING	EASTING	STATION	OFFSET	SURFACE EL.	BOTTOM EL.
BB-5	2868737	362766	16+30	60 RT	138	67.5
BB-6	2868745	362886	16+98	39 LT	145	61
BB-7	2868766	362791	16+23	22 RT	159.5	142.5
BB-8	2868706	362843	17+02	20 RT	159.5	134.5
BB-8A	2868703	362845	17+06	20 RT	159.5	125.5
WB-1	2868822	362747	15+52	20 RT	156.5	124.5
WB-6	2868631	362850	17+64	62 RT	158	85
TP-1	2868786	362834	16+34	24 LT	138	130
TP-2	2868712	362830	16+90	26 RT	138	132
TP-2A	2868754	362857	16+91	22 LT	138	131

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PROJECT FILE NO. 609409

massDOT Massachusetts Department of Transportation Highway Division

FIGURE 2
SUBSURFACE EXPLORATION LOCATION PLAN

SPRINGFIELD

ARMORY STREET OVER ABANDONED CSX SPUR
MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

JULY 2024

BRIDGE NO. S-24-026

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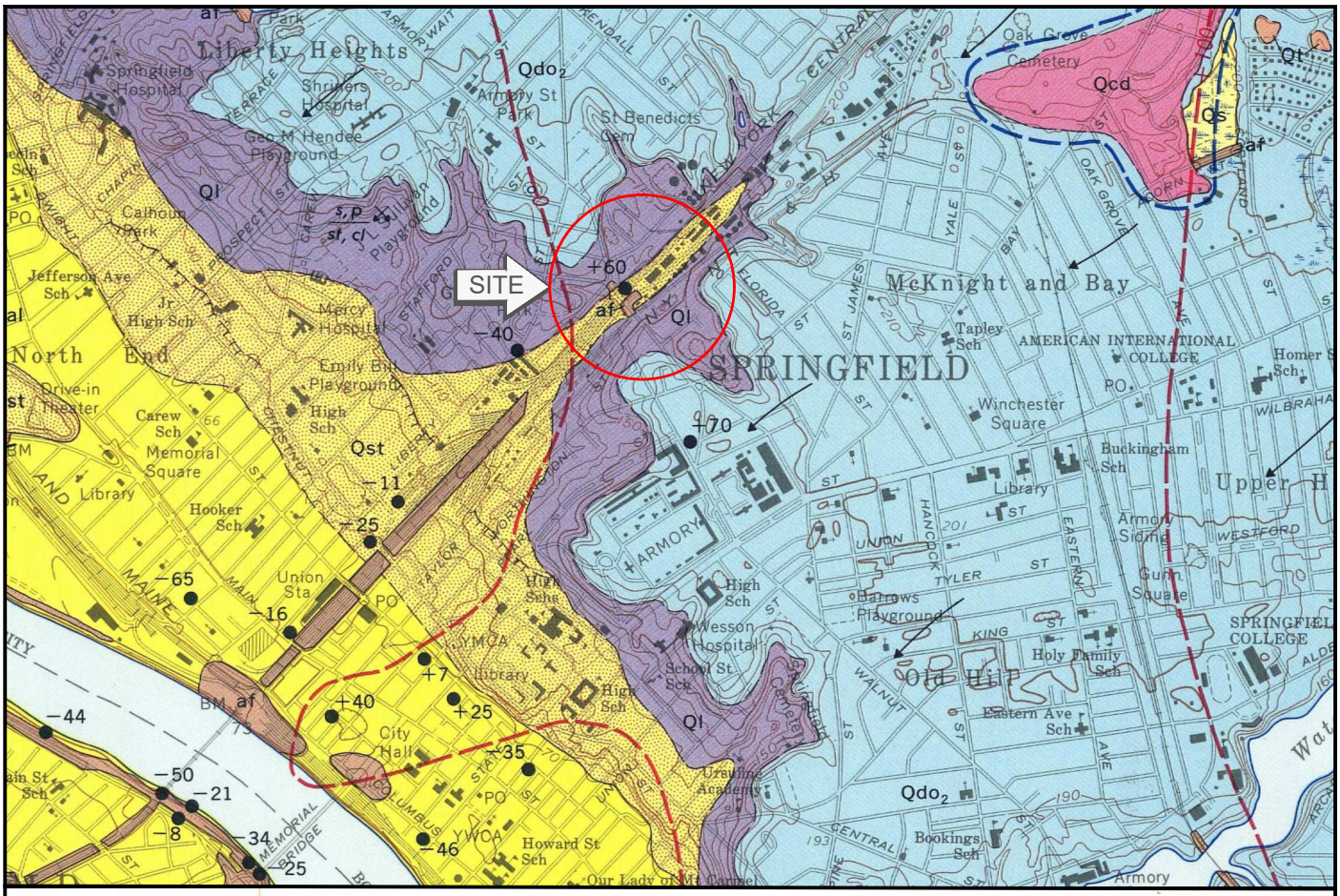

Ql

Lake deposits

Laminated moderate yellowish-brown to gray clayey silt and sand overlying varved lake deposits of yellowish-gray, yellowish-brown, or reddish-brown silt and clay or very fine sand and clay, in alternating layers ½ inch to 2 inches thick. Formed in glacial Lake Hitchcock. May be as much as 230 feet thick. Lake deposits in sides of gullys are covered by colluvium

Qst

Terrace deposits

Yellowish-brown, well-bedded sand, silt, and clay; locally pebbly. Highest terrace from 120 to 145 feet above Connecticut River; numerous non-paired terraces at lower levels on both sides of river. Highest terraces formed by deposition of post-lake sand and gravel on delta-outwash plain deposits (Qdo_2) and lake deposits. Lower terraces are cut-and-fill deposits now trenched by modern streams adjusted to Connecticut River as base level. Some deposits are as much as 75 feet thick

Qdo_2
Qdo_1

Delta-outwash plain deposits

Proglacial kettled to unkettled outwash grading downstream into topset and foreset beds of yellowish-brown to reddish-brown gravel, sand, silt, and clay deposited into glacial Lake Hitchcock. Qdo_1 was deposited after Qkd while glacier front stood near line from Bass Pond to Turner Park; melt-water streams flowed southward. Qdo_2 deposited generally westward from Chicopee River (in Springfield North quadrangle) after glacier front had withdrawn to north

NORTH

1967 USGS SURFICIAL GEOLOGIC MAP

"GEOLOGIC MAP OF THE SPRINGFIELD SOUTH QUADRANGLE, HAMPDEN COUNTY, MASSACHUSETTS, AND HARTFORD AND TOLLAND COUNTIES, CONNECTICUT"
BY JOSEPH H. HARTSHORN AND CARL KOTEFF
NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29)
CONTOUR INTERVAL 10 FEET

APPROXIMATE SCALE
1 INCH =2,000 FEET

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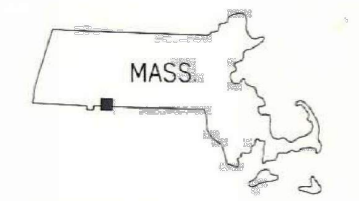

QUADRANGLE LOCATION

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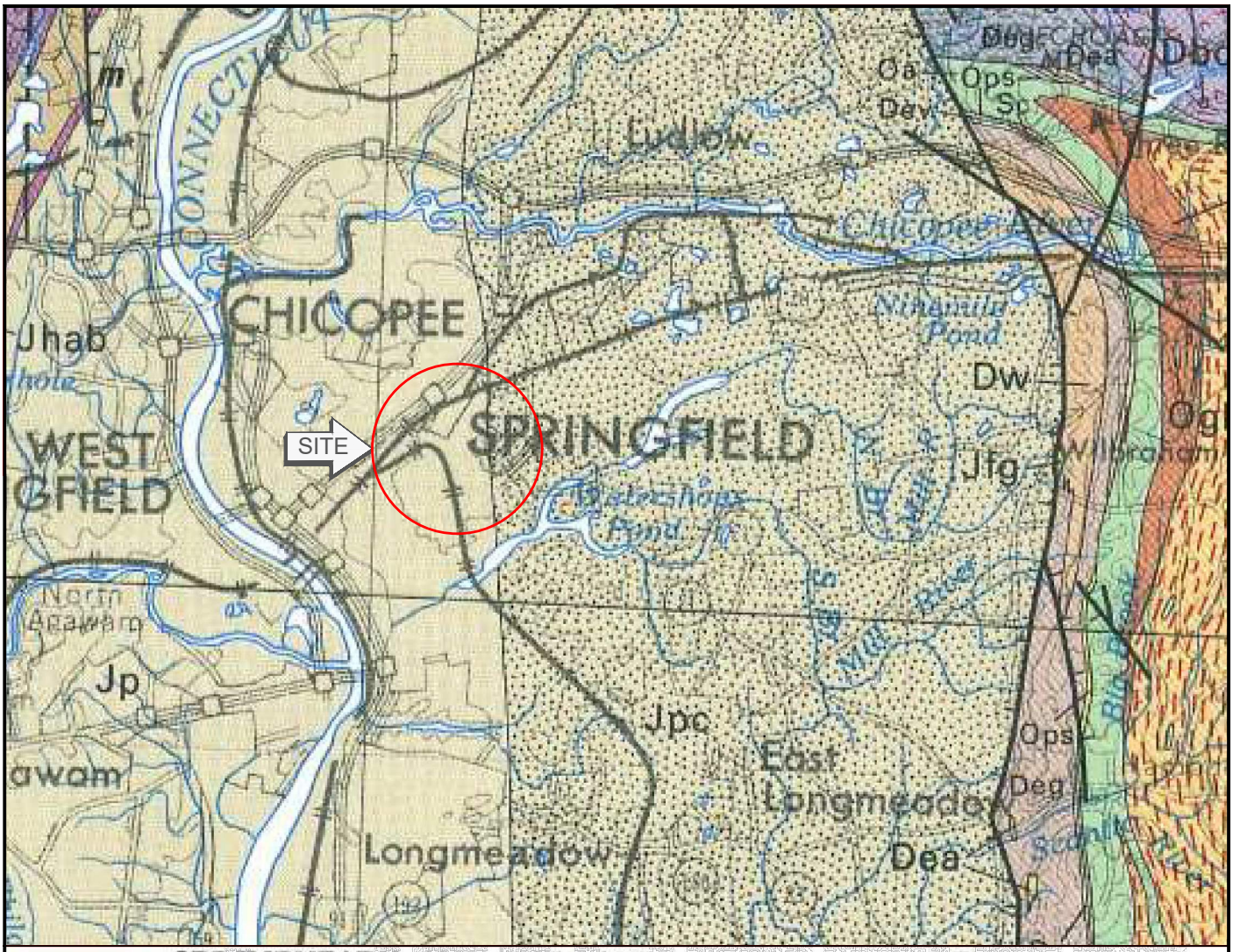
FIGURE 3
USGS SURFICIAL GEOLOGIC MAP
SPRINGFIELD

ARMORY STREET OVER ABANDONED CSX SPUR
MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

SHEET 1 OF 1 APRIL 2024

BRIDGE NO. S-24-026



SEDIMENTARY AND VOLCANIC ROCKS OF HARTFORD BASIN

Portland Formation (Lower Jurassic)

Jp — Reddish-brown to pale red arkose and siltstone, and gray sandstone, gray siltstone, and black shale interpreted as lake beds

Jpc — Reddish-brown to pale red conglomerate and arkose

NORTH

1983 BEDROCK GEOLOGIC MAP OF MASSACHUSETTS

"BEDROCK GEOLOGIC MAP OF MASSACHUSETTS"
COMPILED BY RICHARD GOLDSMITH, NICHOLAS M. RATCLIFFE, PETER ROBINSON, AND ROLFE S. STANLEY
NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29)
CONTOUR INTERVAL 100 FEET & SUPPLEMENTAL CONTOURS AT 50 FEET

APPROXIMATE SCALE
1 INCH =10,000 FEET

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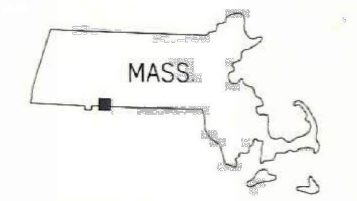

QUADRANGLE LOCATION

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FIGURE 4
BEDROCK GEOLOGIC MAP
SPRINGFIELD

ARMORY STREET OVER ABANDONED CSX SPUR

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

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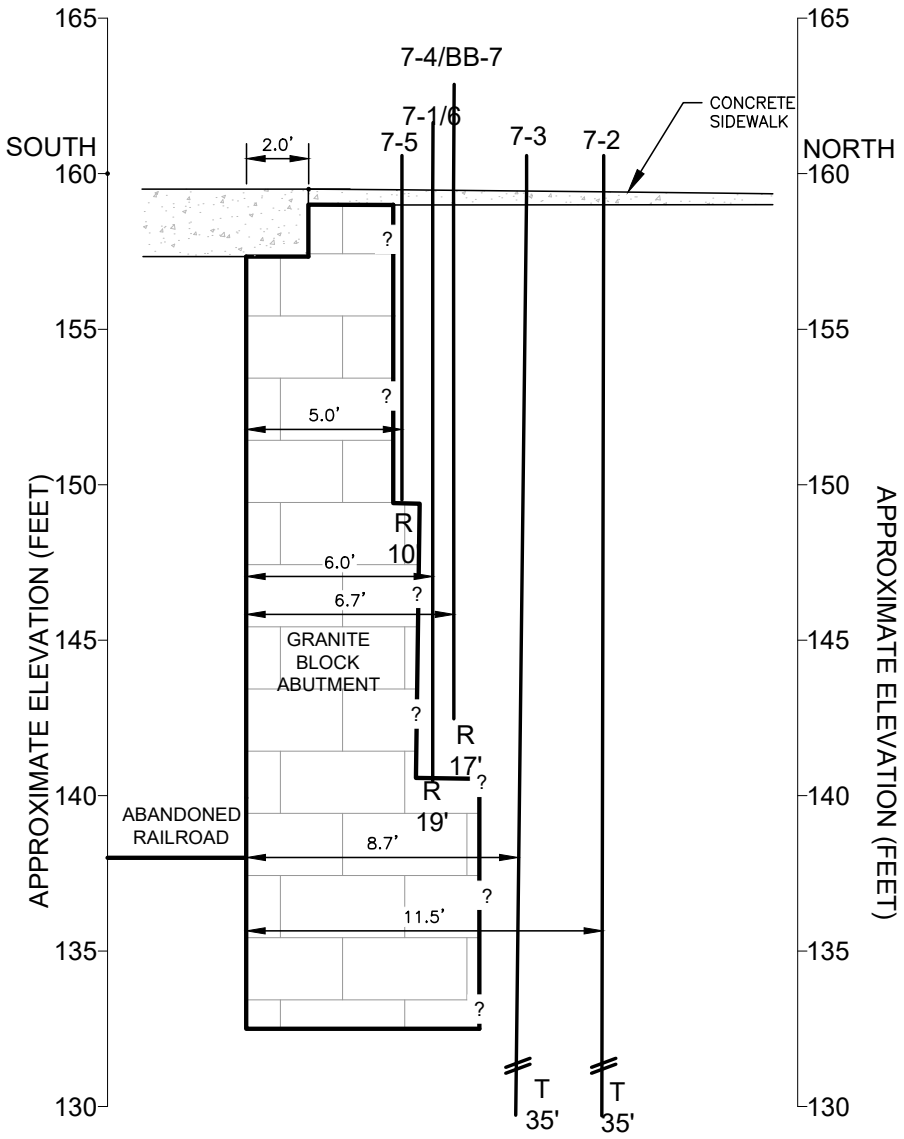

NOTES:
1. T = TERMINATION DEPTH, R = REFUSAL DEPTH.
2. EXISTING ABUTMENT LOCATION AND SUBSURFACE EXPLORATION LOCATIONS ARE BASED ON FIELD OBSERVATIONS AND MEASUREMENTS OBTAINED BY NOBIS ON MAY 19, 2019 THROUGH MAY 21, 2019 AND JULY 9, 2019. LOCATIONS SHOULD BE CONSIDERED APPROXIMATE.
3. DEPTH TO BOTTOM OF THE ABUTMENT DETERMINED VIA TEST PIT EXCAVATION.

PROJECT FILE NO. 609409

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FIGURE 5A: NORTH ABUTMENT
PRELIMINARY CROSS SECTION

SPRINGFIELD

ARMORY STREET OVER ABANDONED CSX SPUR

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

NTS APRIL 2024

BRIDGE NO. S-24-026

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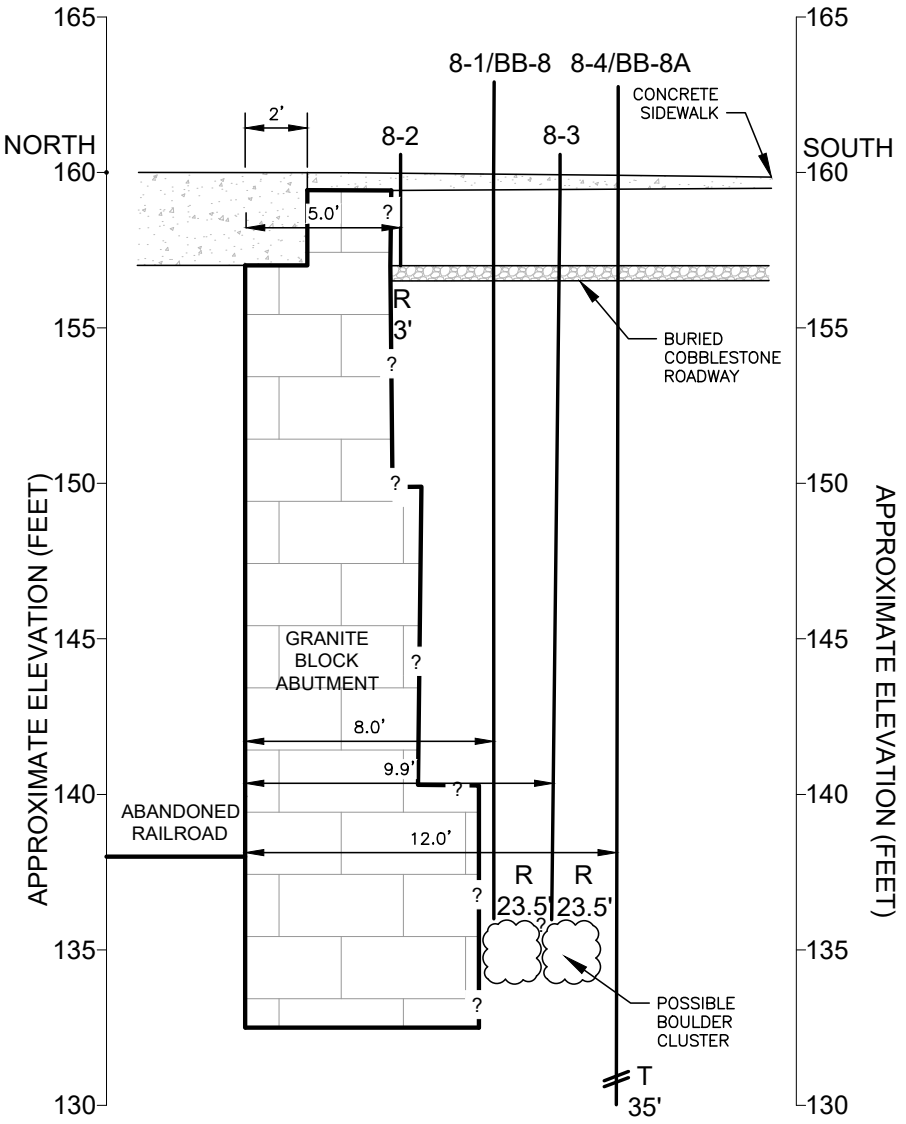

NOTES:
1. T = TERMINATION DEPTH, R = REFUSAL DEPTH.
2. EXISTING ABUTMENT LOCATION AND SUBSURFACE EXPLORATION LOCATIONS ARE BASED ON FIELD OBSERVATIONS AND MEASUREMENTS OBTAINED BY NOBIS ON MAY 19, 2019 THROUGH MAY 21, 2019 AND JULY 9, 2019. LOCATIONS SHOULD BE CONSIDERED APPROXIMATE.
3. DEPTH TO BOTTOM OF THE ABUTMENT DETERMINED VIA TEST PIT EXCAVATION.

PROJECT FILE NO. 609409

MassDOT Massachusetts Department of Transportation Highway Division

FIGURE 5B: SOUTH ABUTMENT
PRELIMINARY CROSS SECTION

SPRINGFIELD

ARMORY STREET OVER ABANDONED CSX SPUR

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

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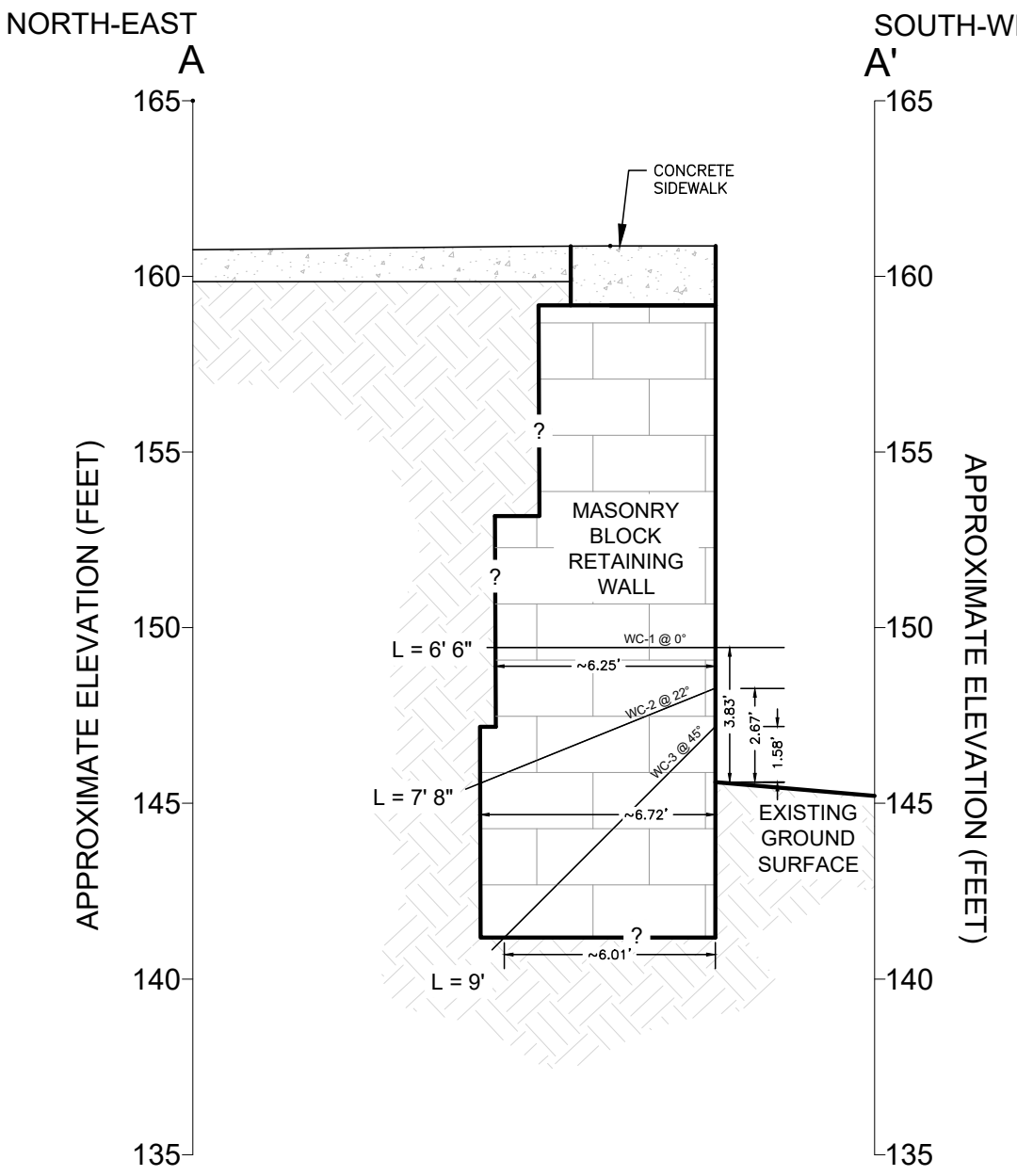

NOTES:

1. L = APPROXIMATE CORE LENGTH.
2. EXISTING RETAINING WALL DIMENSION IS BASED ON CORES PERFORMED BY WITCH ENTERPRISES OF AGAWAM, MASSACHUSETTS AND FIELD OBSERVATIONS BY NOBIS ON FEBRUARY 16 TO FEBRUARY 17, 2023.
3. CORE LENGTH AND LOCATIONS SHOULD BE CONSIDERED APPROXIMATE.
4. DIMENSIONS AND TO BOTTOM ELEVATION OF THE RETAINING WALL ARE APPROXIMATE.

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FIGURE 6A: WALL #7 CROSS SECTION
A–A' @ STA ±17+05

SPRINGFIELD

ARMORY STREET OVER ABANDONED CSX SPUR

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

NTS APRIL 2024

BRIDGE NO. S–24–026

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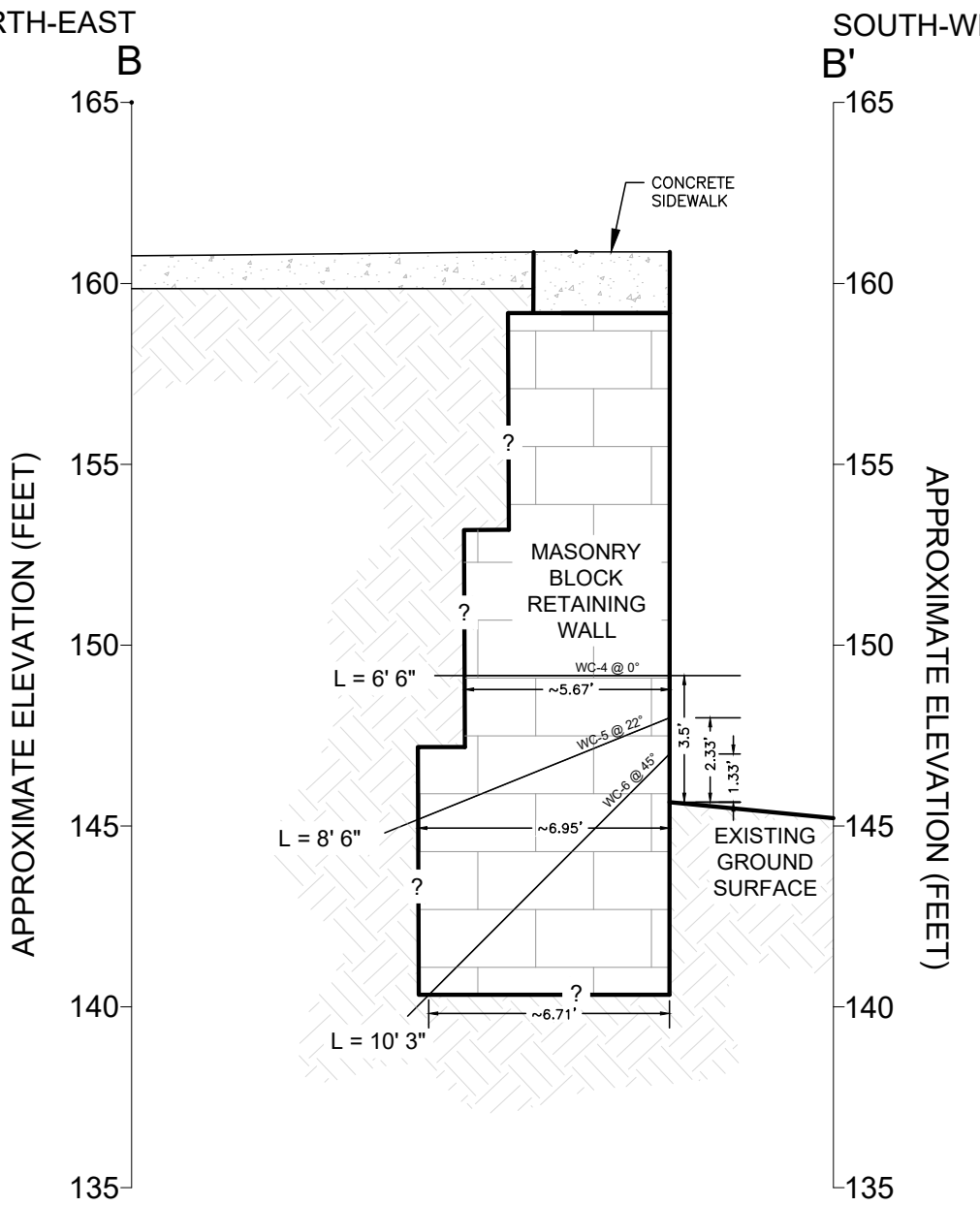

NOTES:

1. L = APPROXIMATE CORE LENGTH.
2. EXISTING RETAINING WALL DIMENSION IS BASED ON CORES PERFORMED BY WITCH ENTERPRISES OF AGAWAM, MASSACHUSETTS AND FIELD OBSERVATIONS BY NOBIS ON FEBRUARY 16 TO FEBRUARY 17, 2023.
3. CORE LENGTH AND LOCATIONS SHOULD BE CONSIDERED APPROXIMATE.
4. DIMENSIONS AND TO BOTTOM ELEVATION OF THE RETAINING WALL ARE APPROXIMATE.

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FIGURE 6B: WALL #7 CROSS SECTION
B–B' @ STA ±17+12

SPRINGFIELD

ARMORY STREET OVER ABANDONED CSX SPUR

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
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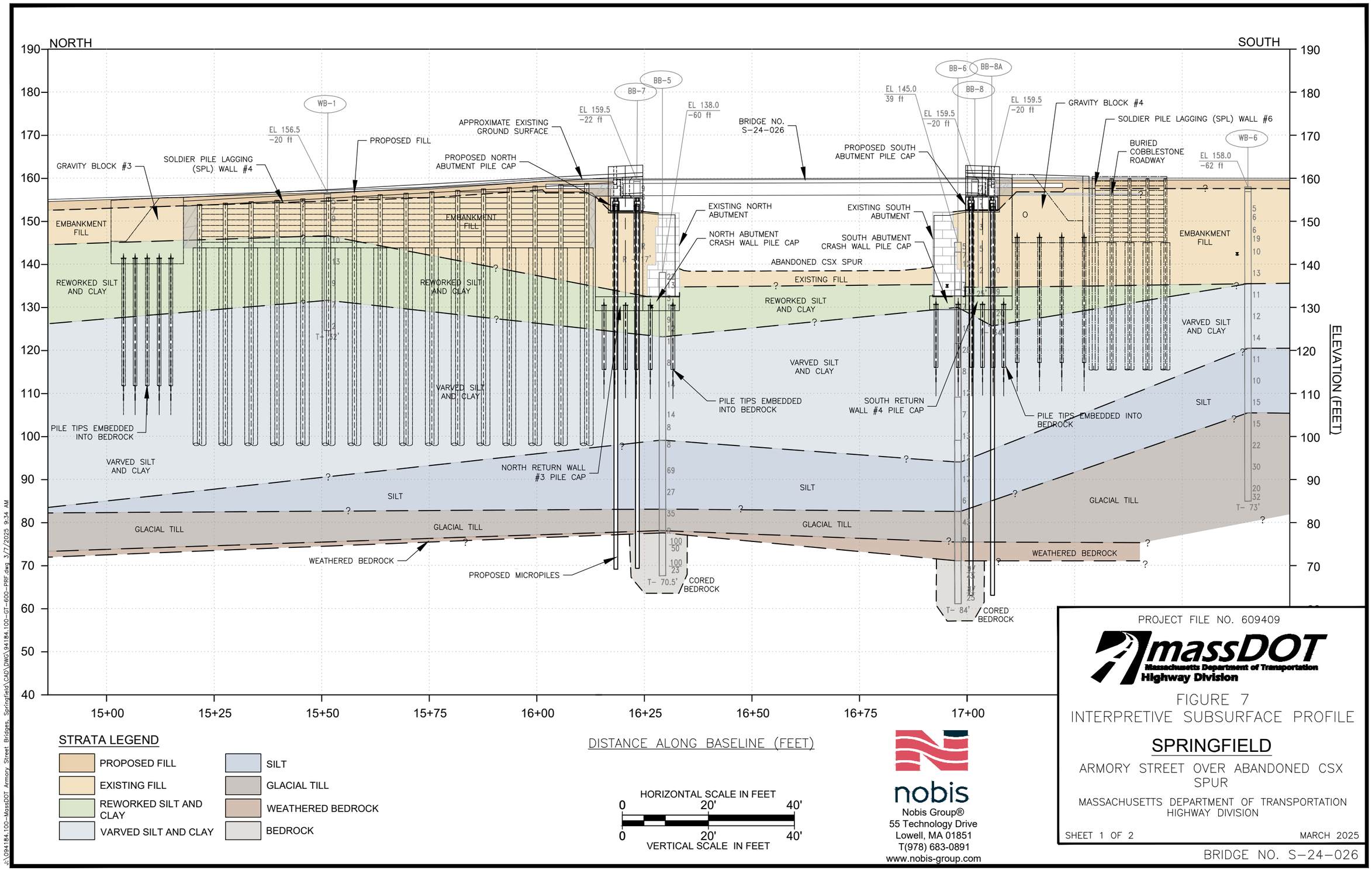

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FIGURE 7
INTERPRETIVE SUBSURFACE PROFILE

SPRINGFIELD

ARMORY STREET OVER ABANDONED CSX SPUR

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

SHEET 1 OF 2 MARCH 2025

BRIDGE NO. S-24-026

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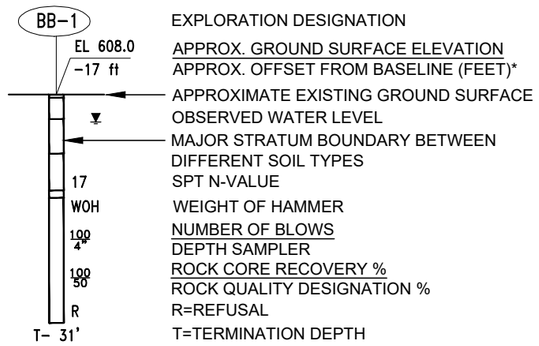
NOTES:

1. THIS INTERPRETIVE SUBSURFACE PROFILE WAS DEVELOPED USING A TOPOGRAPHIC SURVEY DRAWING AND A BRIDGE PLAN AND PROFILE (AUTOCAD) PROVIDED BY TETRA TECH ON JANUARY 28 AND FEBRUARY 1, 2021, RESPECTIVELY.
2. LINES REPRESENTING LIMITS OF STRATA ARE INTERPOLATED FROM SUBSURFACE EXPLORATION LOGS. THE SUBSURFACE EXPLORATIONS ARE WIDELY SPACED AND ARE BASED ON LIMITED SUBSURFACE INFORMATION COLLECTED DURING DRILLING. OTHER INTERPRETATIONS ARE POSSIBLE AND ACTUAL CONDITIONS MAY VARY FROM THOSE PRESENTED.
3. WATER LEVELS PRESENTED WERE COLLECTED DURING DRILLING AND MAY NOT REPRESENT STABILIZED GROUNDWATER CONDITIONS. GROUNDWATER LEVELS WILL FLUCTUATE WITH SEASON, PRECIPITATION AND NEARBY ACTIVITIES.
4. EXISTING AND PROPOSED SITE FEATURES DEPICTED ARE APPROXIMATE AND GIVEN FOR ILLUSTRATIVE PURPOSES.
5. TEST BORINGS WERE DRILLED BY SEABOARD DRILLING, INC. OF CHICOPEE, MASSACHUSETTS, AND OBSERVED BY NOBIS BETWEEN APRIL 17 AND MAY 30, 2019, EXCEPT WB-6 WHICH WAS PERFORMED BETWEEN NOVEMBER 14 AND NOVEMBER 15, 2022.
6. ELEVATIONS ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).
7. REFER TO FIGURE 2 FOR SUBSURFACE EXPLORATION LOCATIONS AND A PLAN VIEW OF THE SITE.

EXPLORATION LEGEND



*POSITIVE OFFSETS ARE IN THE EAST DIRECTION.
NEGATIVE OFFSETS ARE IN THE WEST DIRECTION.

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FIGURE 7
INTERPRETIVE SUBSURFACE PROFILE

SPRINGFIELD

ARMORY STREET OVER ABANDONED CSX SPUR

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

SHEET 2 OF 2 MARCH 2025

BRIDGE NO. S-24-026

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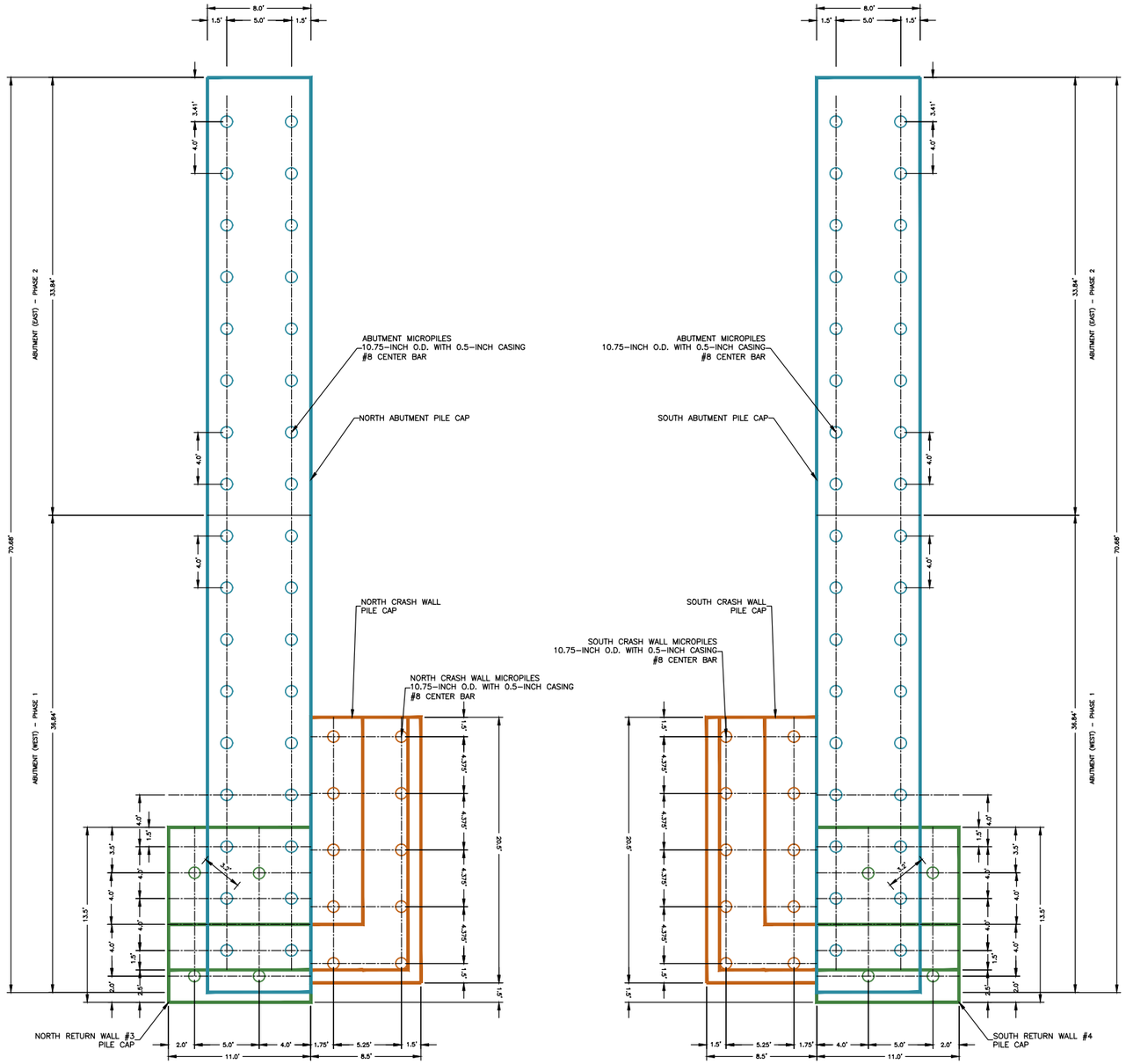
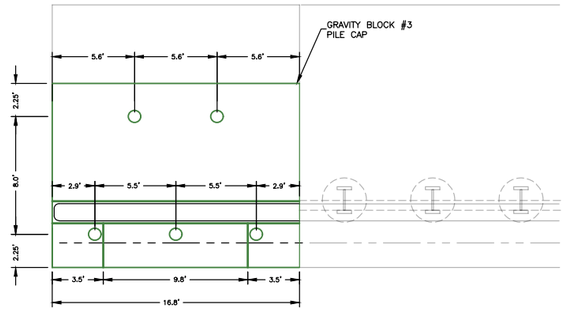
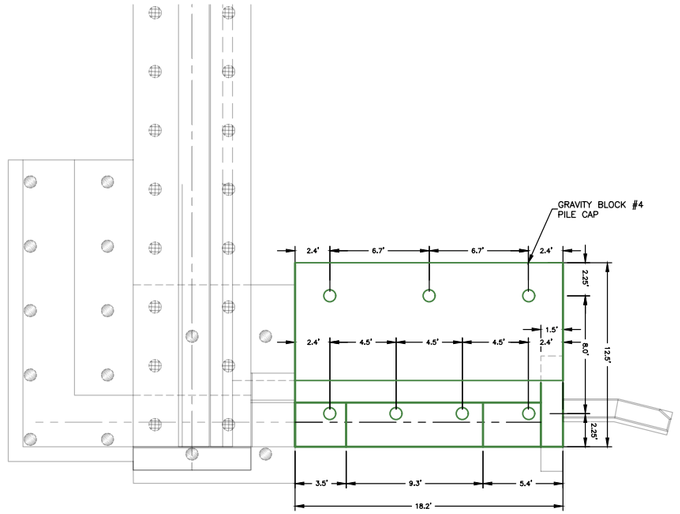


S-24-026
MICROPILE LAYOUT AT
NORTH ABUTMENT

S-24-026
MICROPILE LAYOUT AT
SOUTH ABUTMENT



S-24-026
GRAVITY BLOCK #3



S-24-026
GRAVITY BLOCK #4

0 10' 20'
GRAPHIC SCALE

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FIGURE 8

PROPOSED MICROPILE CONFIGURATIONS
ARMORY STREET OVER ABANDONED CSX SPUR
BRIDGE NO. S-24-026
SPRINGFIELD, MASSACHUSETTS

DRAWN BY: KAK	CHECKED BY: RAC / KJ
PROJECT NO. 094184.100	DATE: MARCH 2025

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APPENDIX A – Limitations

GEOTECHNICAL LIMITATIONS

Explorations and Subsurface Conditions

1. The analyses and design recommendations submitted in this report are based in part upon the data obtained from subsurface explorations. The nature and extent of variations between these explorations may not become evident until construction. If variations then appear evident, it will be necessary to reevaluate the recommendations of this report.

   In preparing this report, Nobis relied on certain information provided by the Client and other parties referenced therein which were made available to Nobis at the time of our evaluation. Nobis did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.

2. The generalized soil profile described in the text is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized and have been developed by interpretations of widely spaced explorations and samples; actual soil transitions are probably more erratic. For specific information, refer to the exploration logs.

3. Water level readings have been made in the explorations at times and under conditions stated on the logs. These data have been reviewed and interpretations have been made in the text of this report. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall, temperature, and other factors occurring since the time measurements were made. The water table encountered in the course of the work may differ from that indicated in the Report.

   Recommendations for foundation drainage, waterproofing, and moisture control address the conventional geotechnical engineering aspects of seepage control. These recommendations may not preclude an environment that allows the infestation of mold or other biological pollutants.

4. Nobis' geotechnical services did not include an assessment of the presence of oil or hazardous materials at the property. Consequently, we did not consider the potential impacts (if any) that contaminants in soil or groundwater may have on construction activities, or the use of structures on the property.

Additional Services

5. Nobis recommends that we be retained to provide services during future site observations, design, implementation activities, construction and/or property development/ redevelopment. This will allow us the opportunity to: i) observe conditions and compliance with our recommendations, design concepts and/or opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design recommendations; and iv) assess the consequences of changes in technologies and/or regulations.

Use of Report

6. Nobis prepared this report on behalf of, and for the exclusive use of our Client for the stated purpose(s) and location(s) identified in our proposal and/or report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Reliance by any party not expressly identified in the agreement, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to Nobis.

   This report is for design purposes only and is not sufficient to prepare an accurate construction bid. Contractors wishing a copy of the report may secure it with the understanding that its scope is limited to design considerations only.

7. Nobis' findings and conclusions are based on the work conducted as part of the scope of work set forth in our proposal and/or report, and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions considering the limited data gathered during the course of our work. If conditions other than those described in this report are found at the subject location(s), or the project design has been altered in any way, Nobis shall be so notified and afforded the opportunity to revise the report, as appropriate, to reflect the unanticipated changed conditions.

8. Nobis' services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.

Compliance with Codes and Regulations

9. Nobis used reasonable care in identifying and interpreting applicable codes and regulations. These codes and regulations are subject to various, and possibly contradictory, interpretations. Compliance with codes and regulations by other parties is beyond our control.

Opinion of Cost

10. This report may contain or be based on comparative cost opinions for the purpose of evaluating alternative foundation schemes. These opinions may also involve approximate quantity evaluations. It should be noted that quantity estimates may not be accurate enough for construction bids. In addition, since we are not professional estimators of labor and materials cost, the evaluation of construction costs should be considered as approximate guidelines and could vary significantly from actual costs. Nobis does not guarantee the accuracy of our cost opinions as compared to contractor's bids for construction costs.

END OF LIMITATIONS

APPENDIX B.1 – Test Boring Logs

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **BB-5**
Boring Location: N: 2868736.94 E: 362765.84
Checked by: K. Kocia
Date Start: May 28, 2019
Date Finish: May 30, 2019

Contractor: Seaboard Drilling, Inc.
Driller: M. Glynn
Nobis Rep.: S. Kurtzer

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Automatic Hammer
Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 138
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 05/29/19	09:00	8.2	30	34	18 hr

Depth (ft.)	Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	REC % / RQD %	Drilling Rate (min/ft)	Ground Water	Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
1	S-1	18	0-2	18					URBAN FILL	S-1: Medium dense, dark brown to black, fine to coarse SAND, some fine to coarse Gravel, some Silt, several pieces of glass, concrete, brick, and other debris. Moist.	
2				12							
3	S-2	14	2-4	10						S-2: Medium dense, brown to black, fine to coarse SAND, some fine to coarse Gravel, some Silt, several coal ash fragments, few brick fragments, few organics. Moist. obstruction between 4 and 5 feet bgs.	
4				9							
5				7							1
6	S-3	18	5-7	6							
7				5							
8	S-4	10	7-9	3						S-3A (10"): Very loose, reddish-brown to gray, Clayey SILT, some fine to coarse Sand, few coal ash fragments. Moist. Redoximorphic staining present. S-3B (8"): Very loose, reddish-brown to gray, SILT & CLAY, trace fine Sand. Moist.	
9				2							
10				1			▼			S-4A (4"): Medium dense, tan, fine to medium SAND, some Silt. Wet. S-4B (6"): Medium dense, reddish-brown, Clayey SILT, little fine Gravel. Moist to wet.	
11				4							
12	S-5	12	10-12	6					REWORKED SANDY SILT AND CLAY	S-5: Medium dense, reddish-brown, Clayey SILT, some fine to coarse Gravel. Wet.	
13				9							
14	S-6	10	12-14	11						S-6: Medium dense, reddish-brown to gray, SILT & CLAY, some fine to coarse Gravel, little fine to coarse Sand. Wet.	
15				4							
16	S-7	14	15-17	5					123.0 / 15.0	S-7: Medium dense, reddish-brown to gray, SILT, trace Clay, trace fine Sand. Wet.	
17				7							
18									VARVED SILT AND CLAY		
19											
20											
21	S-8	10	20-22	1						S-8: Medium stiff, gray, Clayey SILT, trace fine Sand. Wet.	
22				4							
				4							
				3							

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:
1) Water introduced into borehole via drive and wash methods at a depth of 5 feet.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **BB-5**
Boring Location: N: 2868736.94 E: 362765.84
Checked by: K. Kocia
Date Start: May 28, 2019
Date Finish: May 30, 2019

Contractor: Seaboard Drilling, Inc.
Driller: M. Glynn
Nobis Rep.: S. Kurtzer

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Automatic Hammer
Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 138
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 05/29/19	09:00	8.2	30	34	18 hr

Depth (ft.)	Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	REC % / RQD %	Drilling Rate (min/ft)	Ground Water	Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
23											
24	ST-1	0	23-25							ST-1: Approximately 200 psf of downward pressure applied from 23 to 24.5 feet bgs and 500 psf applied from 24.5 to 25 feet bgs. Last 12 inches of shelby tube crushed upon removal. Sample discarded.	
25											
26	S-9	16	25-27	6 6						S-9: Stiff, gray, Clayey SILT, trace fine Sand. Wet.	
27				8 10							
28											
29	ST-2	0	28-30							ST-2: Approximately 100 to 0 psf of downward pressure applied. No recovery.	
30											
31	ST-3	24	30-32						VARVED SILT AND CLAY	ST-3: Stiff, gray, CLAY, trace fine Sand. Wet. Approximately 100 to 0 psf of downward pressure applied. Shelby Tube was left overnight. [Laboratory Analysis Performed - Grain Size, Sieve Only, Atterberg Limits & Moisture: Moisture = 25.7% Gravel = 0.0% Sand = 1.6% Fines = 98.4% LL = 38 PL = 23 PI = 15 LI = 0.2].	
32											
33	S-10	18	32-34	9 7						S-10: Stiff, gray, SILT, trace fine Sand, trace Clay. Wet.	
34				7 7							
35											
36	S-11	19	35-37	3 4						S-11: Medium stiff, gray, Silty CLAY. Wet.	
37				4 5							
38	ST-4	12	37-39							ST-4: Medium stiff, gray, Silty CLAY, trace fine Sand. Wet. Approximately 0 to 150 psf of downward pressure applied. [Laboratory Analysis Performed - Grain Size, Sieve Only, Atterberg Limits & Moisture: Moisture = 27.7% Gravel = 0.1% Sand = 1.5% Fines = 98.4% LL = 29 PL = 18 PI = 11 LI = 0.9].	
39									99.0 / 39.0		
40	S-12	18	39-41	3 2						S-12: Loose, gray, SILT, little fine Sand, trace Clay. Wet.	
41				6 8							
42									SILT		
43											
44											

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIE\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **BB-5**
Boring Location: N: 2868736.94 E: 362765.84
Checked by: K. Kocia
Date Start: May 28, 2019
Date Finish: May 30, 2019

Contractor: Seaboard Drilling, Inc.
Driller: M. Glynn
Nobis Rep.: S. Kurtzer

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Automatic Hammer
Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 138
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 05/29/19	09:00	8.2	30	34	18 hr

Depth (ft.)	Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	REC % / RQD %	Drilling Rate (min/ft)	Ground Water	Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
45											
	S-13	17	45-47	16						S-13: Very dense, gray, SILT, some fine Sand, trace Clay. Wet.	
46				36							
				33							
47				32							
48											
49											
50									SILT		
	S-14	18	50-52	12						S-14: Medium dense, gray, SILT, little fine Sand, trace Clay. Wet.	
51				13							
				14							
52				18							
53											
54											
55									83.0 / 55.0		
	S-15	16	55-57	21						S-15A (6"): Dense, reddish-brown, fine to coarse SAND and fine to coarse Gravel, little Silt. Wet.	
56				17						S-15B (5"): Dense, gray, SILT, little fine Sand, trace Clay. Wet.	
				18							
57				32						S-15C (5"): Dense, reddish-brown, fine to coarse SAND, little fine Gravel, trace Silt. Wet.	
58									GLACIAL TILL		
59											
60									78.0 / 60.0		
	S-16	0	60-60.1	50/1"					WEATHERED ROCK	S-16: No recovery. Weathered rock in spoon tip.	
61	C-1	60	60.5-65.5		100/50	4.25			77.5 / 60.5	C-1: Medium Hard, fresh to slightly weathered, moderately to severely fractured, reddish-brown, fine-grained, ARGILLACEOUS SANDSTONE, slightly dipping to horizontal joints, multiple mechanical break joints. Wet.	
62						5.25					
63						7.5			BEDROCK		
64						6					
65						6.5					
66	C-2	60	65.5-70.5		100/23	4.25				C-2: Medium Hard, fresh to slightly weathered, moderately to severely fractured,	

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **BB-5**
Boring Location: N: 2868736.94 E: 362765.84
Checked by: K. Kocia
Date Start: May 28, 2019
Date Finish: May 30, 2019

Contractor: Seaboard Drilling, Inc.
Driller: M. Glynn
Nobis Rep.: S. Kurtzer

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Automatic Hammer
Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 138
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 05/29/19	09:00	8.2	30	34	18 hr

Depth (ft.)	SAMPLE INFORMATION Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	REC % / RQD %	Drilling Rate (min/ft)	Ground Water	LITHOLOGY Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
67						6.75				reddish-brown, fine-grained, ARGILLACEOUS SANDSTONE, slightly dipping to horizontal joints, multiple mechanical break joints. Wet.	
68						8					
69						7.25			BEDROCK		
70						10.25					
									67.5 / 70.5		2
71										Boring terminated at 70.5 feet.	
72											
73											
74											
75											
76											
77											
78											
79											
80											
81											
82											
83											
84											
85											
86											
87											
88											

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:
2) Boring backfilled with spoils.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **BB-6**
Boring Location: N: 2868745.48 E: 362886.02
Checked by: N. Belanger
Date Start: April 17, 2019
Date Finish: April 19, 2019

Contractor: Seaboard Drilling, Inc.
Driller: D. Feeley / M. Glynn
Nobis Rep.: K. Kocia

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Automatic Hammer
Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 145
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 04/18/19	08:20	10.4	51	51	16 hrs

Depth (ft.)	Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	REC % / RQD %	Drilling Rate (min/ft)	Ground Water	Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
1	S-1	16	0-2	2 2 3 3					URBAN FILL	S-1A (7"): Loose, brown and red, fine to coarse SAND, little Silt, numerous brick pieces / fragments. Dry to Moist. S-1B (9"): Loose, black, SILT, some fine to medium Sand, numerous coal/ash particles / fragments. Moist.	
2											
3	S-2	18	2-4	3 3 4 4						S-2A (3"): Loose, black to gray, SILT and fine to medium Sand. numerous coal/ash particles / fragments, few brick fragments. Moist. Very faint red smearing / staining present. S-2B (15"): Medium stiff, brown, SILT & CLAY, some fine to medium Sand, very few coal/ash particles. Moist.	
4											
5	S-3	12	4-6	4 6 6 6						S-3: Stiff, brown, SILT & CLAY, some fine Sand, very few coal/ash particles. Moist. Faint black smearing present within sample.	1
6											
7									REWORKED SANDY SILT AND CLAY	Casing commenced after sample S-3 obtained. Wash color change from black to brown at approximately 2.5 feet bgs.	
8											
9											
10	S-4	20	9-11	3 3 4 4			▼			S-4: Medium stiff, brown to gray, Silty CLAY, little fine Sand. Wet. Multiple redoximorphic staining seams / pockets present. [Laboratory Analysis Performed - Grain Size, Sieve Only: Gravel = 0.2% Sand = 2.1% Fine = 97.7%].	
11									134.0 / 11.0		
12											
13											
14											
15	S-5	21	14-16	4 2 5 5					VARVED CLAYEY SILT	S-5: Medium stiff, brown to gray, Clayey SILT, little fine Sand. Wet. Varved pockets / seams (ranging in 0.5 inches to 4 inches in thickness). Faint redoximorphic staining pockets present.	
16											
17											
18											
19											
20	S-6	21	19-21	9 10 8 10						S-6: Very stiff, gray, Clayey SILT, some fine Sand. Wet.	
21											
22											

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:
1) Water introduced into borehole via drive and wash methods at a depth of 4 feet.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **BB-6**
Boring Location: N: 2868745.48 E: 362886.02
Checked by: N. Belanger
Date Start: April 17, 2019
Date Finish: April 19, 2019

Contractor: Seaboard Drilling, Inc.
Driller: D. Feeley / M. Glynn
Nobis Rep.: K. Kocia

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Automatic Hammer
Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 145
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 04/18/19	08:20	10.4	51	51	16 hrs

Depth (ft.)	Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	REC % / RQD %	Drilling Rate (min/ft)	Ground Water	Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
23									VARVED CLAYEY SILT		
24										Change in precent of sand and silt during drive and wash procedure at approximately 23.5 feet bgs.	
	S-7	14	24-26	16						S-7: Medium dense, reddish-brown to gray, SILT and fine to coarse Sand, little fine Gravel. Wet.	
25				15							
				13							
26				14							
27											
28											
29											
	S-8	13	29-31	3					VARVED SANDY SILT	S-8: Loose, gray, SILT, little fine Sand. Wet. Very faint reddish-brown smearing / staining present.	
30				4							
				4							
31				5							
32											
33											
34											
	S-9	17	34-36	7						S-9: Medium dense, gray, SILT, some fine Sand, trace fine Gravel. Wet. Varved pockets / seams (ranging in 0.5 inches to 3 inches in thickness).	
35				5							
				7							
36				8							
37											
38											
39											
	S-10	18	39-41	4					VARVED SILT AND CLAY	S-10: Medium stiff, gray, Clayey SILT, little fine Sand. Wet. Varved pockets / seams (ranging in 0.5 inches to 3 inches in thickness).	
40				3							
				4							
41				5							
42											
43											
44											

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **BB-6**
Boring Location: N: 2868745.48 E: 362886.02
Checked by: N. Belanger
Date Start: April 17, 2019
Date Finish: April 19, 2019

Contractor: Seaboard Drilling, Inc.
Driller: D. Feeley / M. Glynn
Nobis Rep.: K. Kocia

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Automatic Hammer
Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 145
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 04/18/19	08:20	10.4	51	51	16 hrs

Depth (ft.)	Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	REC % / RQD %	Drilling Rate (min/ft)	Ground Water	Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
45	S-11	14	44-46	6					VARVED SILT AND CLAY	S-11: Medium dense, gray, Clayey SILT, little fine Sand. Wet.	
				5							
46				8							
				8							
47											
48											
49									VARVED SANDY SILT		
50	S-12	15	49-51	4						S-12: Medium dense, gray, SILT, some fine Sand. Wet.	
				6							
51				6							
				6					94.0 / 51.0		
52											
53											
54											
55	S-13	16	54-56	7						S-13: Medium dense, gray, Clayey SILT, little fine Sand. Wet. Very faint reddish-brown smearing / staining present.	
				8							
56				9							
				11							
57									SILT		
58											
59											
60	S-14	16	59-61	3						S-14: Loose, gray, SILT, little fine Sand, trace fine Gravel. Wet. Faint reddish-brown smearing / staining present.	
				3							
61				3							
				4							
62											
63									82.5 / 62.5		
64										Increase drilling resistance occurred at approximately 62.5 feet bgs, with wash color change to reddish-brown and increase in sand percent in wash.	
65	S-15	17	64-66	14					GLACIAL TILL	S-15: Dense, reddish-brown to gray, SILT and fine to medium Sand, some fine to coarse Gravel. Wet.	
				23							
66				20							
				22							

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES, SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **BB-6**
Boring Location: N: 2868745.48 E: 362886.02
Checked by: N. Belanger
Date Start: April 17, 2019
Date Finish: April 19, 2019

Contractor: Seaboard Drilling, Inc.
Driller: D. Feeley / M. Glynn
Nobis Rep.: K. Kocia

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Automatic Hammer
Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 145
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 04/18/19	08:20	10.4	51	51	16 hrs

Depth (ft.)	SAMPLE INFORMATION Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	REC % / RQD %	Drilling Rate (min/ft)	Ground Water	LITHOLOGY Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
67									GLACIAL TILL		
68											
69											
	S-16	5	69-69.5	62					75.4 / 69.6	S-16: Very dense, reddish-brown, fine to coarse SAND, some Silt, few weathered rock fragments. Wet.	
70				60/0"						Increase drilling resistance occurred at approximately 69.6 feet bgs, with presence of weathered rock within wash.	
71									WEATHERED BEDROCK		
72											
73											
74									71.0 / 74.0		
	C-1	58	74-79		97/45	5			BEDROCK	C-1: Medium Hard to Hard, fresh to slightly weathered, slightly to moderately fractured, reddish-brown, fine-grained, ARGILLACEOUS SANDSTONE, slightly dipping to horizontal joints, multiple mechanical break joints. Wet.	
75						7.5					
76						8.5					
77						6.5					
78						9.5					
79											
	C-2	52	79-84		87/25	10				C-2: Medium Hard, fresh to slightly weathered, moderately fractured, reddish-brown, fine-grained, ARGILLACEOUS SANDSTONE, vertical to horizontal joints, multiple mechanical break joints. Wet.	
80						9.5					
81						7					
82						9					
83						9					
84									61.0 / 84.0		
85										Boring terminated at 84 feet.	2
86											
87											
88											

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:
2) Boring backfilled with spoils.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **BB-7**
Boring Location: N: 2868765.58 E: 362791.38
Checked by: K. Kocia
Date Start: May 20, 2019
Date Finish: May 20, 2019

Contractor: Seaboard Drilling, Inc.
Driller: M. Glynn
Nobis Rep.: S. Kurtzer

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Automatic Hammer
Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 159.5
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
05/20/19	22:00	Not Encountered	15	17	5 min

Depth (ft.)	Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	Ground Water	Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
1							CONCRETE SIDEWALK 159.1 / 0.4	Concrete sidewalk approximately 4-inches thick.	
2	S-1	3	1-3	6 4				S-1: Loose, brown to black, fine to coarse SAND, some Silt, some fine Gravel, few asphalt fragments. Moist.	
3				5 4					
4	S-2	8	3-5	8 5				S-2: Loose, brown to tan, fine to coarse SAND, some Silt, some fine to coarse Gravel, few asphalt fragments. Moist.	
5				3 2					
6	S-3	2	5-7	5 3				S-3: Loose, brown, fine to coarse SAND, little Silt, little fine Gravel, very few wood fragments. Moist. Rock in spoon tip.	1
7				2 3					
8									
9							URBAN FILL		
10									
11	S-4	8	10-12	WOH WOH				S-4: Very loose, brown, fine to coarse SAND, some Silt. Wet.	
12				1 1					
13									
14									
15									
16	S-5	9	15-15.8	1 50/4"				S-5: Dense, brown to tan, fine to medium SAND, some Silt, few roots, faint redoximorphic staining. Wet. Granite pieces in spoon tip.	
17							142.5 / 17.0		
18								Boring terminated at 17 feet on roller bit refusal.	2 3
19									
20									
21									
22									

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:
1) Water introduced into borehole via drive and wash methods at a depth of 5 feet.
2) Upon casing refusal at 17 feet bgs, the boring was attempted to be advanced using the roller bit. The roller bit was unable to be advanced due to an obstruction.
3) Boring backfilled with spoils and two (2) bags of filter sand. Concrete sidewalk patched with quick set concrete.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **BB-8**
Boring Location: N: 2868705.94 E: 362842.55
Checked by: K. Kocia
Date Start: May 22, 2019
Date Finish: May 23, 2019

Contractor: Seaboard Drilling, Inc.
Driller: M. Glynn
Nobis Rep.: S. Kurtzer

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Automatic Hammer
Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 159.5
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	3"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
05/23/19	00:00	Not Encountered	25	25	2 hours

Depth (ft.)	Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	Ground Water	Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
1							CONCRETE SIDEWALK 159.1 / 0.4	Concrete sidewalk approximately 4.5-inches thick.	
2	S-1	11	1-3	2 3				S-1: Loose, black to brown, fine to coarse SAND, little Silt, little fine Gravel, several asphalt pieces. Moist.	
3				4 3					
4	S-2	18	3-5	3 3				S-2: Loose, tan, fine to medium SAND, trace Silt, trace fine Gravel. Moist. [Laboratory Analysis Performed - Grain Size, Sieve Only: Gravel = 1.6% Sand = 92.7% Fines = 5.7%].	
5				2 2					
6	S-3	8	5-7	WOH 1				S-3: Very loose, brown to tan, fine to medium SAND, little Silt, very few wood pieces. seams of redoximorphic staining present Moist.	1
7				WOH 1					
8									
9									
10									
11	S-4	9	10-12	3 2			EMBANKMENT FILL	S-4: Very loose, brown, fine to medium SAND, little Silt. Moist to wet.	
12				1 2					
13									
14									
15									
16	S-5	6	15-17	8 3				S-5: Loose, gray to brown, fine to coarse SAND, trace Silt, several pieces of decomposed granite. Wet.	
17				2 4					
18									
19									
20									
21	S-6	1	20-22	WOH 1				S-6: Very loose, brown, fine to coarse SAND, trace Silt, few pieces of granite and decomposed granite.	
22				1 3					

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:
1) Water introduced into borehole via drive and wash methods at a depth of 5 feet.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

nobis

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **BB-8**
Boring Location: N: 2868705.94 E: 362842.55
Checked by: K. Kocia
Date Start: May 22, 2019
Date Finish: May 23, 2019

Contractor: Seaboard Drilling, Inc.
Driller: M. Glynn
Nobis Rep.: S. Kurtzer

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Automatic Hammer
Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 159.5
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	3"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
05/23/19	00:00	Not Encountered	25	25	2 hours

Depth (ft.)	SAMPLE INFORMATION Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	Ground Water	LITHOLOGY Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
23							EMBANKMENT FILL		
24									
25							134.5 / 25.0		
26								Drilling becomes difficult on presumed boulder cluster. Boring terminated at 25 feet.	2
27									
28									
29									
30									
31									
32									
33									
34									
35									
36									
37									
38									
39									
40									
41									
42									
43									
44									

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:
2) Hydraulic line on rig broke due to difficult drilling conditions. Rods and casing were pulled and the boring was backfilled with spoils and 5 bags of filter sand. Concrete sidewalk patched with quick set concrete.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **BB-8A**
Boring Location: N: 2868702.80 E: 362844.90
Checked by: K. Kocia
Date Start: May 23, 2019
Date Finish: May 23, 2019

Contractor: Seaboard Drilling, Inc.
Driller: M. Glynn
Nobis Rep.: S. Kurtzer

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Automatic Hammer
Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 159.5
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
05/23/19	22:30	Not Encountered	30	34	5 mins

Depth (ft.)	Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	Ground Water	Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
1							CONCRETE SIDEWALK 159.1 / 0.4	Concrete sidewalk approximately 4-inches thick.	1
2								Drive and wash techniques performed to 20 feet bgs.	
3									
4									
5									
6									
7									
8									
9									
10									
11							EMBANKMENT FILL		
12									
13									
14									
15									
16									
17									
18									
19									
20									
	S-1	3	20-22	WOH				S-1: Very loose, tan, fine to medium SAND, little Silt. Wet.	
21				WOH					
22				WOH 1					

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:
1) Water introduced into borehole via drive and wash methods at a depth of 0 feet.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **BB-8A**
Boring Location: N: 2868702.80 E: 362844.90
Checked by: K. Kocia
Date Start: May 23, 2019
Date Finish: May 23, 2019

Contractor: Seaboard Drilling, Inc.
Driller: M. Glynn
Nobis Rep.: S. Kurtzer

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Automatic Hammer
Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 159.5
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
05/23/19	22:30	Not Encountered	30	34	5 mins

Depth (ft.)	Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	Ground Water	Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
23							EMBANKMENT FILL		
24									
25									
	S-2	16	25-27	4				S-2: Loose, tan to gray, Clayey SILT, little fine to coarse Sand. Moist.	
26				4					
				5					
27				10					
28									
29									
30							REWORKED SILT AND CLAY		
	S-3	14	30-32	9				S-3: Medium dense, brown, Clayey SILT, some fine to coarse Sand, trace fine Gravel. Moist.	
31				10					
				10					
32				12					
	S-4	0	32-34	5				S-4: No recovery.	
33				7					
				12					
34				12			125.5 / 34.0		
35								Boring terminated at 34 feet.	2
36									
37									
38									
39									
40									
41									
42									
43									
44									

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:
2) Boring backfilled with spoils and 4 bags of filter sand. Concrete sidewalk patched with quick set concrete.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **WB-1**
Boring Location: N: 2868822.12 E: 362746.98
Checked by: K. Kocia
Date Start: May 19, 2019
Date Finish: May 19, 2019

Contractor: Seaboard Drilling, Inc.
Driller: M. Glynn
Nobis Rep.: S. Kurtzer

Rig Type / Model: Track / B-53 Mobile
Hammer Type: Automatic Hammer
Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 156.5
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	3"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
05/19/19	22:30	Not Encountered	20	32	5 min

Depth (ft.)	Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	Ground Water	Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
1							CONCRETE SIDEWALK 156.1 / 0.4	Concrete sidewalk approximately 4-inches thick.	
2	S-1	10	1-3	4 3				S-1A (6"): Loose, brown, fine to coarse SAND, little Silt, little fine Gravel. Wet.	
3				2 3				S-1B (4"): Loose, dark brown, fine to medium SAND, little Silt, trace fine Gravel, very few asphalt and brick fragments. Moist.	
4	S-2	10	3-5	3 4				S-2: Loose, tan to brown, fine to coarse SAND, little Silt, trace fine Gravel. Moist.	
5				3 2			EMBANKMENT FILL		
6	S-3	24	5-7	3 5				S-3: Loose, tan, fine SAND, some Silt. Moist.	1
7				4 6					
8									
9									
10									
11	S-4	13	10-12	3 5				S-4: Medium dense, tan and gray, SILT, little fine Sand, trace Clay, faint redoximorphic staining present. Wet.	
12				5 4					
13									
14									
15									
16	S-5	13	15-17	2 7			REWORKED SILT AND CLAY	S-5A (9"): Stiff, gray to brown, Clayey SILT, little fine Sand. Wet.	
17				6 6				S-5B (4"): Medium dense, tan to orangish brown, fine to coarse SAND, little Silt. Wet.	
18									
19									
20									
21	S-6	14	20-22	4 4				S-6: Loose, tan, fine to coarse SAND, some Silt, redoximorphic staining present. Wet.	
22				5 6					

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:
1) Water introduced into borehole via drive and wash methods at a depth of 5 feet.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES - SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **WB-1**
Boring Location: N: 2868822.12 E: 362746.98
Checked by: K. Kocia
Date Start: May 19, 2019
Date Finish: May 19, 2019

Contractor: Seaboard Drilling, Inc.
Driller: M. Glynn
Nobis Rep.: S. Kurtzer

Rig Type / Model: Track / B-53 Mobile
Hammer Type: Automatic Hammer
Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 156.5
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	3"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
05/19/19	22:30	Not Encountered	20	32	5 min

Depth (ft.)	Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	Ground Water	Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
23							REWORKED SILT AND CLAY		
24									
25							131.5 / 25.0		
	S-7	14	25-27	3				S-7: Loose, brown to gray, SILT, little fine Sand, trace Clay, faint redoximorphic staining present. Wet.	
26				4					
				3					
27				4					
28									
29							VARVED SAND AND SILT		
30									
	S-8	0	30-32	2				S-8: No recovery.	
31				1					
				1					
32				2			124.5 / 32.0		
33								Boring terminated at 32 feet.	2
34									
35									
36									
37									
38									
39									
40									
41									
42									
43									
44									

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:
2) Boring backfilled with spoils and one (1) bag of filter sand. Concrete sidewalk patched with quick set concrete.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **WB-6**
Boring Location: N: 2868631.27 E: 362849.63
Checked by: K. Stanway
Date Start: November 14, 2022
Date Finish: November 15, 2022

Contractor: Seaboard Drilling, Inc.
Driller: M. Glynn
Nobis Rep.: K. Kocia

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Safety Hammer
Hammer Hoist: Wire Winch

Ground Surface Elev.: (+/-) 158
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 11/15/22	23:50	15.8	69	73	20 min

Depth (ft.)	Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	Ground Water	Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
1							ASPHALT 156.9 / 1.1	Asphalt encountered was approximately 13-inches thick, consisting of two-layers, top portion being 7-inches thick and bottom portion being 6-inches.	
2								Base Coarse encountered underlying asphalt, approximately 3-inches thick, consisting primarily of fine to coarse gravel and fine to coarse sand.	
3								Soil was hand cleared from approximately 1 to 4 feet bgs by Seaboard. Fill material consisted primarily of brown - gray, fine to coarse SAND, little Silt, trace fine Gravel, with few cobbles present.	
4								S-1: Loose, brown, fine to medium SAND, trace Silt, very few asphalt fragments/particles. Moist.	
5	S-1	19	4-6	2 2					
6				3 3					
7	S-2	18	6-8	3 3				S-2: Loose, brown - tan, fine to medium SAND, trace Silt, very few asphalt fragments/particles. Moist.	
8				3 3					
9									1
10	S-3	17	9-11	2 3				S-3: Loose, brown - dark brown, fine to coarse SAND, some Silt, very few brick fragments/particles. Moist.	
11				3 9					
12	S-4	19	11-13	16 12			FILL	S-4A (10"): Medium dense, dark brown, fine to coarse SAND and Silt. Wet.	
13				7 7				S-4B (9"): Medium dense, tan - orangish-brown, fine SAND, little Silt. Faint redoximorphic staining present. Wet.	
14									
15	S-5	20	14-16	5 5				S-5: Stiff, brown, Clayey SILT, little fine Sand. Faint redoximorphic staining present. Wet.	
16				5 8	▼				
17									
18									
19									
20	S-6	20	19-21	6 6				S-6: Stiff, brown, Clayey SILT, trace fine Sand. Wet.	
21				7 9					
22									

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:
1) Water was introduced into borehole starting at approximately 8 feet below ground surface (bgs).

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **WB-6**
Boring Location: N: 2868631.27 E: 362849.63
Checked by: K. Stanway
Date Start: November 14, 2022
Date Finish: November 15, 2022

Contractor: Seaboard Drilling, Inc.
Driller: M. Glynn
Nobis Rep.: K. Kocia

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Safety Hammer
Hammer Hoist: Wire Winch

Ground Surface Elev.: (+/-) 158
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 11/15/22	23:50	15.8	69	73	20 min

Depth (ft.)	Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	Ground Water	Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
23							FILL 135.5 / 22.5		
24									
	S-7	16	24-26	4				S-7: Stiff, brown - reddish-brown, Clayey SILT, little fine to coarse Sand. Varved pockets / seams (ranging in 0.5 inches to 2 inches in thickness) every 2 to 6 inches. Wet.	
25				5					
				6					
26				5					
27									
28									
29									
	S-8	16	29-31	6				S-8: Stiff, brown - reddish-brown, Clayey SILT, little fine Gravel, little fine to coarse Sand. Varved pockets / seams (ranging in 0.25 inches to 3 inches in thickness) every 2 to 9 inches. Wet.	
30				6			VARVED CLAYEY SILT		
				6					
31				5					
32									
33									
34									
	S-9	15	34-36	8				S-9: Stiff, brown - reddish-brown, Clayey SILT, little fine to coarse Sand. Varved pockets / seams (ranging in 0.5 inches to 3 inches in thickness) every 2 to 6 inches. Wet.	
35				7					
				7					
36				6					
37									
38									
39									
	S-10	19	39-41	6				S-10: Stiff, brown - gray, SILT, some fine to coarse Sand, trace Clay. Wet.	
40				6					
				5					
41				5			SILT		
42									
43									
44									

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **WB-6**
Boring Location: N: 2868631.27 E: 362849.63
Checked by: K. Stanway
Date Start: November 14, 2022
Date Finish: November 15, 2022

Contractor: Seaboard Drilling, Inc.
Driller: M. Glynn
Nobis Rep.: K. Kocia

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Safety Hammer
Hammer Hoist: Wire Winch

Ground Surface Elev.: (+/-) 158
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 11/15/22	23:50	15.8	69	73	20 min

Depth (ft.)	Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	Ground Water	Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
	S-11	15	44-46	5				S-11: Stiff, brownish-gray, SILT, little fine to coarse Sand, trace Clay. Wet.	
45				5					
				5					
46				5					
47									
48									
49							SILT		
	S-12	8	49-51	8				S-12: Medium dense, brown - gray, fine to coarse SAND and Silt. Wet.	
50				7					
				8					
51				9					
52									
							105.5 / 52.5		
53									
54									
	S-13	17	54-56	6				S-13: Very stiff, brown - gray, SILT & CLAY, little fine to coarse Sand. Wet.	
55				7					
				8					
56				12					
57									
58									
59									
	S-14	18	59-61	7			GLACIAL TILL	S-14: Medium dense, gray, SILT, little fine to coarse Sand, trace fine Gravel. Wet. [Laboratory Analysis Performed - Grain Size, Sieve Only: 6.6% Gravel, 13.1% Sand, 80.3% Fines].	
60				10					
				12					
61				12					
62									
63									
64									
	S-15	18	64-66	8				S-15: Dense, gray, SILT and fine to coarse Sand. Wet.	
65				12					
				18					
66				17					

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

BORING LOG

Project: MassDOT Armory Street Over CSX Mainline and Abandoned CSX Spur
Location: Springfield, Massachusetts
Nobis Project No.: 94184.01

Boring No.: **WB-6**
Boring Location: N: 2868631.27 E: 362849.63
Checked by: K. Stanway
Date Start: November 14, 2022
Date Finish: November 15, 2022

Contractor: Seaboard Drilling, Inc.
Driller: M. Glynn
Nobis Rep.: K. Kocia

Rig Type / Model: Truck / B-53 Mobile
Hammer Type: Safety Hammer
Hammer Hoist: Wire Winch

Ground Surface Elev.: (+/-) 158
Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4"	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 11/15/22	23:50	15.8	69	73	20 min

Depth (ft.)	SAMPLE INFORMATION Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	Ground Water	LITHOLOGY Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
67									
68									
69									
	S-16	22	69-71	11			GLACIAL TILL	S-16: Very stiff, brownish-gray, SILT and fine to coarse Sand, trace Clay. Wet.	
70				10					
				10					
71				12					
	S-17	4	71-73	11				S-17: Dense, brownish-gray, fine to coarse SAND and Silt, trace Clay. Wet.	
72				12					
				20					
73				24			85.0 / 73.0		
								Boring terminated at 73 feet.	2
74									
75									
76									
77									
78									
79									
80									
81									
82									
83									
84									
85									
86									
87									
88									

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:
2) Borehole was backfilled with spoils, one (1) bag of filter sand, and topped with asphalt cold patch at ground surface.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BOREHOLE LOG - NOBIS GINT DATA TEMPLATE OCT 7 2011.GDT - 11/16/23 12:41 - J:\094184.100-MASSDOT ARMORY STREET BRIDGES_SPRINGFIELD\FIELD DATA\SUBSURFACE EXPLORATIONS\GINT\94184.10 BORING LOGS.GPJ

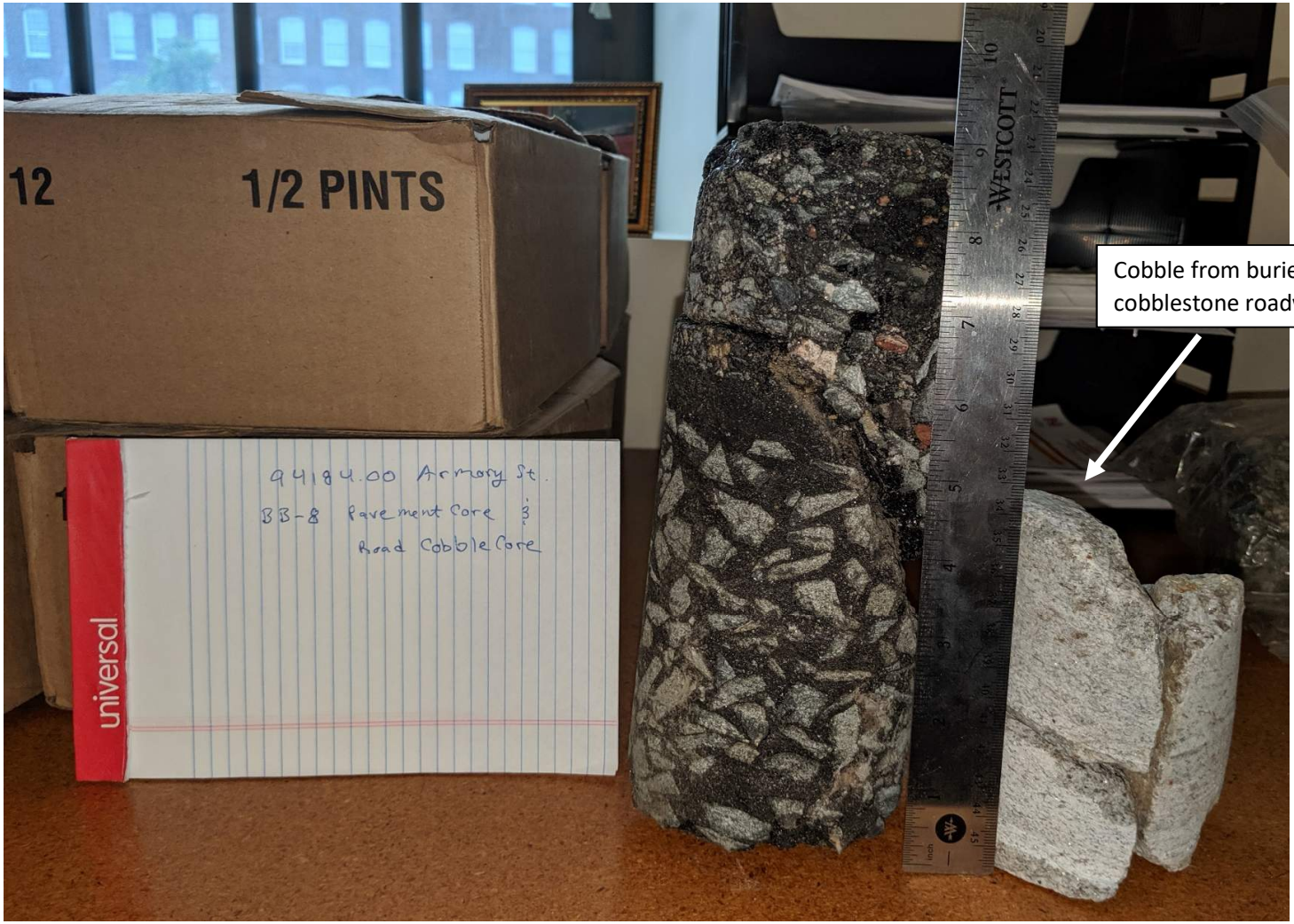
APPENDIX B.2 – Asphalt Pavement Core Photo Log

nobis

WB-1: 7 ¾” of Asphalt

WB-3: 18” of Asphalt

nobis



BB-8: 9” of Asphalt

APPENDIX B.3 – Test Pit Logs

TEST PIT LOG

nobis

PROJECT		TEST PIT NO.	TP-1
Armory Street over		SHEET	1 of 2
Abandoned CSX Spur		FILE NO.	94184.100
Springfield, Massachusetts		CHKD BY	JV

Engineer	S. Kurtzer	Make	Komatsu	Ground El.	±138 FT
Contractor	Seaboard Drilling, Inc.	Model	PC 40	Datum	NAVD88
Operator	A. Griswold	Capacity	4.08 CF	Date Start	7/8/2019
Weather	75°F Partly Cloudy	Reach	10 FT	Date Finish	7/8/2019

Depth Below Grade (ft)	Strata Change & Water Level	Subsurface Description	Excavation Effort	Boulder Qty/Class	USDA Textural Class
1	0.5'	Brown and red, fine to coarse SAND, little Silt, numerous brick pieces / fragments. Dry to Moist. (URBAN FILL)	M	-	Sandy Loam
2		Dark brown to black, fine to coarse SAND, some fine to coarse Gravel, some Silt, several pieces of glass, concrete, brick, ties, and other debris. Moist. (URBAN FILL)	M-E	-	Gravelly, Sandy Loam
3					
4	3.5'	Tan, fine to medium SAND, some clumps of clayey Silt and Silt. Moist. (REWORKED FILL)	E	1B	Loam
5	Granite Block Wall				
6		Brown, coarse GRAVEL, some Clay. Moist. (FILL) abandoned 4-6" jetline pipe unearthed approx. 5' from granite block wall		A	Gravelly Clay
7	7.0'				
8	8.0'	Gray, Clayey SILT, trace fine Sand. Moist. (VARVED SILT AND CLAY)	E	-	Silty Loam
9		Test pit terminated at approximately 8.0' bgs.			
10					
11					
12					
13					
14					
15					

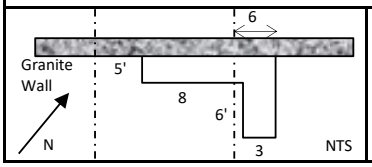
Notes: 1.) Test pit backfilled with excavated soils and compacted with excavator bucket in 12" lifts to ground surface.

2.) Groundwater not encountered.

WATER SYMBOLS

Groundwater

Estimated Seasonal High Groundwater



BOULDER	CLASS
12" - 24"	A
24" - 36"	B
>36"	C

PROPORTIONS USED	
0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

EXCAVATION EFFORT

E = Easy

M = Moderate

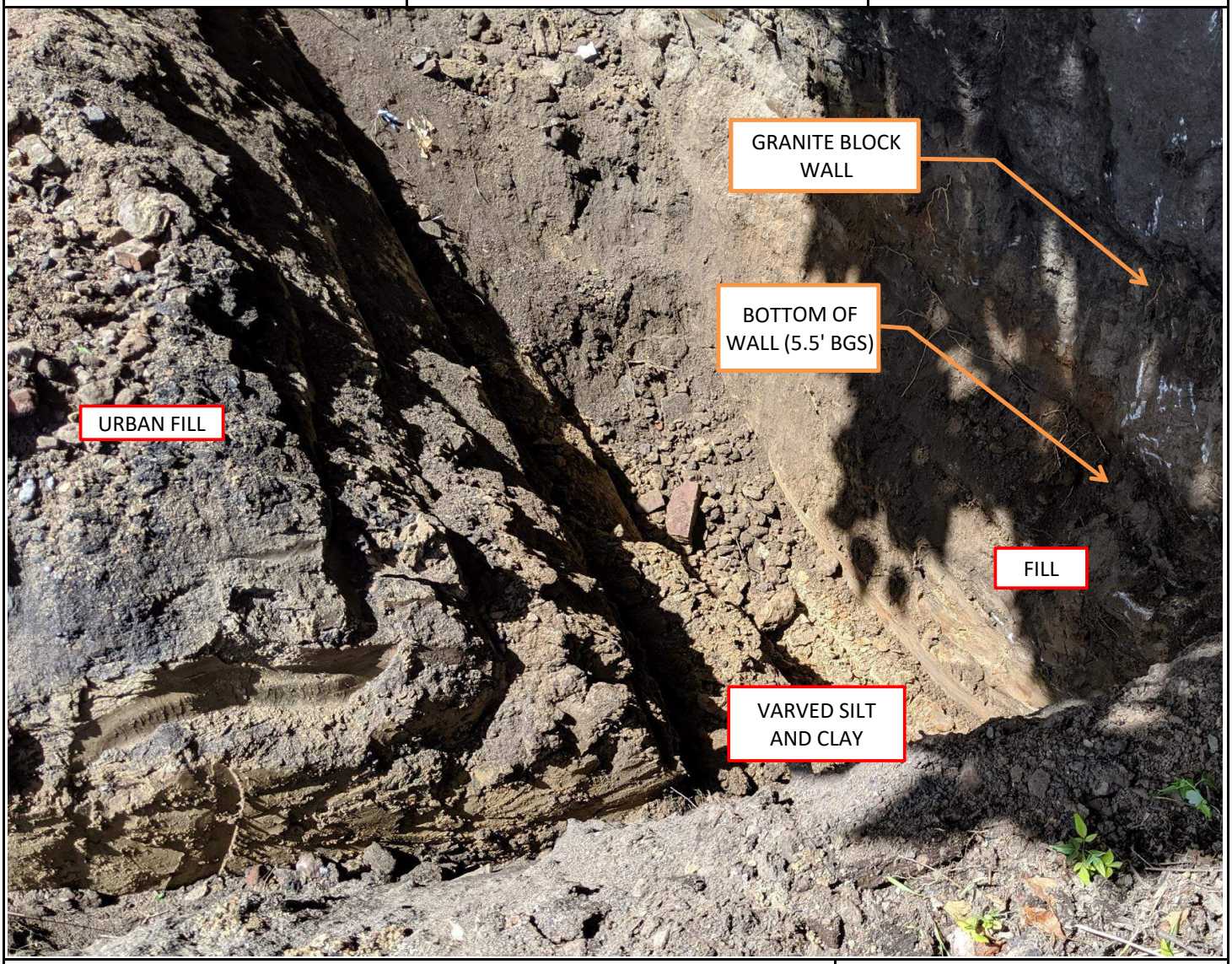
D = Difficult

TEST PIT LOG

nobis

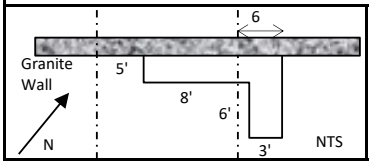
PROJECT		TEST PIT NO.	TP-1
Armory Street over		SHEET	2 of 2
Abandoned CSX Spur		FILE NO.	94184.100
Springfield, Massachusetts		CHKD BY	JV

Engineer	S. Kurtzer	Make	Komatsu	Ground El.	±138 FT
Contractor	Seaboard Drilling, Inc.	Model	PC 40	Datum	NAVD88
Operator	A. Griswold	Capacity	4.08 CF	Date Start	7/8/2019
Weather	75°F Partly Cloudy	Reach	10 FT	Date Finish	7/8/2019



Notes: 1.) Photo of TP-1 in progress.

WATER SYMBOLS
Groundwater
Estimated Seasonal High Groundwater



TEST PIT LOG

nobis

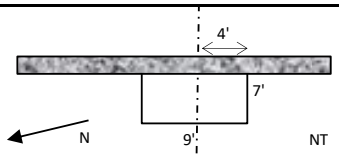
PROJECT		TEST PIT NO.	TP-2
Armory Street over		SHEET	1 of 2
Abandoned CSX Spur		FILE NO.	94184.100
Springfield, Massachusetts		CHKD BY	JV

Engineer	S. Kurtzer	Make	Komatsu	Ground El.	±138 FT
Contractor	Seaboard Drilling, Inc.	Model	PC 40	Datum	NAVD88
Operator	A. Griswold	Capacity	4.08 CF	Date Start	7/8/2019
Weather	80°F Sunny	Reach	10 FT	Date Finish	7/8/2019

Depth Below Grade (ft)	Strata Change & Water Level	Subsurface Description	Excavation Effort	Boulder Qty/Class	USDA Textural Class
1	0.5'	Brown and red, fine to coarse SAND, little Silt, numerous brick pieces / fragments. Dry to Moist. (URBAN FILL)	M	-	Sandy
2		Dark brown to black, fine to coarse SAND, some fine to coarse Gravel, some Silt, several pieces of glass, concrete with rebar, brick, wood, and metal. Moist. (URBAN FILL)	M-E	-	Gravelly, Loamy Sand
3	2.5'				
4		Tan, Clayey SILT, Moist. (REWORKED FILL)			
5	Granite Block Wall		E	-	Silty Loam
6	▼ 6.0'	Water seeping in at ~5'-6" between granite blocks and bottom of wall, indicating retained water between clay and granite blocks.			
7		Test pit terminated at approximately 6.0' bgs.			
8					
9					
10					
11					
12					
13					
14					
15					

Notes:
1.) Test pit backfilled with excavated soils and compacted with excavator bucket in 12" lifts, to ground surface.
2.) Groundwater not encountered.

WATER SYMBOLS
▼ Groundwater
▽ Estimated Seasonal High Groundwater



BOULDER	CLASS
12" - 24"	A
24" - 36"	B
>36"	C

PROPORTIONS USED

0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

EXCAVATION EFFORT
E = Easy
M = Moderate
D = Difficult

TEST PIT LOG

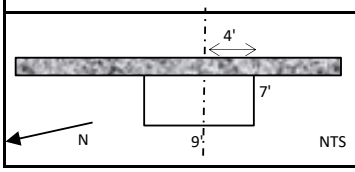
nobis

PROJECT		TEST PIT NO.	TP-2
Armory Street over		SHEET	2 of 2
Abandoned CSX Spur		FILE NO.	94184.100
Springfield, Massachusetts		CHKD BY	JV

Engineer	S. Kurtzer	Make	Komatsu	Ground El.	±138 FT
Contractor	Seaboard Drilling, Inc.	Model	PC 40	Datum	NAVD88
Operator	A. Griswold	Capacity	4.08 CF	Date Start	7/8/2019
Weather	80°F Sunny	Reach	10 FT	Date Finish	7/8/2019

Notes: 1.) Photo of TP-2 in progress.

WATER SYMBOLS
Groundwater
Estimated Seasonal High Groundwater



TEST PIT LOG

nobis

PROJECT
Armory Street over
Abandoned CSX Spur
Springfield, Massachusetts

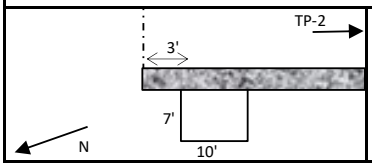
TEST PIT NO. TP-2A
SHEET 1 of 2
FILE NO. 94184.100
CHKD BY JV

Engineer	S. Kurtzer	Make	Komatsu	Ground El.	±138 FT
Contractor	Seaboard Drilling, Inc.	Model	PC 40	Datum	NAVD88
Operator	A. Griswold	Capacity	4.08 CF	Date Start	7/8/2019
Weather	80°F Sunny	Reach	10 FT	Date Finish	7/8/2019

Depth Below Grade (ft)	Strata Change & Water Level	Subsurface Description	Excavation Effort	Boulder Qty/Class	USDA Textural Class
1	0.5'	Brown and red, fine to coarse SAND, little Silt, numerous brick pieces / fragments. Dry to Moist. (URBAN FILL)	M	-	Sandy
2		Brown, fine to medium SAND and Silt, some fine to coarse Gravel, some Silt, several pieces of glass, concrete blocks, and brick. Moist. (URBAN FILL)	M-E	-	Gravelly Loam
3	2.5'	Tan, SILT, some Clay, trace Sand. Moist. (REWORKED FILL)			
4					
5	← Granite Block Wall		E	-	Sily Clay
6					
7	▼ 6.5'	Water seeping in at bottom of granite footing at ~6.5' bgs.			
	7.0'	Gray, Clayey SILT, trace fine Sand. Moist. (VARVED SILT AND CLAY)	E	-	Silty Loam
8		Test pit terminated at approximately 7.0' bgs.			
9					
10					
11					
12					
13					
14					
15					

Notes:
1.) Test pit backfilled with excavated soils and compacted with excavator bucket in 12" lifts, to ground surface.
2.) Groundwater not encountered.

WATER SYMBOLS
▼ Groundwater
▽ Estimated Seasonal High Groundwater



BOULDER	CLASS
12" - 24"	A
24" - 36"	B
>36"	C

PROPORTIONS USED
0-10% Trace
10-20% Little
20-35% Some
35-50% And

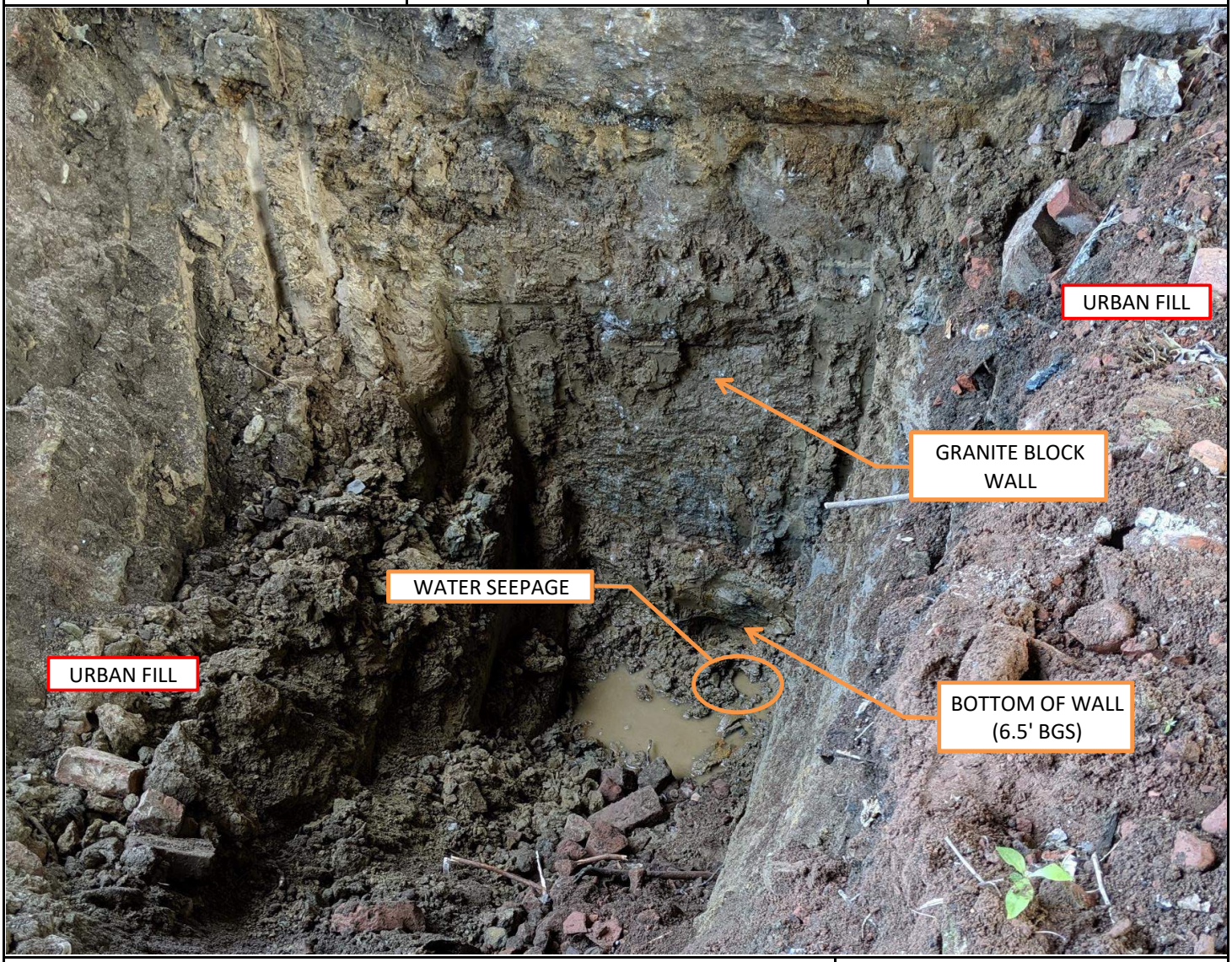
EXCAVATION EFFORT
E = Easy
M = Moderate
D = Difficult

TEST PIT LOG

nobis

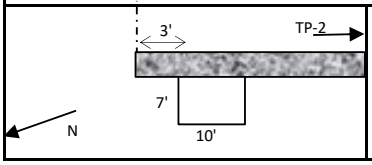
PROJECT		TEST PIT NO.	TP-2A
Armory Street over		SHEET	2 of 2
Abandoned CSX Spur		FILE NO.	94184.100
Springfield, Massachusetts		CHKD BY	JV

Engineer	S. Kurtzer	Make	Komatsu	Ground El.	±138 FT
Contractor	Seaboard Drilling, Inc.	Model	PC 40	Datum	NAVD88
Operator	A. Griswold	Capacity	4.08 CF	Date Start	7/8/2019
Weather	80°F Sunny	Reach	10 FT	Date Finish	7/8/2019



Notes: 1.) Photo of test pit TP-2A in progress.

WATER SYMBOLS
Groundwater
Estimated Seasonal High Groundwater



APPENDIX C – Laboratory Testing Results

GeoTesting EXPRESS

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	BB-1	Sample Type:	tube	Tested By:	ckg
Sample ID:	ST-1	Test Date:	05/10/19	Checked By:	bfs
Depth :	22-24 ft	Test Id:	501656		
Test Comment:	---				
Visual Description:	Moist, dark gray silt				
Sample Comment:	---				

Moisture Content of Soil and Rock - ASTM D2216

Boring ID	Sample ID	Depth	Description	Moisture Content,%
BB-1	ST- 1	22-24 ft	Moist, dark gray silt	16.8

Notes: Temperature of Drying : 110º Celsius

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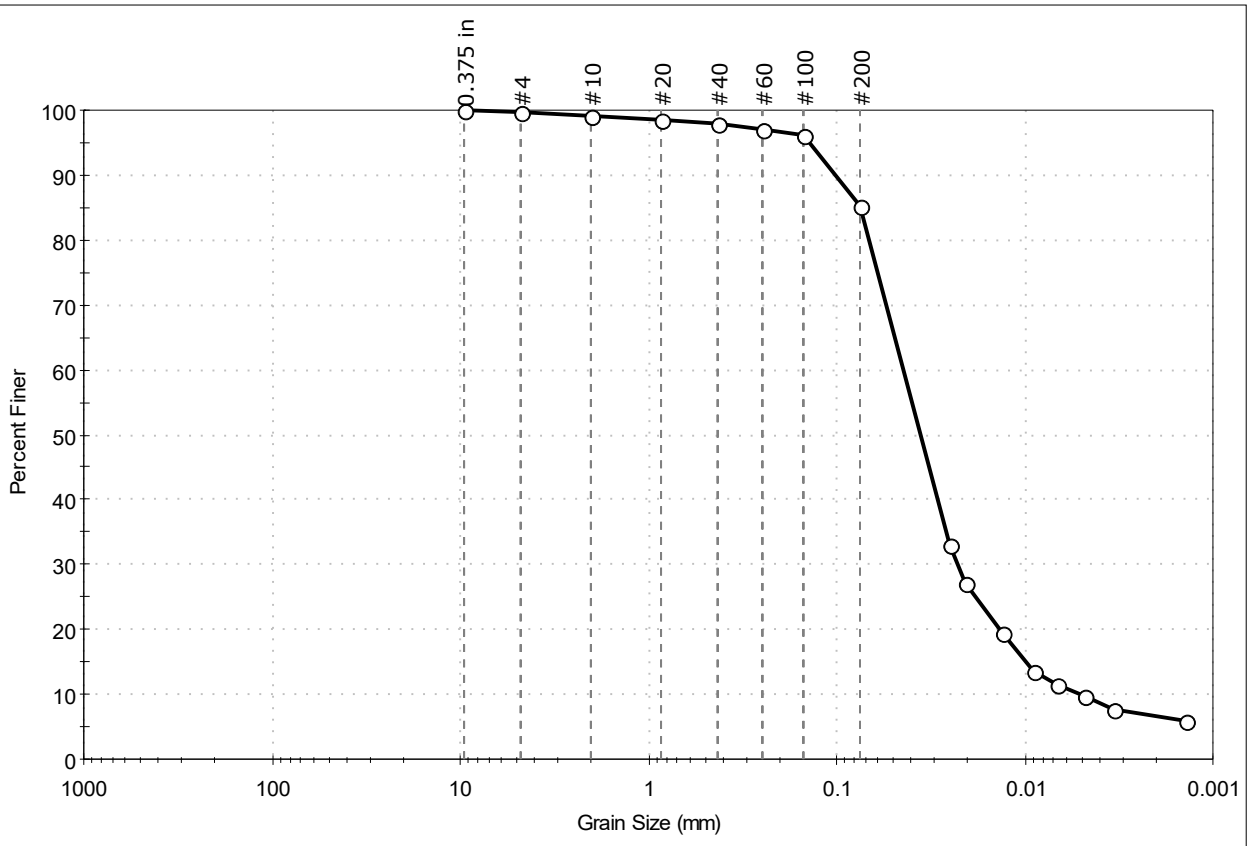
GeoTesting EXPRESS

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	BB-1	Sample Type:	tube	Tested By:	ckg
Sample ID:	ST-1	Test Date:	05/10/19	Checked By:	bfs
Depth :	22-24 ft	Test Id:	501654		
Test Comment:	---				
Visual Description:	Moist, dark gray silt				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
--	0.4	14.4	85.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	100		
#10	2.00	99		
#20	0.85	99		
#40	0.42	98		
#60	0.25	97		
#100	0.15	96		
#200	0.075	85		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0253	33		
---	0.0209	27		
---	0.0130	19		
---	0.0090	14		
---	0.0067	12		
---	0.0048	10		
---	0.0033	8		
---	0.0014	6		

Coefficients

D_{85} = 0.0748 mm D_{30} = 0.0230 mm
D_{60} = 0.0444 mm D_{15} = 0.0098 mm
D_{50} = 0.0361 mm D_{10} = 0.0051 mm
C_u = 8.706 C_c = 2.336

Classification

ASTM SILT (ML)

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---
Sand/Gravel Hardness : ---
Dispersion Device : Apparatus A - Mech Mixer
Dispersion Period : 1 minute
Est. Specific Gravity : 2.65
Separation of Sample: #200 Sieve

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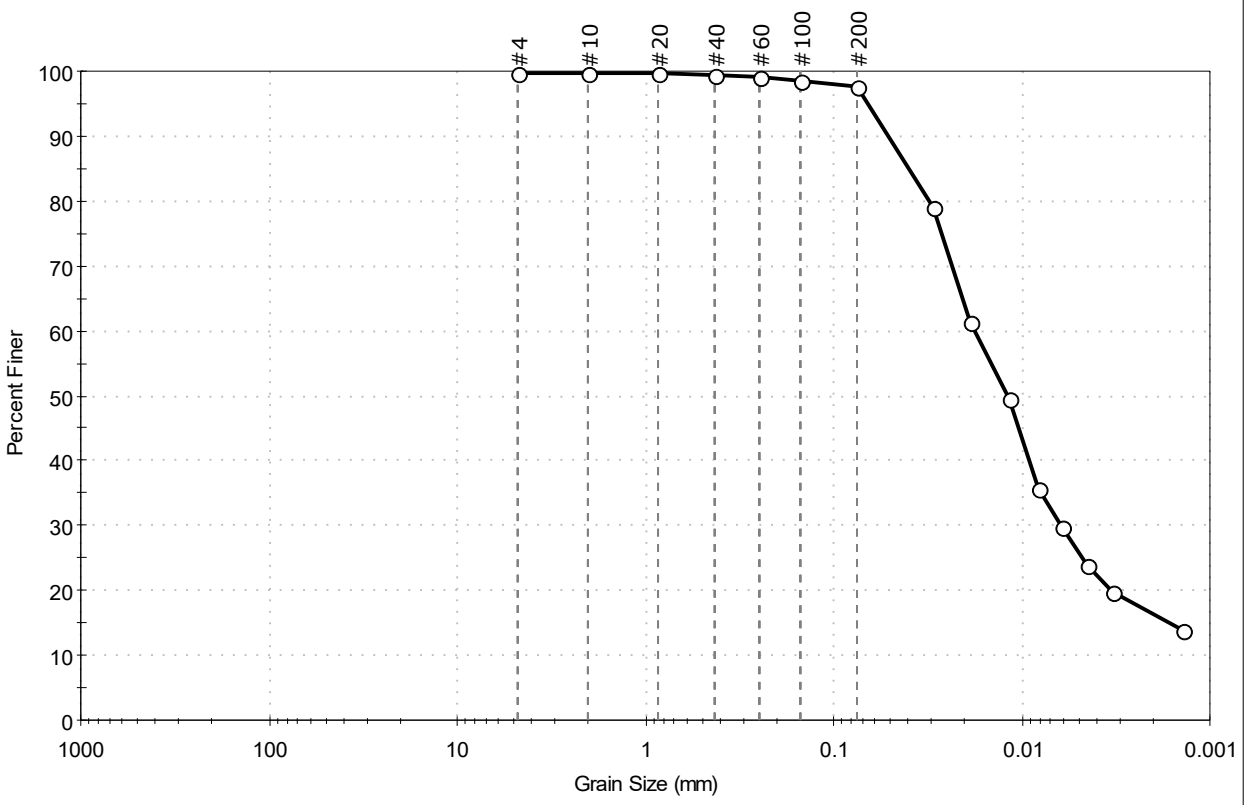
GeoTesting EXPRESS

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	BB-6	Sample Type:	jar	Tested By:	ckg
Sample ID:	S-4	Test Date:	05/10/19	Checked By:	bfs
Depth :	9-11 ft	Test Id:	501655		
Test Comment:	---				
Visual Description:	Moist, light olive brown clay				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
--	0.2	2.1	97.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	99		
#60	0.25	99		
#100	0.15	99		
#200	0.075	98		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0294	79		
---	0.0189	61		
---	0.0116	49		
---	0.0082	36		
---	0.0062	30		
---	0.0045	24		
---	0.0033	20		
---	0.0014	14		

Coefficients

D_{85} = 0.0395 mm D_{30} = 0.0063 mm
D_{60} = 0.0179 mm D_{15} = 0.0016 mm
D_{50} = 0.0118 mm D_{10} = N/A
C_u = N/A C_c = N/A

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Dispersion Device : Apparatus A - Mech Mixer
Dispersion Period : 1 minute
Est. Specific Gravity : 2.65
Separation of Sample: #200 Sieve

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GeoTesting EXPRESS

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	BB-1	Sample Type:	tube	Tested By:	cam
Sample ID:	ST-1	Test Date:	05/09/19	Checked By:	bfs
Depth :	22-24 ft	Test Id:	501653		
Test Comment:	---				
Visual Description:	Moist, dark gray silt				
Sample Comment:	---				

Atterberg Limits - ASTM D4318

Sample Determined to be non-plastic

Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	ST-1	BB-1	22-24 ft	17	n/a	n/a	n/a	n/a	SILT (ML)

2% Retained on #40 Sieve
Dry Strength: HIGH
Dilatancy: RAPID
Toughness: n/a
The sample was determined to be Non-Plastic

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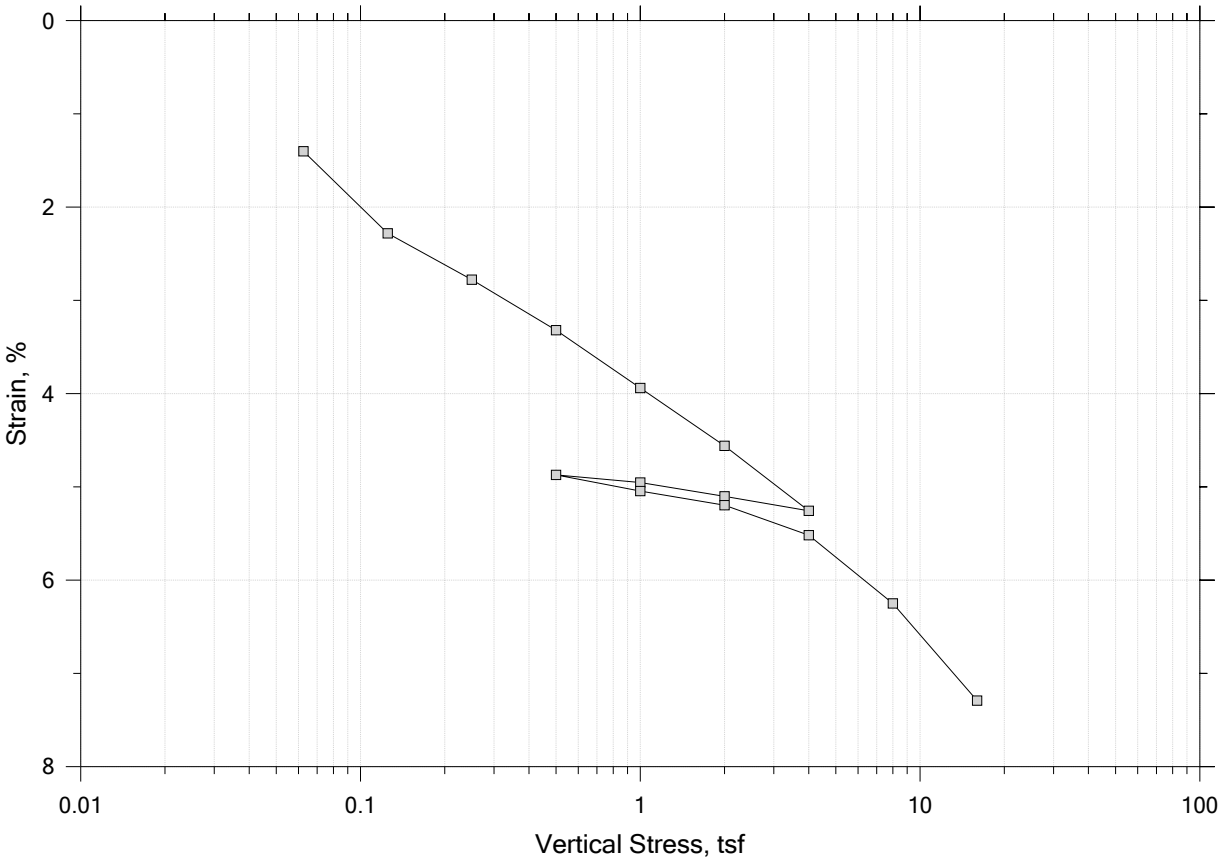
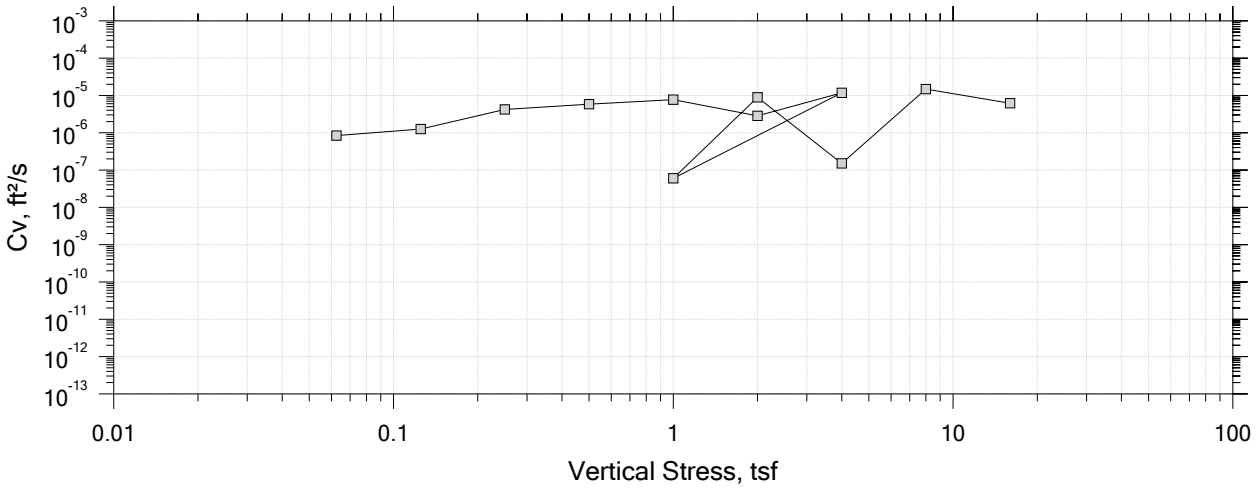
One-Dimensional Consolidation by ASTM D2435 - Method B

Summary Report

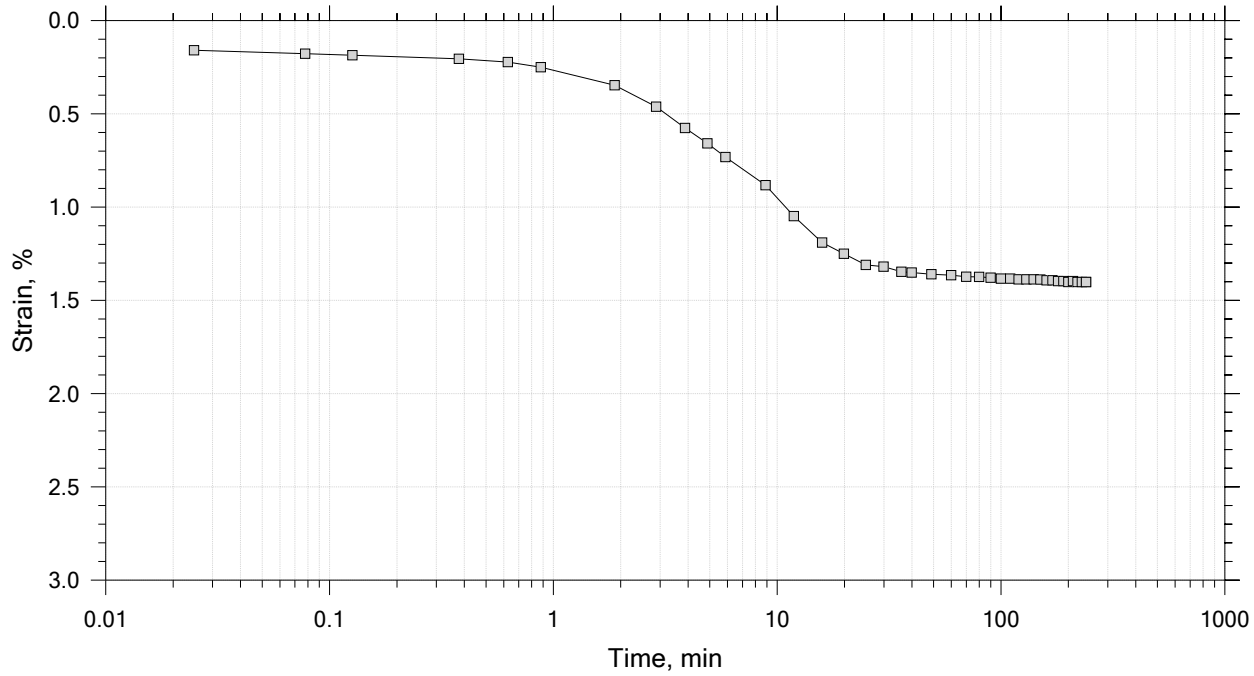


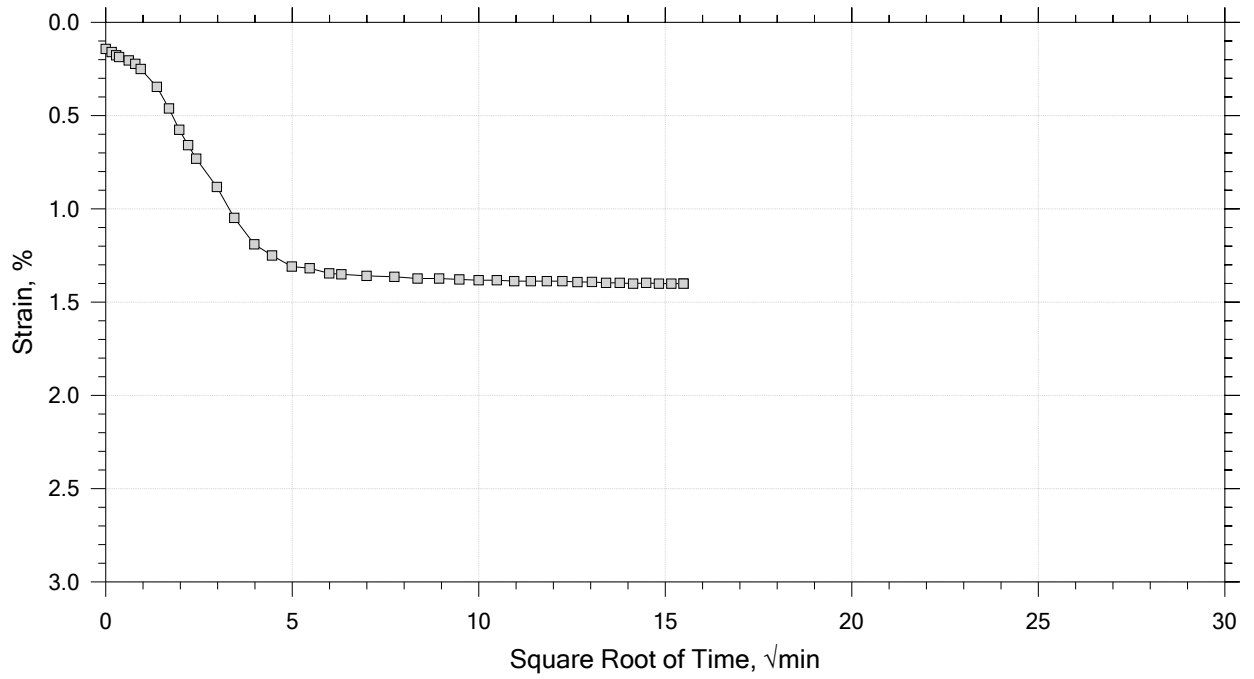


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		
	Displacement at End of Increment		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 1 of 15
Constant Load Step
Stress: 0.0625 tsf

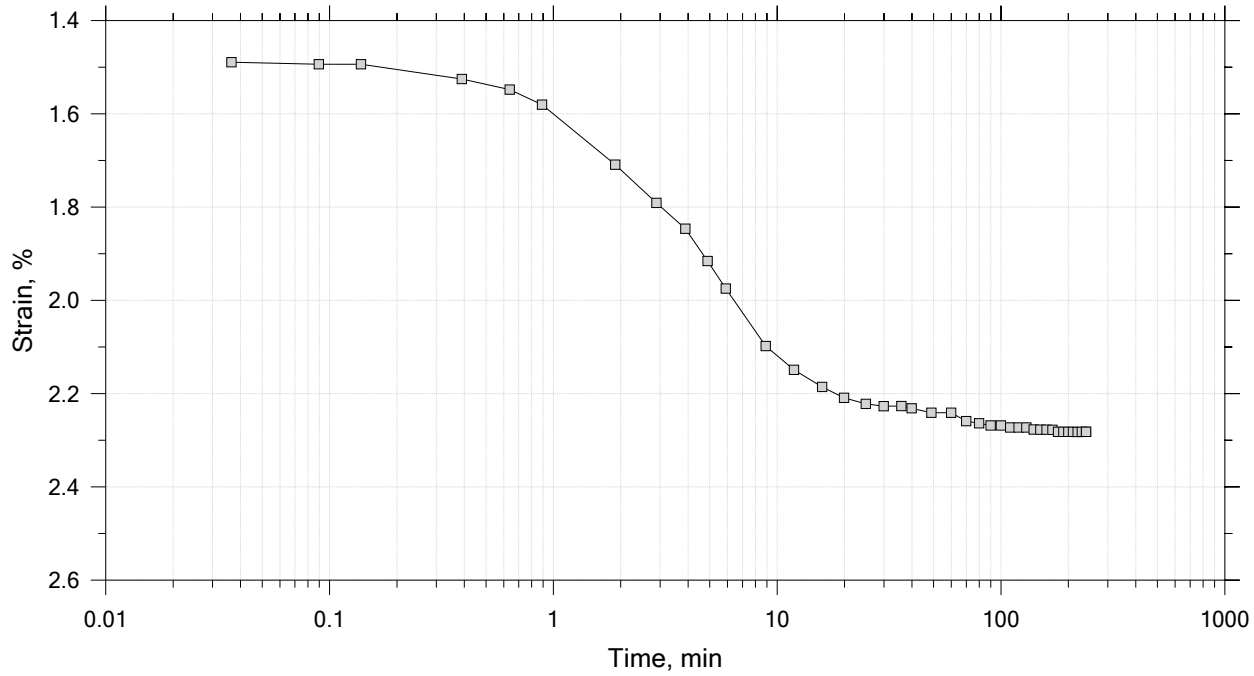


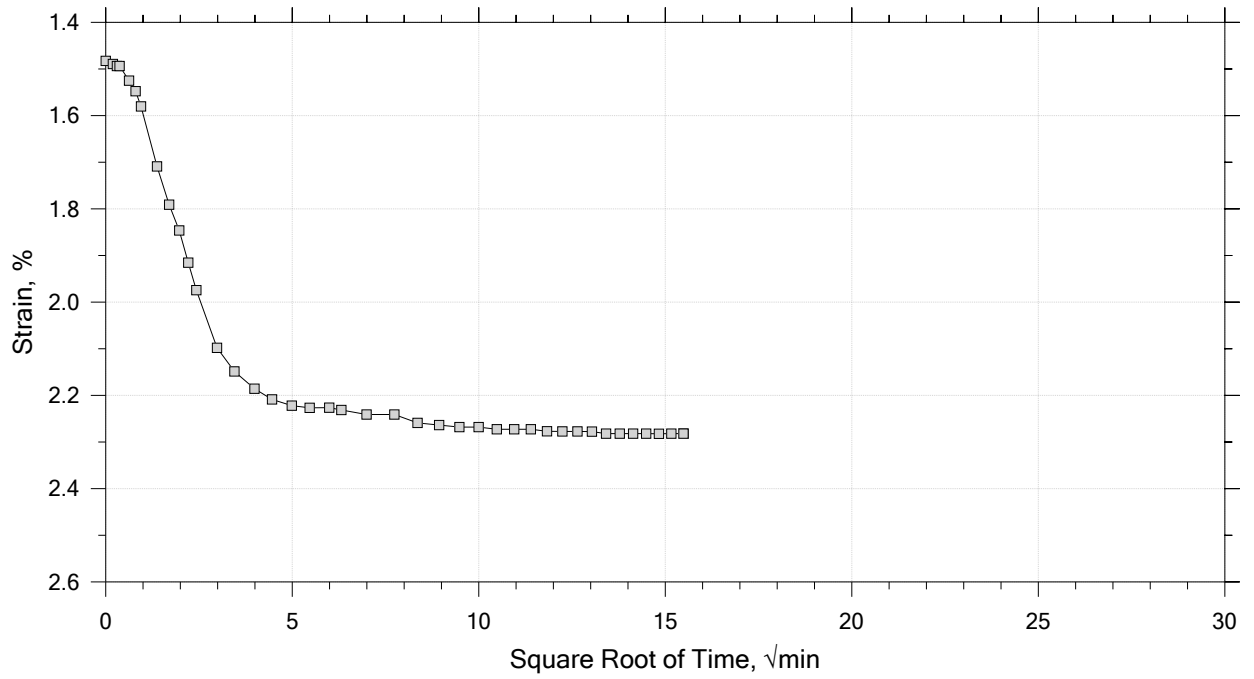


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 2 of 15
Constant Load Step
Stress: 0.125 tsf

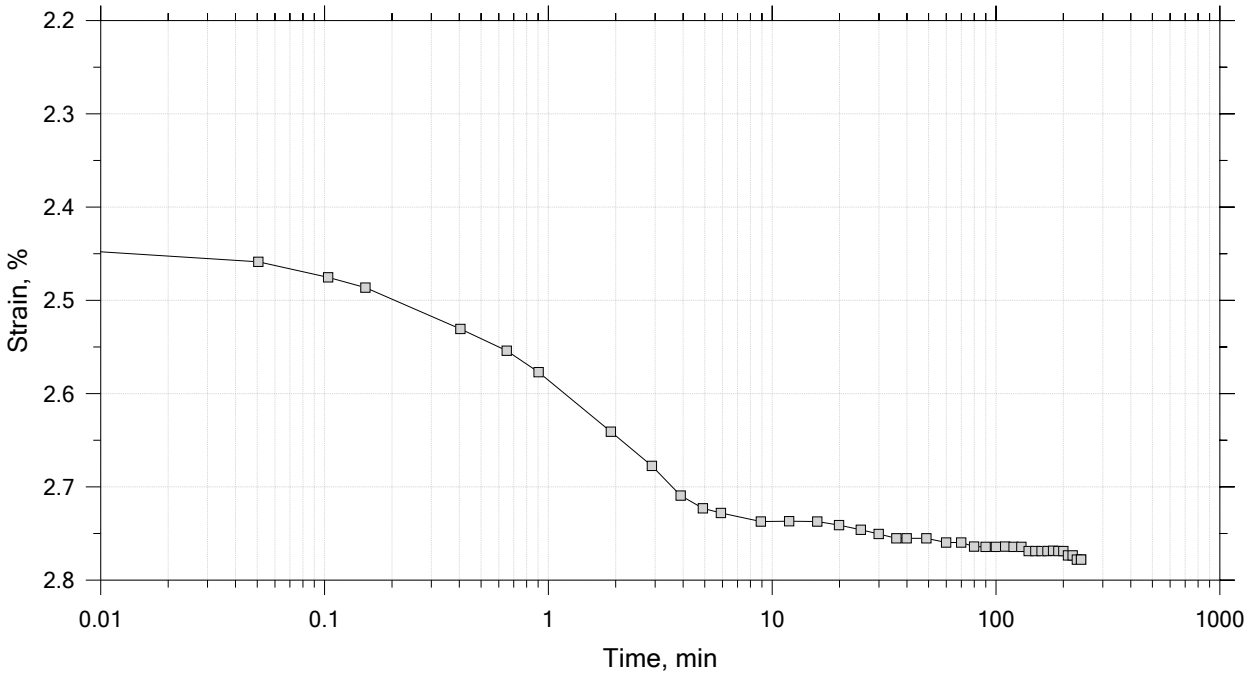


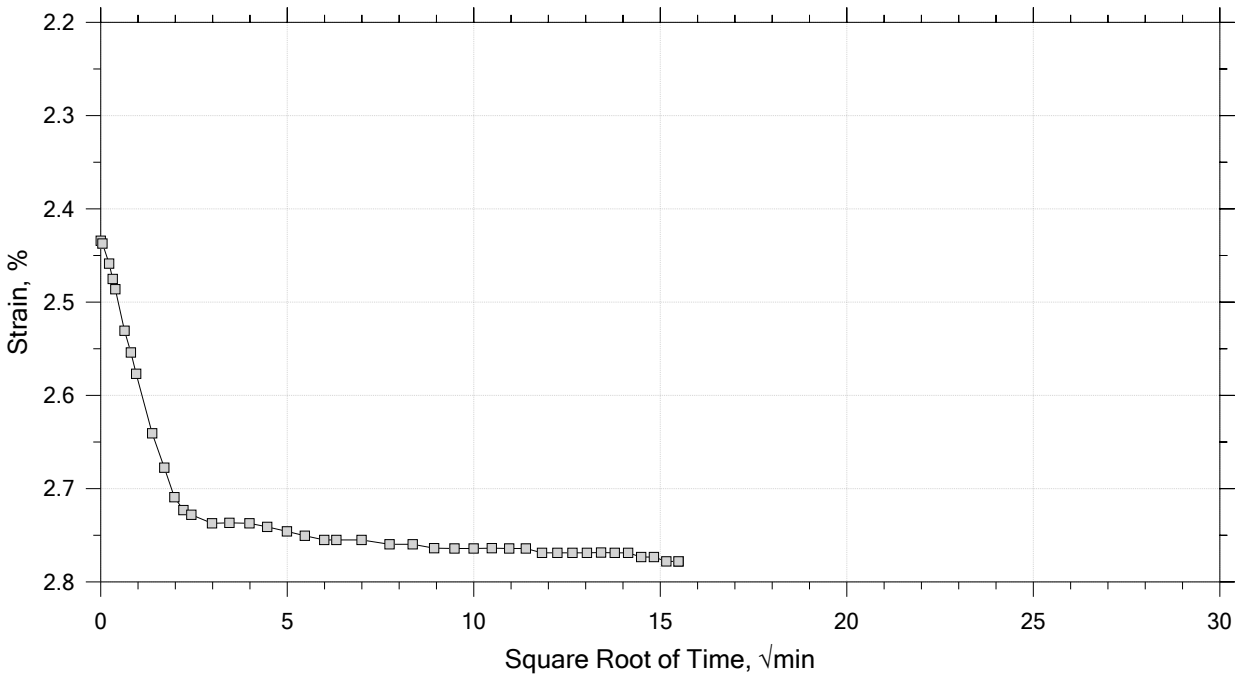


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 3 of 15
Constant Load Step
Stress: 0.25 tsf

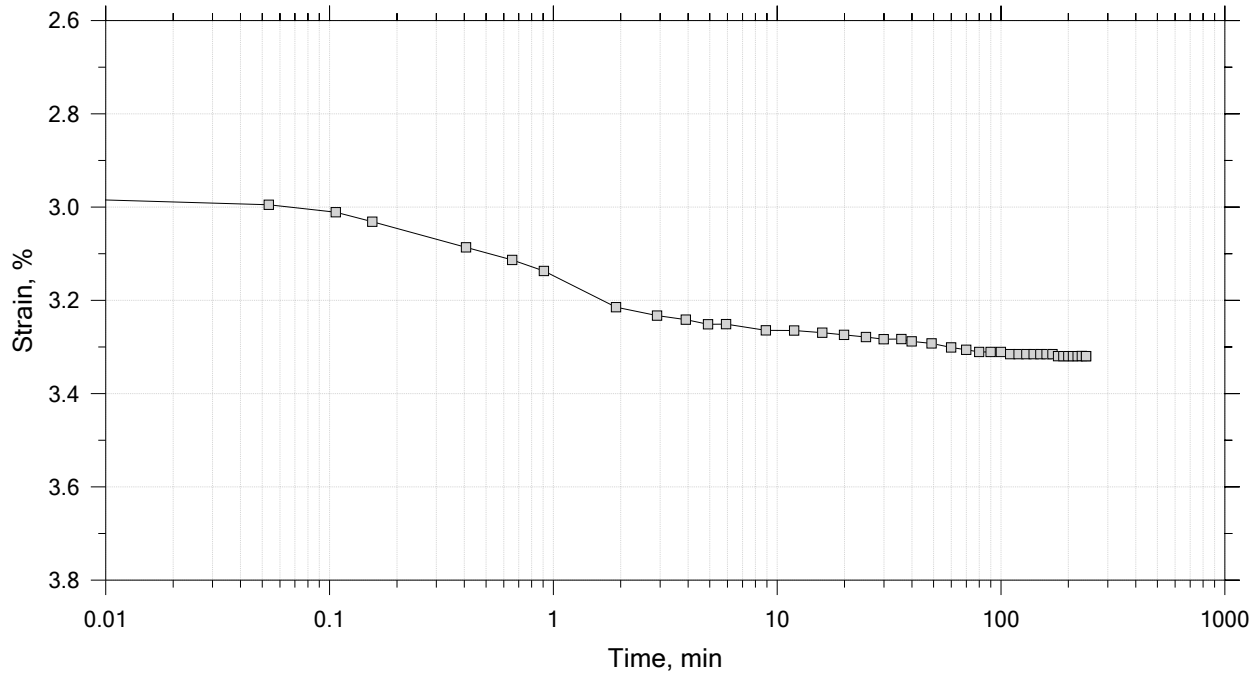


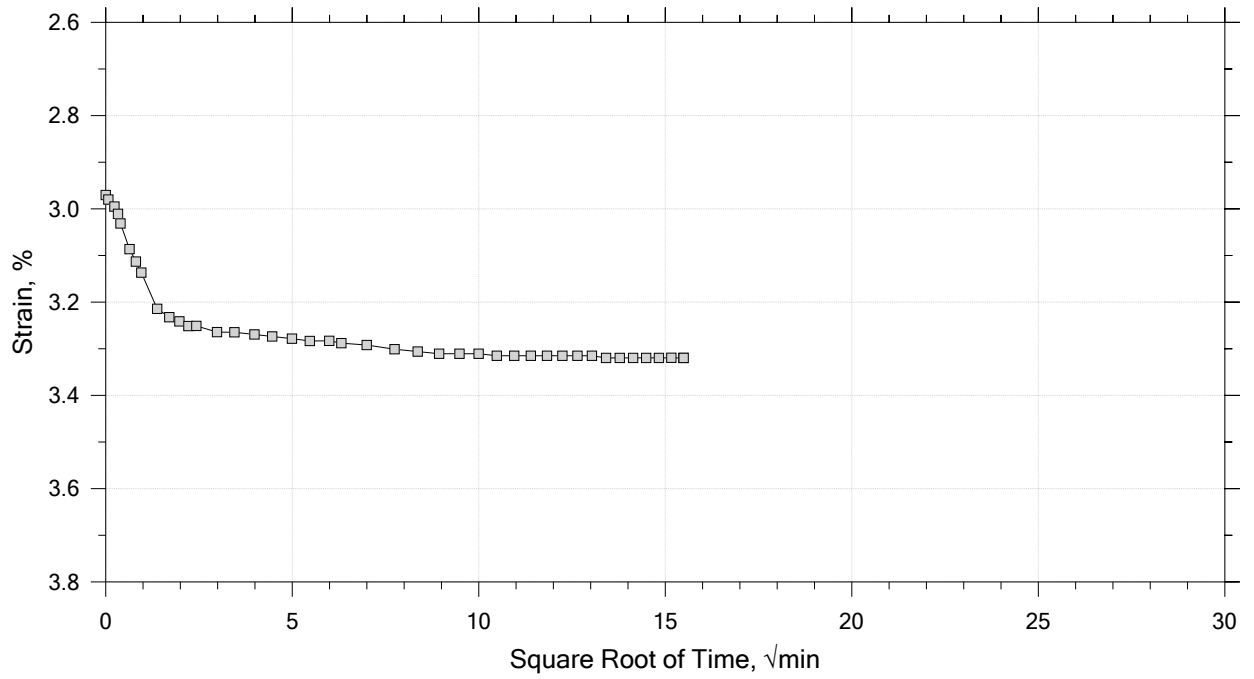


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 4 of 15
Constant Load Step
Stress: 0.5 tsf

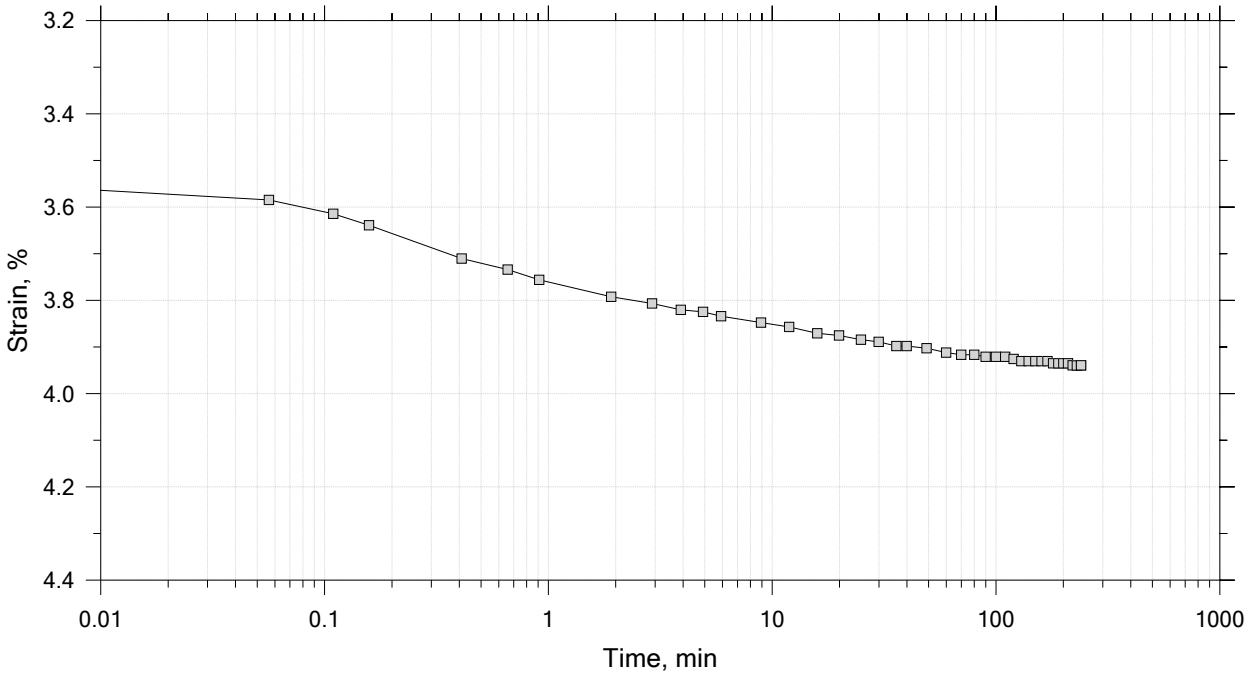


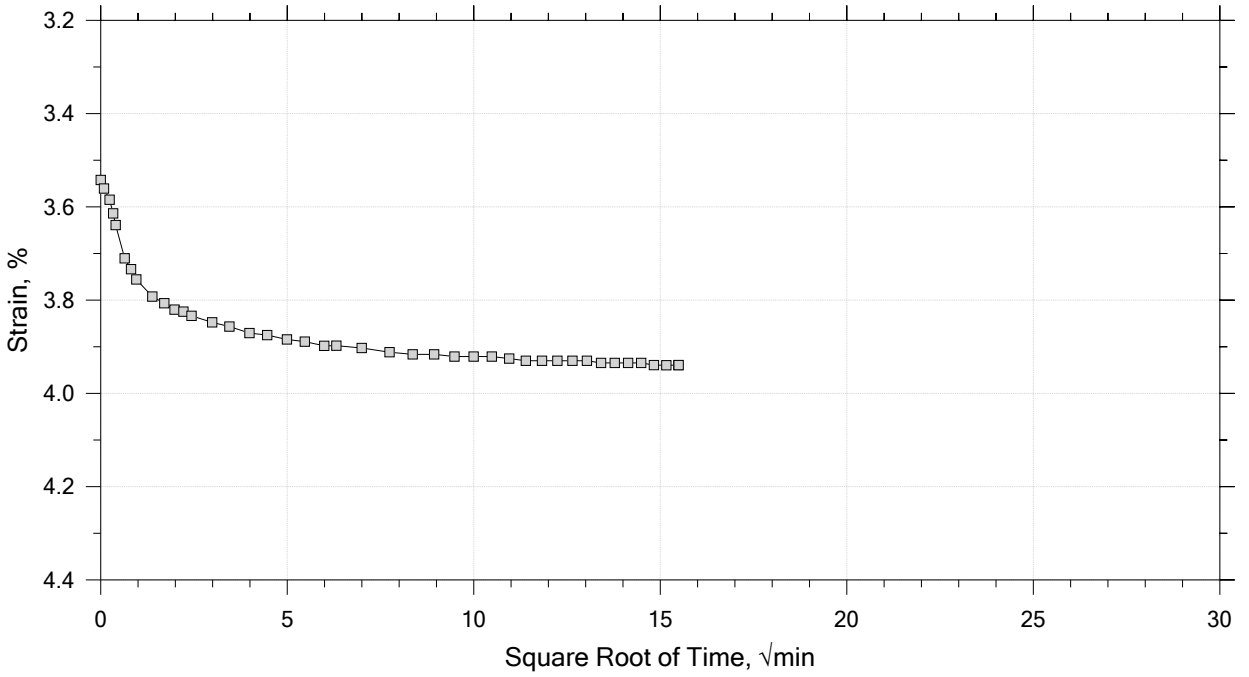


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 5 of 15
Constant Load Step
Stress: 1 tsf

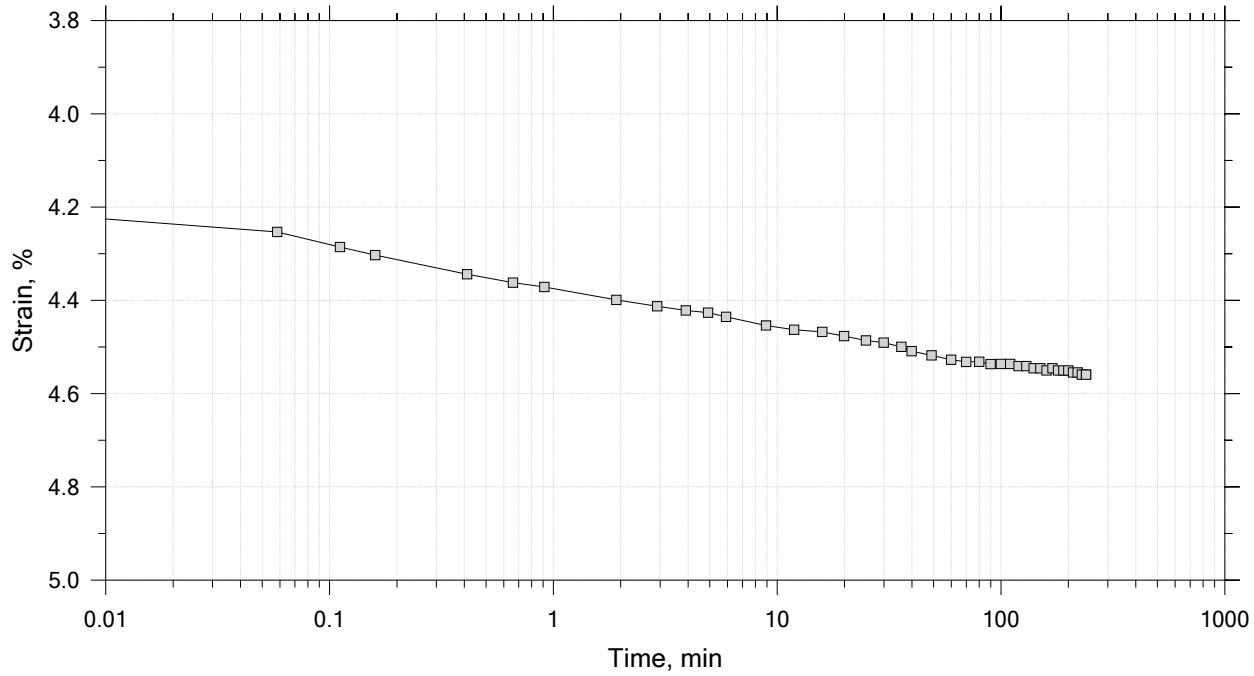


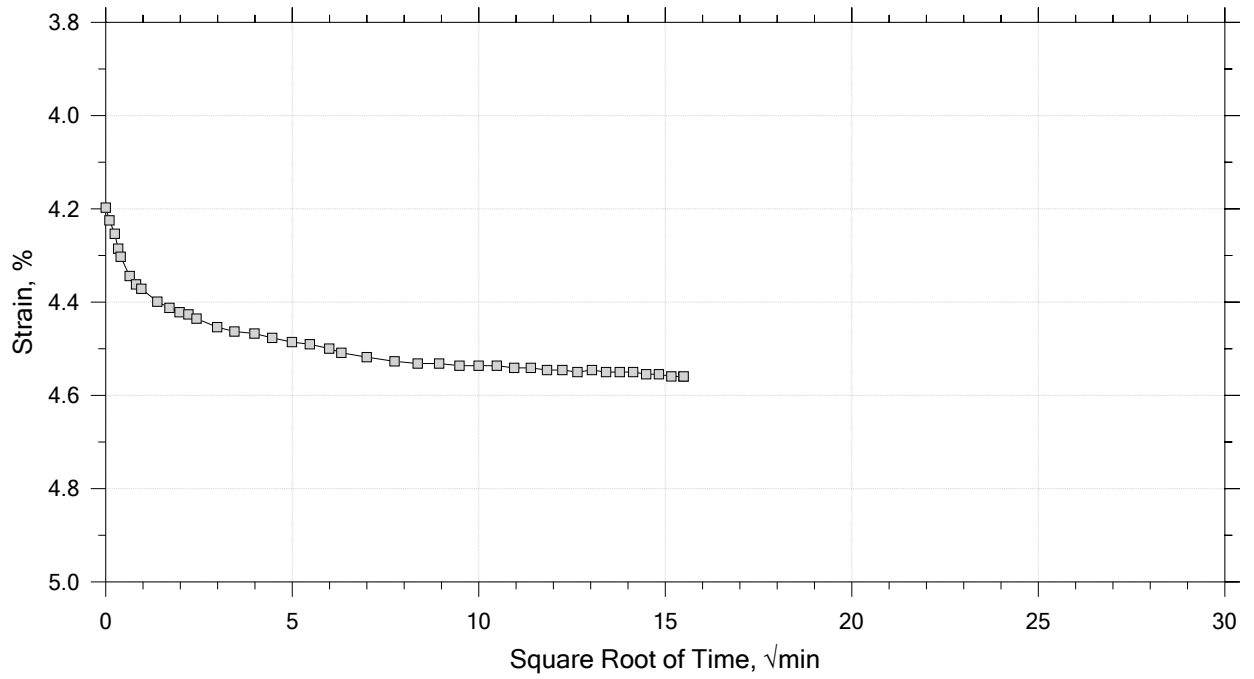


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 6 of 15
Constant Load Step
Stress: 2 tsf

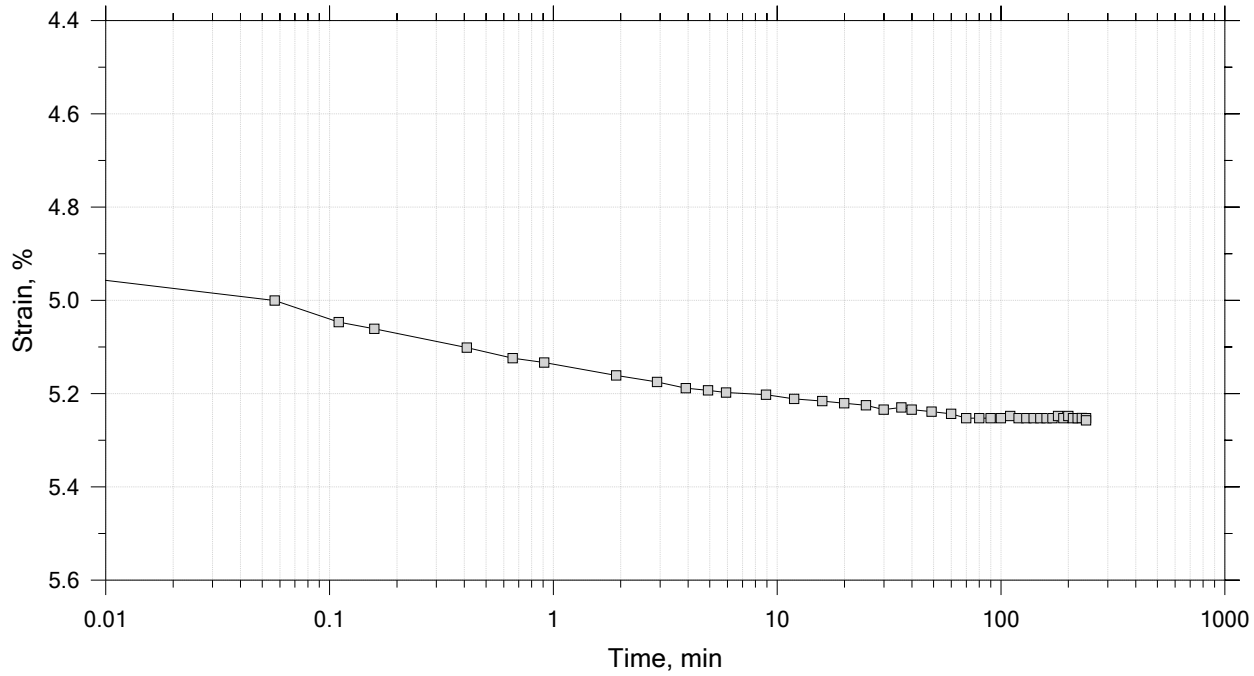


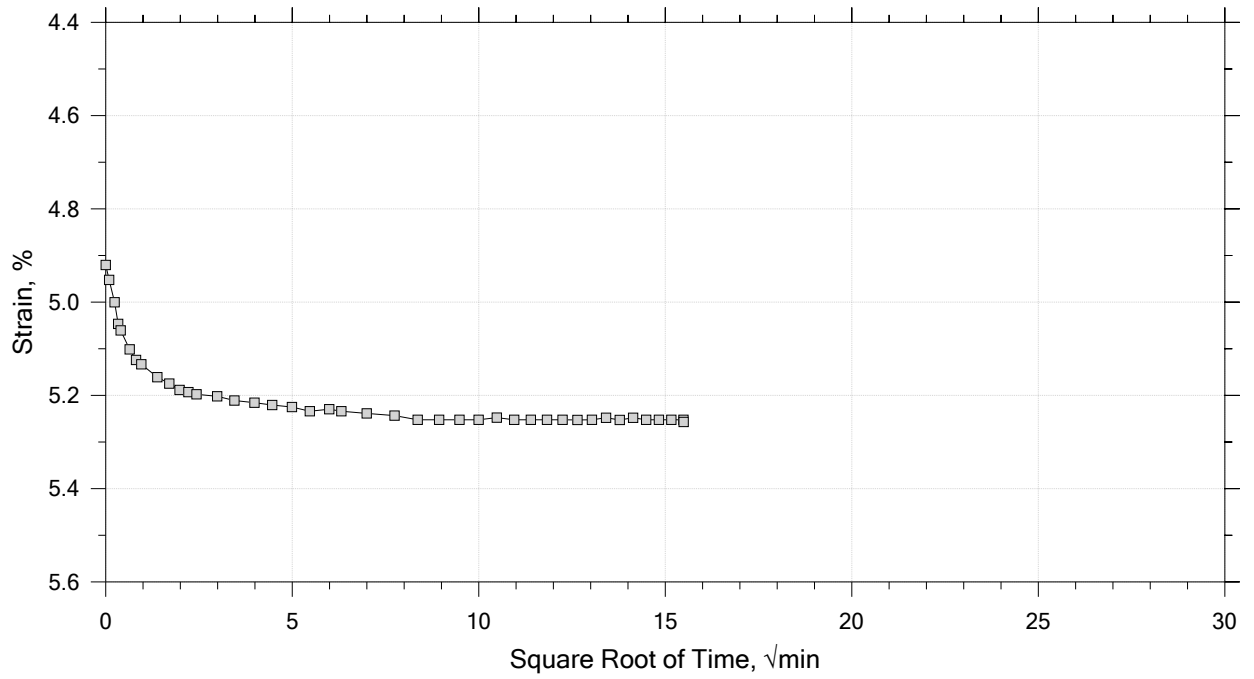


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 7 of 15
Constant Load Step
Stress: 4 tsf

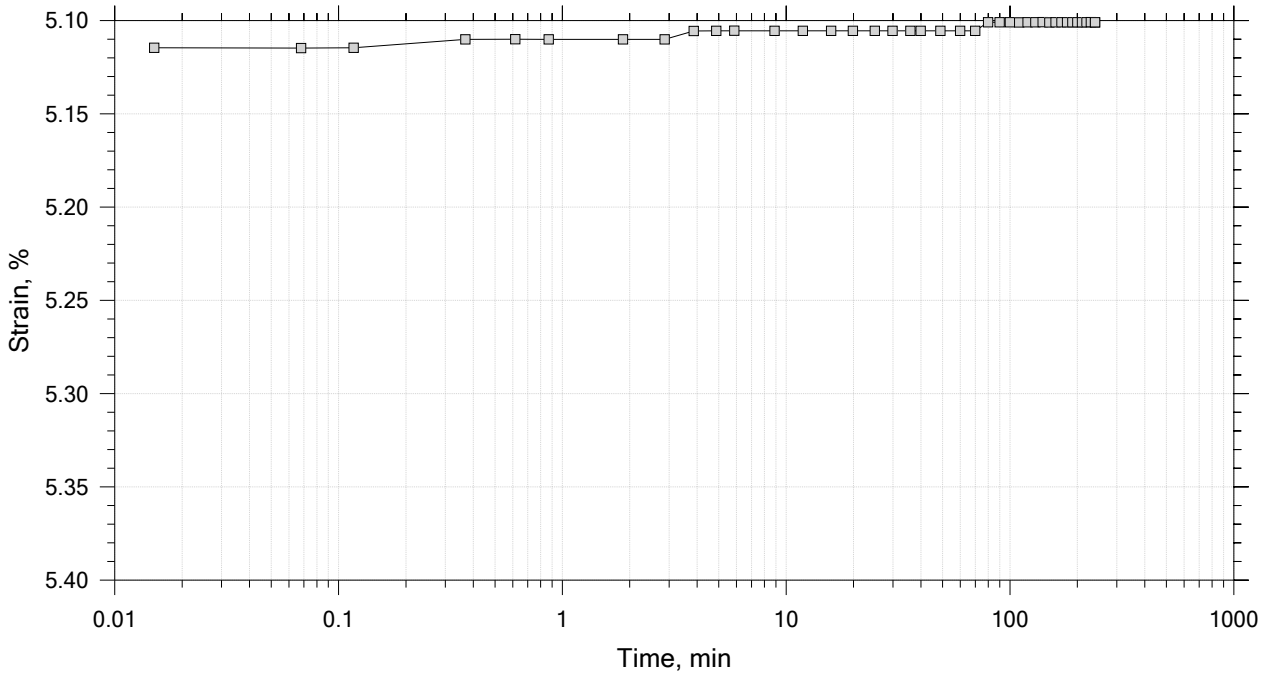


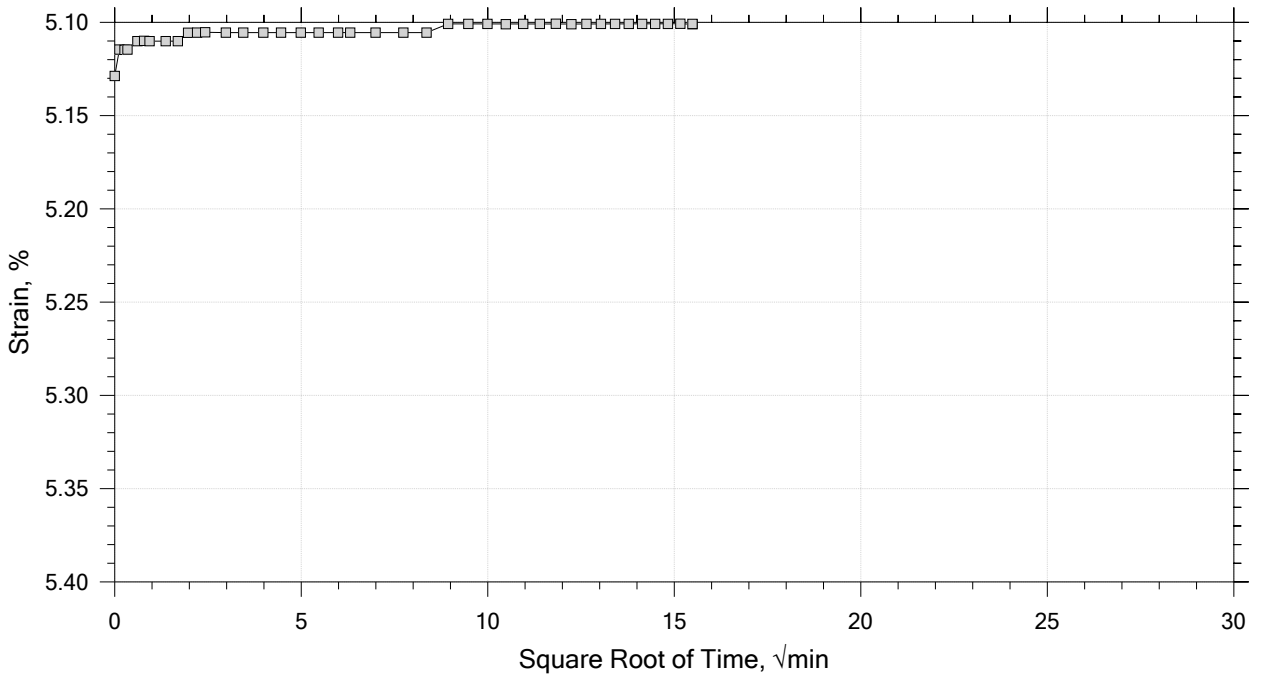


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 8 of 15
Constant Load Step
Stress: 2 tsf

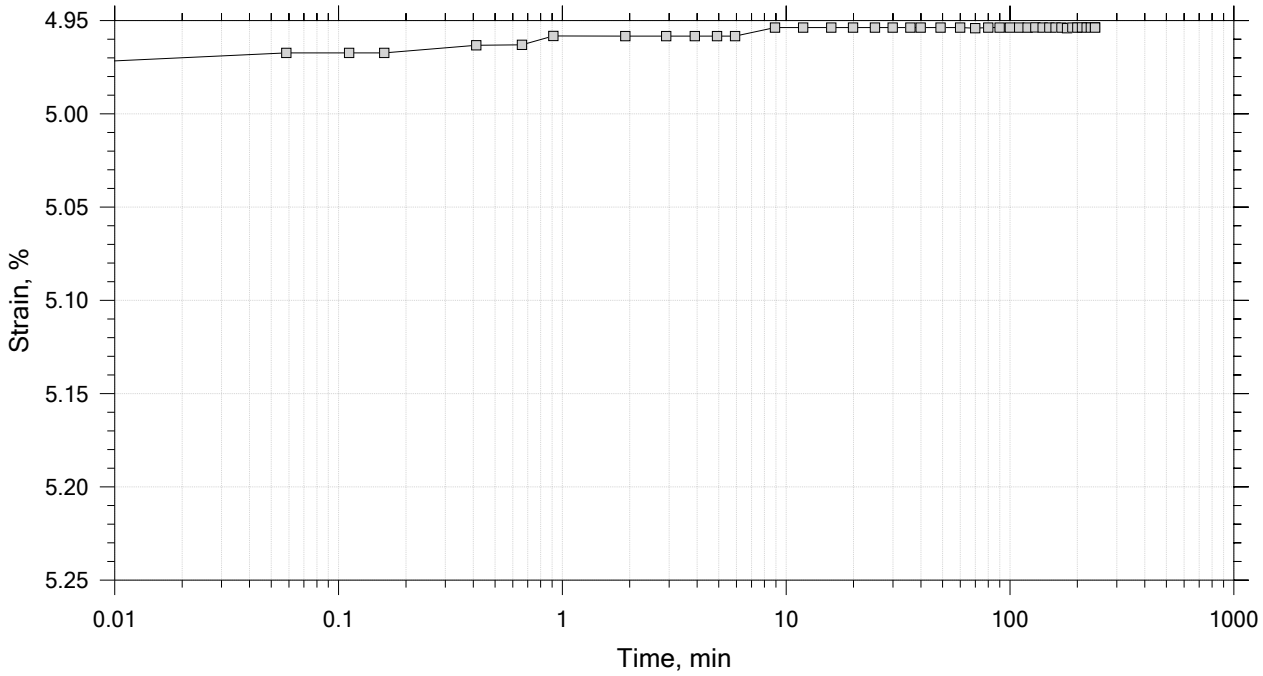


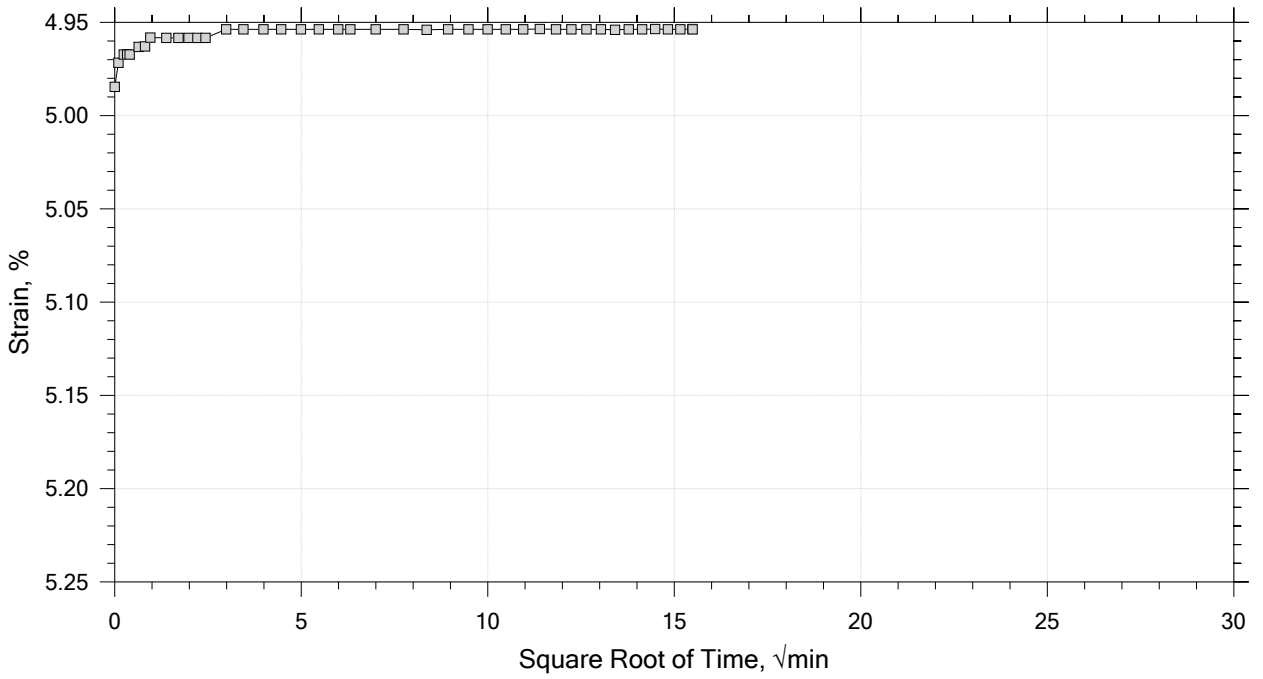


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 9 of 15
Constant Load Step
Stress: 1 tsf

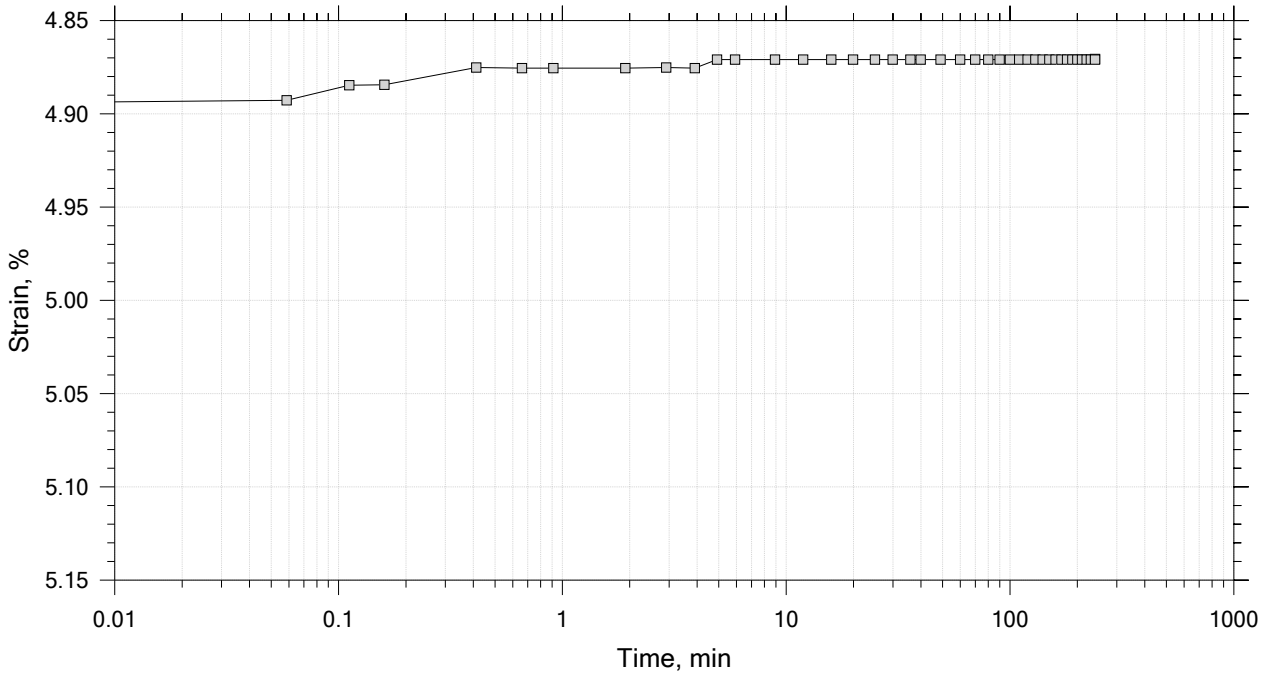


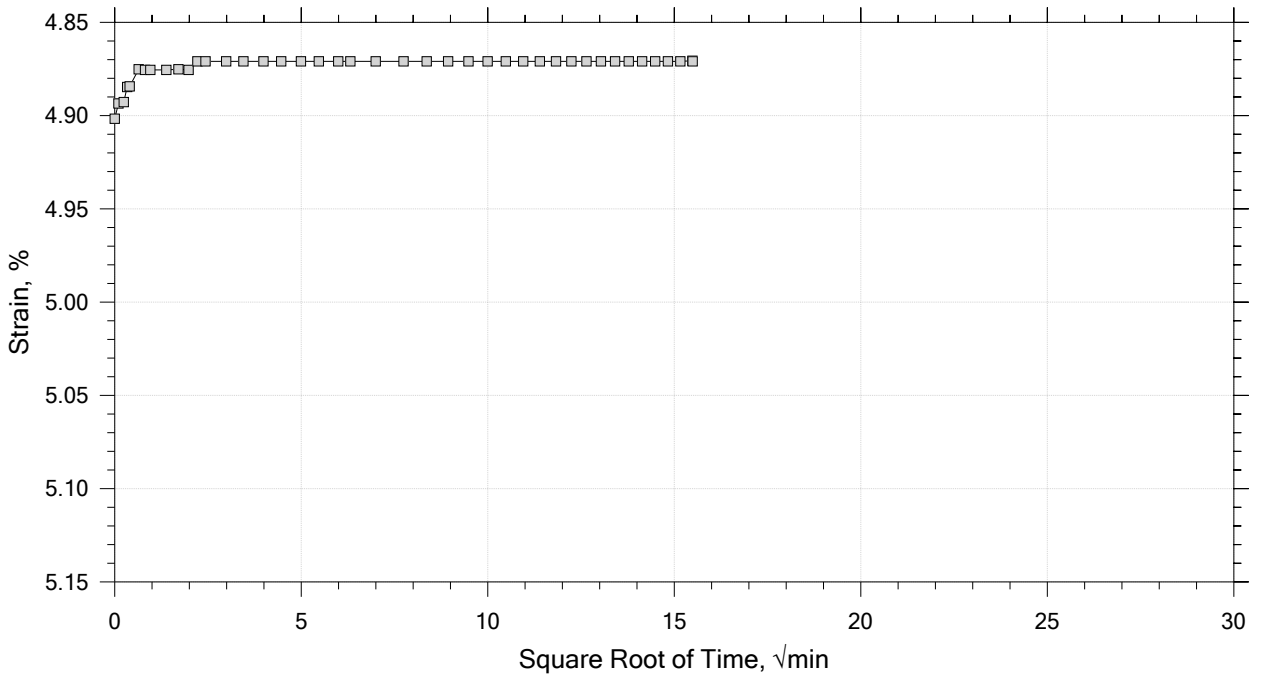


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 10 of 15
Constant Load Step
Stress: 0.5 tsf

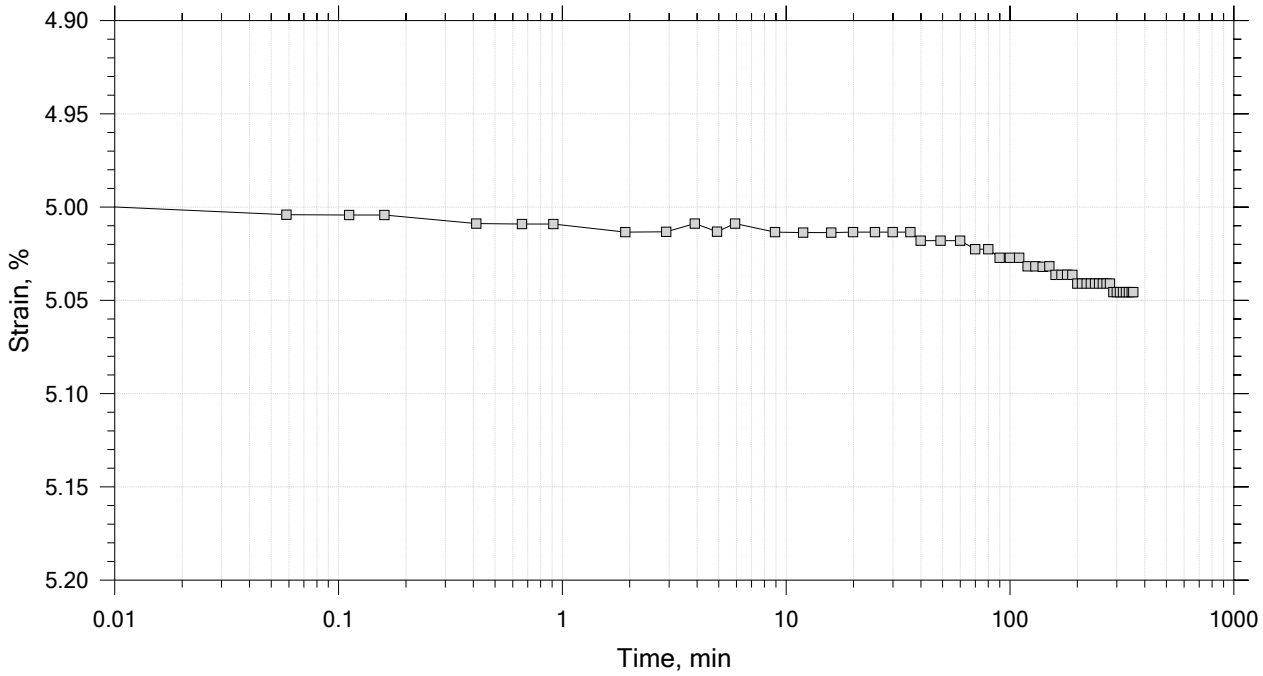


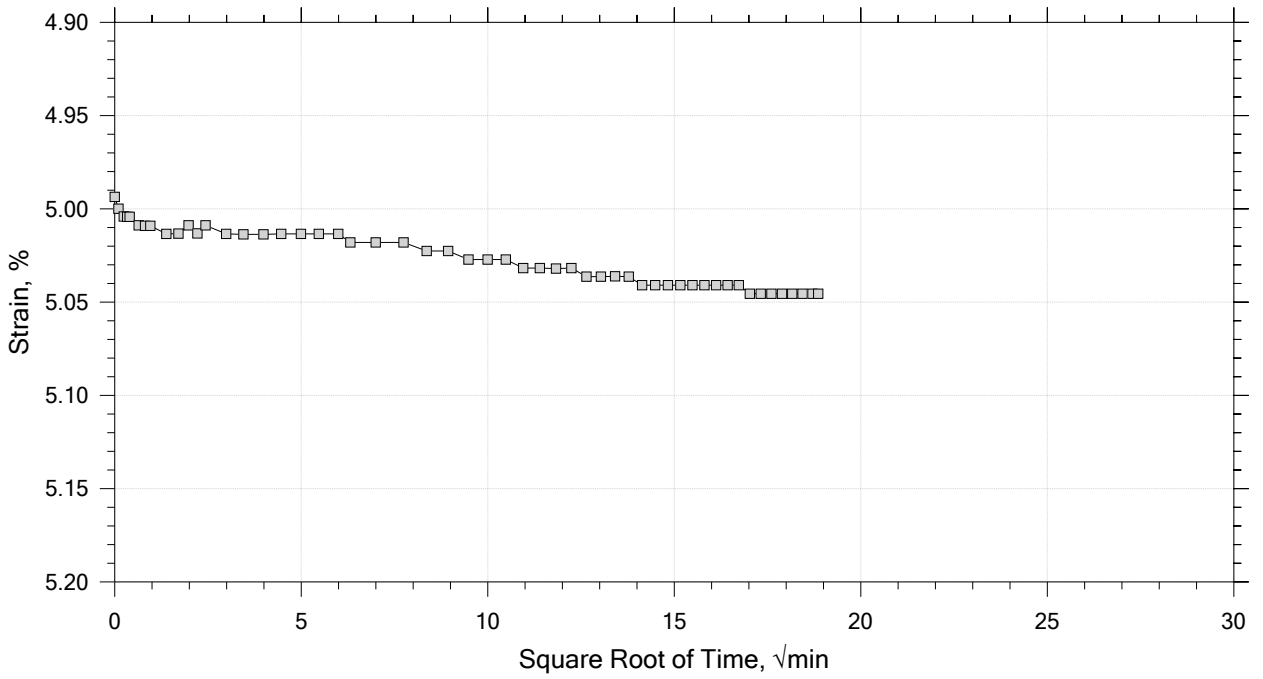


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 11 of 15
Constant Load Step
Stress: 1 tsf

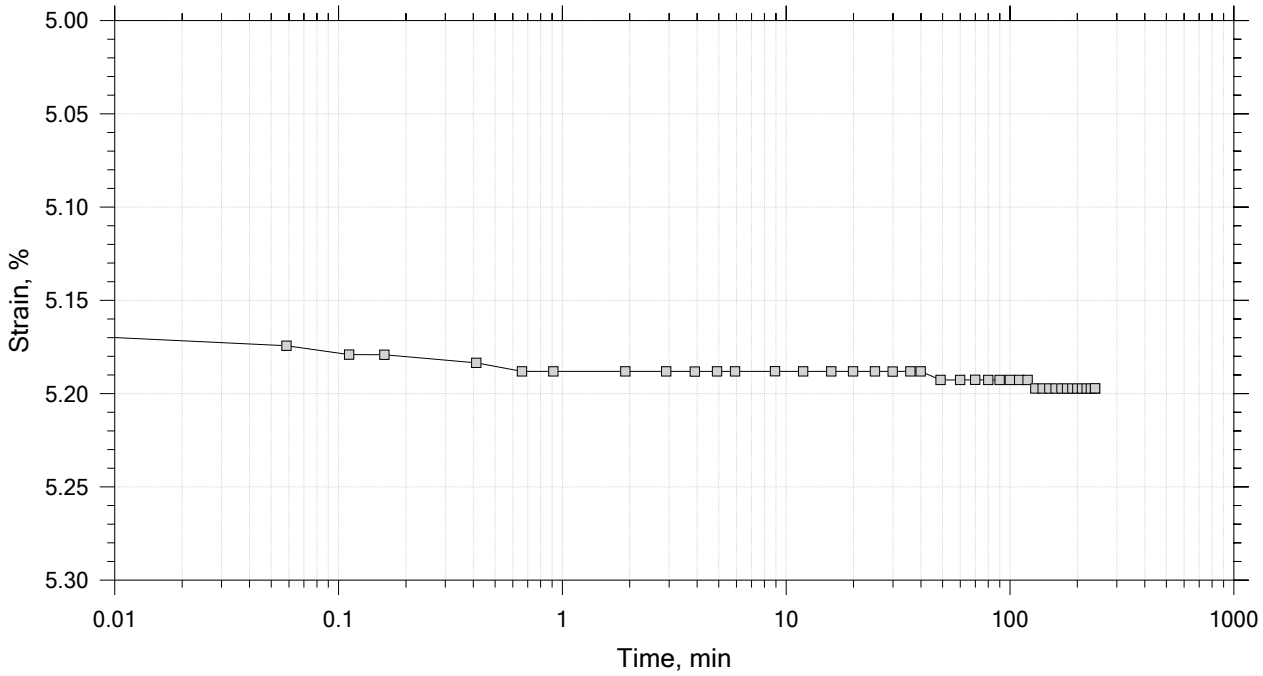


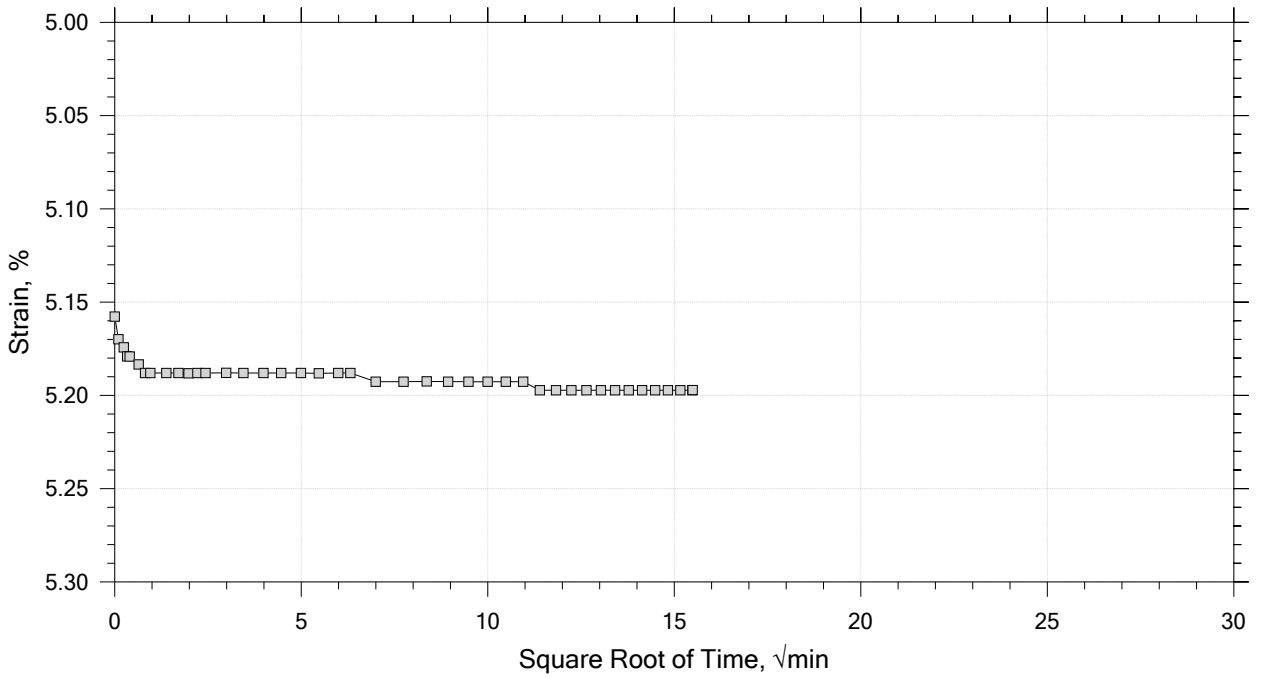


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 12 of 15
Constant Load Step
Stress: 2 tsf

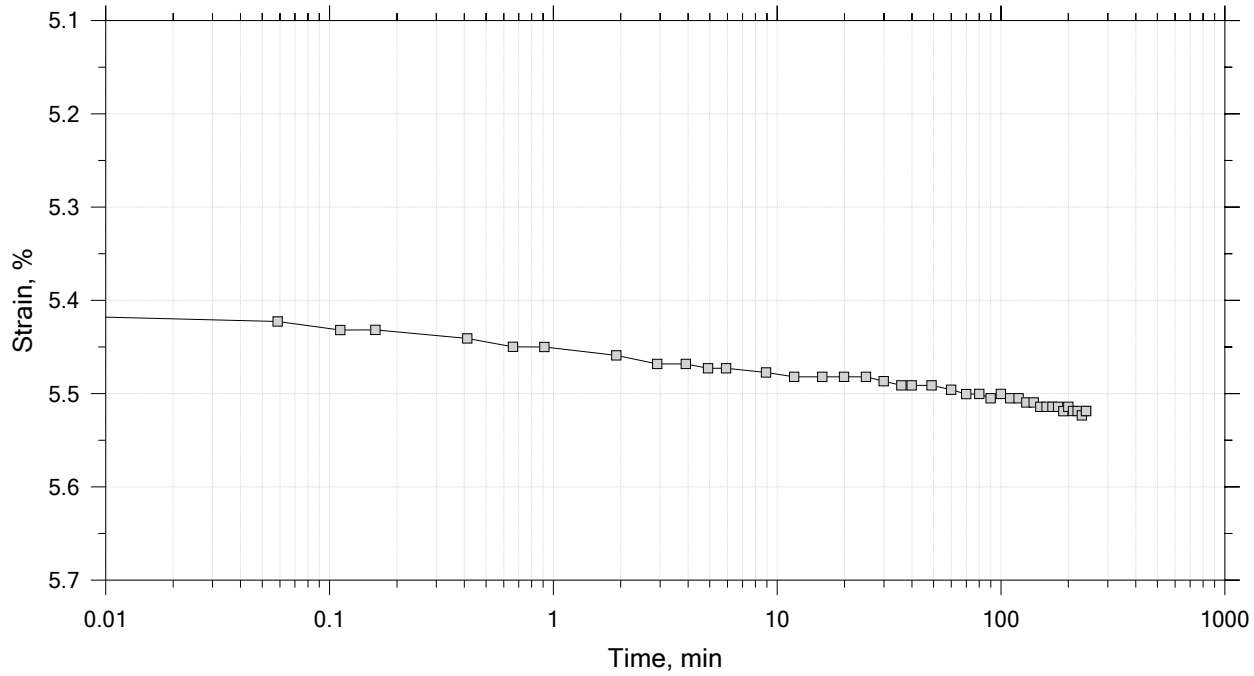


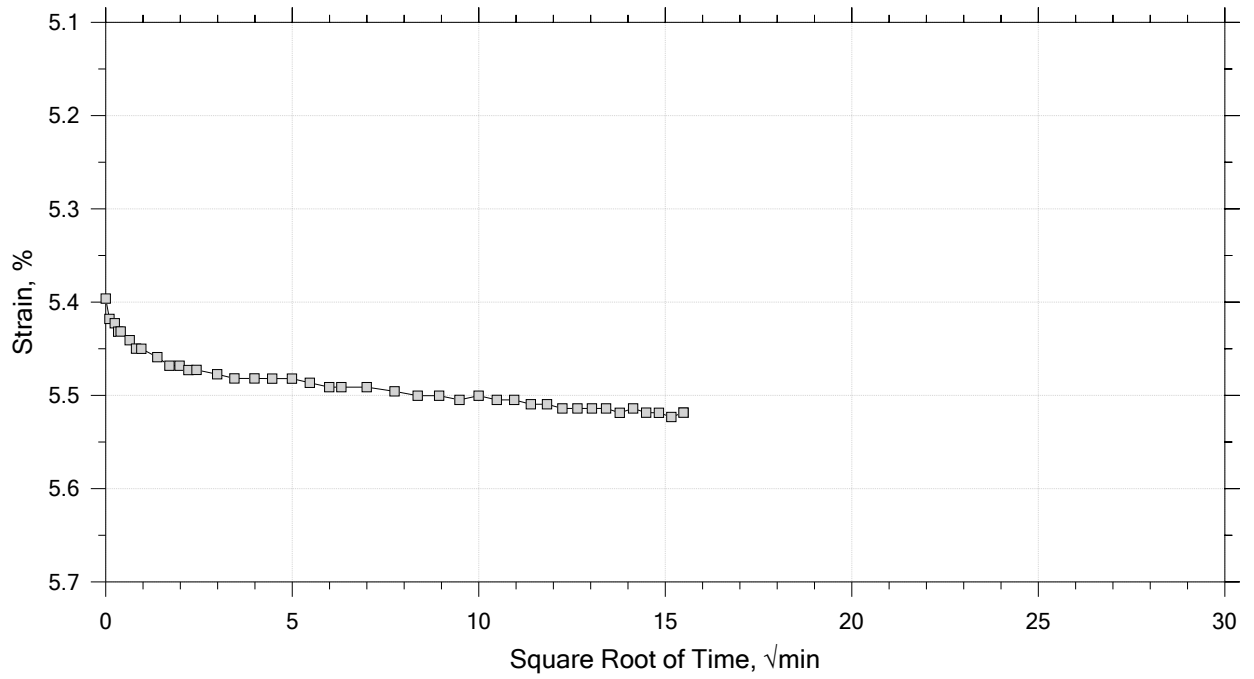


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 13 of 15
Constant Load Step
Stress: 4 tsf

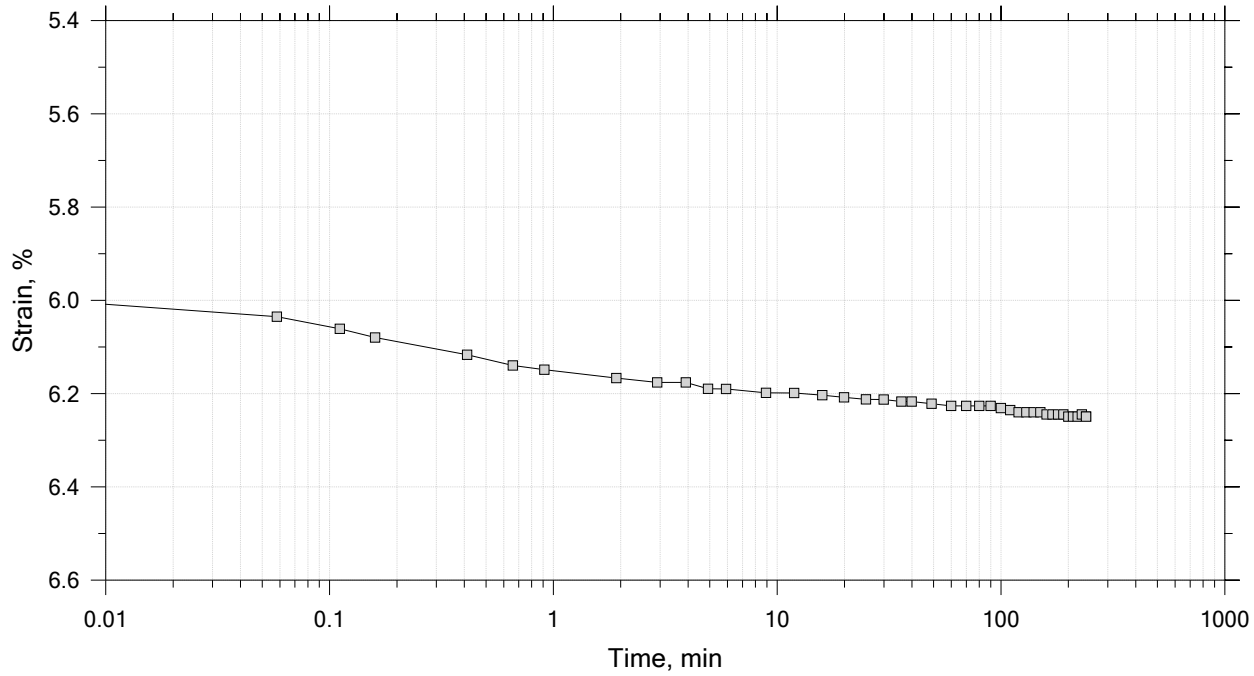


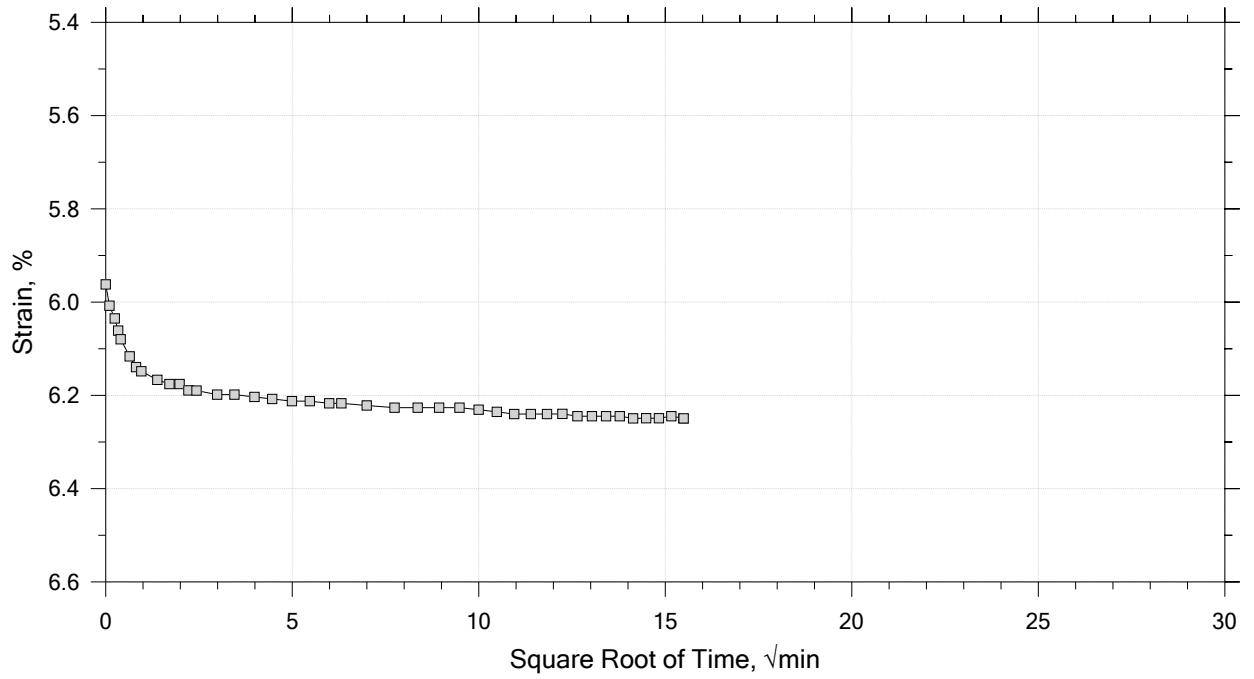


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 14 of 15
Constant Load Step
Stress: 8 tsf

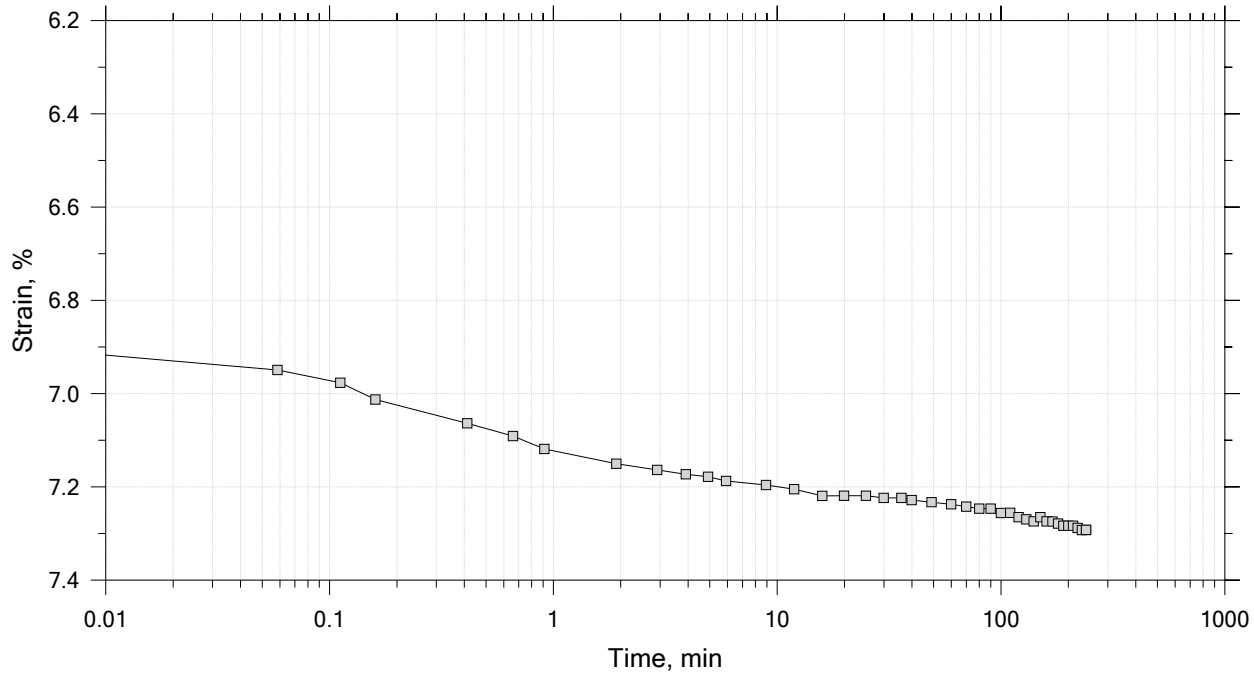


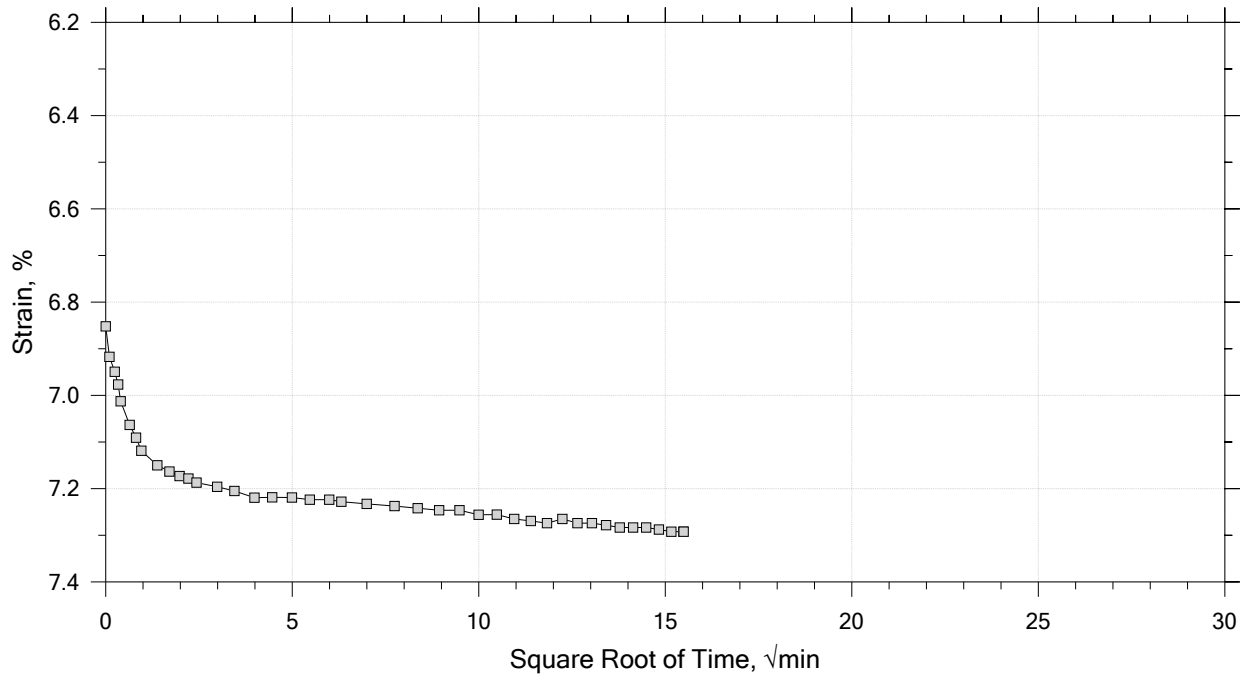


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 15 of 15
Constant Load Step
Stress: 16 tsf





GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		

One-Dimensional Consolidation by ASTM D2435 - Method B

Specimen Diameter: 2.50 in	Estimated Specific Gravity: 2.77	Liquid Limit: NP
Initial Height: 1.00 in	Initial Void Ratio: 0.5	Plastic Limit: NP
Final Height: 0.93 in	Final Void Ratio: 0.401	Plasticity Index: NP

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	A1454	RING		A-3044
Mass Container, gm	8.3	109.48	109.48	8.33
Mass Container + Wet Soil, gm	316.31	284.71	279.44	177.79
Mass Container + Dry Soil, gm	226.97	257.93	257.93	156.34
Mass Dry Soil, gm	218.67	148.45	148.45	148.01
Water Content, %	40.86	18.04	14.49	14.49
Void Ratio	---	0.50	0.40	---
Degree of Saturation, %	---	99.85	100.00	---
Dry Unit Weight, pcf	---	115.21	123.35	---

Note: Specific Gravity and Void Ratios are calculated assuming the degree of saturation equals 100% at the end of the test. Therefore, values may not represent actual values for the specimen.

GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		

One-Dimensional Consolidation by ASTM D2435 - Method B

Log of Time Coefficients

Step	Applied Stress tsf	Final Displacement in	Void Ratio	Strain at End %	Log T50 min	Cv ft²/s	Mv 1/tsf	k ft/day	Ca %
1	0.0625	0.01401	0.479	1.40	5.104	1.10e-06	2.24e-01	6.66e-04	0.00e+00
2	0.125	0.02282	0.466	2.28	3.673	1.50e-06	1.41e-01	5.68e-04	0.00e+00
3	0.250	0.02778	0.459	2.78	1.311	4.13e-06	3.97e-02	4.42e-04	0.00e+00
4	0.500	0.03320	0.450	3.32	1.004	5.33e-06	2.17e-02	3.12e-04	0.00e+00
5	1.00	0.03939	0.441	3.94	0.565	9.37e-06	1.24e-02	3.13e-04	0.00e+00
6	2.00	0.04559	0.432	4.56	0.000	0.00e+00	6.20e-03	0.00e+00	0.00e+00
7	4.00	0.05257	0.421	5.26	0.000	0.00e+00	3.49e-03	0.00e+00	0.00e+00
8	2.00	0.05101	0.424	5.10	0.000	0.00e+00	7.82e-04	0.00e+00	0.00e+00
9	1.00	0.04954	0.426	4.95	0.000	0.00e+00	1.47e-03	0.00e+00	0.00e+00
10	0.500	0.04871	0.427	4.87	0.000	0.00e+00	1.66e-03	0.00e+00	0.00e+00
11	1.00	0.05046	0.425	5.05	0.000	0.00e+00	3.49e-03	0.00e+00	0.00e+00
12	2.00	0.05197	0.422	5.20	0.000	0.00e+00	1.52e-03	0.00e+00	0.00e+00
13	4.00	0.05519	0.417	5.52	0.000	0.00e+00	1.61e-03	0.00e+00	0.00e+00
14	8.00	0.06249	0.406	6.25	0.283	1.79e-05	1.83e-03	8.80e-05	0.00e+00
15	16.0	0.07292	0.391	7.29	0.000	0.00e+00	1.30e-03	0.00e+00	0.00e+00

GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		
	Displacement at End of Increment		

One-Dimensional Consolidation by ASTM D2435 - Method B

Square Root of Time Coefficients

Step	Applied Stress tsf	Final Displacement in	Void Ratio	Strain at End %	Sq.Rt. T90 min	Cv ft²/s	Mv 1/tsf	k ft/day
1	0.0625	0.01401	0.479	1.40	34.434	7.03e-07	2.24e-01	4.25e-04
2	0.125	0.02282	0.466	2.28	22.767	1.04e-06	1.41e-01	3.95e-04
3	0.250	0.02778	0.459	2.78	6.057	3.85e-06	3.97e-02	4.12e-04
4	0.500	0.03320	0.450	3.32	4.289	5.38e-06	2.17e-02	3.14e-04
5	1.00	0.03939	0.441	3.94	5.388	4.23e-06	1.24e-02	1.41e-04
6	2.00	0.04559	0.432	4.56	10.076	2.23e-06	6.20e-03	3.73e-05
7	4.00	0.05257	0.421	5.26	3.047	7.28e-06	3.49e-03	6.85e-05
8	2.00	0.05101	0.424	5.10	79.751	2.77e-07	7.82e-04	5.83e-07
9	1.00	0.04954	0.426	4.95	0.902	2.45e-05	1.47e-03	9.73e-05
10	0.500	0.04871	0.427	4.87	0.401	5.53e-05	1.66e-03	2.47e-04
11	1.00	0.05046	0.425	5.05	288.206	7.69e-08	3.49e-03	7.24e-07
12	2.00	0.05197	0.422	5.20	129.909	1.70e-07	1.52e-03	6.95e-07
13	4.00	0.05519	0.417	5.52	187.894	1.17e-07	1.61e-03	5.07e-07
14	8.00	0.06249	0.406	6.25	2.811	7.73e-06	1.83e-03	3.81e-05
15	16.0	0.07292	0.391	7.29	5.388	3.96e-06	1.30e-03	1.39e-05

GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-1	Tested By: trm	Checked By: mcm
	Sample No.: ST-1	Test Date: 4/30/19	Depth: 22-24 ft
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, gray silt		
	Remarks: System S,		
	Displacement at End of Increment		

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	BB-5	Sample Type:	cylinder	Tested By:	tlm
Sample ID:	C-2	Test Date:	06/27/19	Checked By:	smd
Depth :	65.5-70.5	Test Id:	511669		
Test Comment:	---				
Visual Description:	See photograph(s)				
Sample Comment:	---				

Bulk Density and Compressive Strength of Rock Core Specimens by ASTM D7012 Method C

Boring ID	Sample Number	Depth	Bulk Density, pcf	Compressive strength, psi	Failure Type	Meets ASTM D4543	Note(s)
BB-5	C-2	65.53 - 65.88 ft	164	7622	1	No	---

Notes: Density determined on core samples by measuring dimensions and weight and then calculating.

All specimens tested at the approximate as-received moisture content and at standard laboratory temperature.

The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes.

Failure Type: 1 = Intact Material Failure; 2 = Discontinuity Failure; 3 = Intact Material and Discontinuity Failure (See attached photographs)

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Client:	Nobis Engineering. Inc.	Test Date:	6/27/2019
Project Name:	MA DOT Armory St Bridges	Tested By:	jck
Project Location:	Springfield, MA	Checked By:	jsc
GTX #:	309910		
Boring ID:	BB-5		
Sample ID:	C-2		
Depth:	65.53-65.88 ft		
Visual Description:	See photographs		

UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY

	1	2	Average
Specimen Length, in:	4.15	4.15	4.15
Specimen Diameter, in:	1.98	1.98	1.98
Specimen Mass, g:	549.11		
Bulk Density, lb/ft^3	164	**Minimum Diameter Tolerence Met?**	YES
Length to Diameter Ratio:	2.1	**Length to Diameter Ratio Tolerance Met?**	YES

DEVIATION FROM STRAIGHTNESS (Procedure S1)

Maximum gap between side of core and reference surface plate:
Is the maximum gap ≤ 0.02 in.? NO

Maximum difference must be < 0.020 in.
Straightness Tolerance Met? NO

END FLATNESS AND PARALLELISM (Procedure FP1)

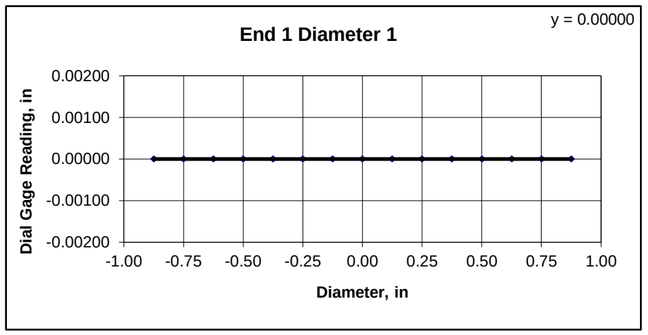
END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Diameter 2, in (rotated 90°)	0.00000	-0.00010	-0.00010	0.00000	0.00000	-0.00010	-0.00010	0.00000	0.00000	0.00010	0.00000	0.00000	0.00000	0.00000	0.00000

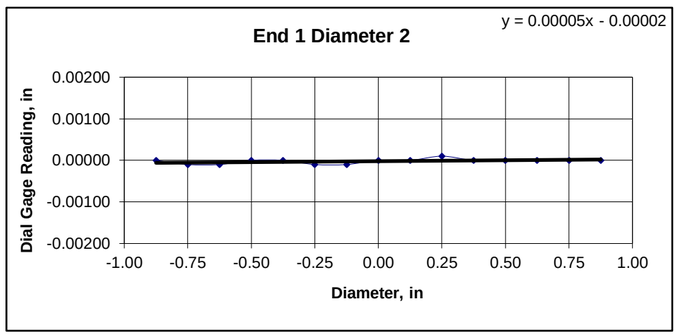
Difference between max and min readings, in:
0° = 0.00000 90° = 0.00020

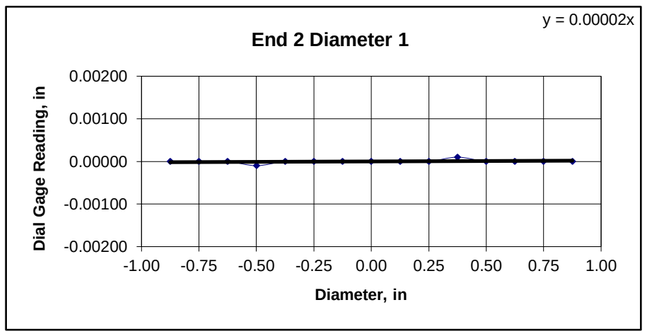
END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	0.00000	0.00000	0.00000	-0.00010	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00010	0.00000	0.00000	0.00000	0.00000
Diameter 2, in (rotated 90°)	0.00000	0.00000	0.00000	0.00000	-0.00010	0.00000	0.00000	0.00000	0.00000	-0.00010	-0.00010	0.00000	0.00000	-0.00010	-0.00010

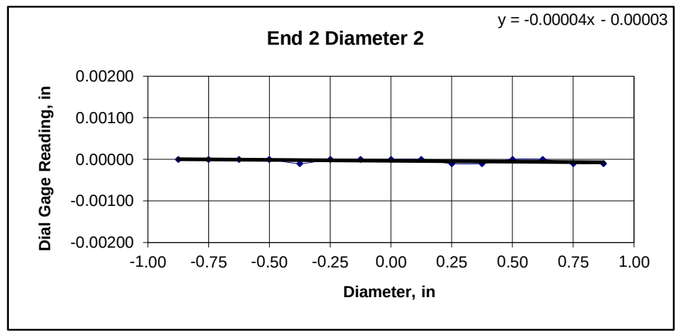
Difference between max and min readings, in:
0° = 0.0002 90° = 0.0001

Maximum difference must be < 0.0020 in. Difference = ± 0.00010
Flatness Tolerance Met? YES









DIAMETER 1

End 1:
Slope of Best Fit Line 0.00000
Angle of Best Fit Line: 0.00000

End 2:
Slope of Best Fit Line 0.00002
Angle of Best Fit Line: 0.00115

Maximum Angular Difference: 0.00115

Parallelism Tolerance Met? YES
Spherically Seated

DIAMETER 2

End 1:
Slope of Best Fit Line 0.00005
Angle of Best Fit Line: 0.00262

End 2:
Slope of Best Fit Line 0.00004
Angle of Best Fit Line: 0.00246

Maximum Angular Difference: 0.00016

Parallelism Tolerance Met? YES
Spherically Seated

PERPENDICULARITY (Procedure P1) (Calculated from End Flatness and Parallelism measurements above)

END 1	Difference, Maximum and Minimum (in.)	Diameter (in.)	Slope	Angle°	Perpendicularity Tolerance Met?
Diameter 1, in	0.00000	1.980	0.00000	0.000	YES
Diameter 2, in (rotated 90°)	0.00020	1.980	0.00010	0.006	YES
END 2					
Diameter 1, in	0.00020	1.980	0.00010	0.006	YES
Diameter 2, in (rotated 90°)	0.00010	1.980	0.00005	0.003	YES

Maximum angle of departure must be ≤ 0.25°
Perpendicularity Tolerance Met? YES

Client:	Nobis Engineering. Inc.
Project Name:	MA DOT Armory St Bridges
Project Location:	Springfield, MA
GTX #:	309910
Test Date:	6/27/2019
Tested By:	jck
Checked By:	jsc
Boring ID:	BB-5
Sample ID:	C-2
Depth, ft:	65.53-65.88

After cutting and grinding

After break

GeoTesting EXPRESS

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	---	Sample Type:	---	Tested By:	ckg
Sample ID:	---	Test Date:	07/08/19	Checked By:	bfs
Depth :	---	Test Id:	509857		

Moisture Content of Soil and Rock - ASTM D2216

Boring ID	Sample ID	Depth	Description	Moisture Content,%
BB-5	ST- 3	30-32	Moist, dark gray clay	25.7
BB-5	ST- 4	37-39	Moist, dark gray clay	27.7
BB-4	S- 7	35-37	Moist, dark gray clay	34.9

Notes: Temperature of Drying : 110º Celsius

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GeoTesting EXPRESS

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	---	Sample Type:	---	Tested By:	ckg
Sample ID:	---	Test Date:	06/21/19	Checked By:	bfs
Depth :	---	Test Id:	509859		

pH of Soil by ASTM D4972

Boring ID	Sample ID	Depth	Visual Description	pH of Soil in Distilled Water	pH of Soil in Calcium Chloride
BB-2A	S-4	35-37	Moist, dark gray silt	6.5	6.3
BB-3	S-4	10-12	Moist, dark yellowish brown silty sand	8.4	7.2
BB-8A	S-2	25-27	Moist, yellowish brown silt	6.8	6.4

Notes: Sample Preparation: screened through #10 sieve

Method A, pH meter used

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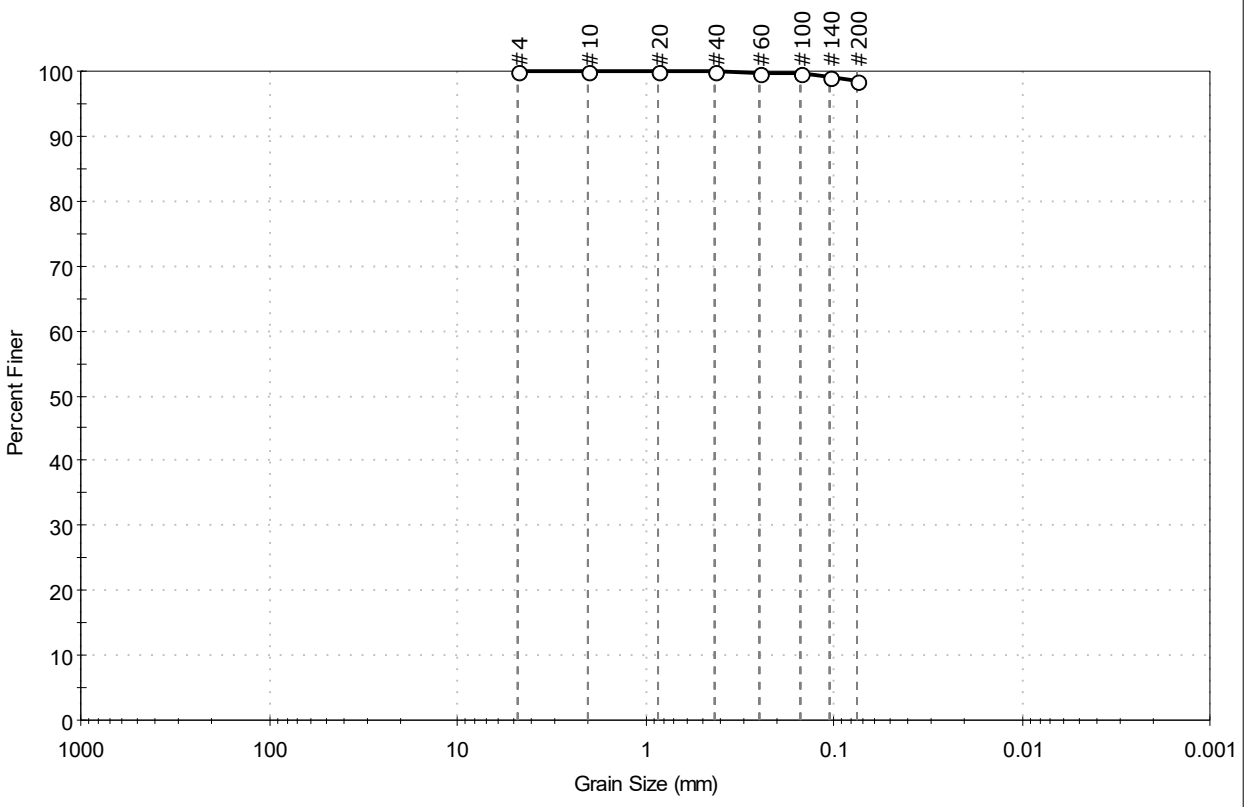
GeoTesting EXPRESS

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	BB-5	Sample Type:	tube	Tested By:	ckg
Sample ID:	ST-3	Test Date:	07/10/19	Checked By:	bfs
Depth :	30-32	Test Id:	509848		
Test Comment:	---				
Visual Description:	Moist, dark gray clay				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
–	0.0	1.6	98.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	100		
#60	0.25	100		
#100	0.15	100		
#140	0.11	99		
#200	0.075	98		

Coefficients

D_{85} = N/A D_{30} = N/A
D_{60} = N/A D_{15} = N/A
D_{50} = N/A D_{10} = N/A
C_u = N/A C_c = N/A

Classification

ASTM Lean CLAY (CL)

AASHTO Clayey Soils (A-6 (16))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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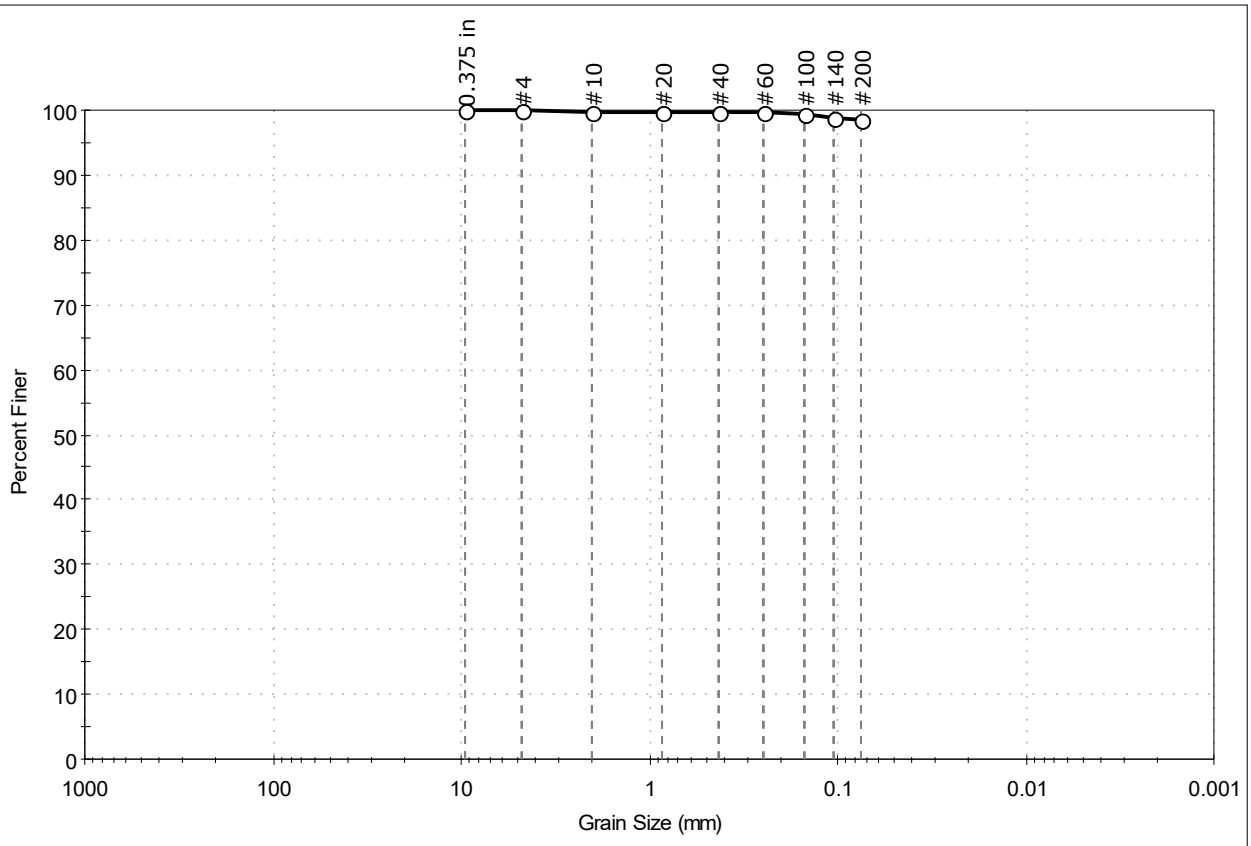
GeoTesting EXPRESS

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	BB-5	Sample Type:	tube	Tested By:	ckg
Sample ID:	ST-4	Test Date:	07/10/19	Checked By:	bfs
Depth :	37-39	Test Id:	509849		
Test Comment:	---				
Visual Description:	Moist, dark gray clay				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
–	0.1	1.5	98.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	100		
#60	0.25	100		
#100	0.15	99		
#140	0.11	99		
#200	0.075	98		

Coefficients

D_{85} = N/A D_{30} = N/A
D_{60} = N/A D_{15} = N/A
D_{50} = N/A D_{10} = N/A
C_u = N/A C_c = N/A

Classification

ASTM Lean CLAY (CL)

AASHTO Clayey Soils (A-6 (10))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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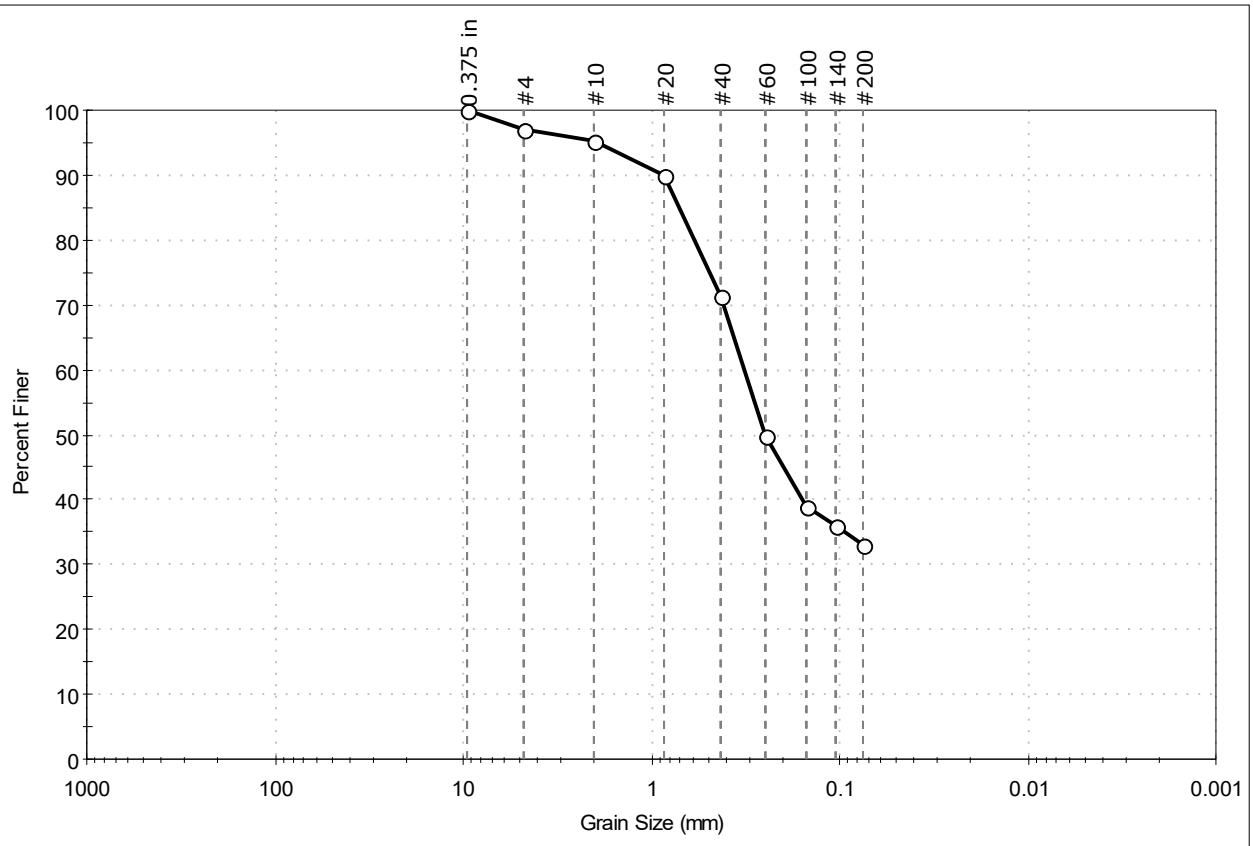
GeoTesting EXPRESS

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	WB-3	Sample Type:	tube	Tested By:	ckg
Sample ID:	S-8	Test Date:	07/10/19	Checked By:	bfs
Depth :	20-22	Test Id:	509850		
Test Comment:	---				
Visual Description:	Moist, olive silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
–	3.0	64.1	32.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	97		
#10	2.00	95		
#20	0.85	90		
#40	0.42	71		
#60	0.25	50		
#100	0.15	39		
#140	0.11	36		
#200	0.075	33		

Coefficients

D_{85} = 0.7034 mm D_{30} = N/A
D_{60} = 0.3211 mm D_{15} = N/A
D_{50} = 0.2515 mm D_{10} = N/A
C_u = N/A C_c = N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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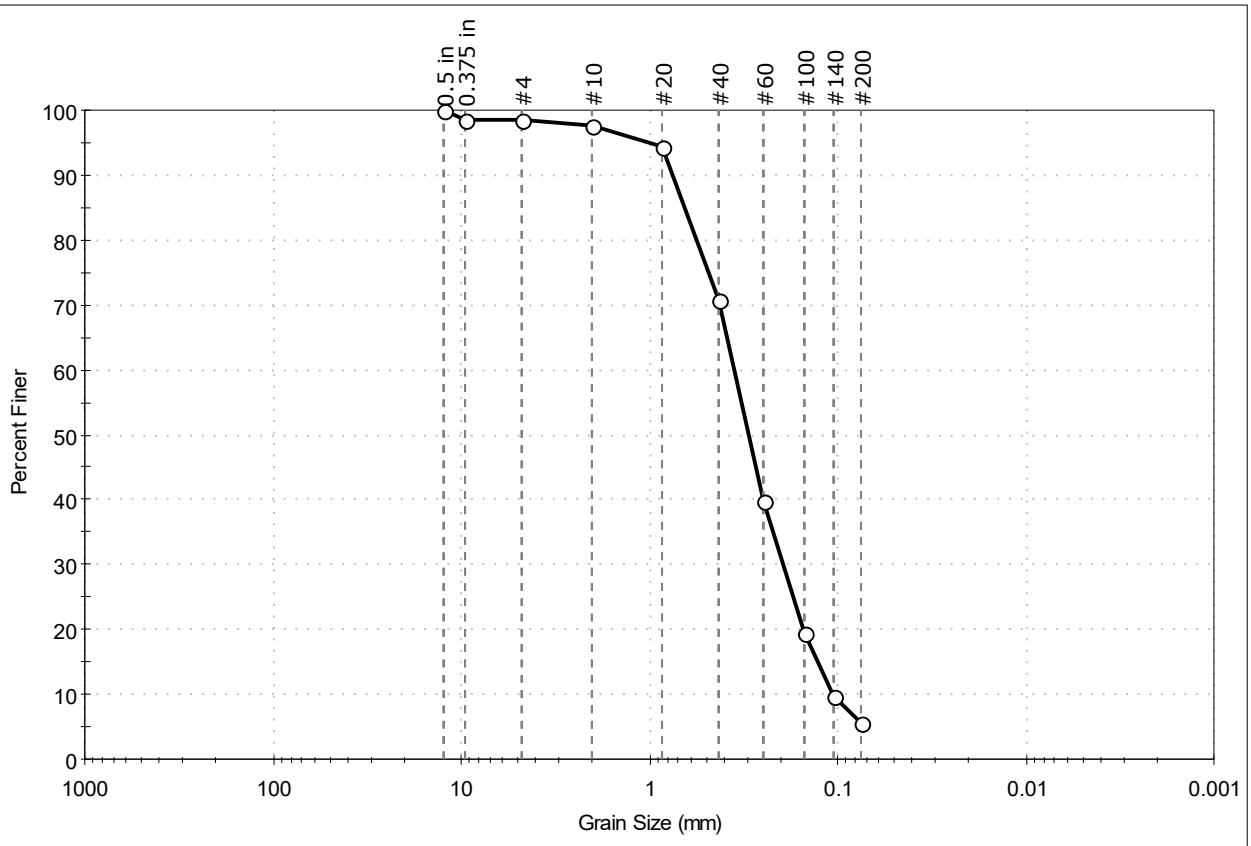
GeoTesting EXPRESS

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	BB-8	Sample Type:	tube	Tested By:	ckg
Sample ID:	S-2	Test Date:	07/10/19	Checked By:	bfs
Depth :	3-5	Test Id:	509851		
Test Comment:	---				
Visual Description:	Moist, dark yellowish brown sand with silt				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
–	1.6	92.7	5.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.5 in	12.50	100		
0.375 in	9.50	99		
#4	4.75	98		
#10	2.00	98		
#20	0.85	94		
#40	0.42	71		
#60	0.25	40		
#100	0.15	19		
#140	0.11	10		
#200	0.075	5.7		

Coefficients

D_{85} = 0.6469 mm D_{30} = 0.1955 mm
D_{60} = 0.3534 mm D_{15} = 0.1280 mm
D_{50} = 0.2975 mm D_{10} = 0.1066 mm
C_u = 3.315 C_c = 1.015

Classification

ASTM N/A

AASHTO Fine Sand (A-3 (1))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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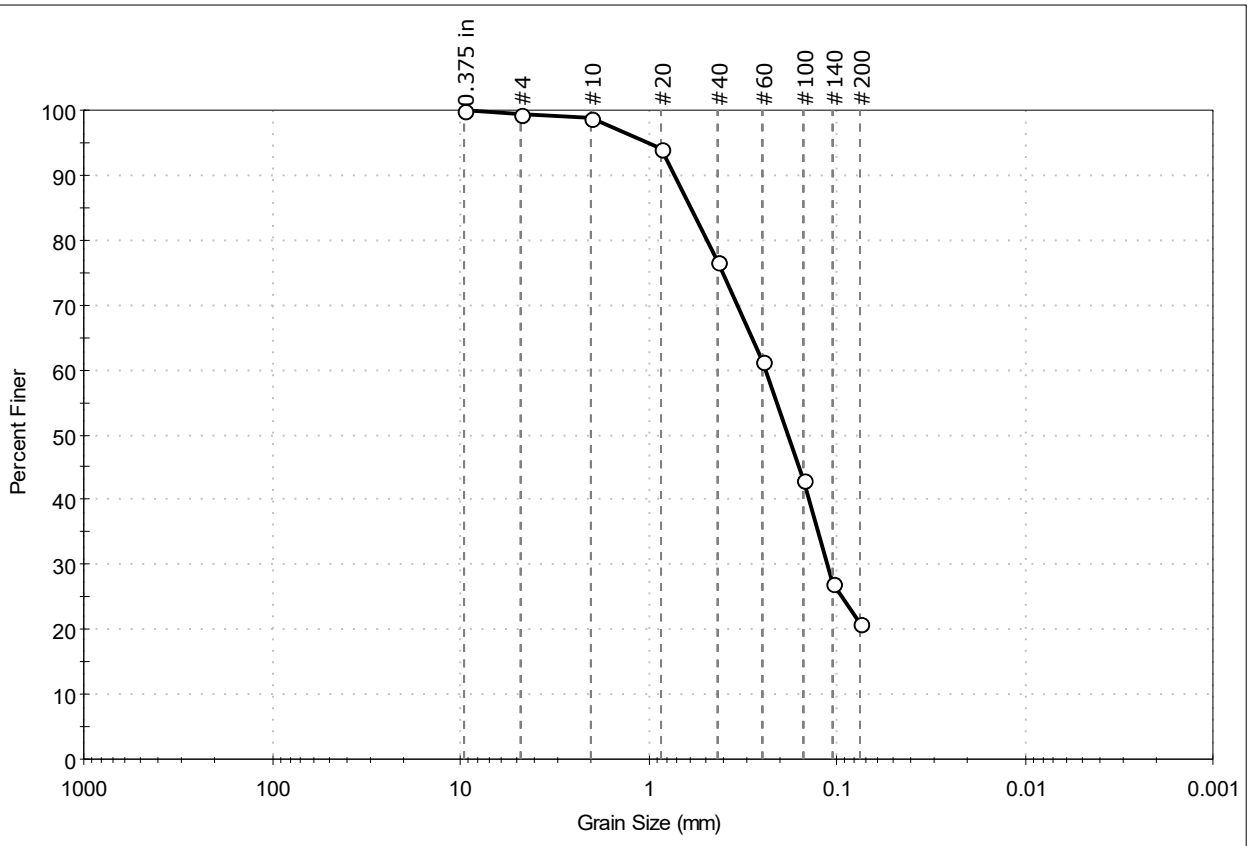
GeoTesting EXPRESS

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	BB-3	Sample Type:	tube	Tested By:	ckg
Sample ID:	S-4	Test Date:	07/10/19	Checked By:	bfs
Depth :	10-12	Test Id:	509852		
Test Comment:	---				
Visual Description:	Moist, dark yellowish brown silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
–	0.5	78.6	20.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	99		
#10	2.00	99		
#20	0.85	94		
#40	0.42	77		
#60	0.25	61		
#100	0.15	43		
#140	0.11	27		
#200	0.075	21		

Coefficients

D_{85} = 0.5911 mm D_{30} = 0.1128 mm
D_{60} = 0.2401 mm D_{15} = N/A
D_{50} = 0.1815 mm D_{10} = N/A
C_u = N/A C_c = N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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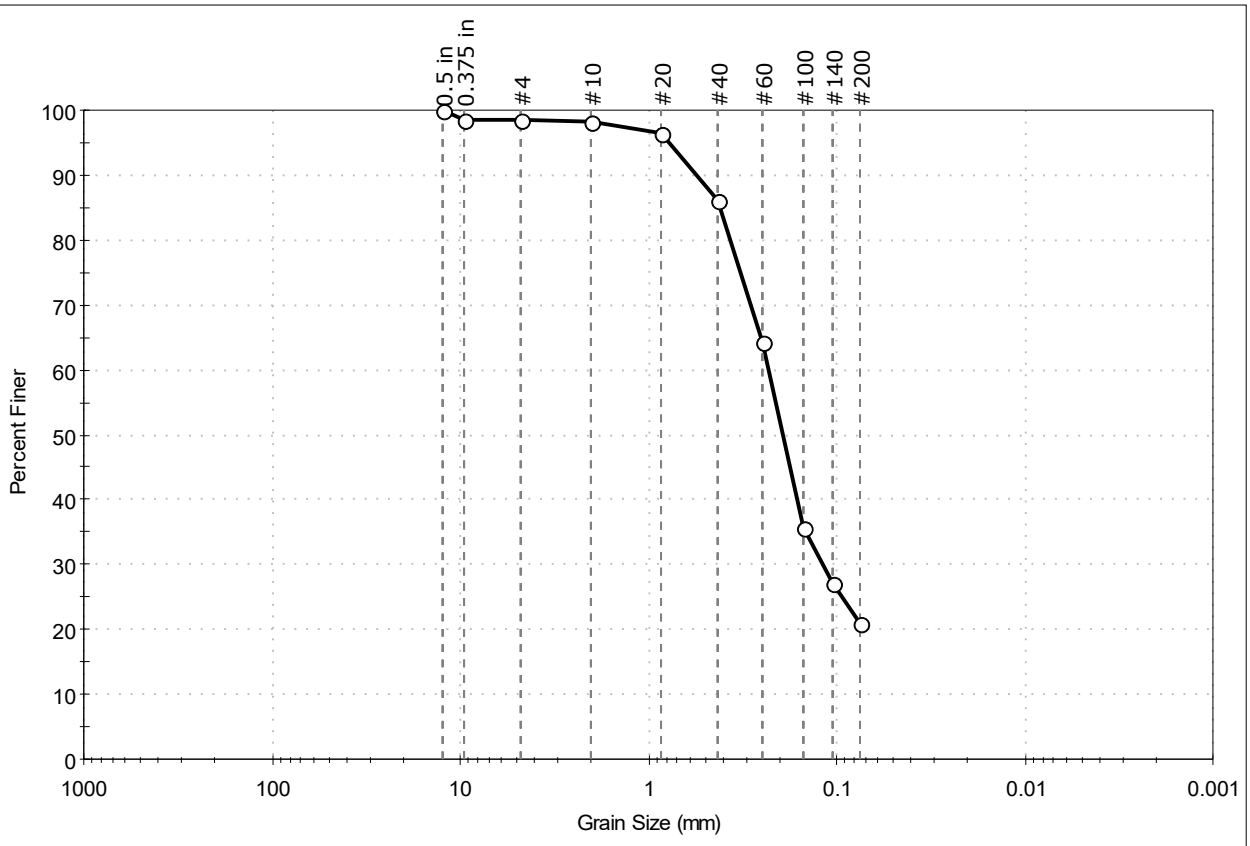
GeoTesting EXPRESS

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	BB-4	Sample Type:	tube	Tested By:	ckg
Sample ID:	S-2	Test Date:	07/10/19	Checked By:	bfs
Depth :	5-7	Test Id:	509853		
Test Comment:	---				
Visual Description:	Moist, olive silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
–	1.4	77.6	21.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.5 in	12.50	100		
0.375 in	9.50	99		
#4	4.75	99		
#10	2.00	98		
#20	0.85	96		
#40	0.42	86		
#60	0.25	64		
#100	0.15	36		
#140	0.11	27		
#200	0.075	21		

Coefficients

D_{85} = 0.4131 mm D_{30} = 0.1192 mm
D_{60} = 0.2320 mm D_{15} = N/A
D_{50} = 0.1940 mm D_{10} = N/A
C_u = N/A C_c = N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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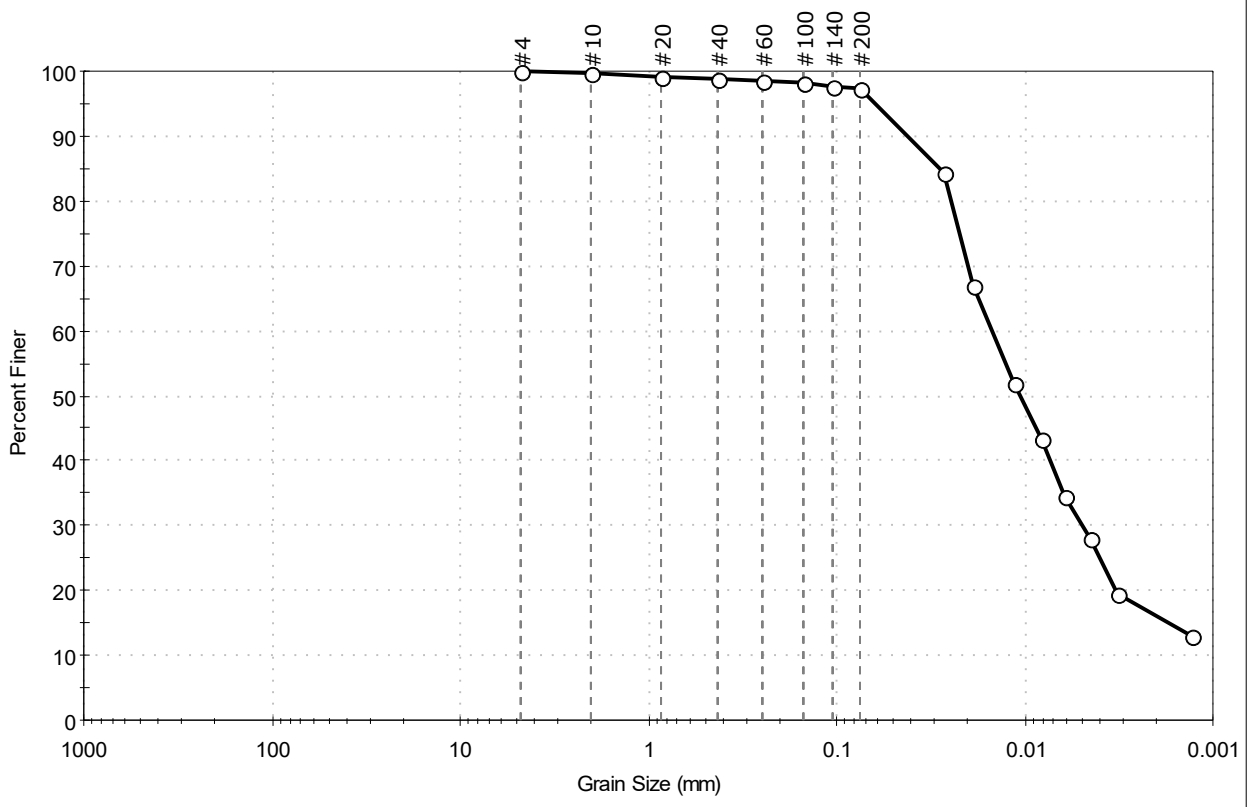
GeoTesting EXPRESS

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	BB-4	Sample Type:	tube	Tested By:	ckg
Sample ID:	S-7	Test Date:	06/24/19	Checked By:	bfs
Depth :	35-37	Test Id:	509854		
Test Comment:	---				
Visual Description:	Moist, dark gray clay				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
–	0.0	2.8	97.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	99		
#40	0.42	99		
#60	0.25	99		
#100	0.15	98		
#140	0.11	98		
#200	0.075	97		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0271	84		
---	0.0190	67		
---	0.0114	52		
---	0.0082	43		
---	0.0061	35		
---	0.0045	28		
---	0.0032	19		
---	0.0013	13		

Coefficients

D_{85} = 0.0286 mm D_{30} = 0.0049 mm
D_{60} = 0.0150 mm D_{15} = 0.0017 mm
D_{50} = 0.0106 mm D_{10} = N/A
C_u = N/A C_c = N/A

Classification

ASTM Lean CLAY (CL)

AASHTO Clayey Soils (A-6 (15))

Sample/Test Description

Sand/Gravel Particle Shape : ---
Sand/Gravel Hardness : ---
Dispersion Device : Apparatus A - Mech Mixer
Dispersion Period : 1 minute
Est. Specific Gravity : 2.65
Separation of Sample: #200 Sieve

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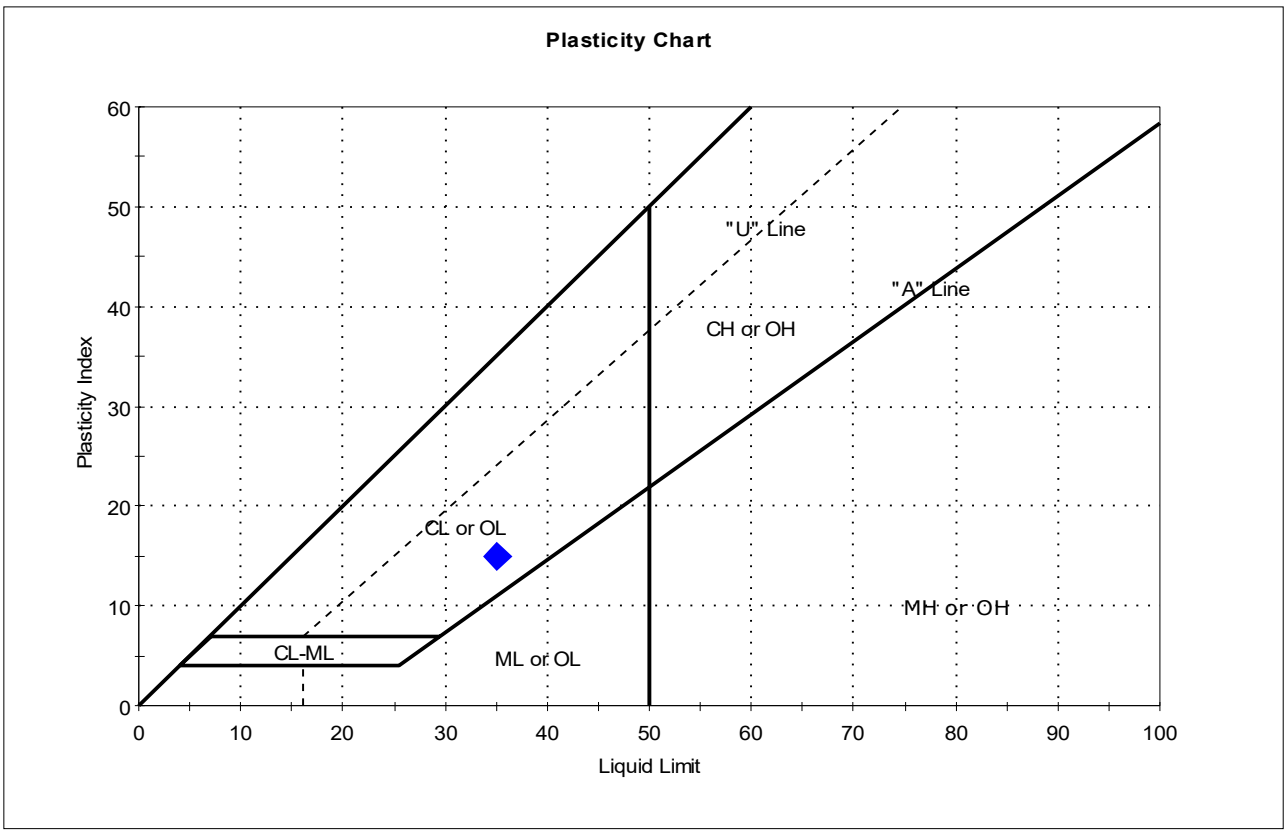
GeoTesting EXPRESS

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	BB-4	Sample Type:	tube	Tested By:	cam
Sample ID:	S-7	Test Date:	06/21/19	Checked By:	bfs
Depth :	35-37	Test Id:	509847		
Test Comment:	---				
Visual Description:	Moist, dark gray clay				
Sample Comment:	---				

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S-7	BB-4	35-37	35	35	20	15	1	Lean CLAY (CL)

Sample Prepared using the WET method
1% Retained on #40 Sieve
Dry Strength: VERY HIGH
Dilatancy: SLOW
Toughness: LOW

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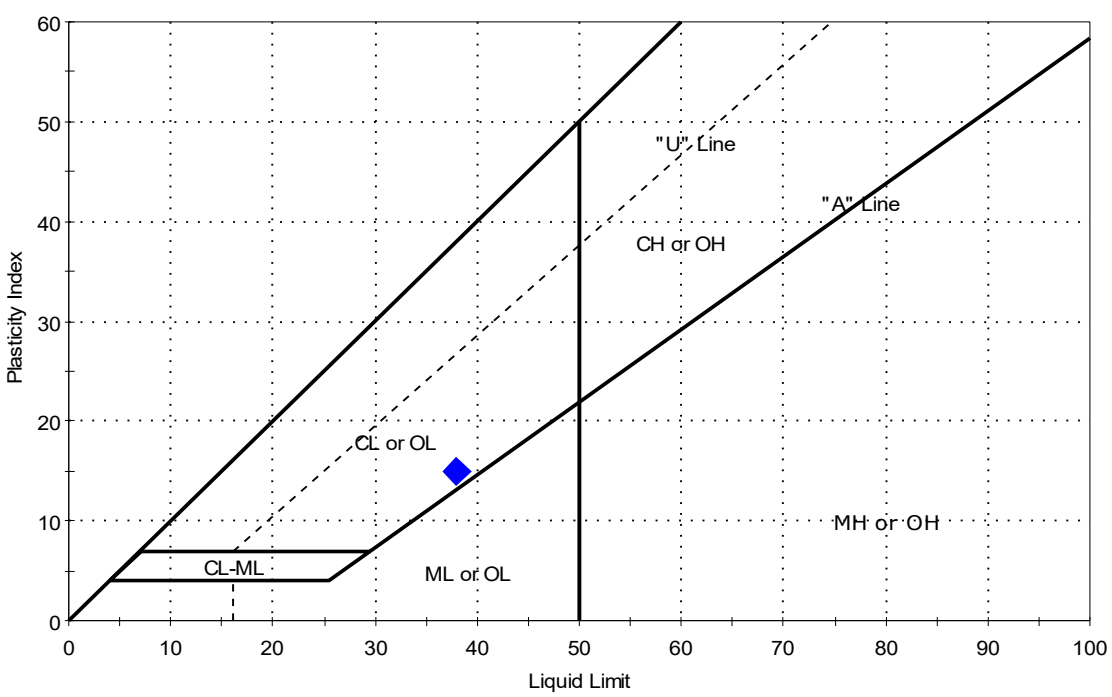
GeoTesting EXPRESS

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	BB-5	Sample Type:	tube	Tested By:	cam
Sample ID:	ST-3	Test Date:	06/27/19	Checked By:	bfs
Depth :	30-32	Test Id:	509845		
Test Comment:	---				
Visual Description:	Moist, dark gray clay				
Sample Comment:	---				

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	ST-3	BB-5	30-32	26	38	23	15	0.2	Lean CLAY (CL)

Sample Prepared using the WET method
0% Retained on #40 Sieve
Dry Strength: HIGH
Dilatancy: SLOW
Toughness: LOW

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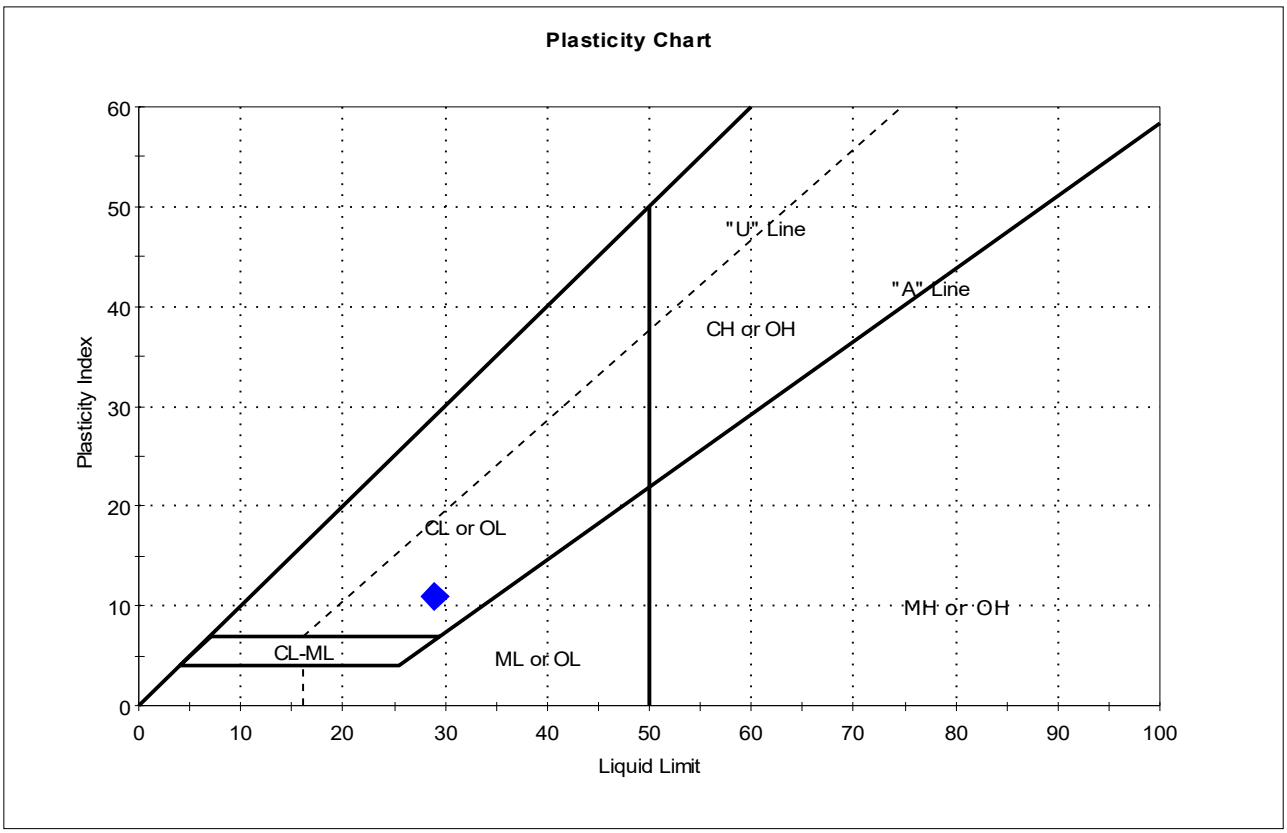
GeoTesting EXPRESS

Client:	Nobis Engineering, Inc.				
Project:	MA DOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-309910
Boring ID:	BB-5	Sample Type:	tube	Tested By:	cam
Sample ID:	ST-4	Test Date:	06/25/19	Checked By:	bfs
Depth :	37-39	Test Id:	509846		
Test Comment:	---				
Visual Description:	Moist, dark gray clay				
Sample Comment:	---				

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	ST-4	BB-5	37-39	28	29	18	11	0.9	Lean CLAY (CL)

Sample Prepared using the WET method
0% Retained on #40 Sieve
Dry Strength: VERY HIGH
Dilatancy: SLOW
Toughness: LOW

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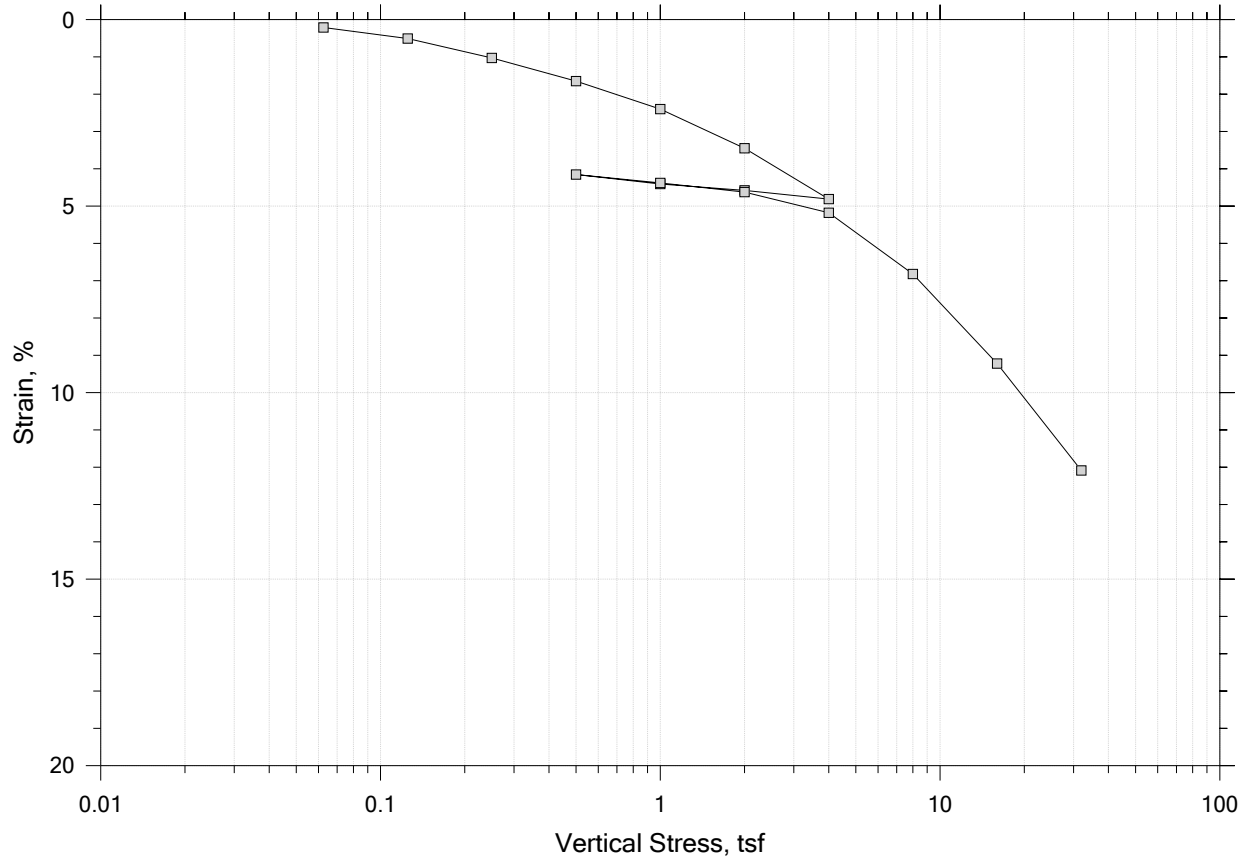
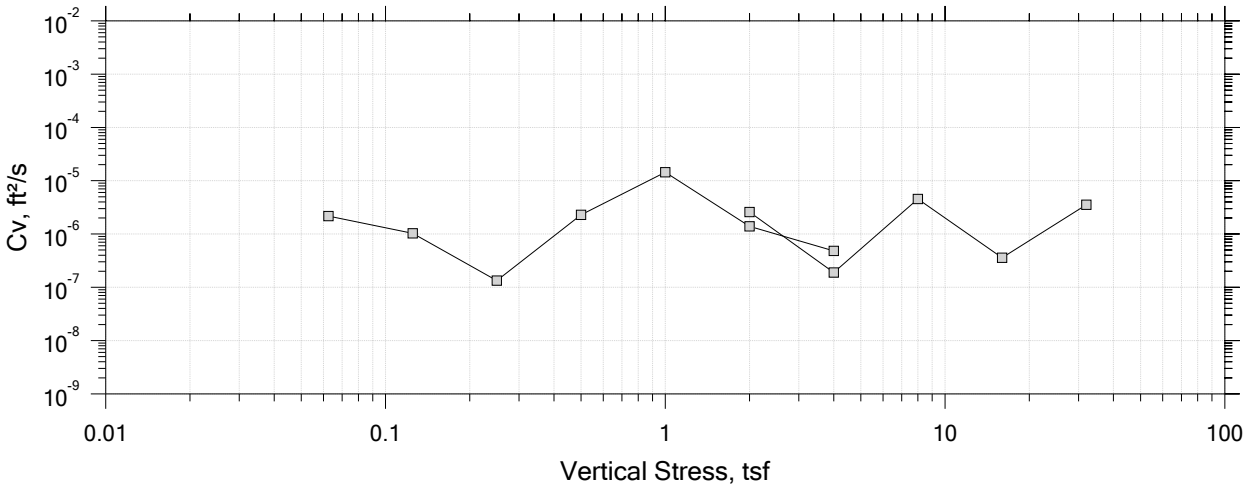
One-Dimensional Consolidation by ASTM D2435 - Method B

Summary Report

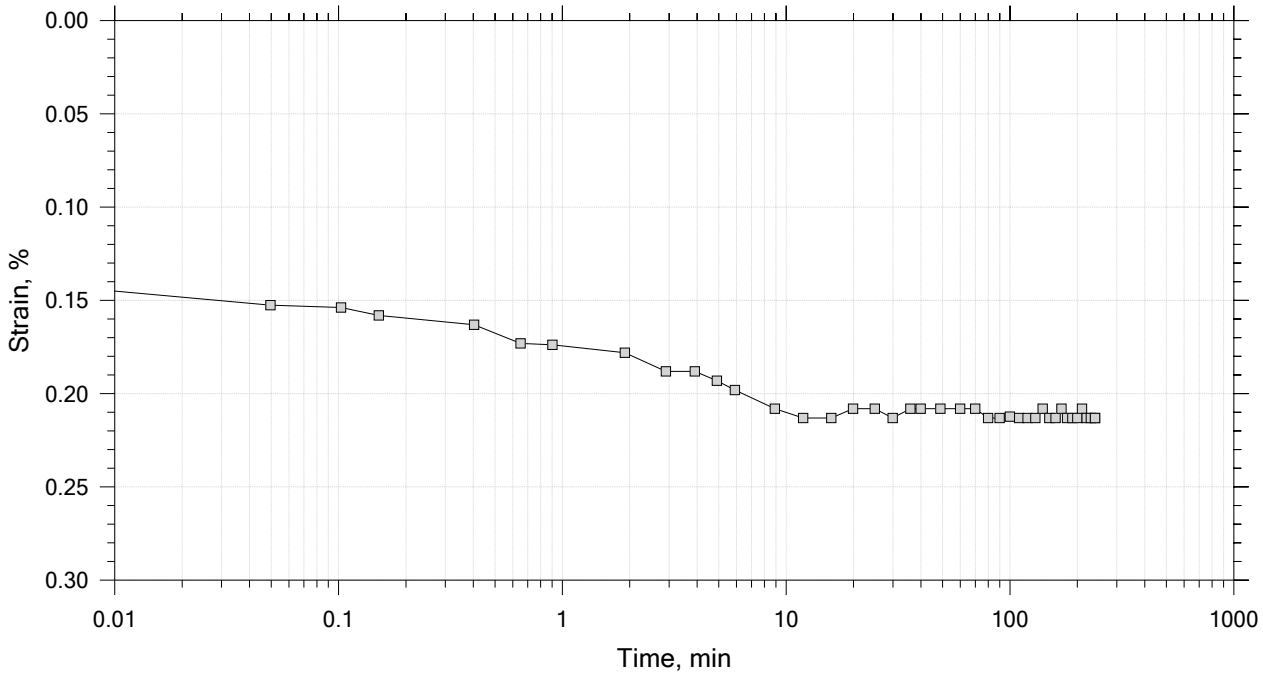


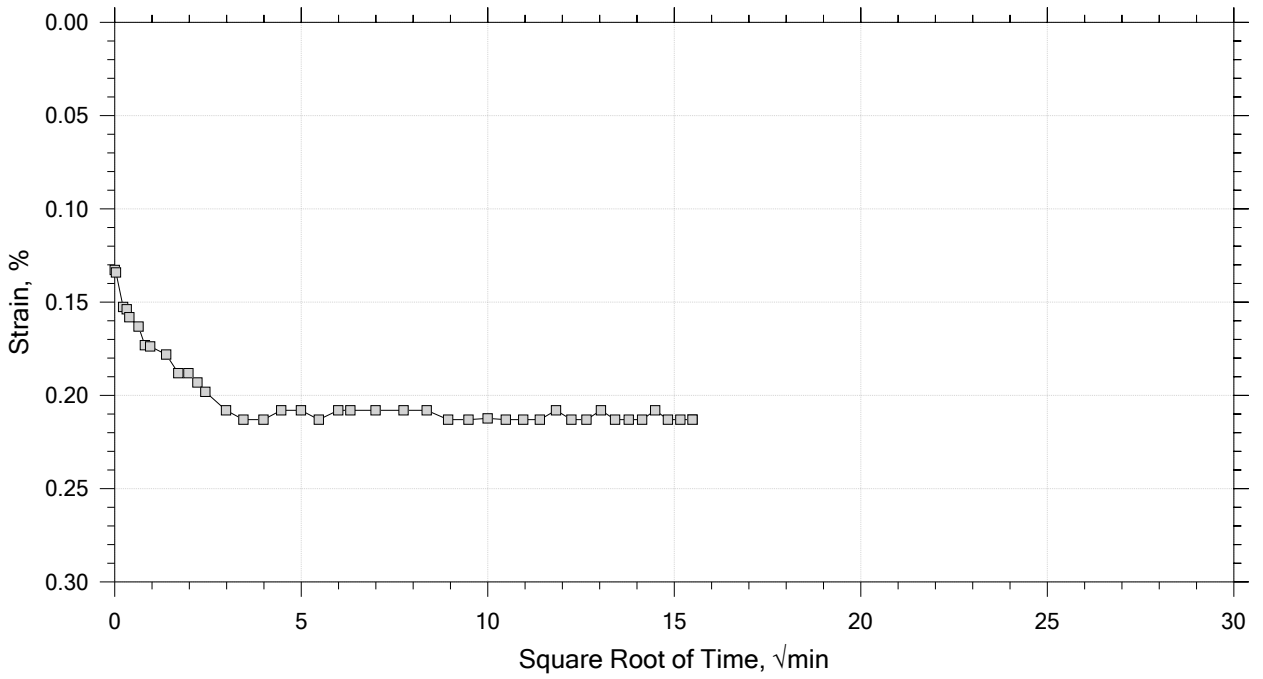


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		
	Displacement at End of Increment		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 1 of 16
Constant Load Step
Stress: 0.0625 tsf

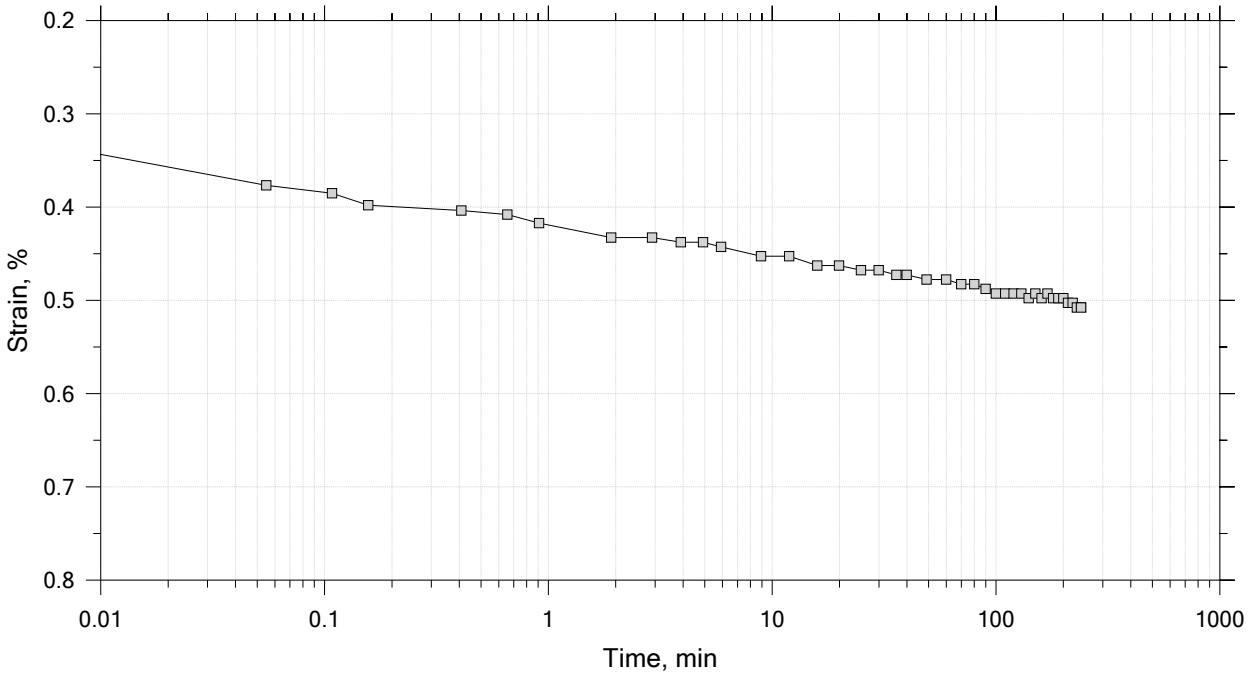


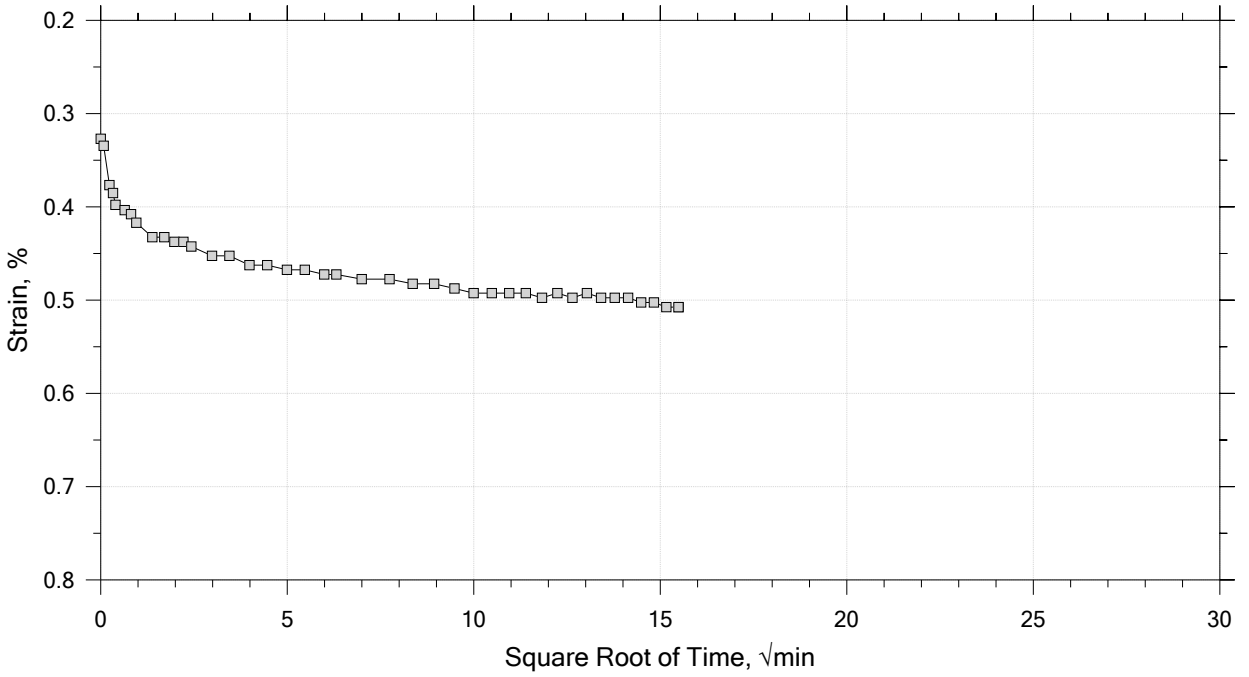


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 2 of 16
Constant Load Step
Stress: 0.125 tsf

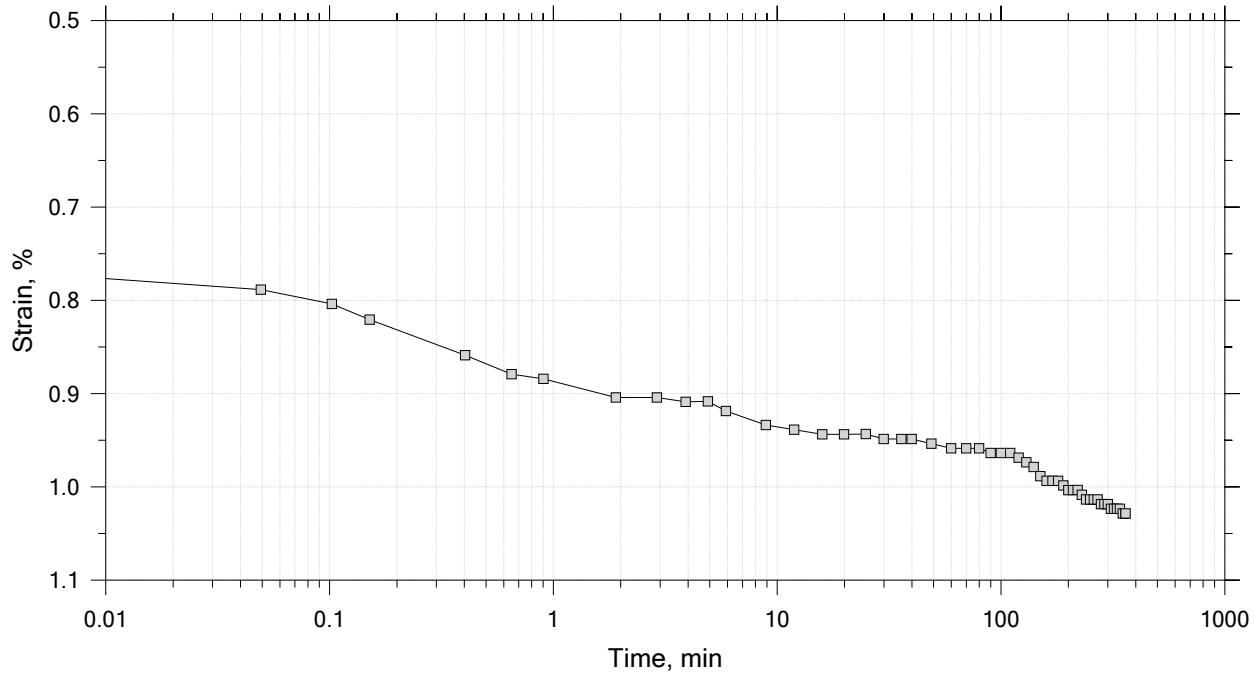


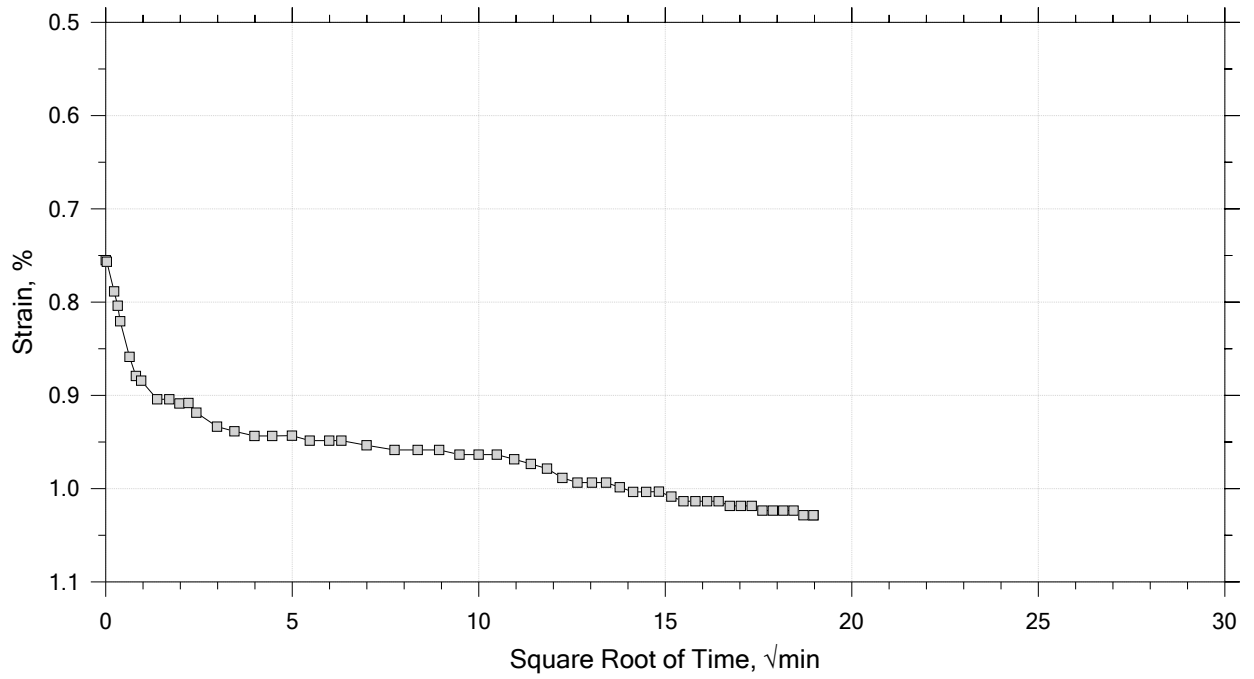


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 3 of 16
Constant Load Step
Stress: 0.25 tsf

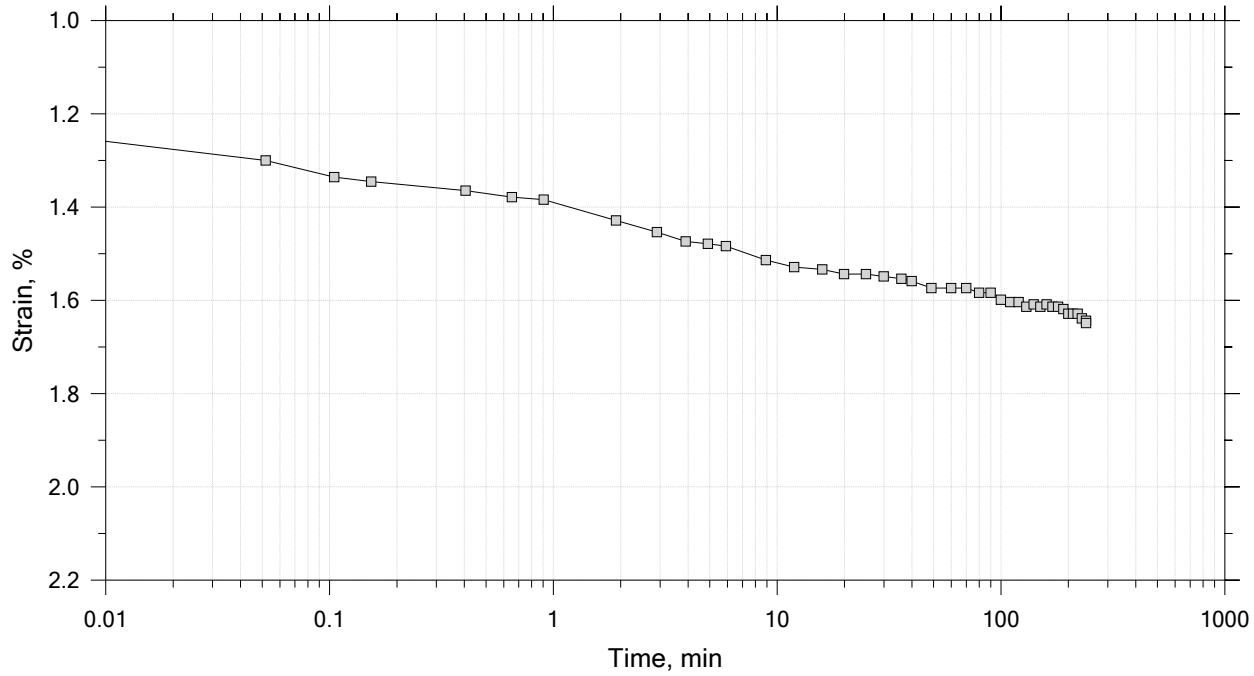


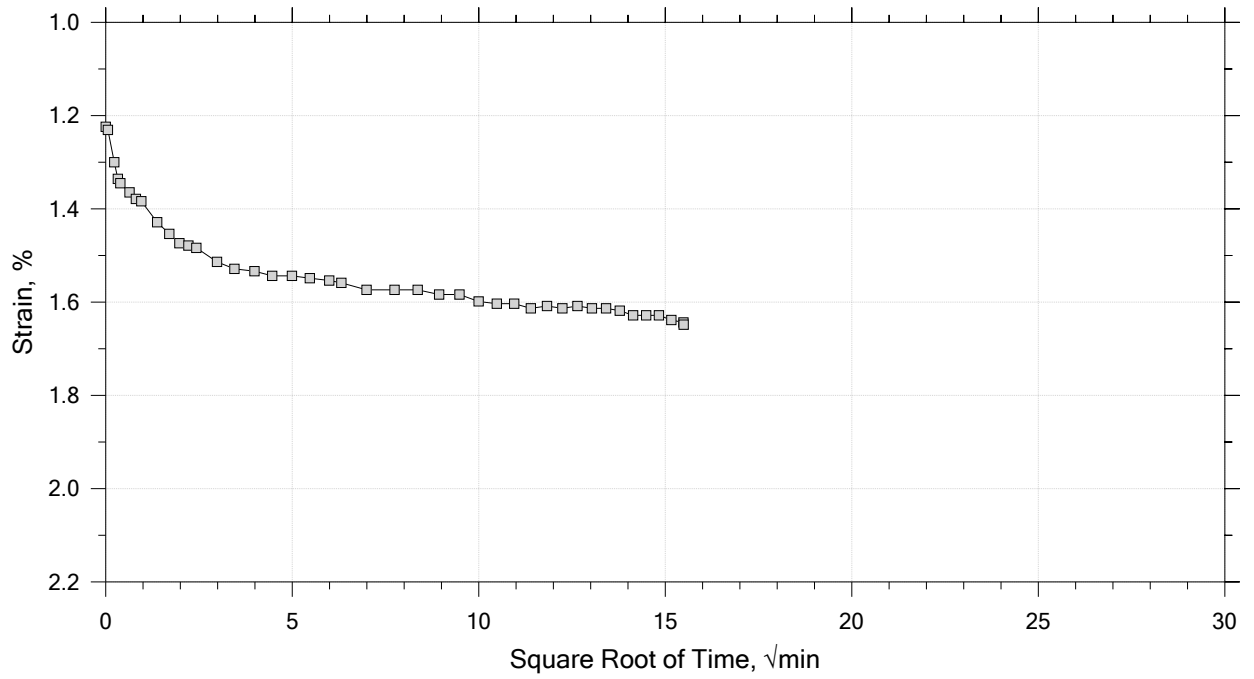


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 4 of 16
Constant Load Step
Stress: 0.5 tsf

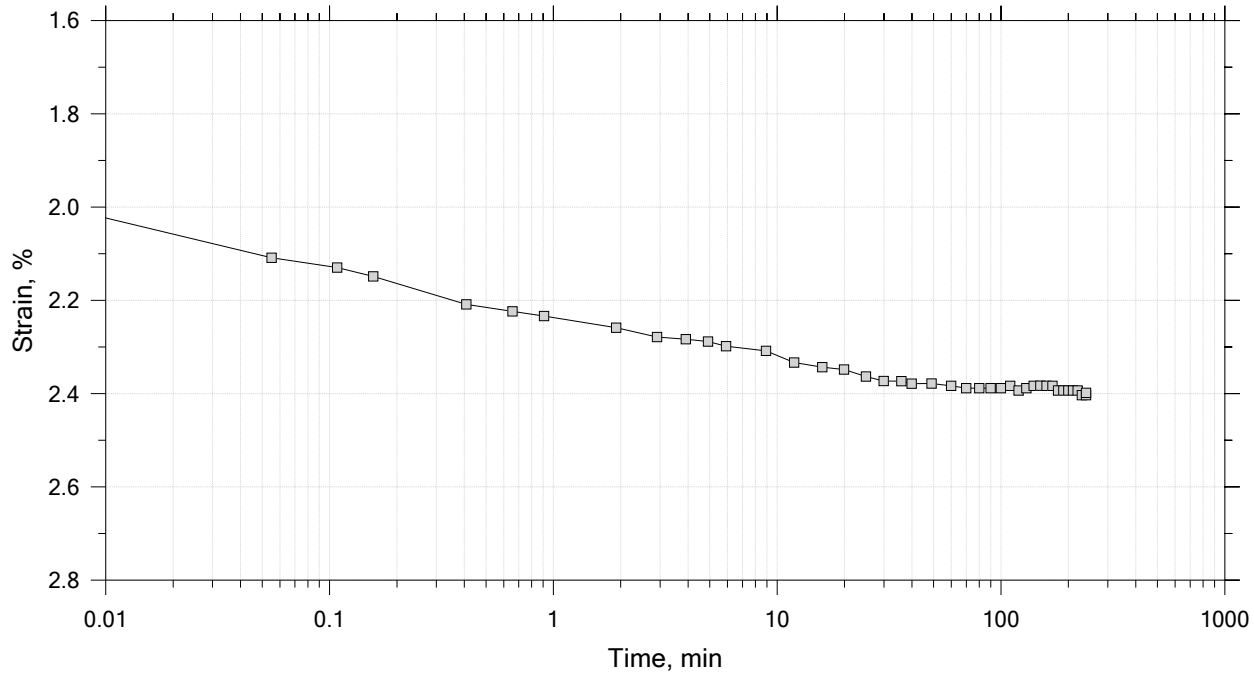


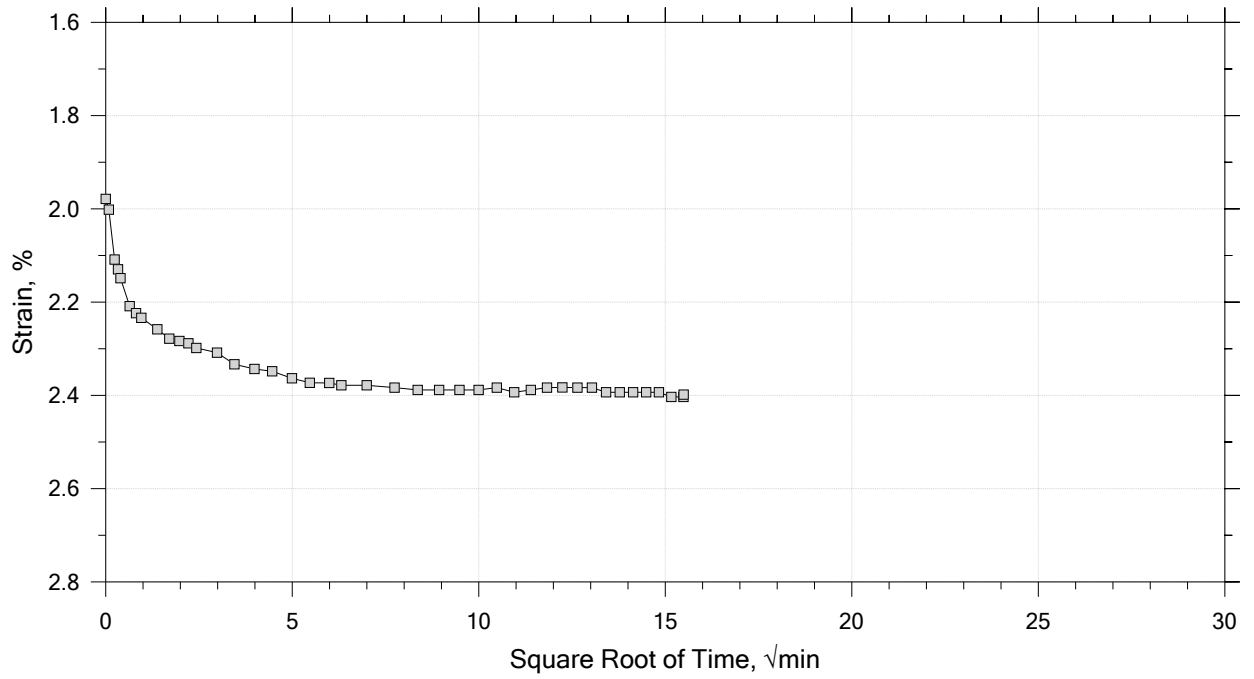


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 5 of 16
Constant Load Step
Stress: 1 tsf

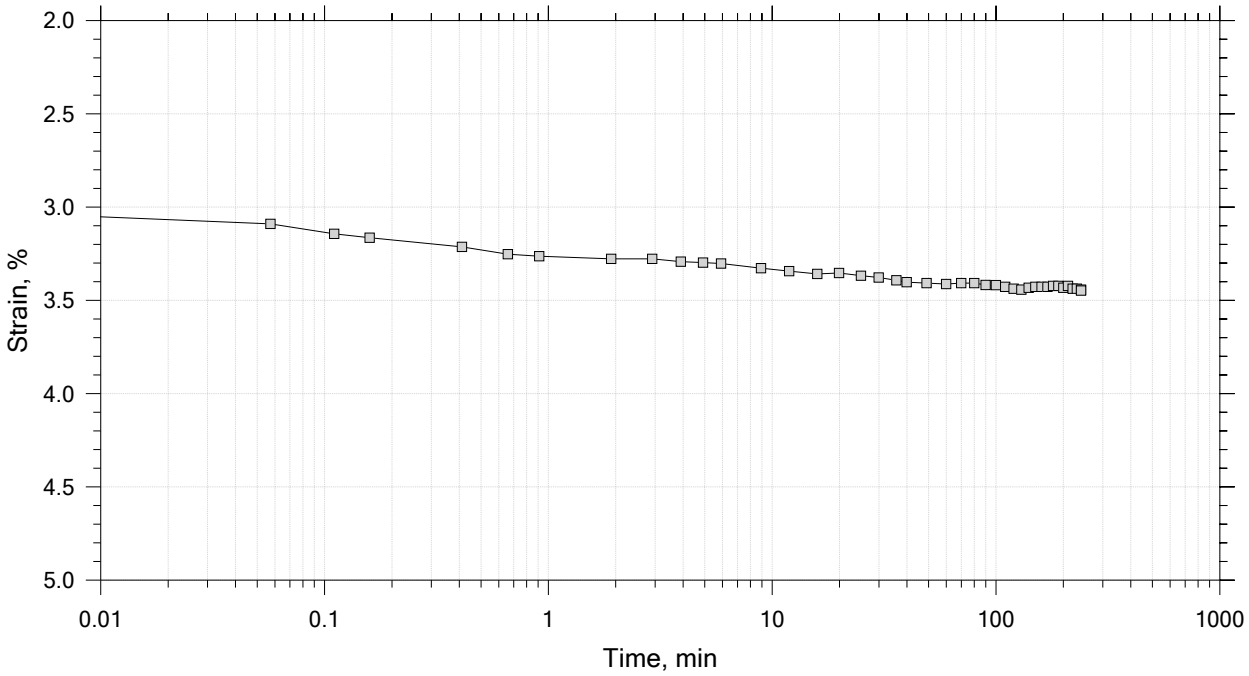


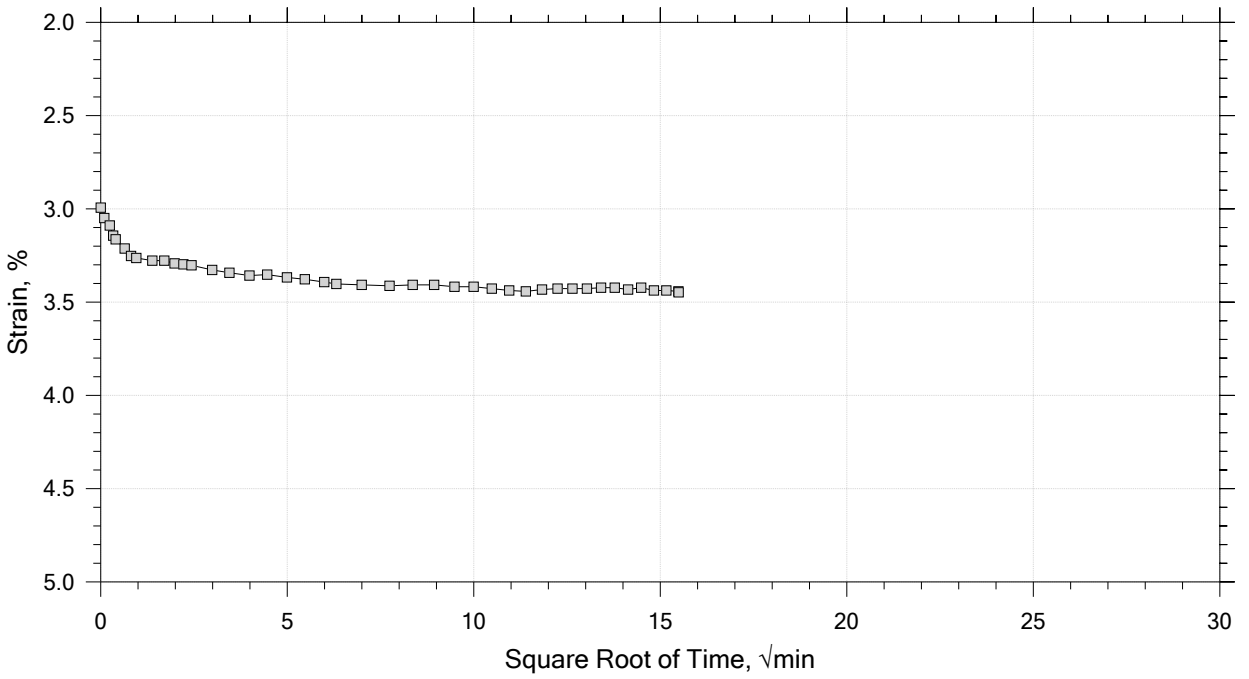


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 6 of 16
Constant Load Step
Stress: 2 tsf

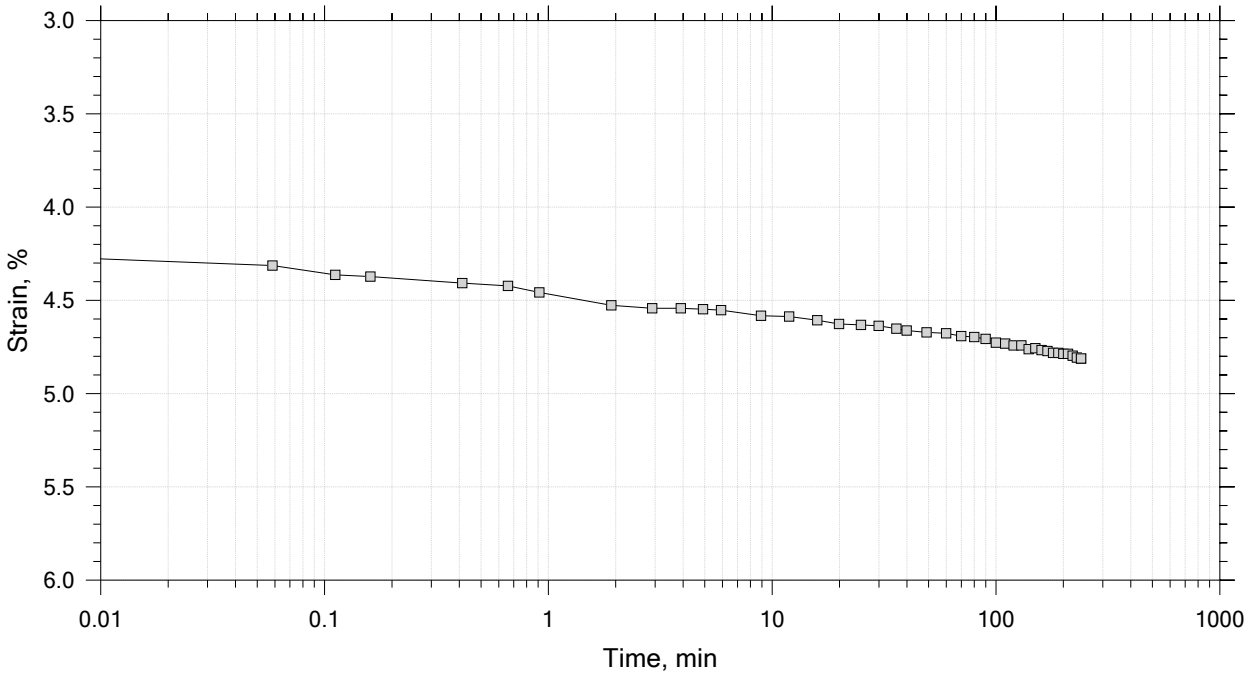


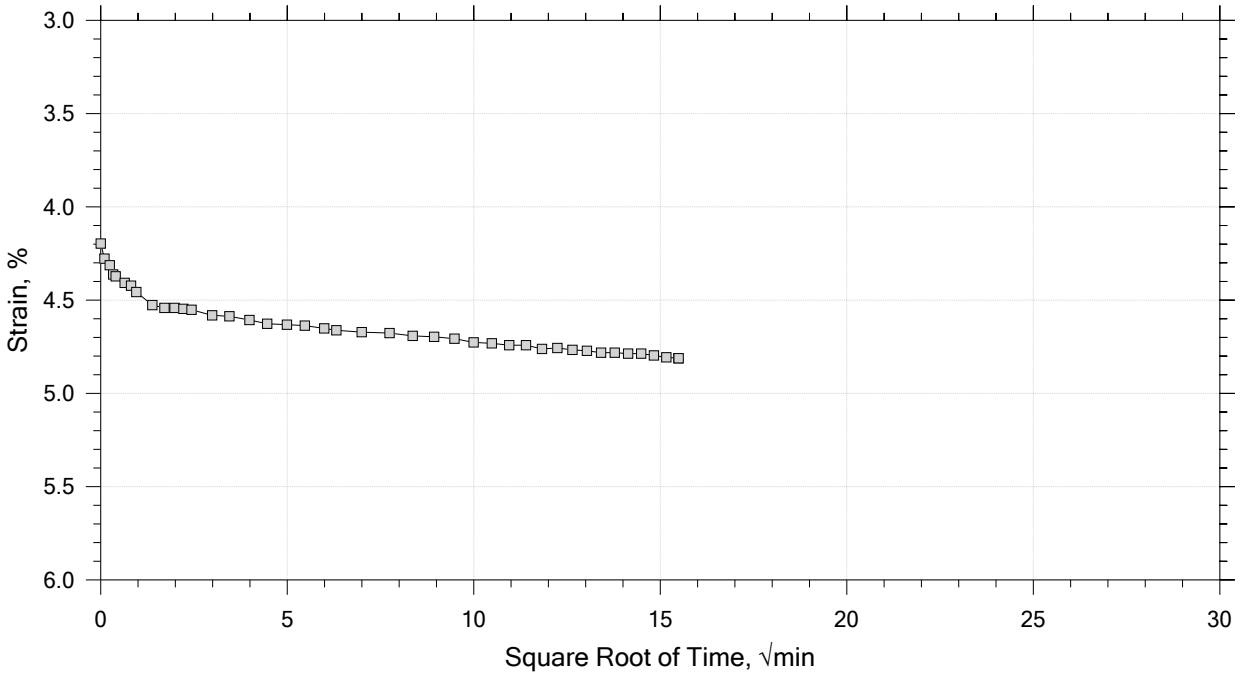


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 7 of 16
Constant Load Step
Stress: 4 tsf

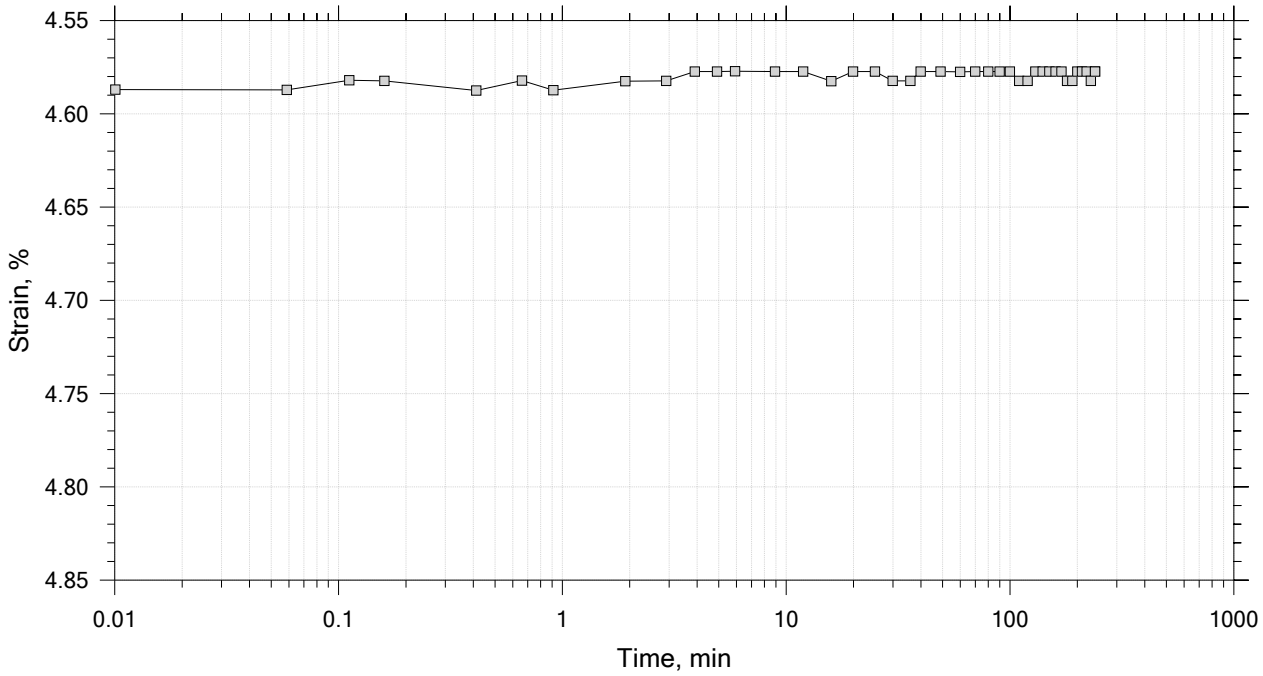


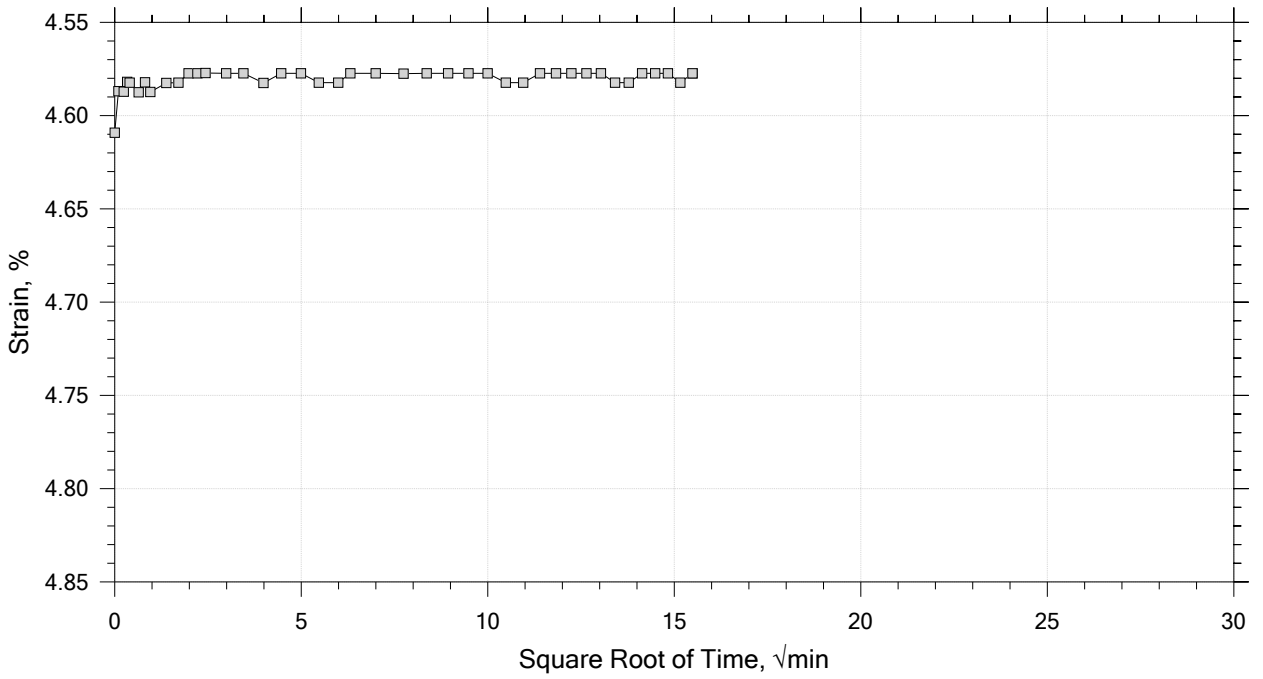


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 8 of 16
Constant Load Step
Stress: 2 tsf

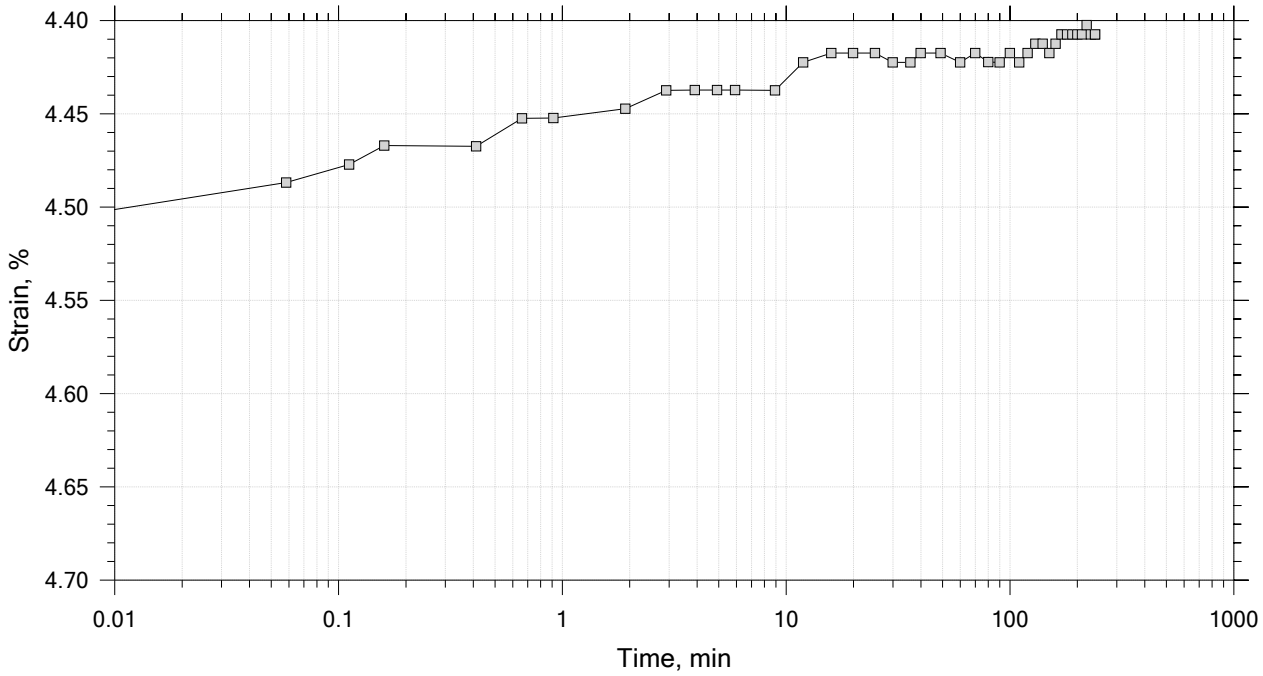


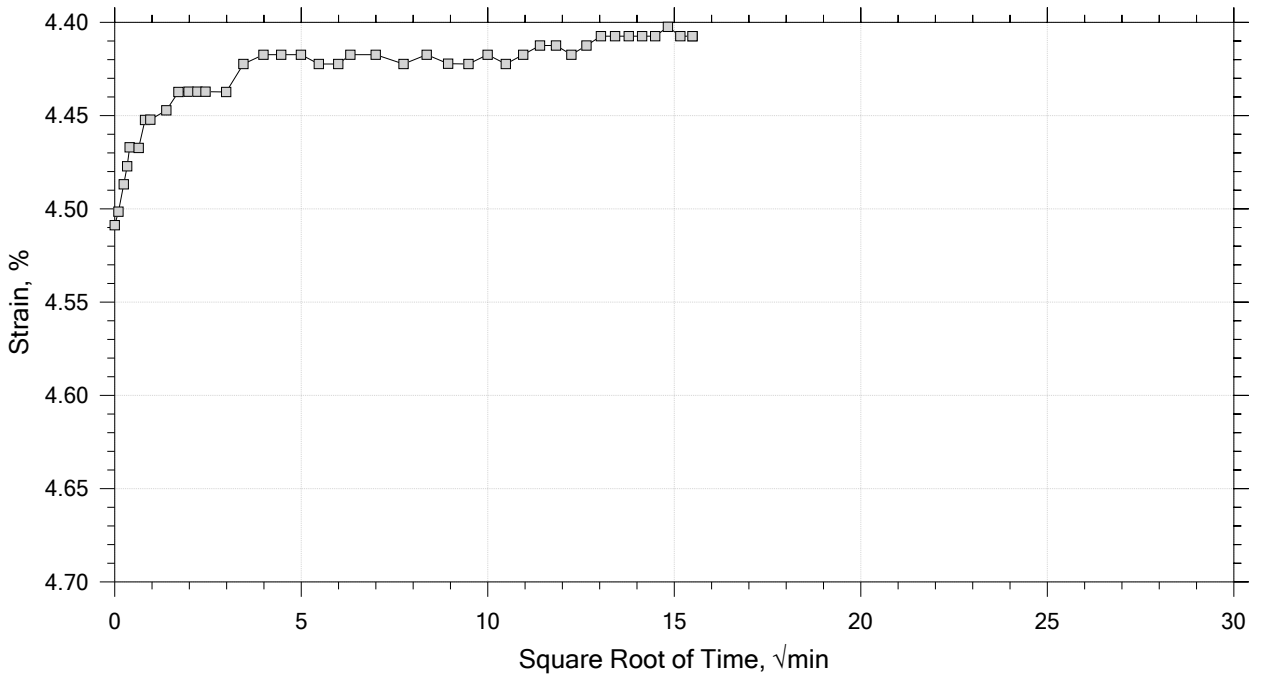


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 9 of 16
Constant Load Step
Stress: 1 tsf

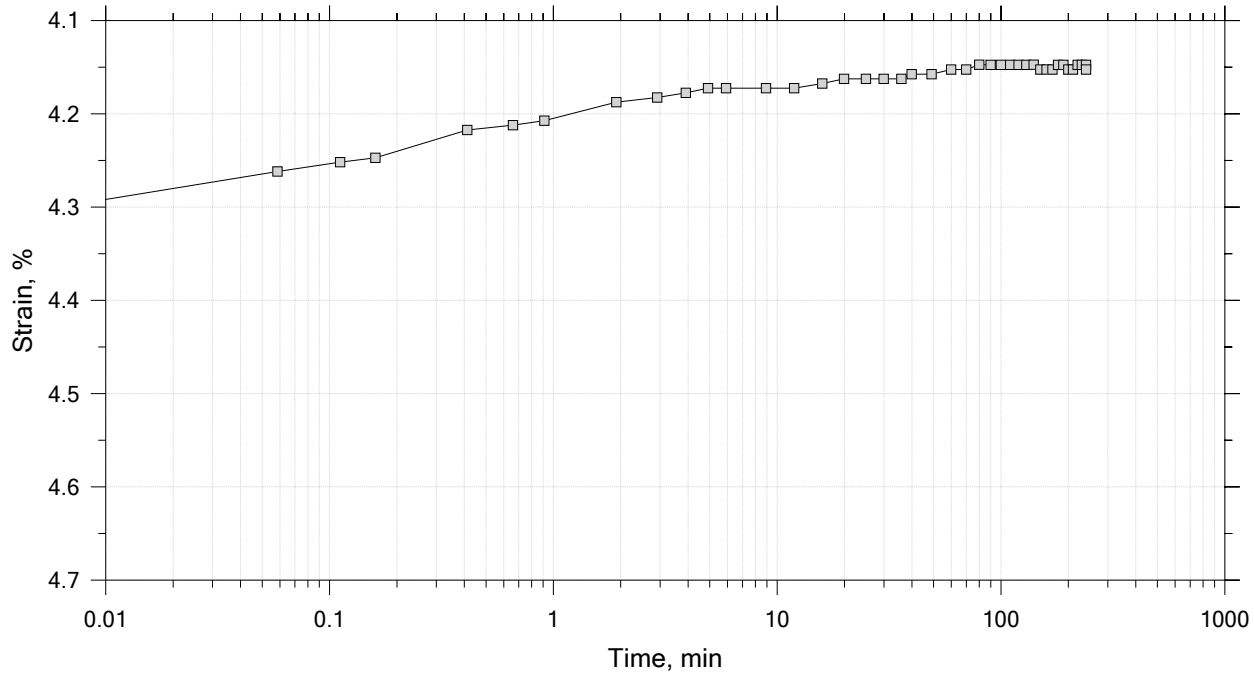


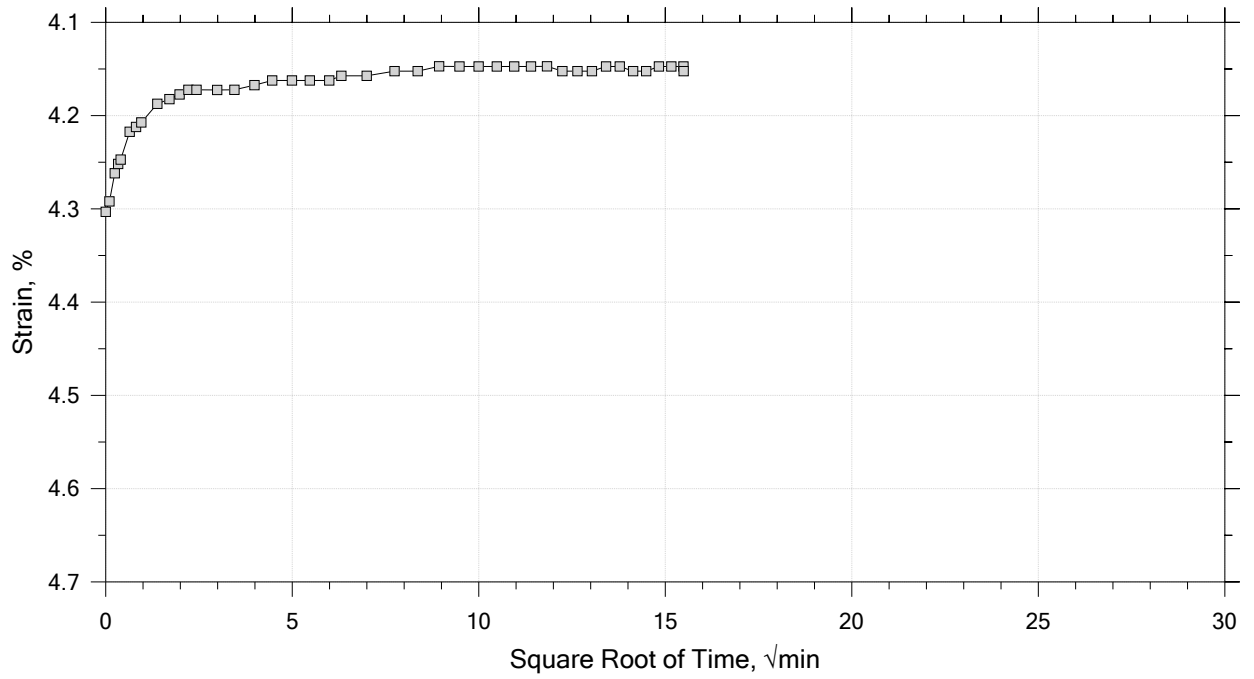


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 10 of 16
Constant Load Step
Stress: 0.5 tsf

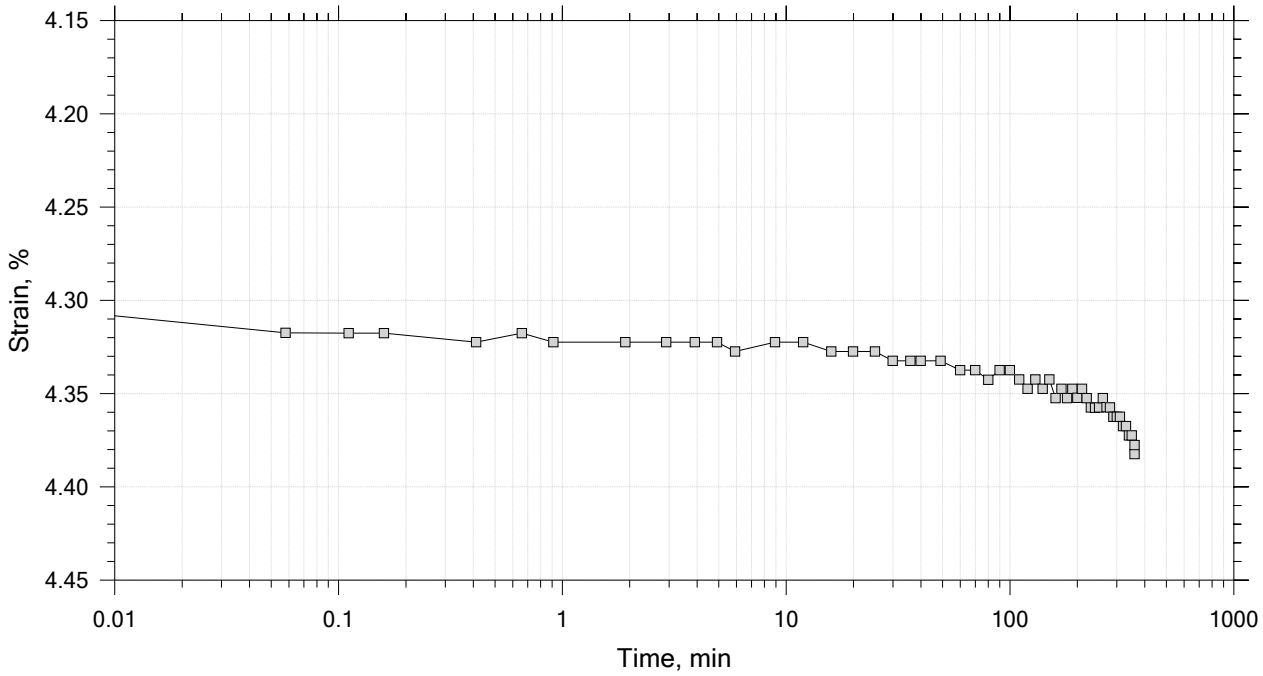


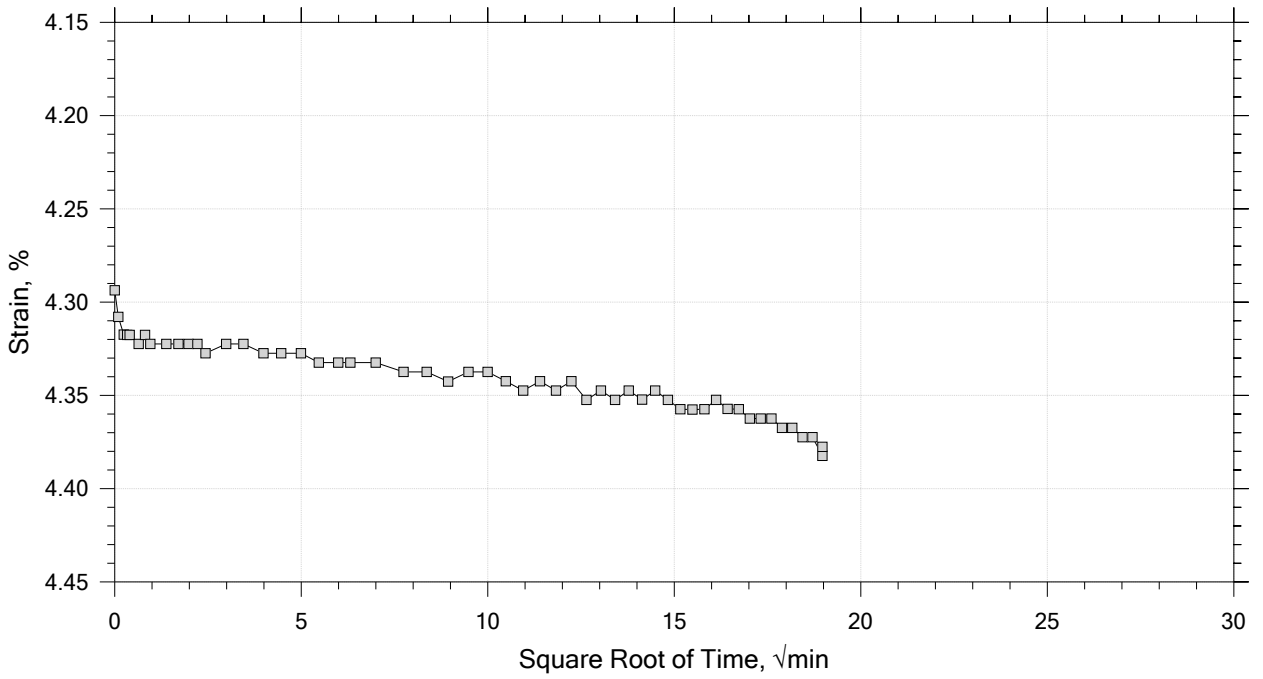


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 11 of 16
Constant Load Step
Stress: 1 tsf

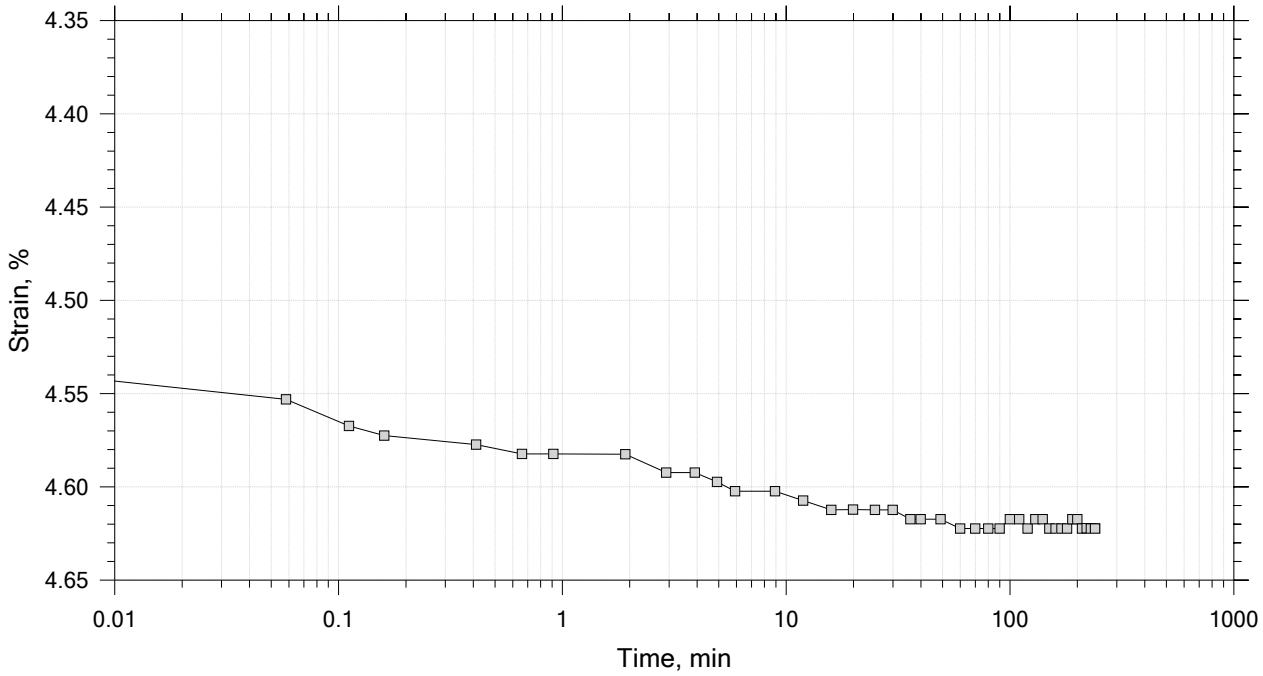


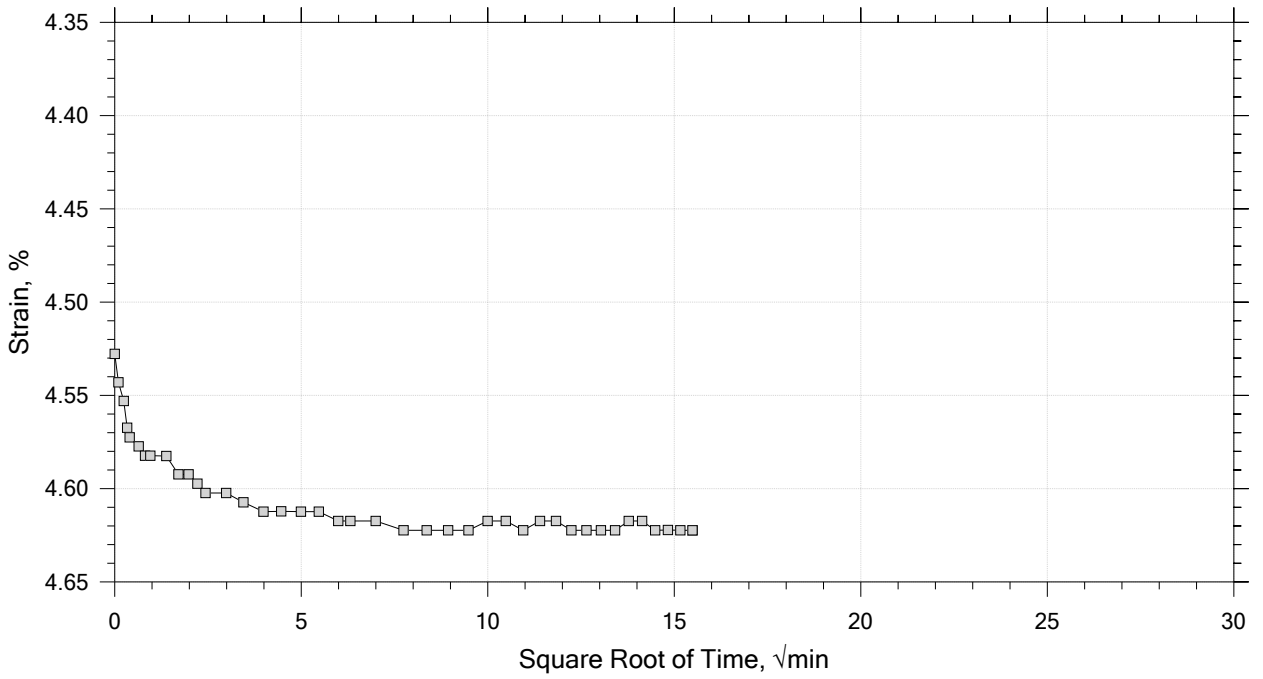


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 12 of 16
Constant Load Step
Stress: 2 tsf

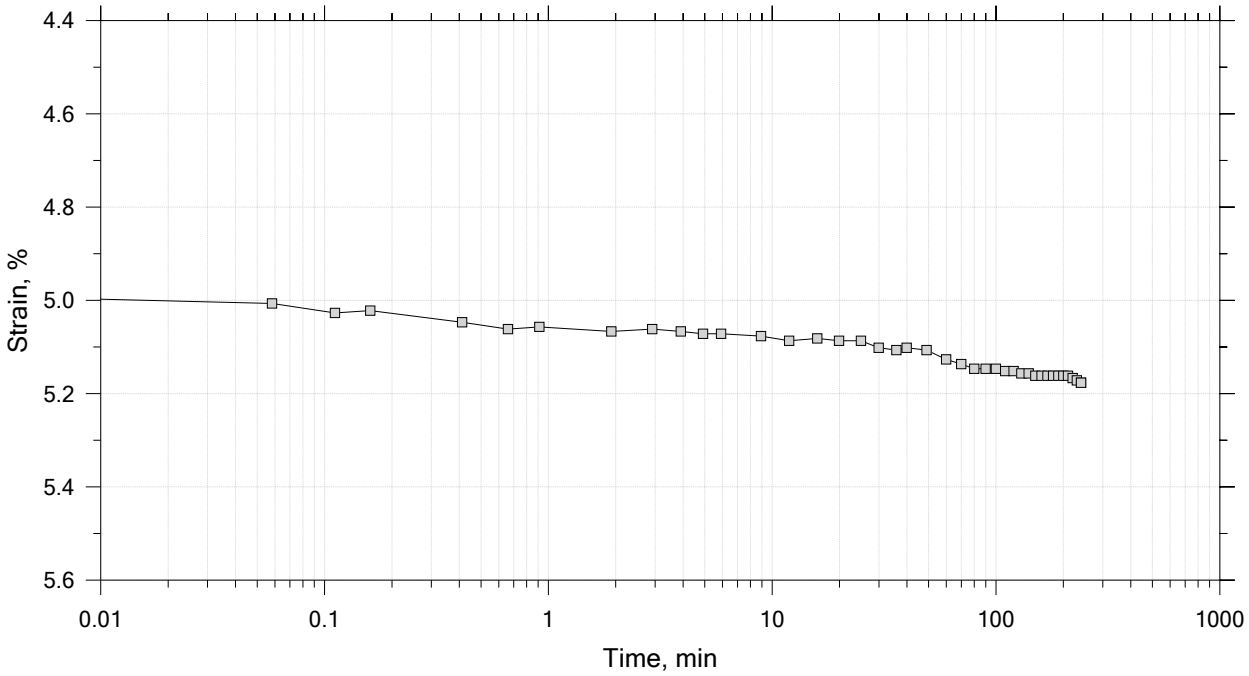


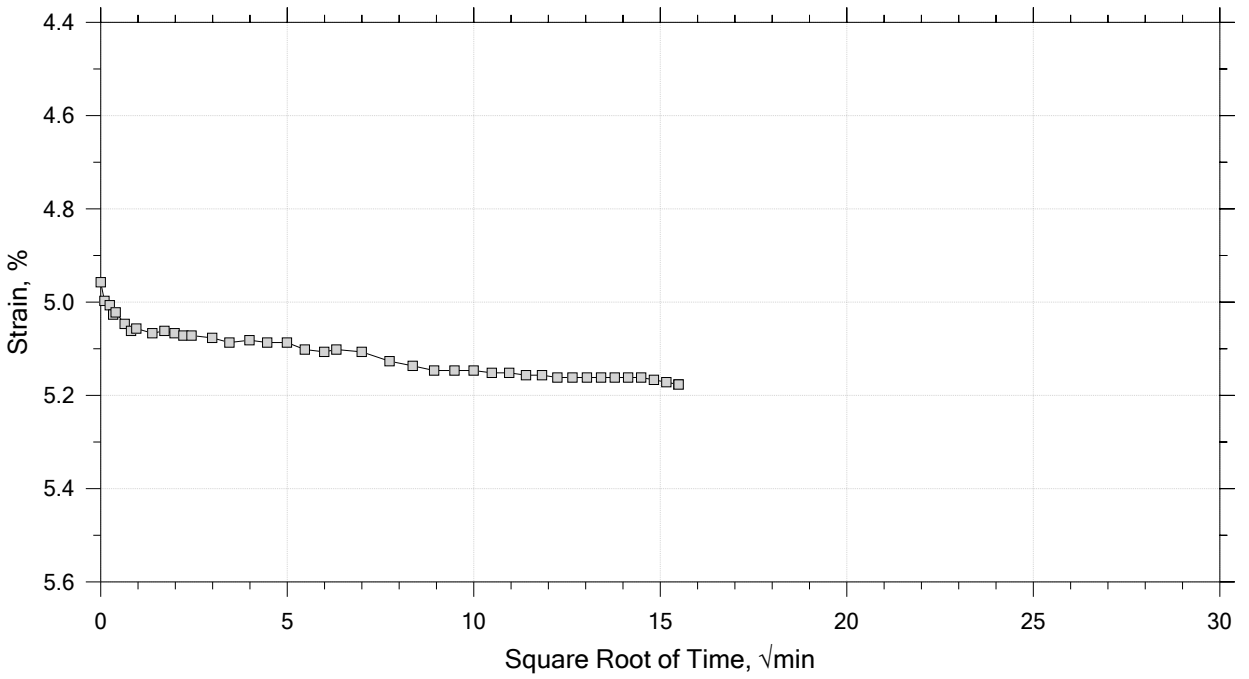


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 13 of 16
Constant Load Step
Stress: 4 tsf

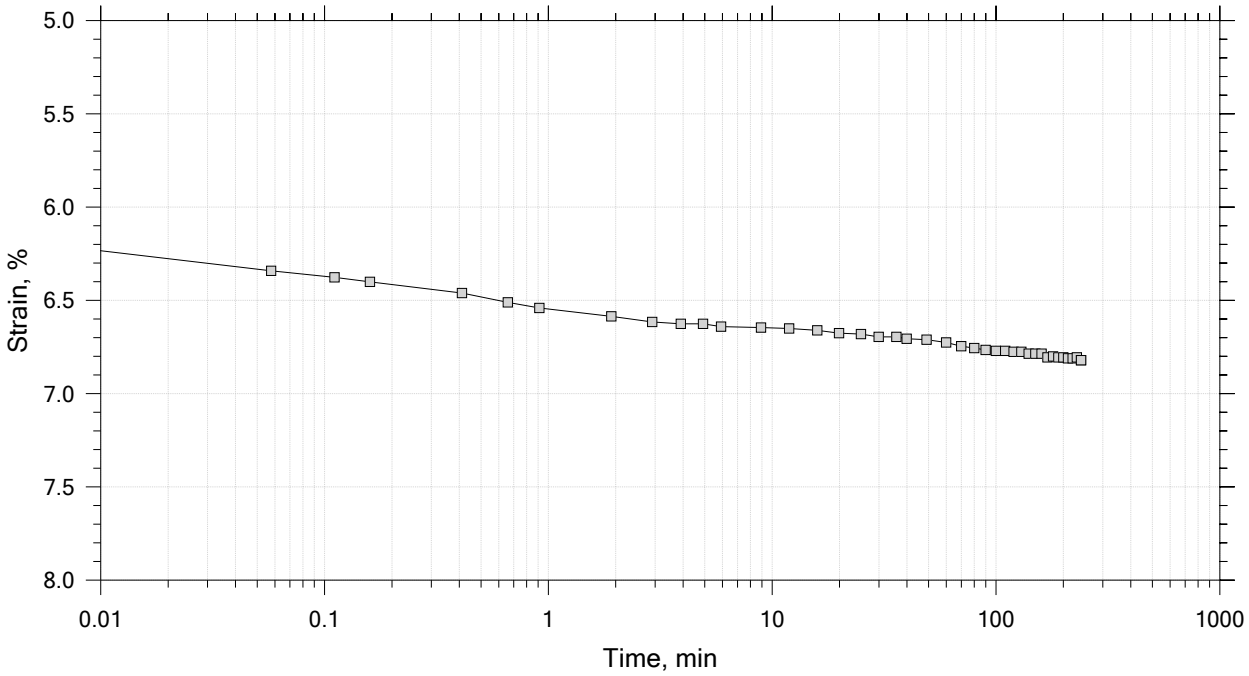


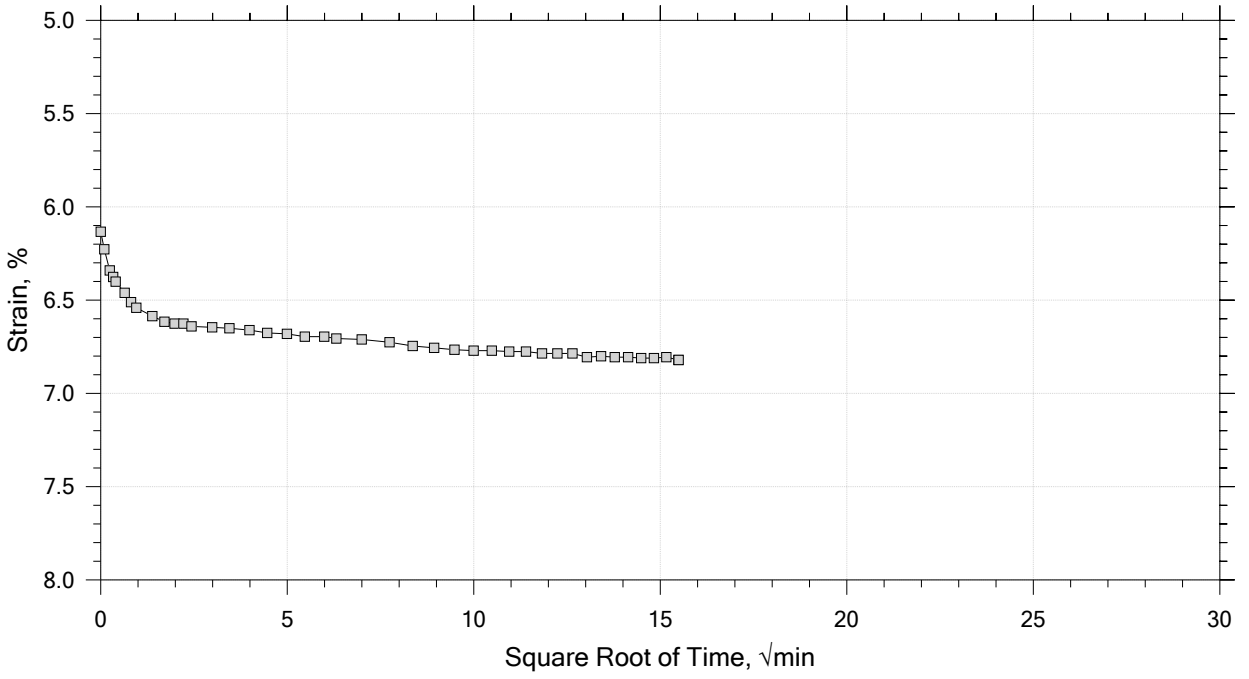


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 14 of 16
Constant Load Step
Stress: 8 tsf

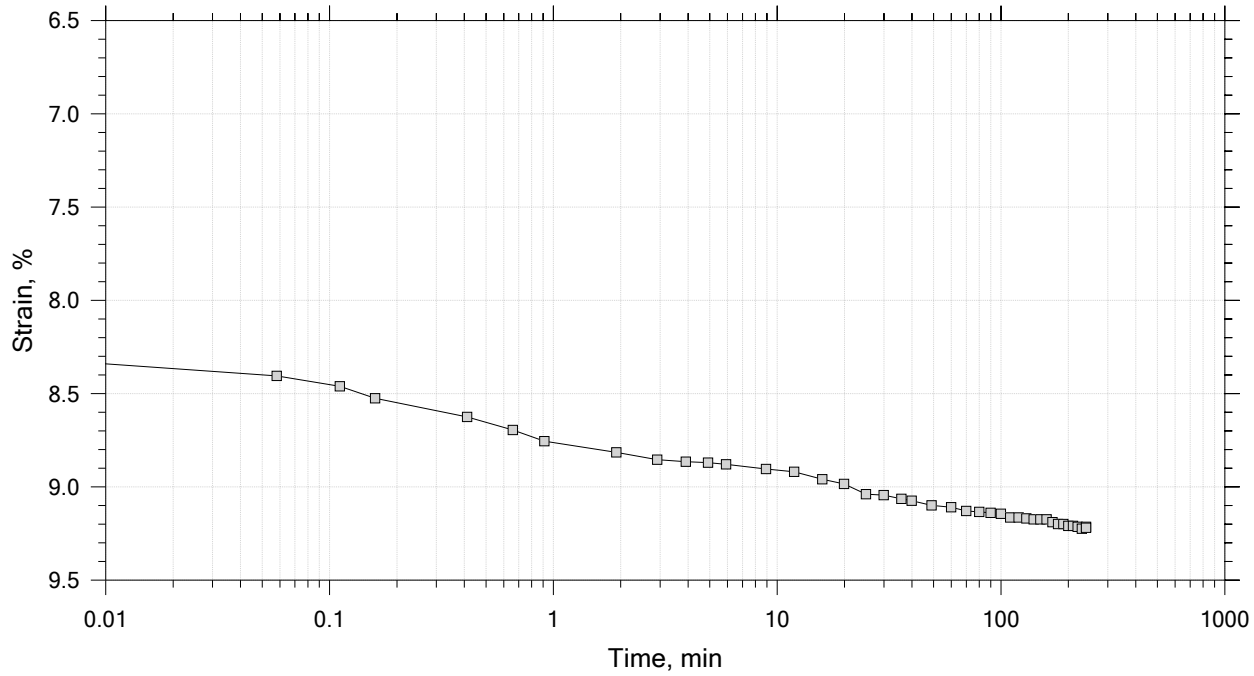


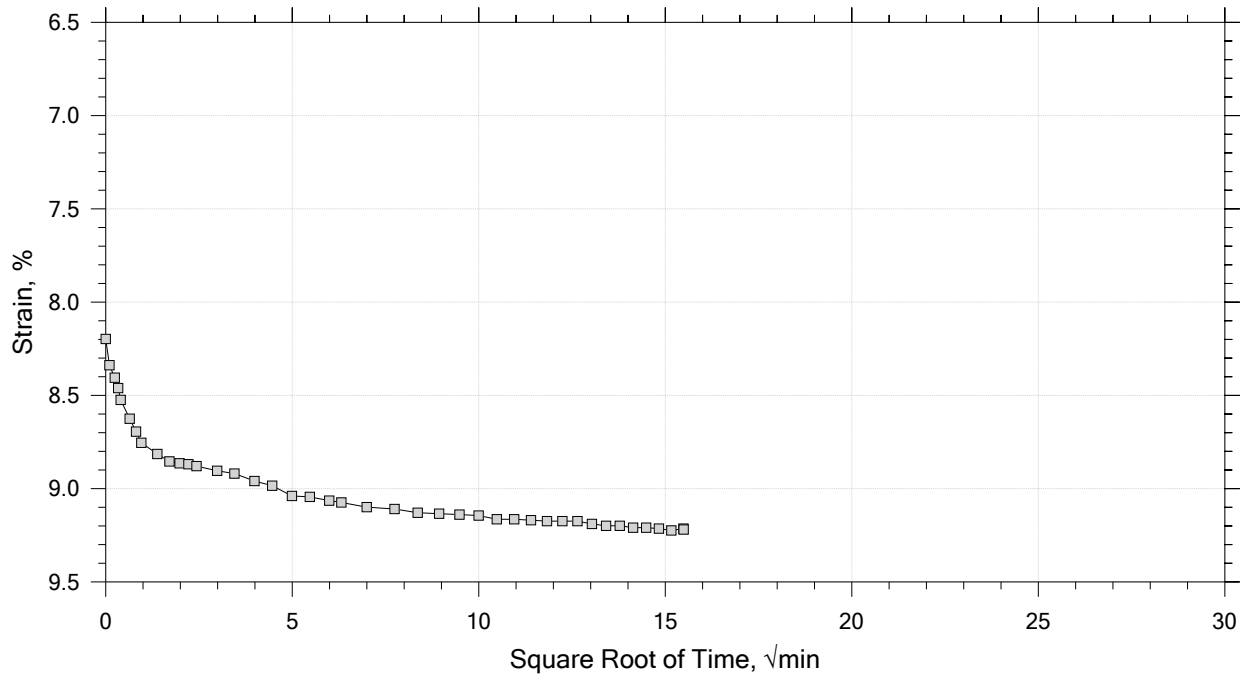


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 15 of 16
Constant Load Step
Stress: 16 tsf

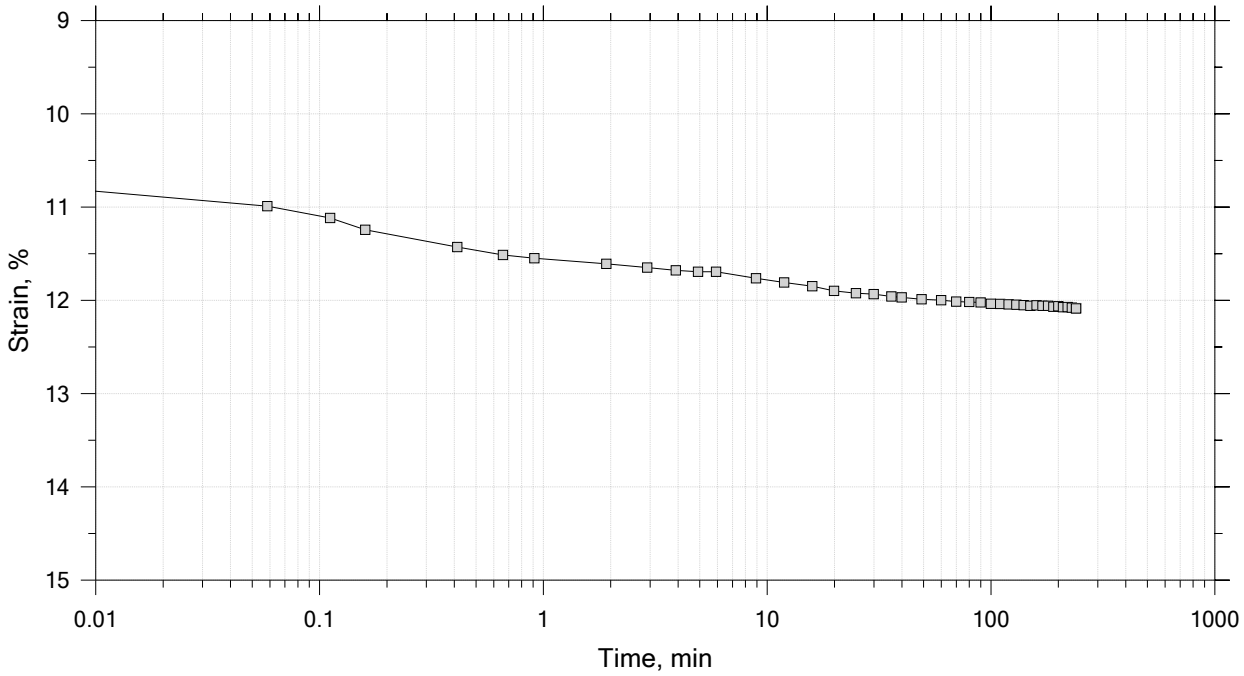


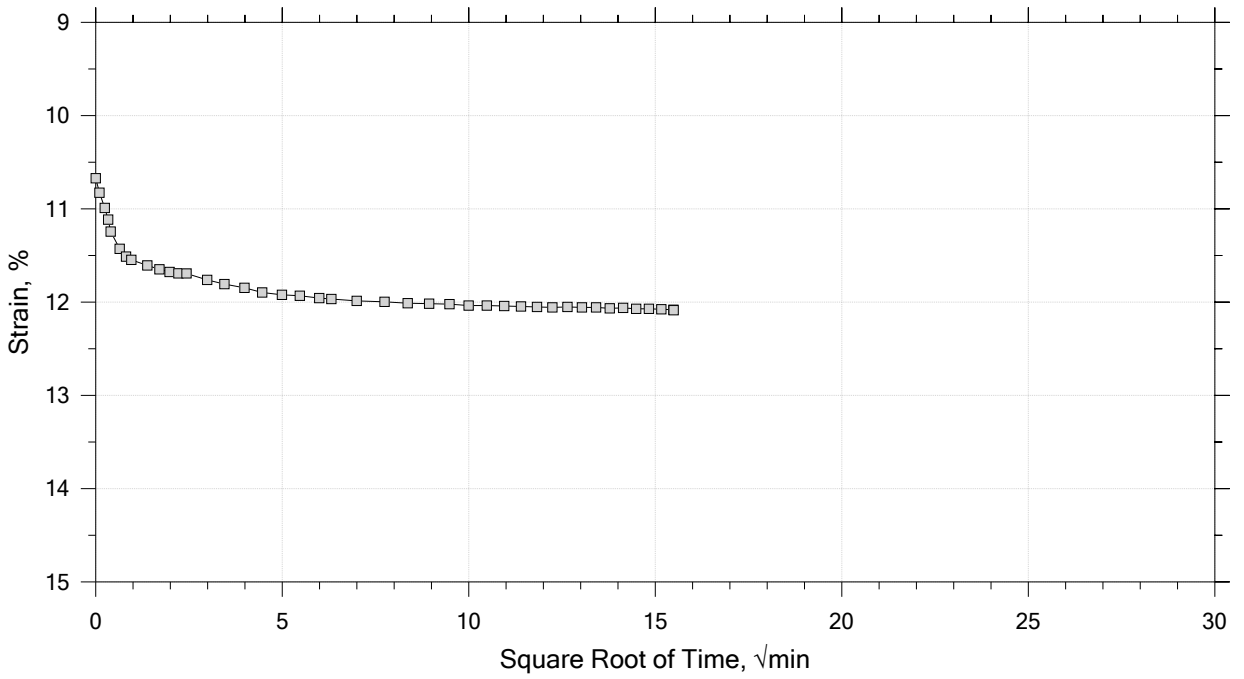


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 16 of 16
Constant Load Step
Stress: 32 tsf





GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Specimen Diameter: 2.50 in	Estimated Specific Gravity: 2.74	Liquid Limit: ---
Initial Height: 1.00 in	Initial Void Ratio: 0.843	Plastic Limit: ---
Final Height: 0.88 in	Final Void Ratio: 0.62	Plasticity Index: ---

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	B2509	RING		B-2599
Mass Container, gm	9.14	106.2	106.2	9.19
Mass Container + Wet Soil, gm	116.93	259.77	252.96	152.25
Mass Container + Dry Soil, gm	94.86	225.9	225.9	125.87
Mass Dry Soil, gm	85.72	119.7	119.7	116.68
Water Content, %	25.75	28.30	22.61	22.61
Void Ratio	---	0.84	0.62	---
Degree of Saturation, %	---	92.08	100.00	---
Dry Unit Weight, pcf	---	92.895	105.67	---

Note: Specific Gravity and Void Ratios are calculated assuming the degree of saturation equals 100% at the end of the test. Therefore, values may not represent actual values for the specimen.

GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		

One-Dimensional Consolidation by ASTM D2435 - Method B

Log of Time Coefficients

Step	Applied Stress tsf	Final Displacement in	Void Ratio	Strain at End %	Log T50 min	Cv ft²/s	Mv 1/tsf	k ft/day	Ca %
1	0.0625	0.002130	0.839	0.213	0.000	0.00e+00	3.41e-02	0.00e+00	0.00e+00
2	0.125	0.005076	0.833	0.508	0.000	0.00e+00	4.71e-02	0.00e+00	0.00e+00
3	0.250	0.01029	0.824	1.03	0.000	0.00e+00	4.17e-02	0.00e+00	0.00e+00
4	0.500	0.01649	0.812	1.65	0.000	0.00e+00	2.48e-02	0.00e+00	0.00e+00
5	1.00	0.02398	0.798	2.40	0.000	0.00e+00	1.50e-02	0.00e+00	0.00e+00
6	2.00	0.03448	0.779	3.45	0.000	0.00e+00	1.05e-02	0.00e+00	0.00e+00
7	4.00	0.04812	0.754	4.81	0.000	0.00e+00	6.82e-03	0.00e+00	0.00e+00
8	2.00	0.04577	0.758	4.58	0.000	0.00e+00	1.17e-03	0.00e+00	0.00e+00
9	1.00	0.04407	0.761	4.41	0.000	0.00e+00	1.70e-03	0.00e+00	0.00e+00
10	0.500	0.04152	0.766	4.15	0.000	0.00e+00	5.10e-03	0.00e+00	0.00e+00
11	1.00	0.04378	0.762	4.38	0.000	0.00e+00	4.50e-03	0.00e+00	0.00e+00
12	2.00	0.04622	0.757	4.62	0.000	0.00e+00	2.45e-03	0.00e+00	0.00e+00
13	4.00	0.05177	0.747	5.18	0.000	0.00e+00	2.77e-03	0.00e+00	0.00e+00
14	8.00	0.06821	0.717	6.82	0.000	0.00e+00	4.11e-03	0.00e+00	0.00e+00
15	16.0	0.09219	0.673	9.22	0.000	0.00e+00	3.00e-03	0.00e+00	0.00e+00
16	32.0	0.1209	0.620	12.1	0.233	1.95e-05	1.79e-03	9.44e-05	0.00e+00

GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		
	Displacement at End of Increment		

One-Dimensional Consolidation by ASTM D2435 - Method B

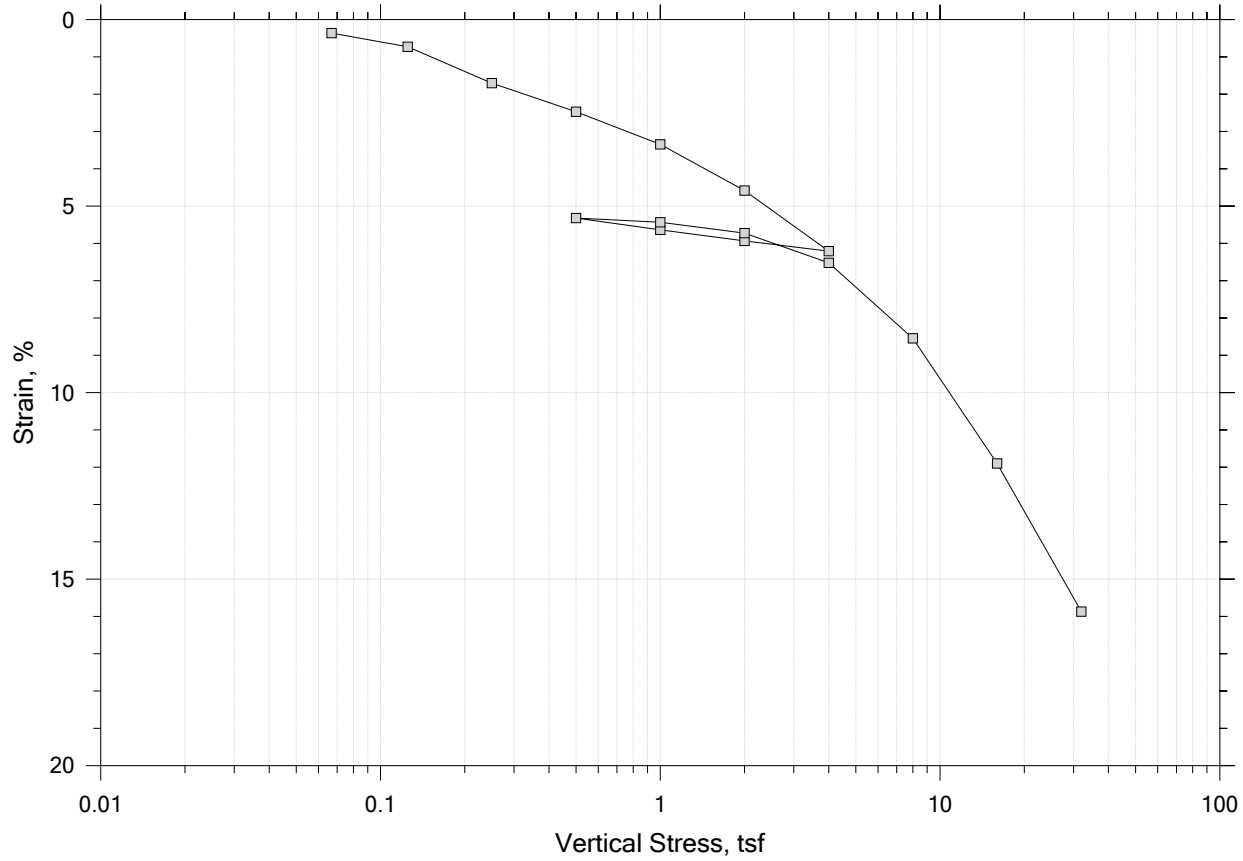
Square Root of Time Coefficients

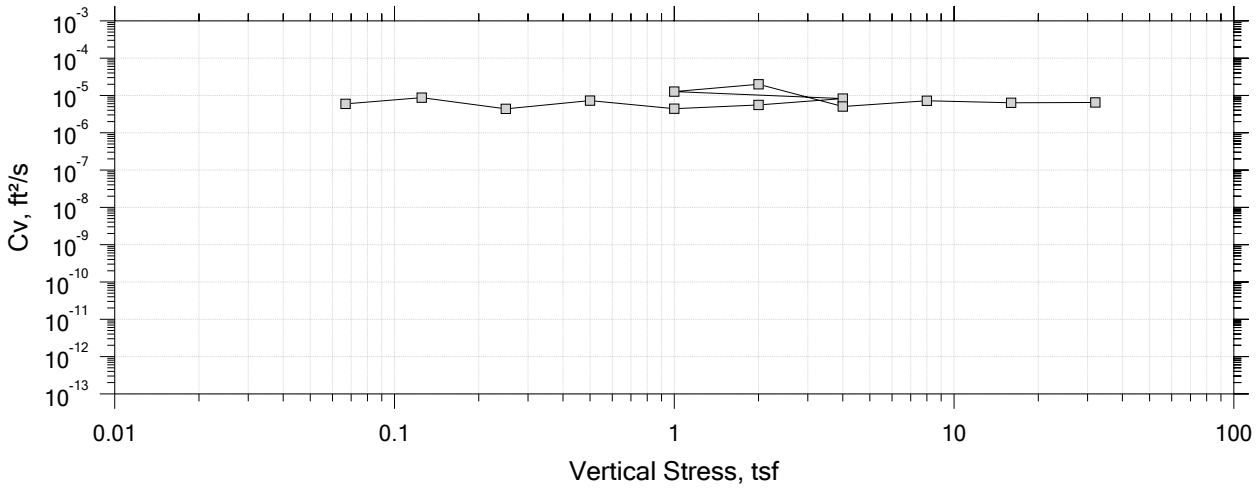
Step	Applied Stress tsf	Final Displacement in	Void Ratio	Strain at End %	Sq.Rt. T90 min	Cv ft²/s	Mv 1/tsf	k ft/day
1	0.0625	0.002130	0.839	0.213	11.900	2.06e-06	3.41e-02	1.89e-04
2	0.125	0.005076	0.833	0.508	22.913	1.06e-06	4.71e-02	1.35e-04
3	0.250	0.01029	0.824	1.03	349.902	6.91e-08	4.17e-02	7.76e-06
4	0.500	0.01649	0.812	1.65	12.385	1.93e-06	2.48e-02	1.29e-04
5	1.00	0.02398	0.798	2.40	3.068	7.68e-06	1.50e-02	3.10e-04
6	2.00	0.03448	0.779	3.45	15.367	1.50e-06	1.05e-02	4.26e-05
7	4.00	0.04812	0.754	4.81	47.777	4.72e-07	6.82e-03	8.68e-06
8	2.00	0.04577	0.758	4.58	3.480	6.40e-06	1.17e-03	2.03e-05
9	1.00	0.04407	0.761	4.41	15.570	1.44e-06	1.70e-03	6.59e-06
10	0.500	0.04152	0.766	4.15	2.006	1.12e-05	5.10e-03	1.54e-04
11	1.00	0.04378	0.762	4.38	0.000	0.00e+00	4.50e-03	0.00e+00
12	2.00	0.04622	0.757	4.62	5.910	3.79e-06	2.45e-03	2.50e-05
13	4.00	0.05177	0.747	5.18	124.258	1.79e-07	2.77e-03	1.33e-06
14	8.00	0.06821	0.717	6.82	6.640	3.27e-06	4.11e-03	3.62e-05
15	16.0	0.09219	0.673	9.22	50.825	4.08e-07	3.00e-03	3.30e-06
16	32.0	0.1209	0.620	12.1	12.374	1.58e-06	1.79e-03	7.65e-06

GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: njh
	Sample No.: ST-3	Test Date: 6/24/19	Depth: 30-32
	Test No.: IP-2	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System S		
	Displacement at End of Increment		

One-Dimensional Consolidation by ASTM D2435 - Method B

Summary Report

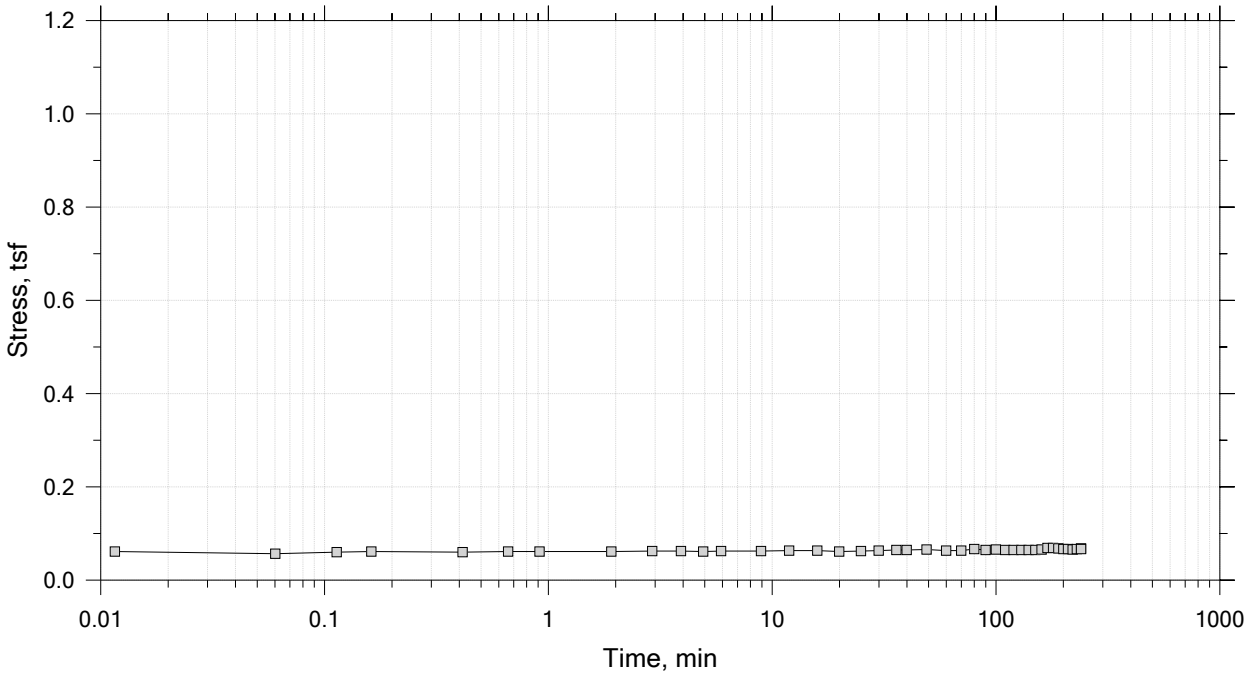


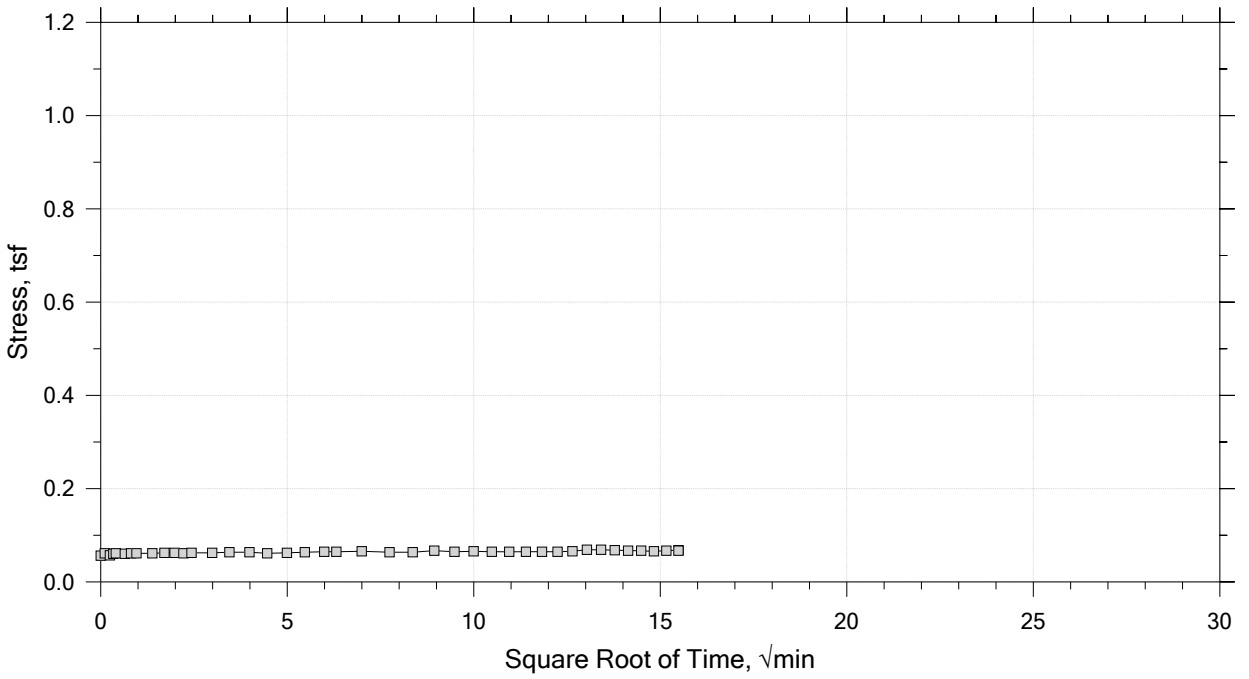


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		
	Displacement at End of Increment		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 1 of 16
Constant Volume Step
Stress: 0.0668 tsf

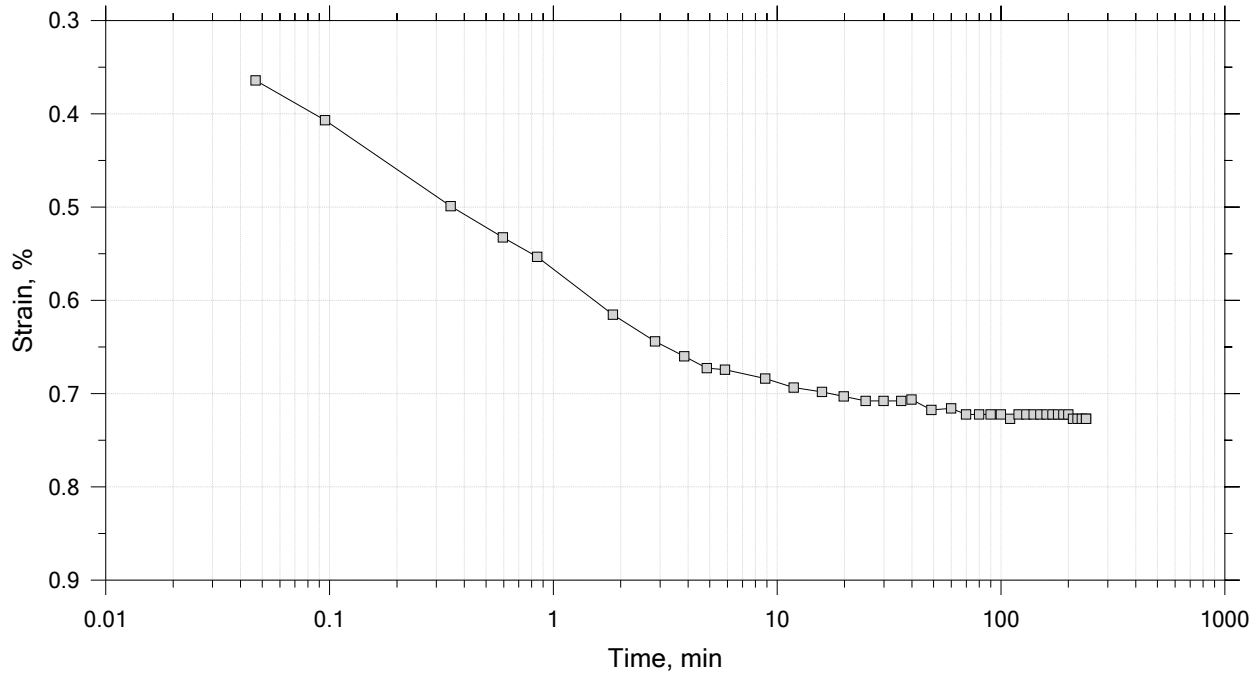


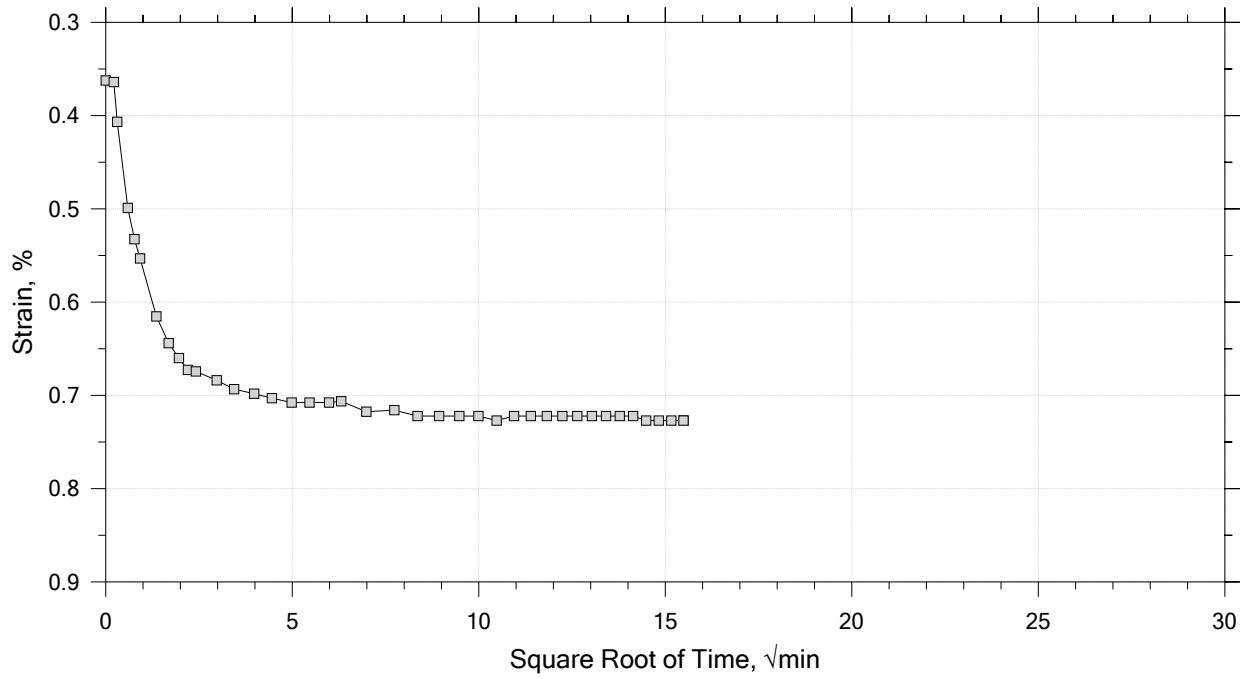


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 2 of 16
Constant Load Step
Stress: 0.125 tsf

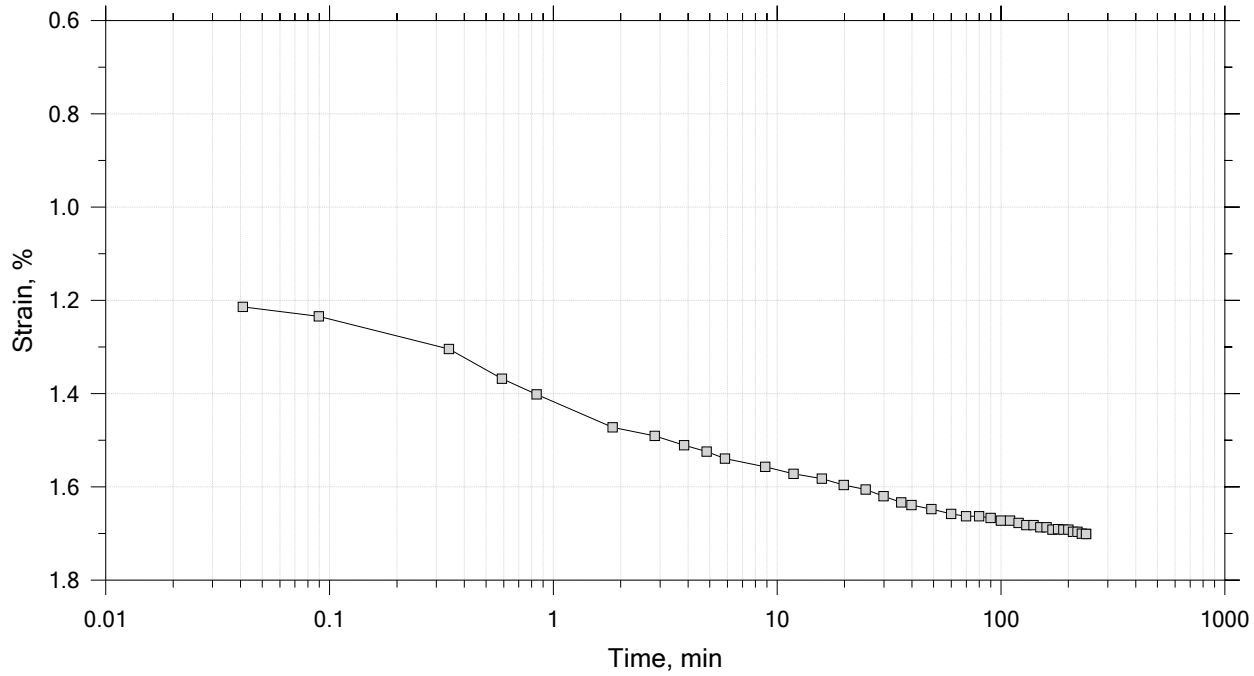


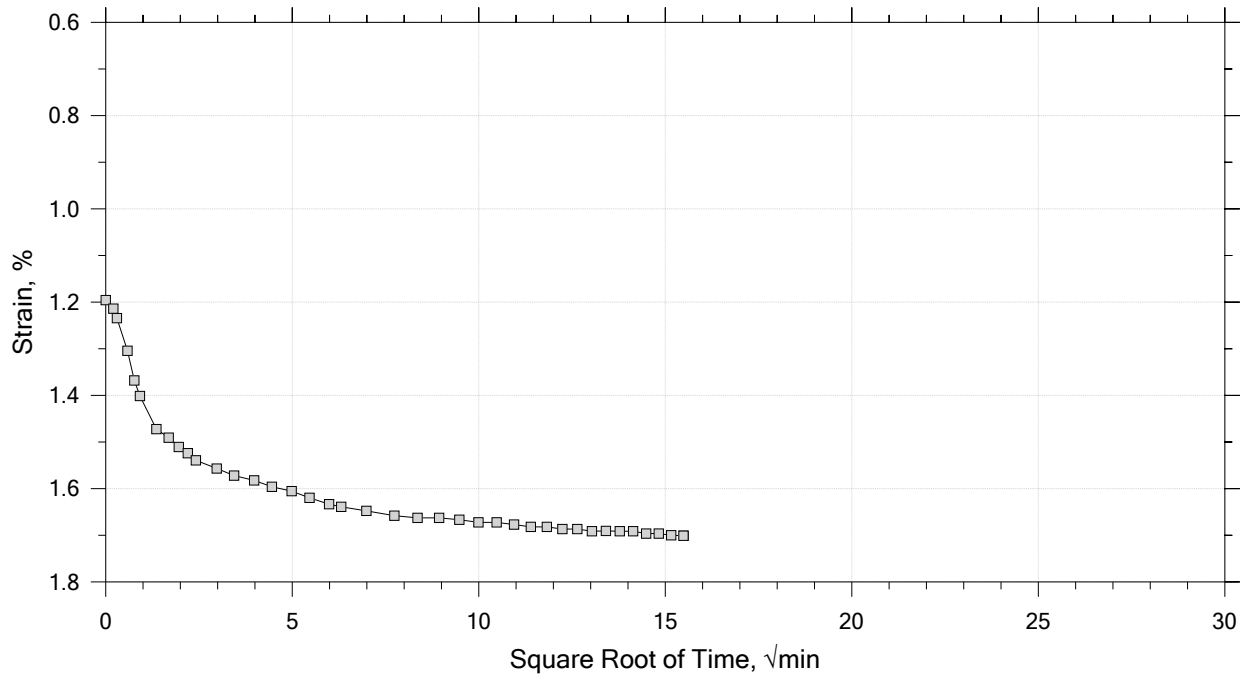


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 3 of 16
Constant Load Step
Stress: 0.25 tsf

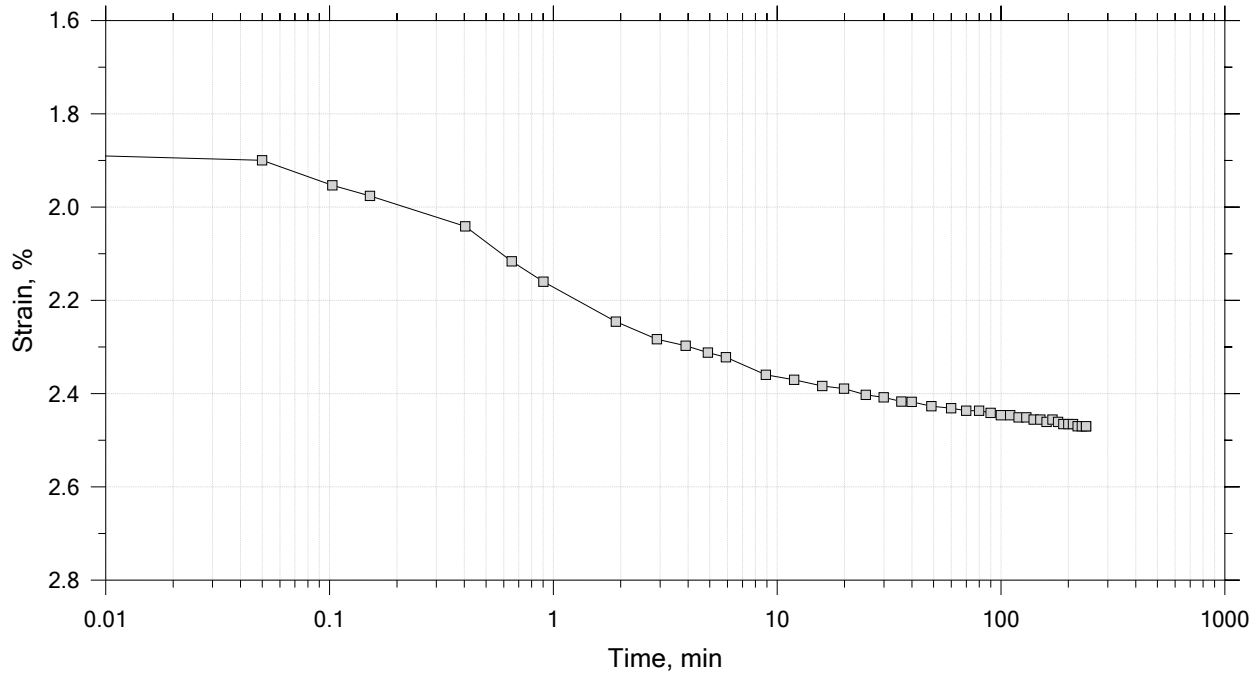


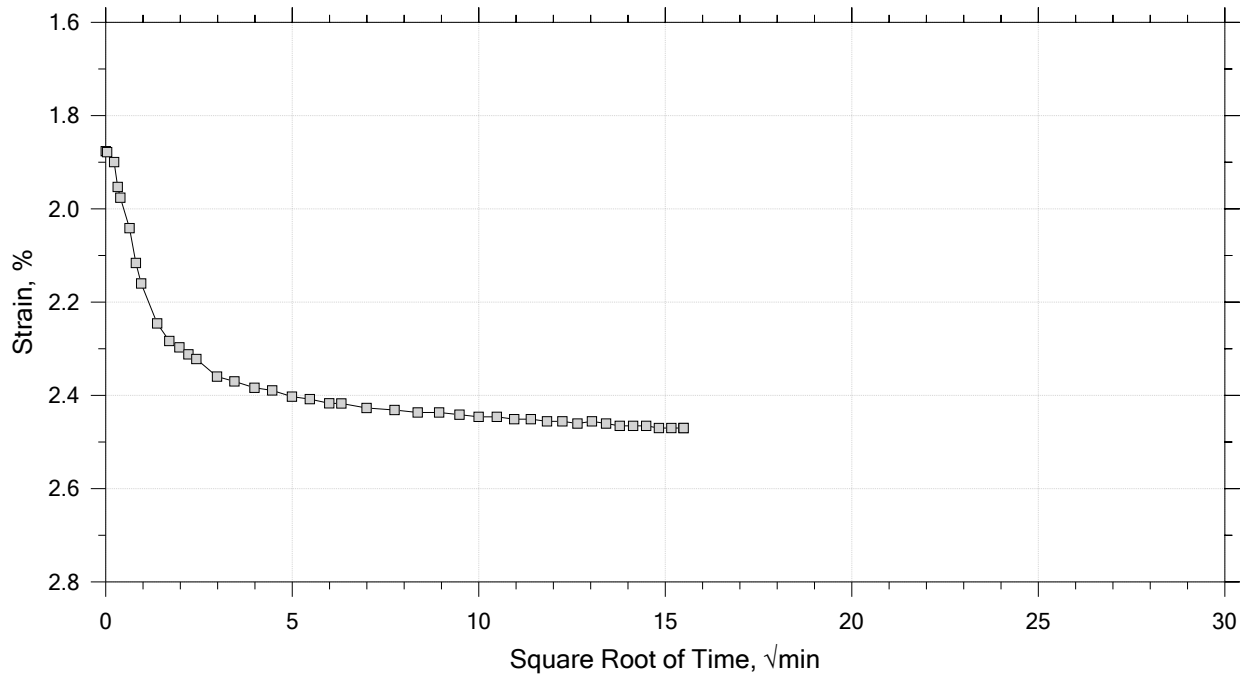


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 4 of 16
Constant Load Step
Stress: 0.5 tsf

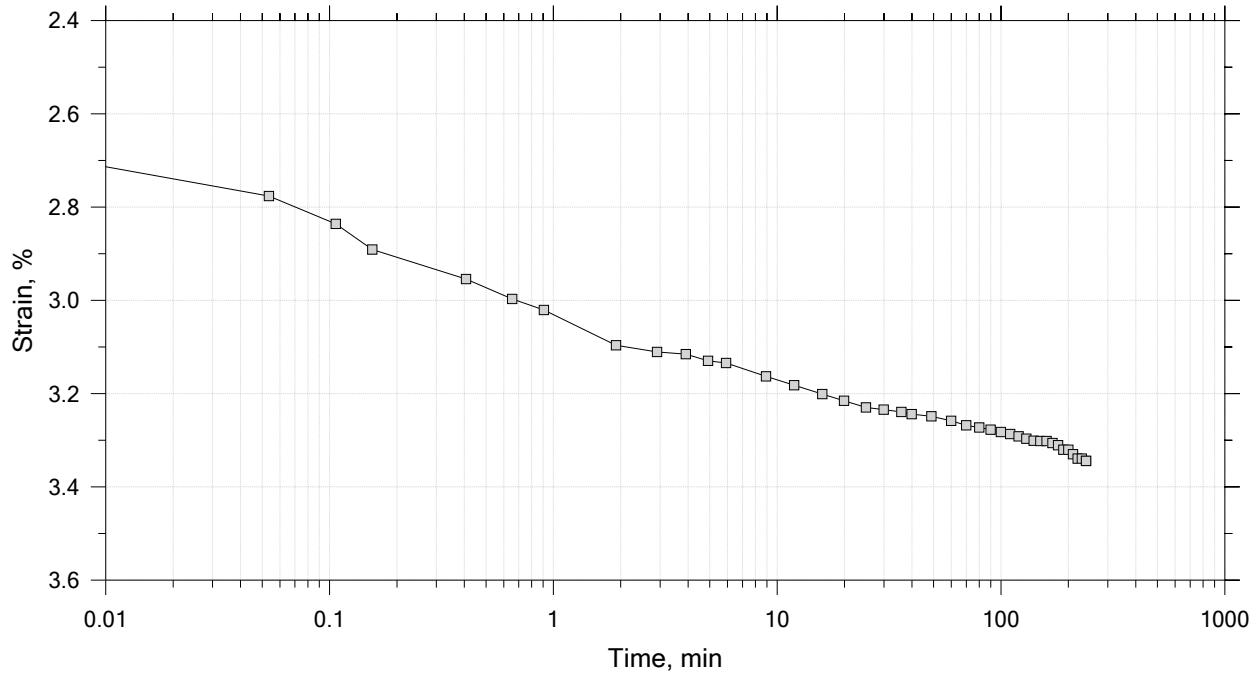


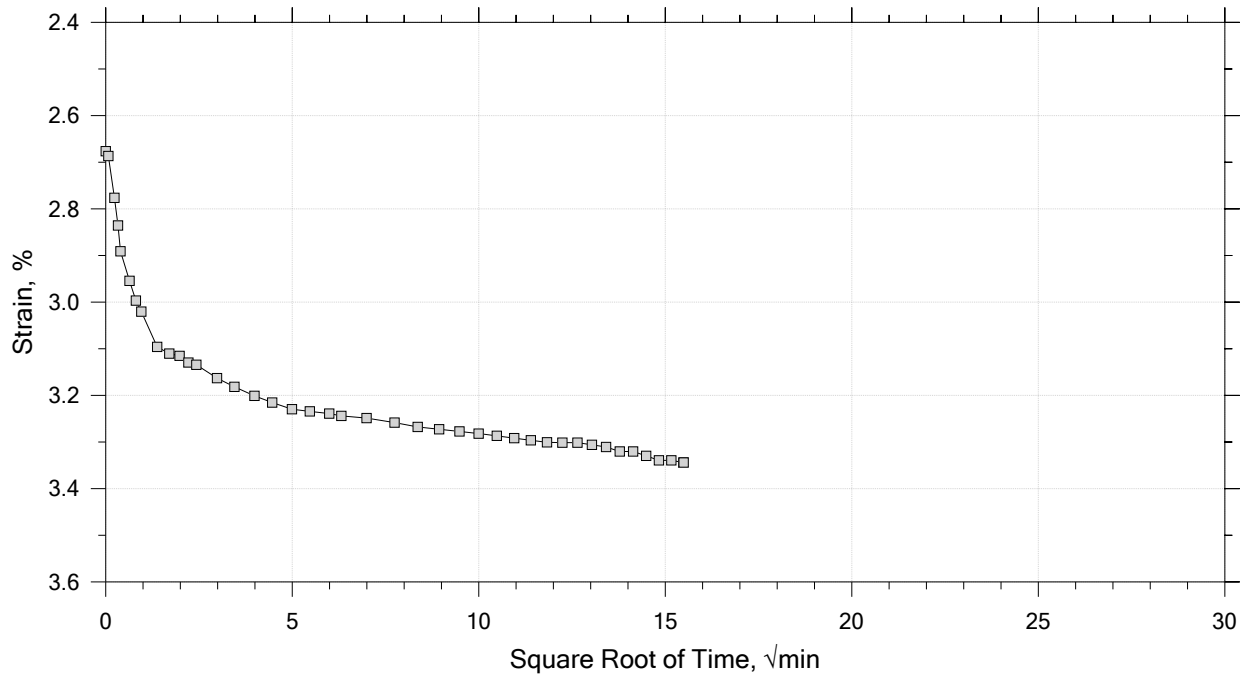


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 5 of 16
Constant Load Step
Stress: 1 tsf

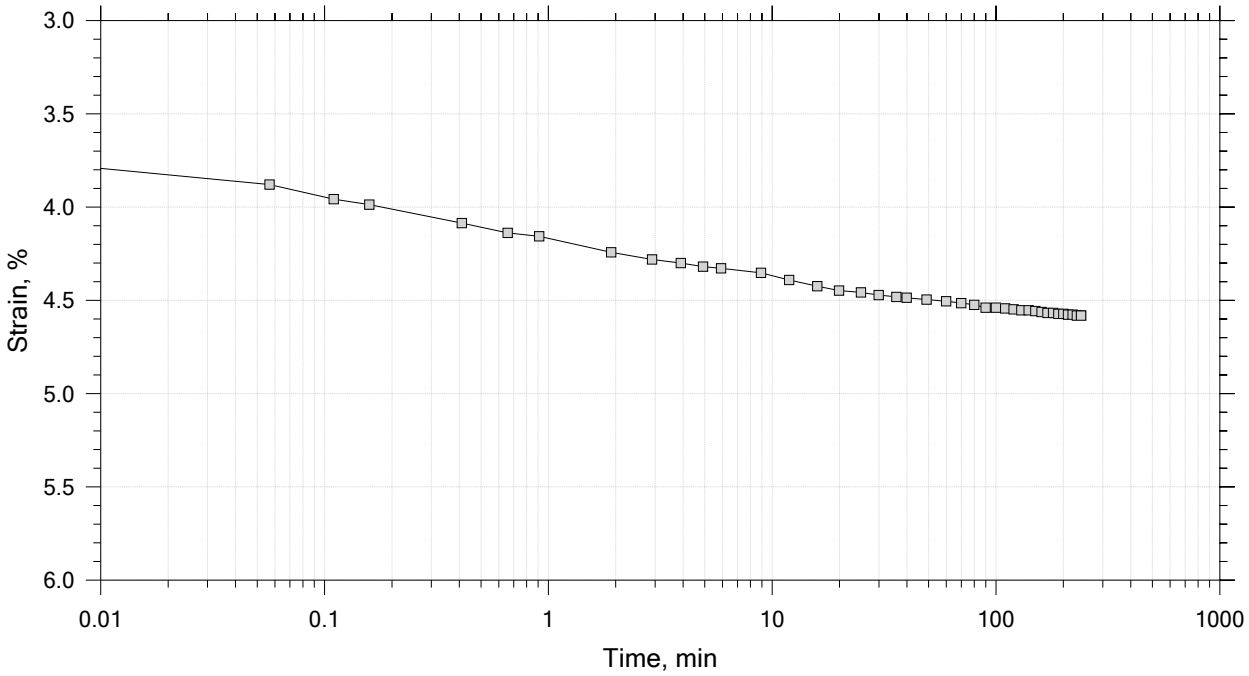


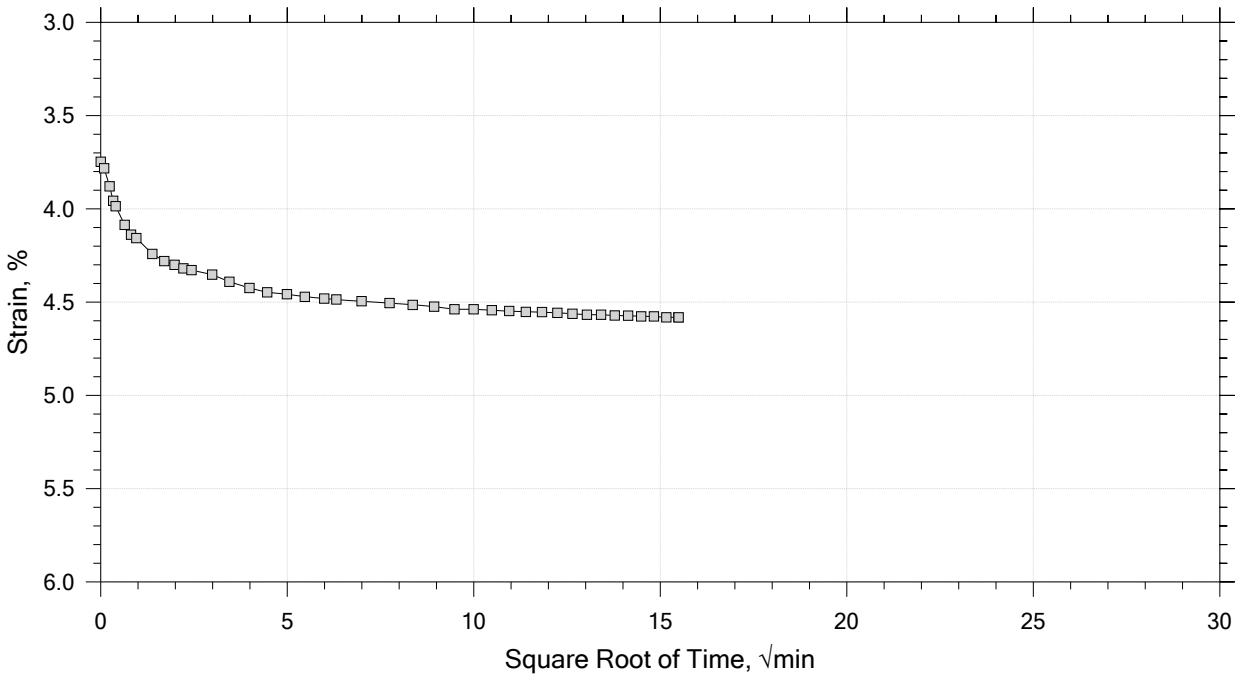


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 6 of 16
Constant Load Step
Stress: 2 tsf

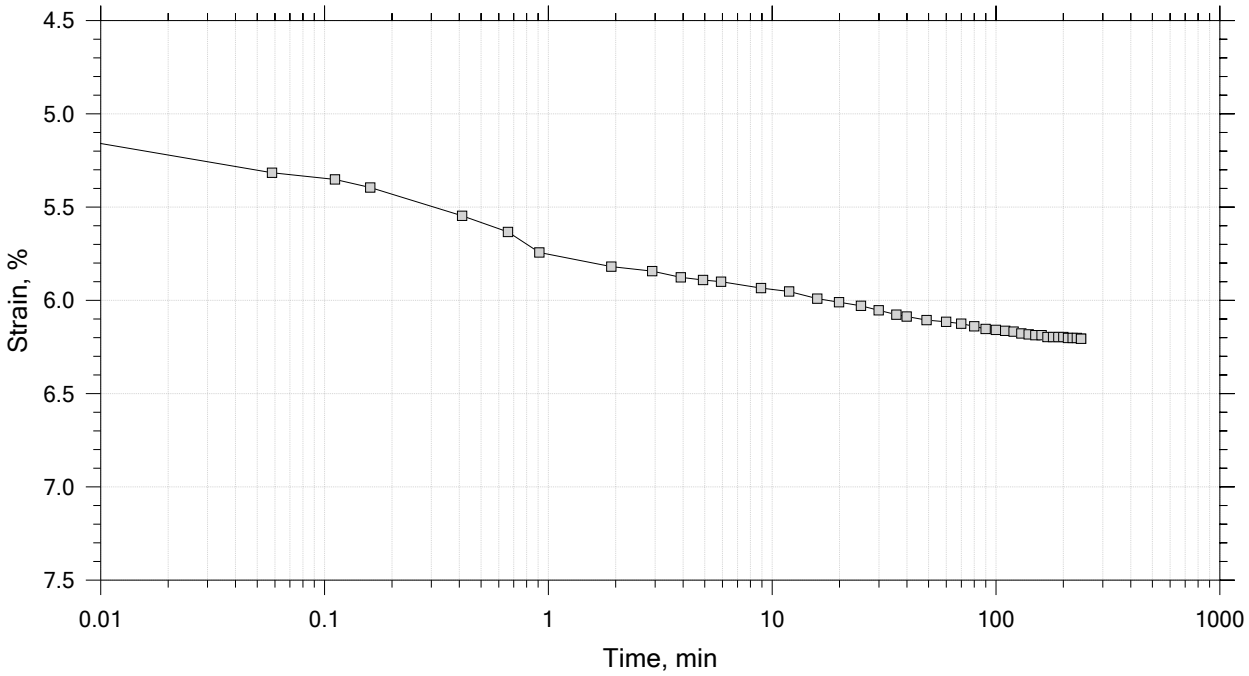


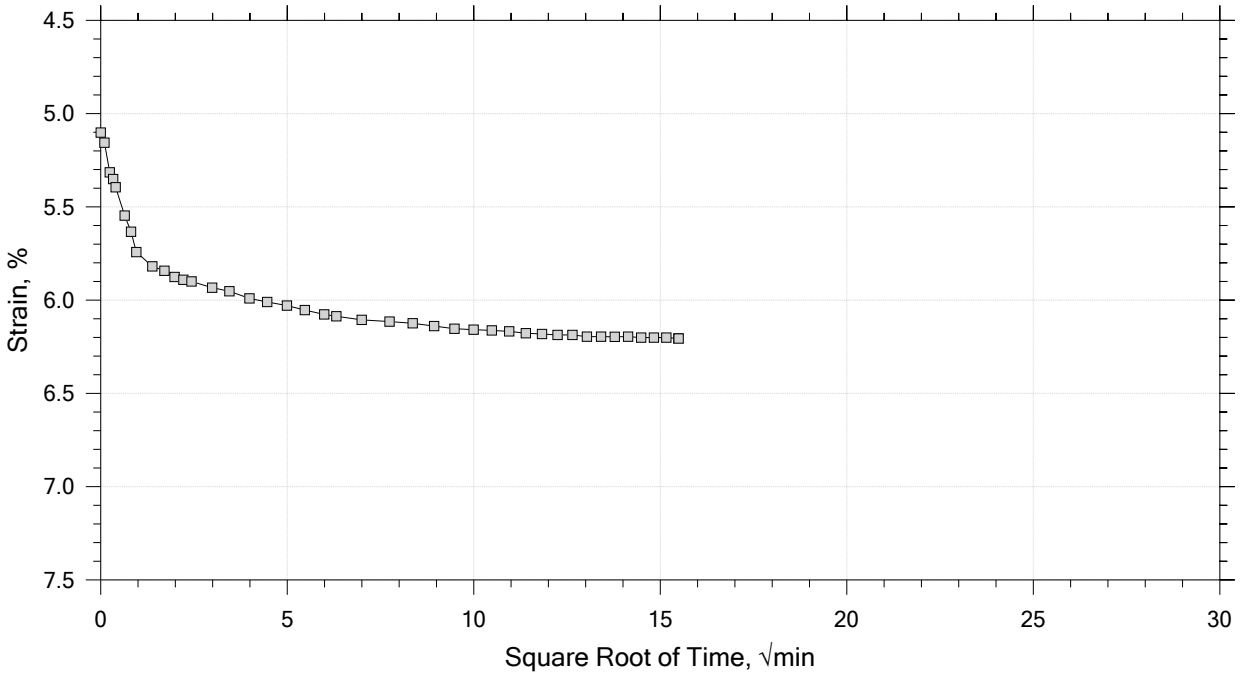


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 7 of 16
Constant Load Step
Stress: 4 tsf

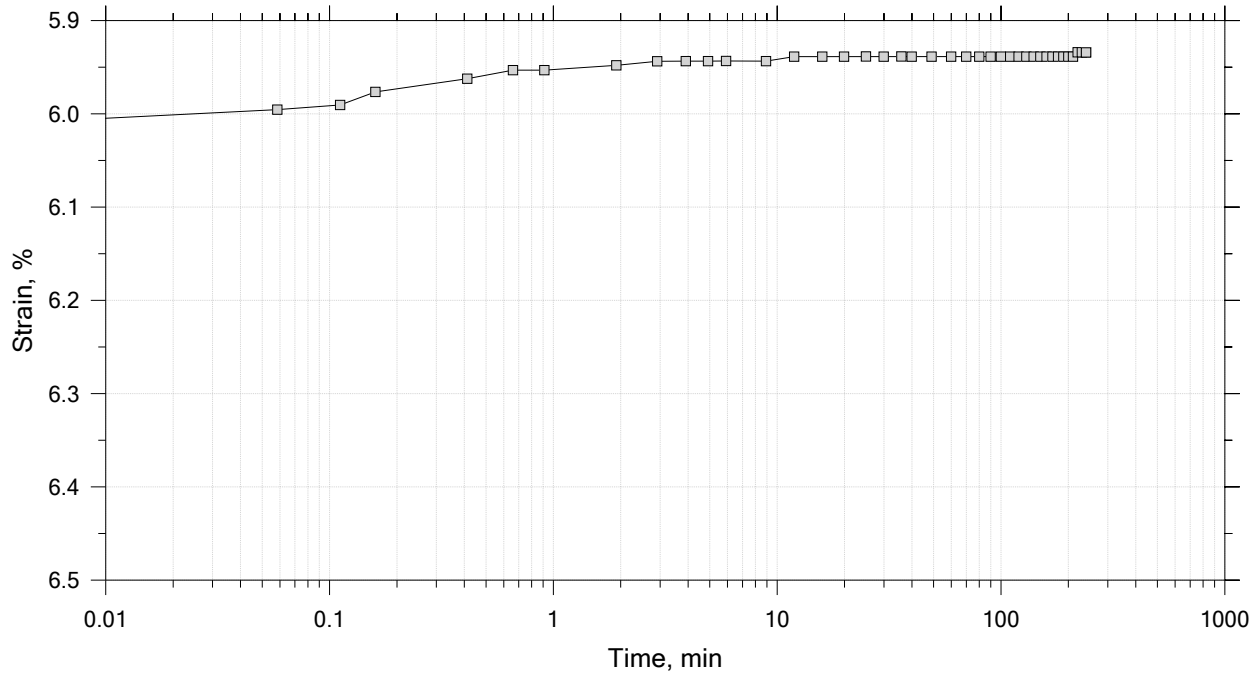


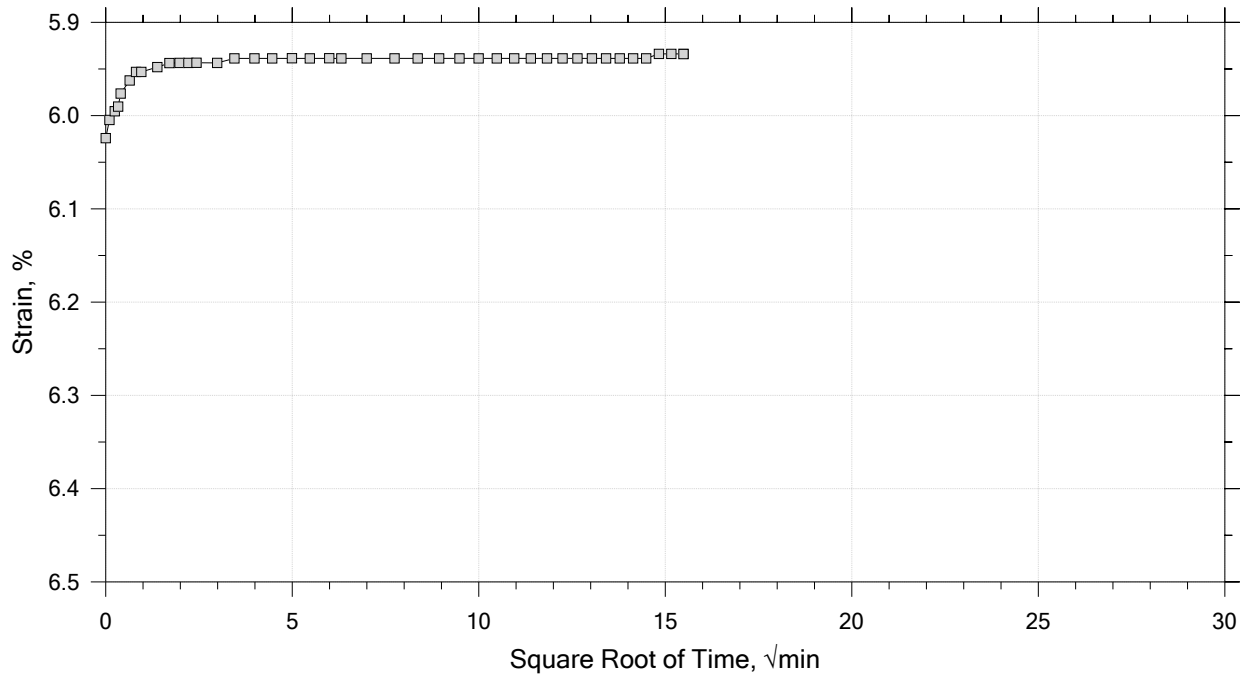


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 8 of 16
Constant Load Step
Stress: 2 tsf

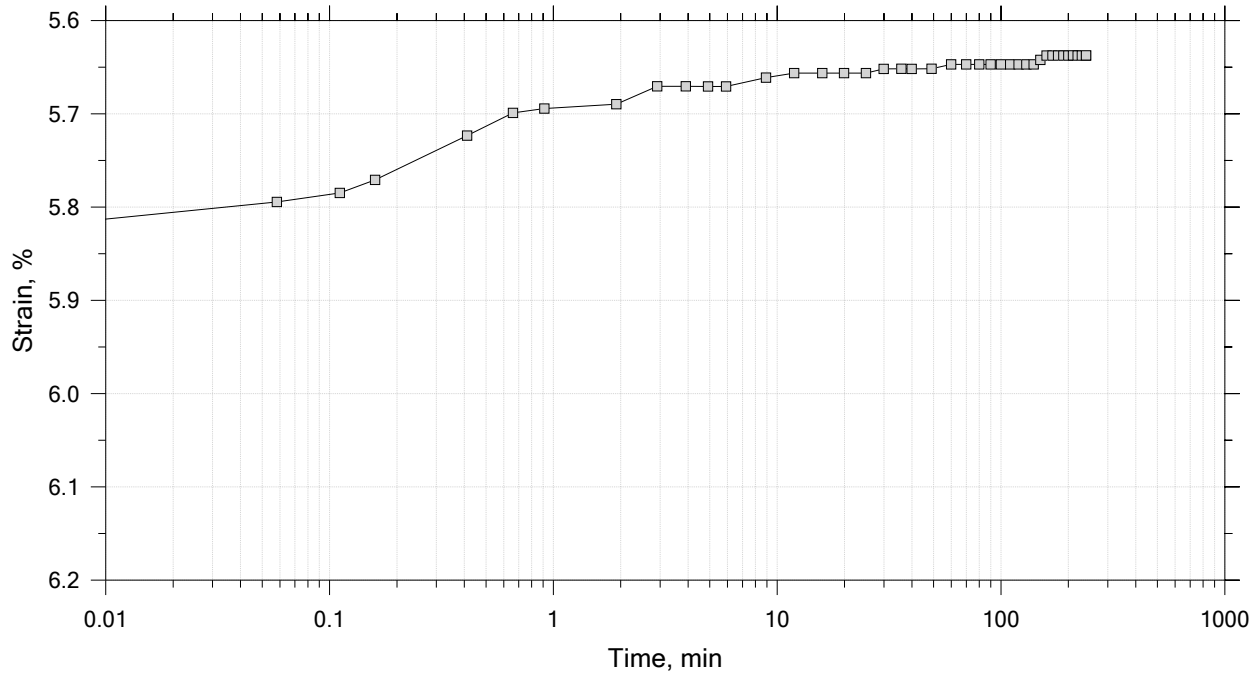


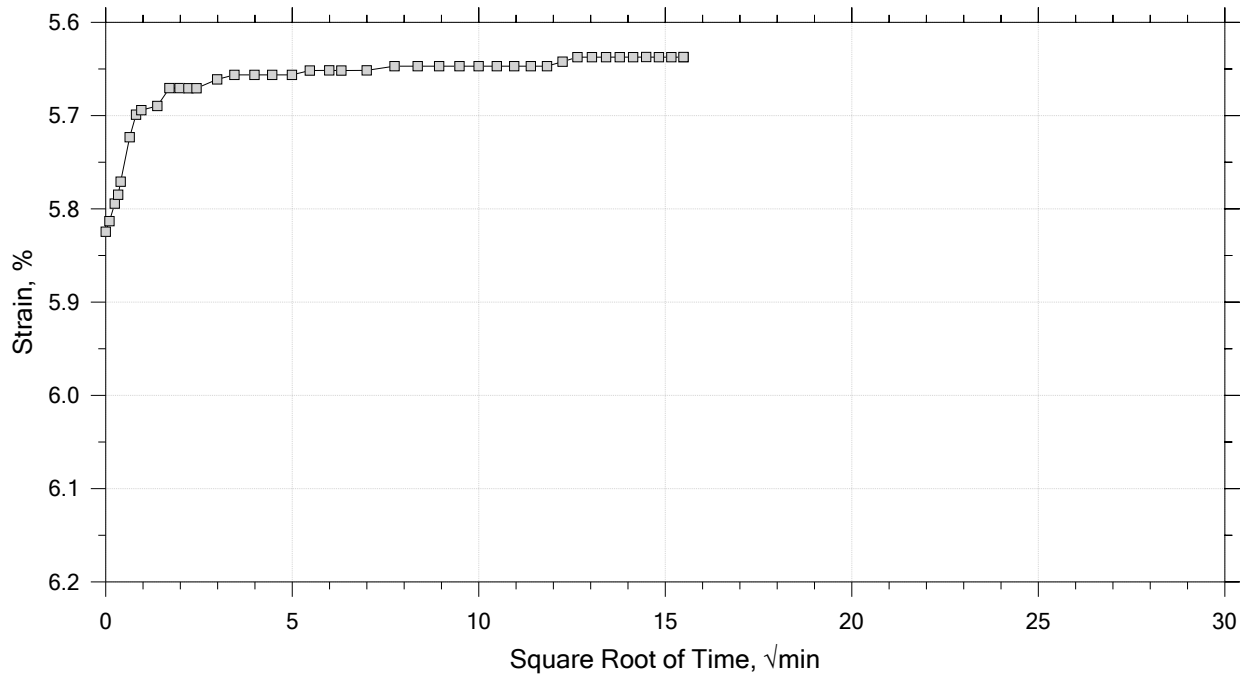


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 9 of 16
Constant Load Step
Stress: 1 tsf

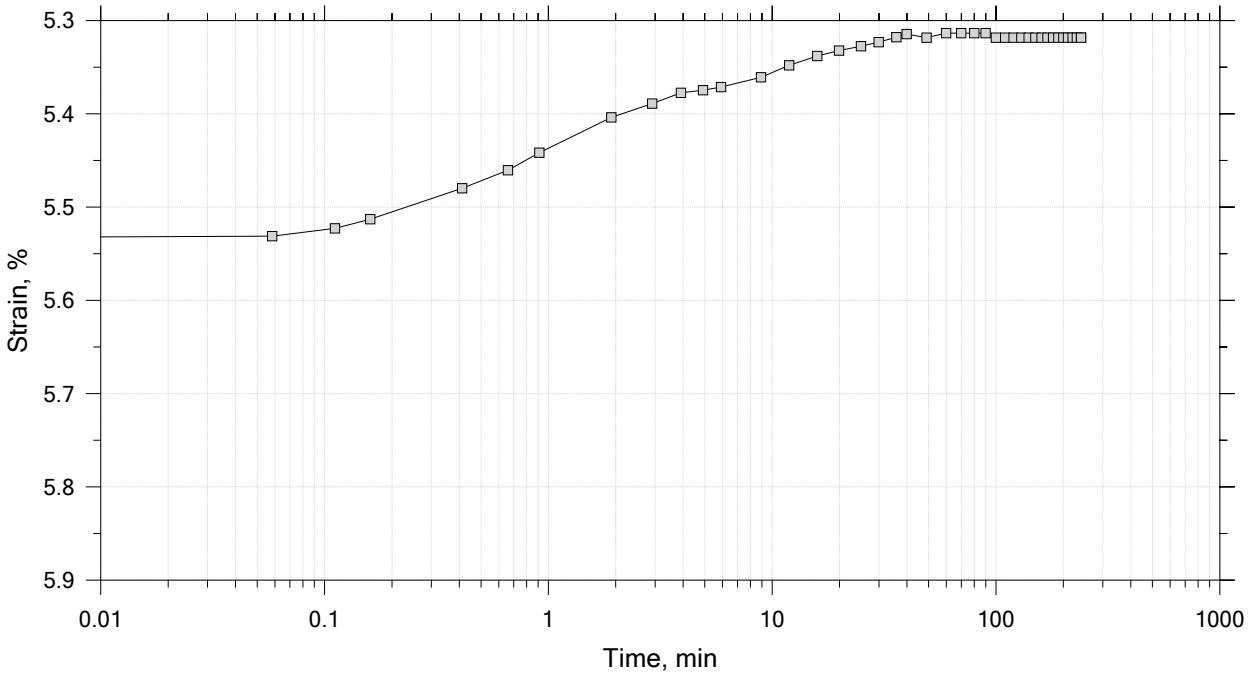


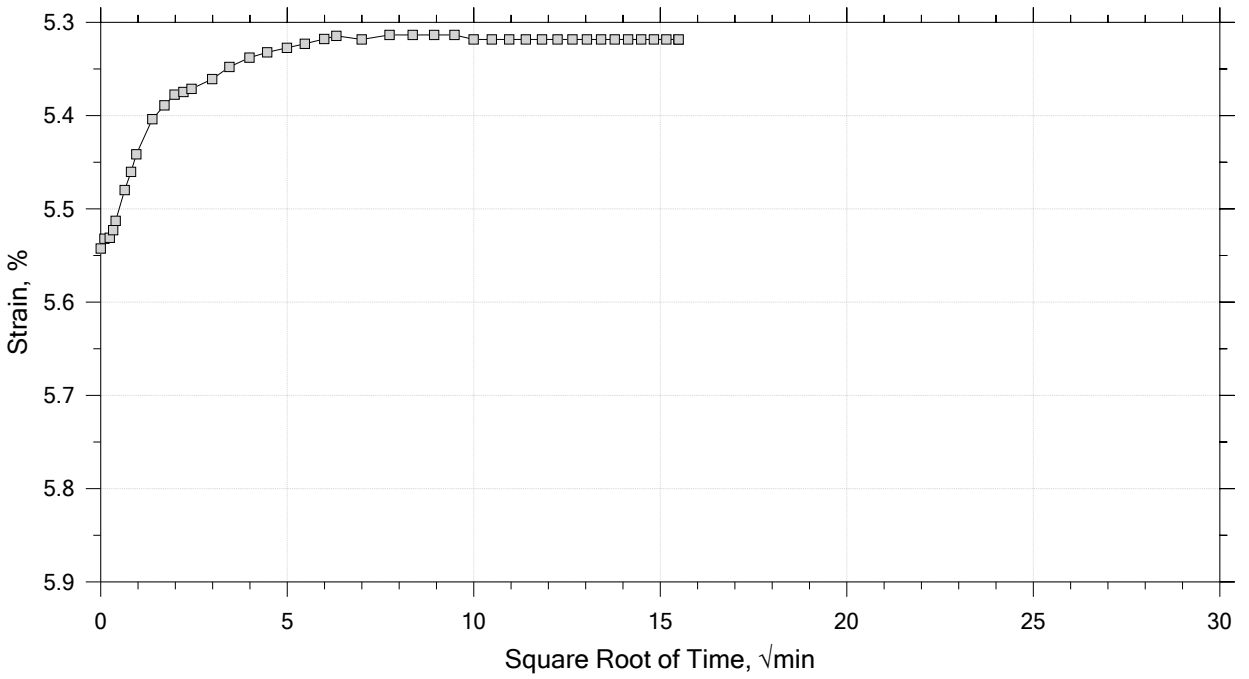


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 10 of 16
Constant Load Step
Stress: 0.5 tsf

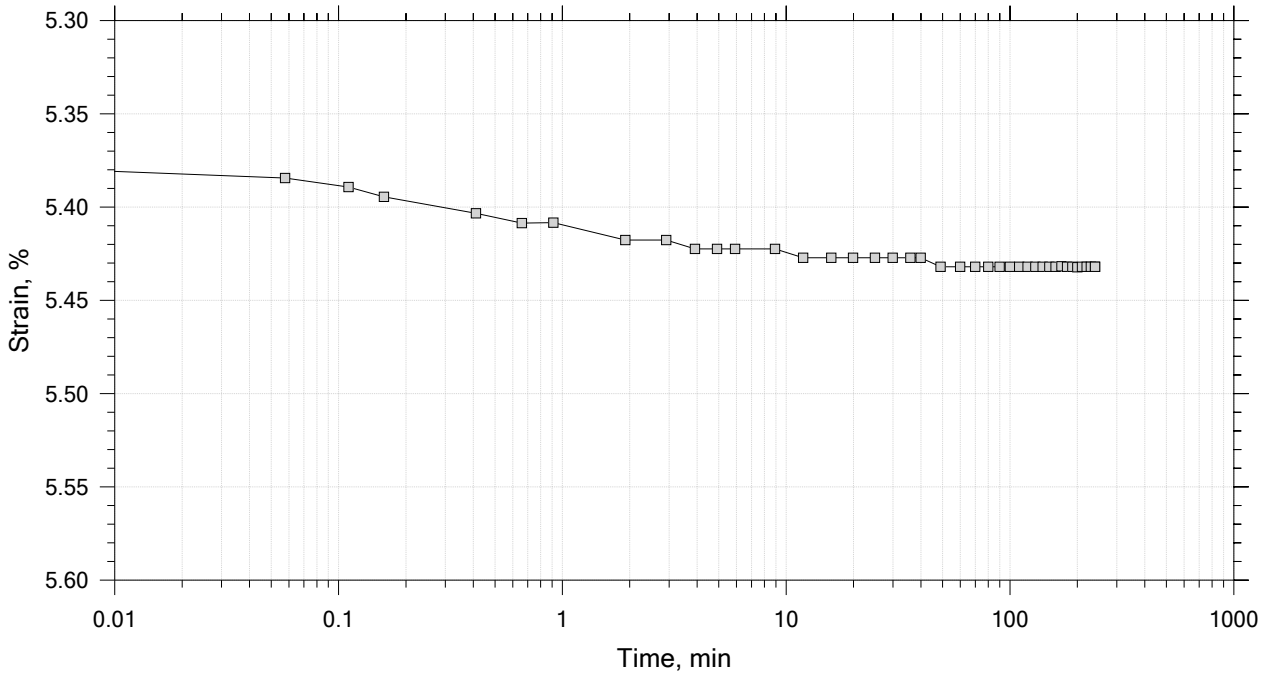


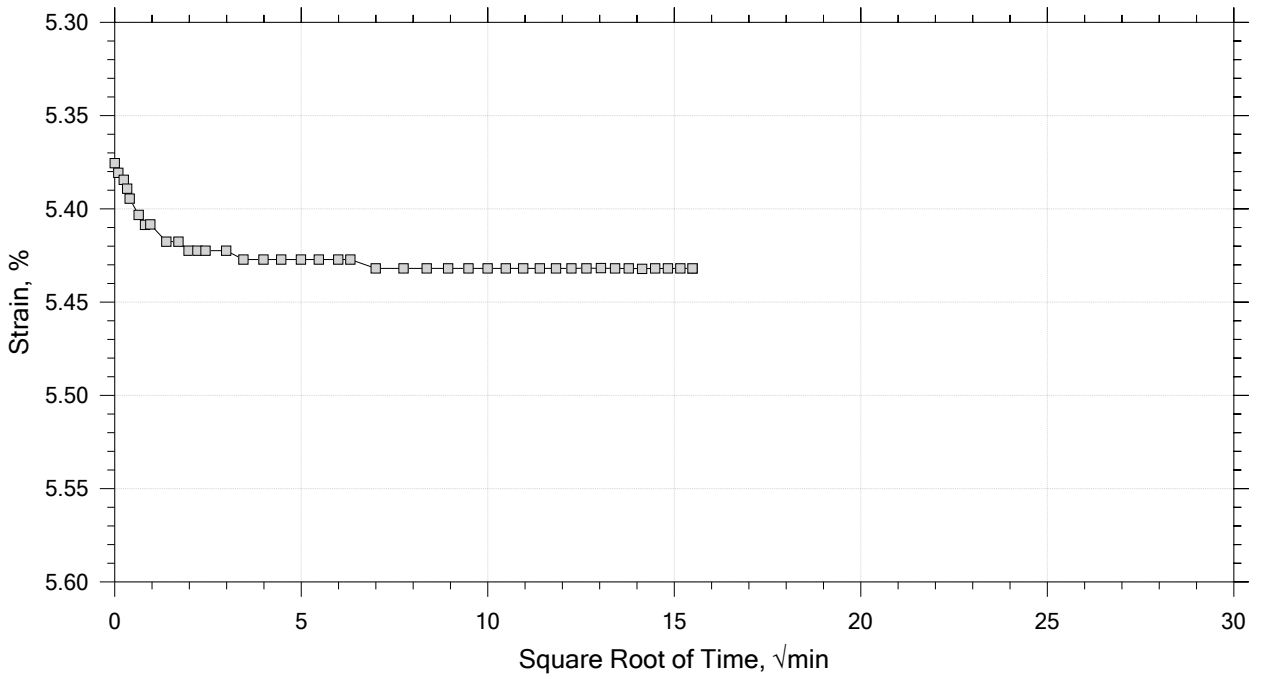


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 11 of 16
Constant Load Step
Stress: 1 tsf

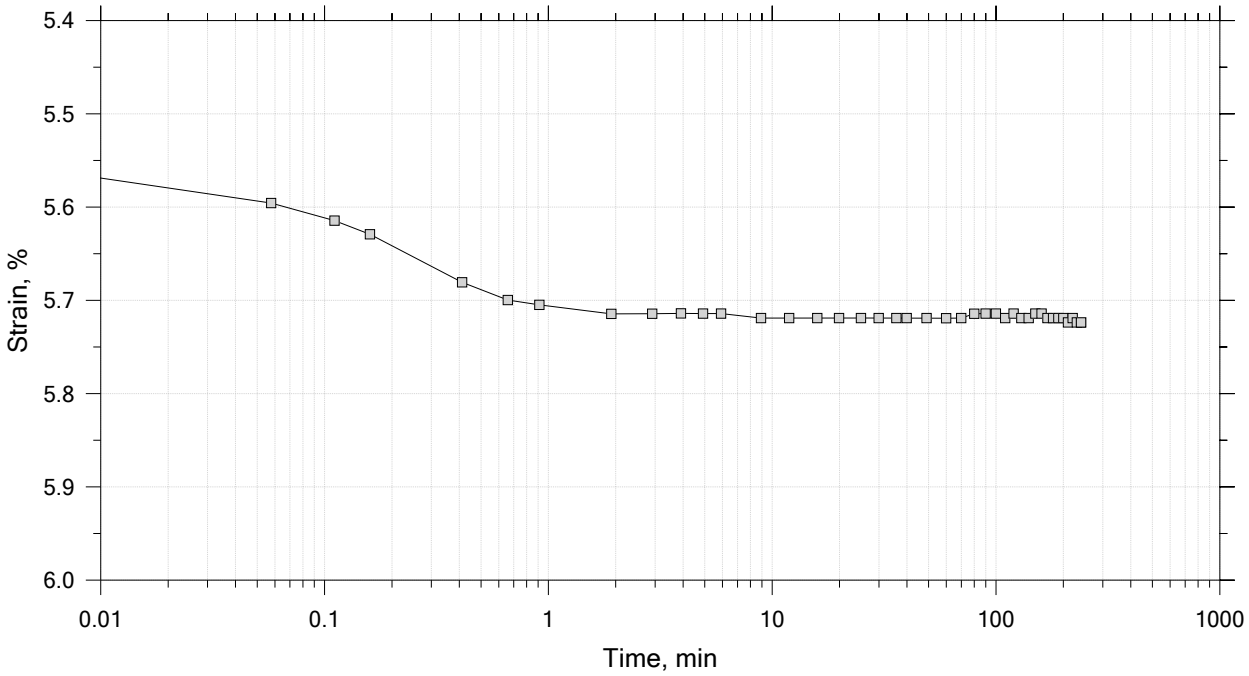


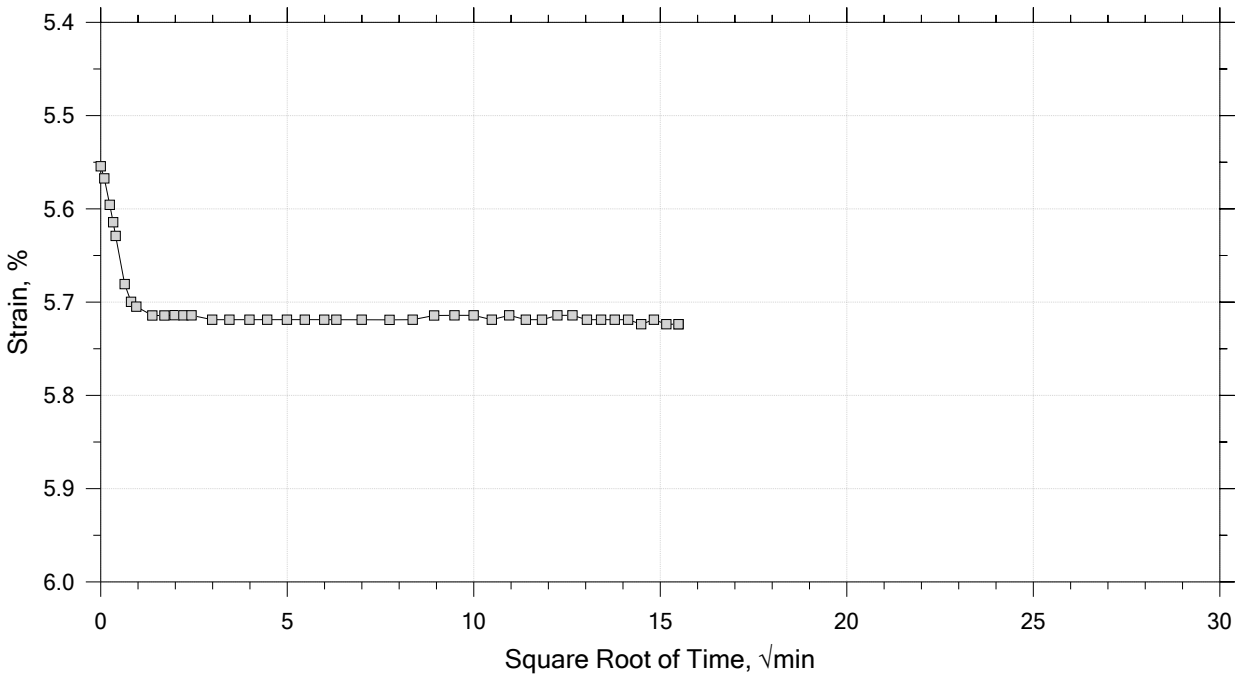


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 12 of 16
Constant Load Step
Stress: 2 tsf

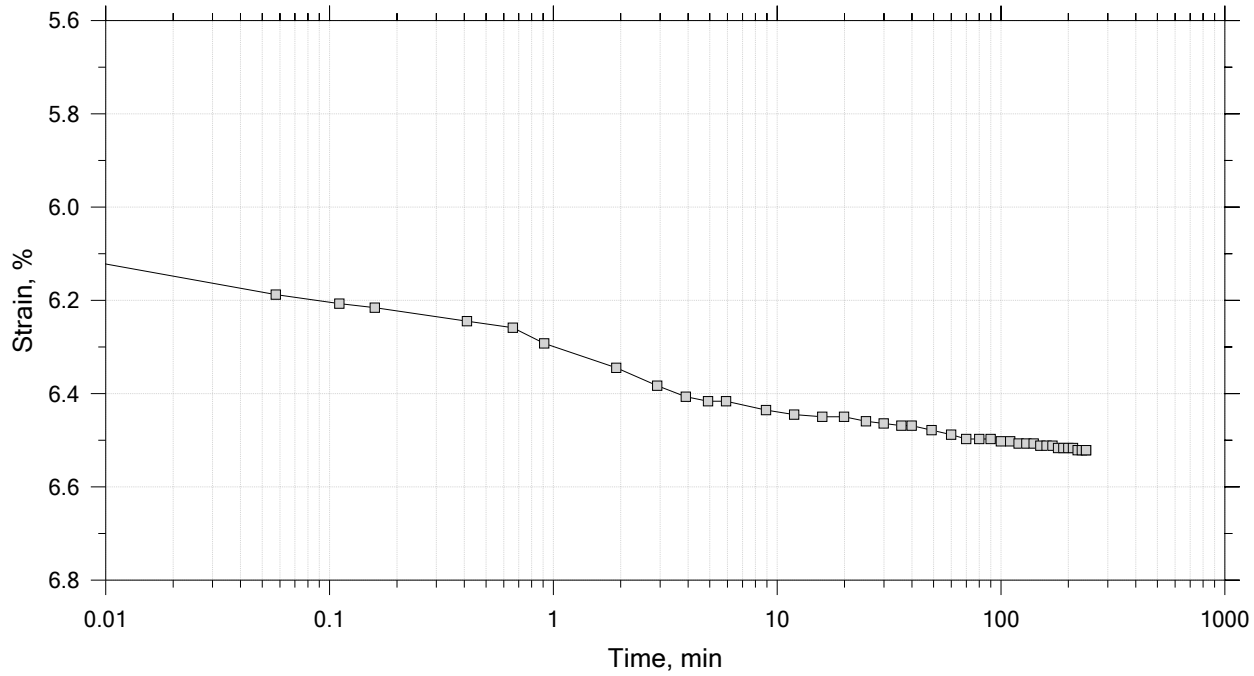


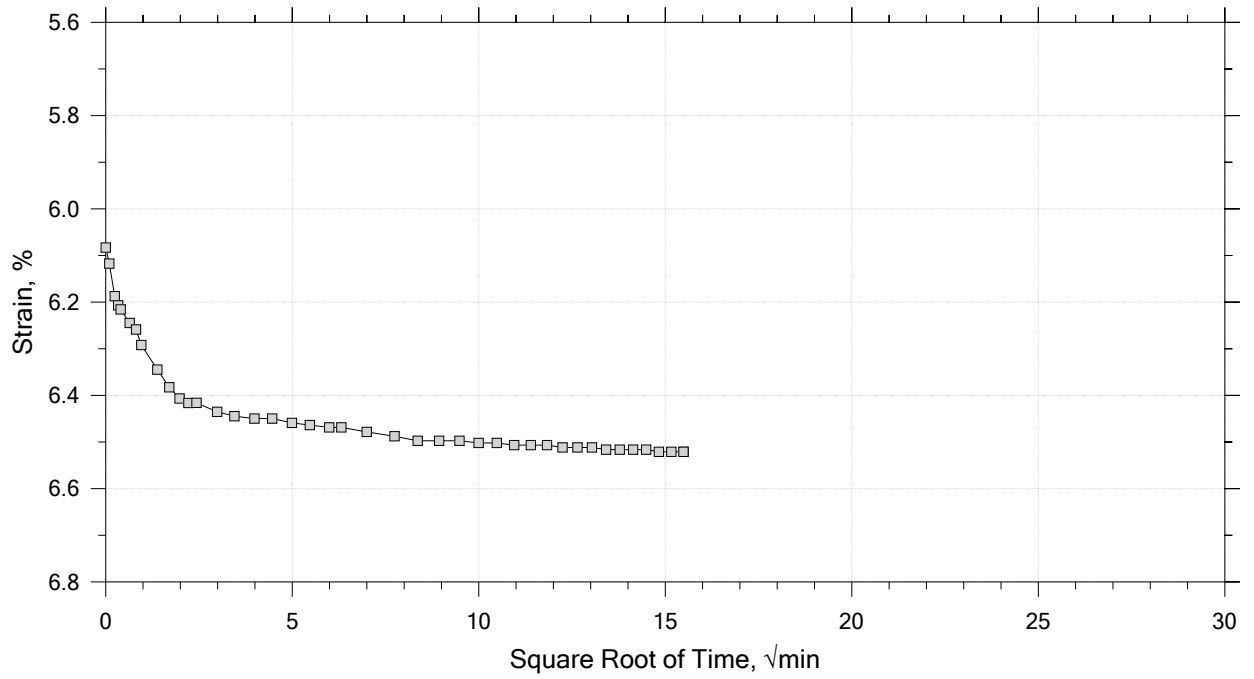


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 13 of 16
Constant Load Step
Stress: 4 tsf

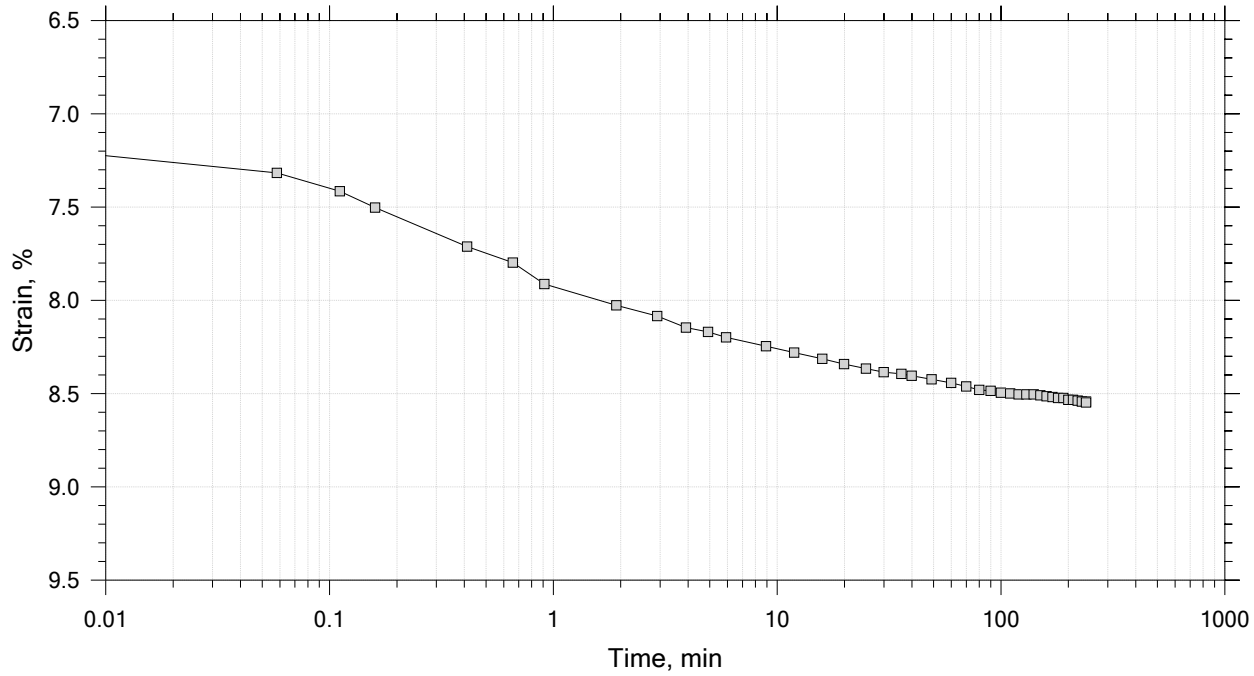


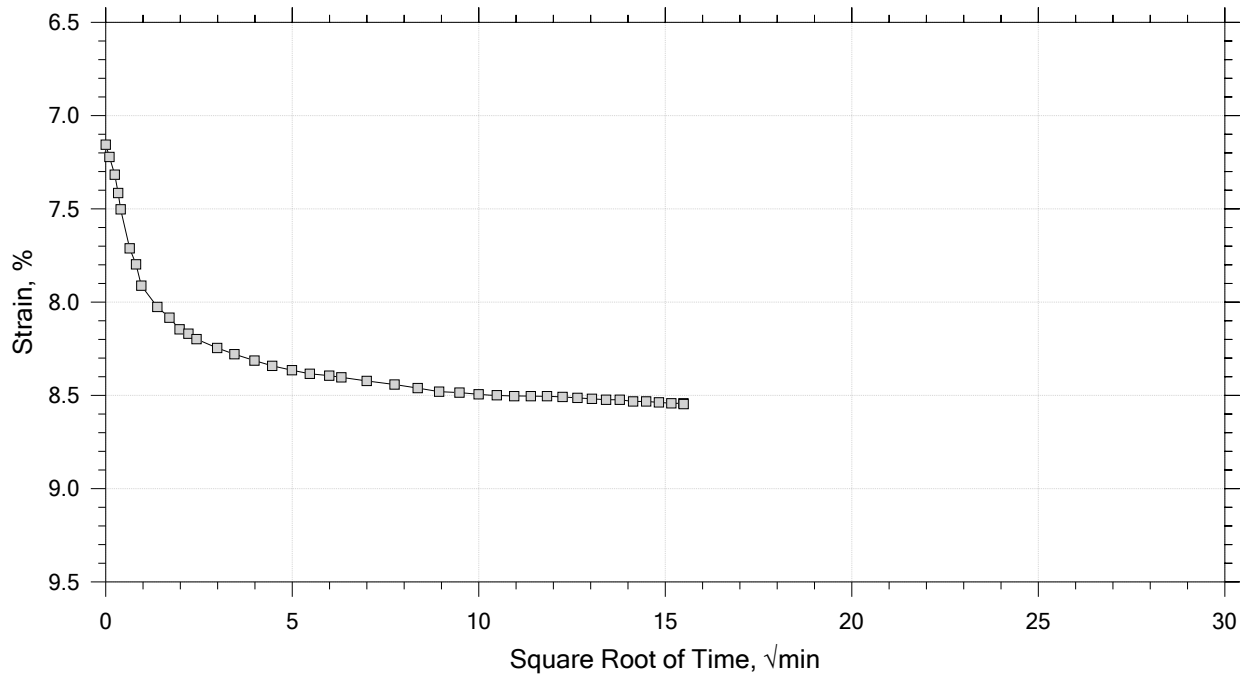


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 14 of 16
Constant Load Step
Stress: 8 tsf

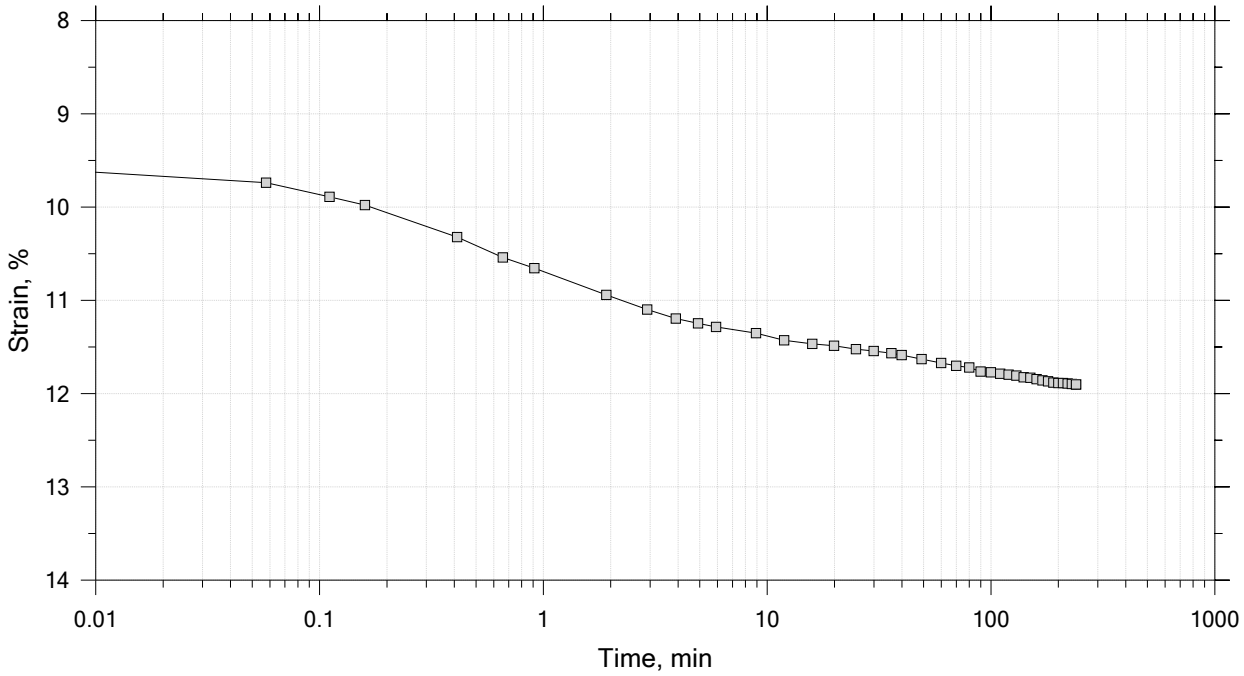


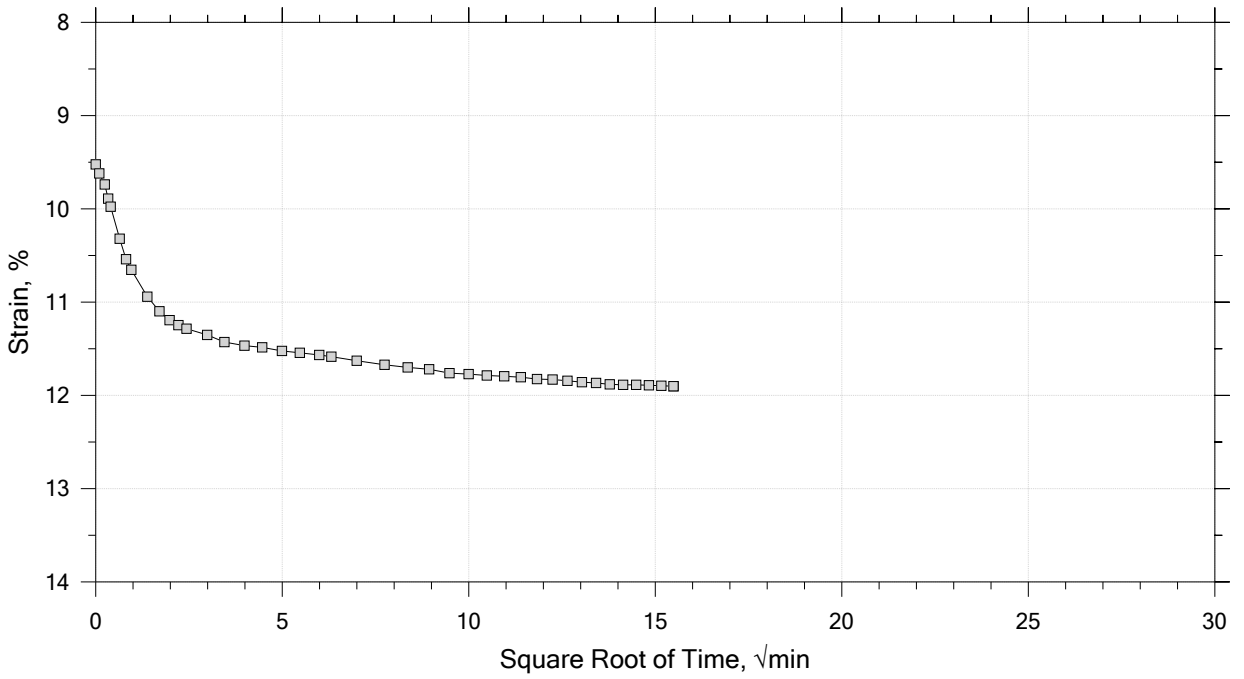


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 15 of 16
Constant Load Step
Stress: 16 tsf

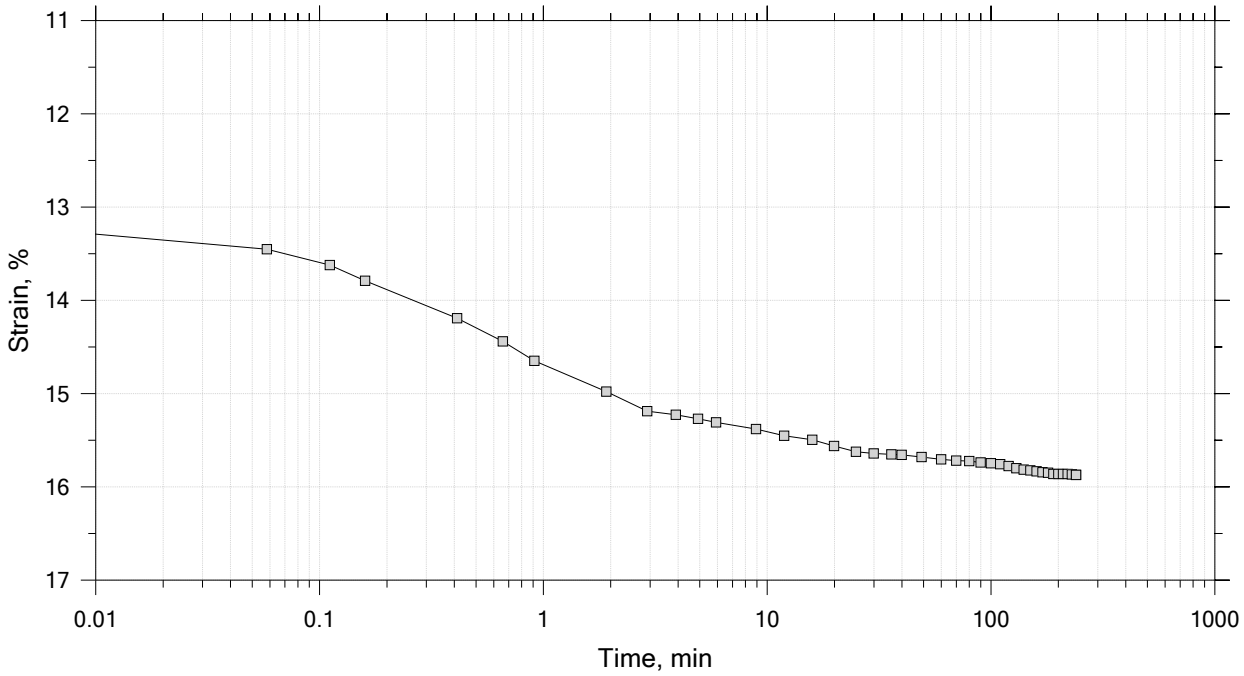


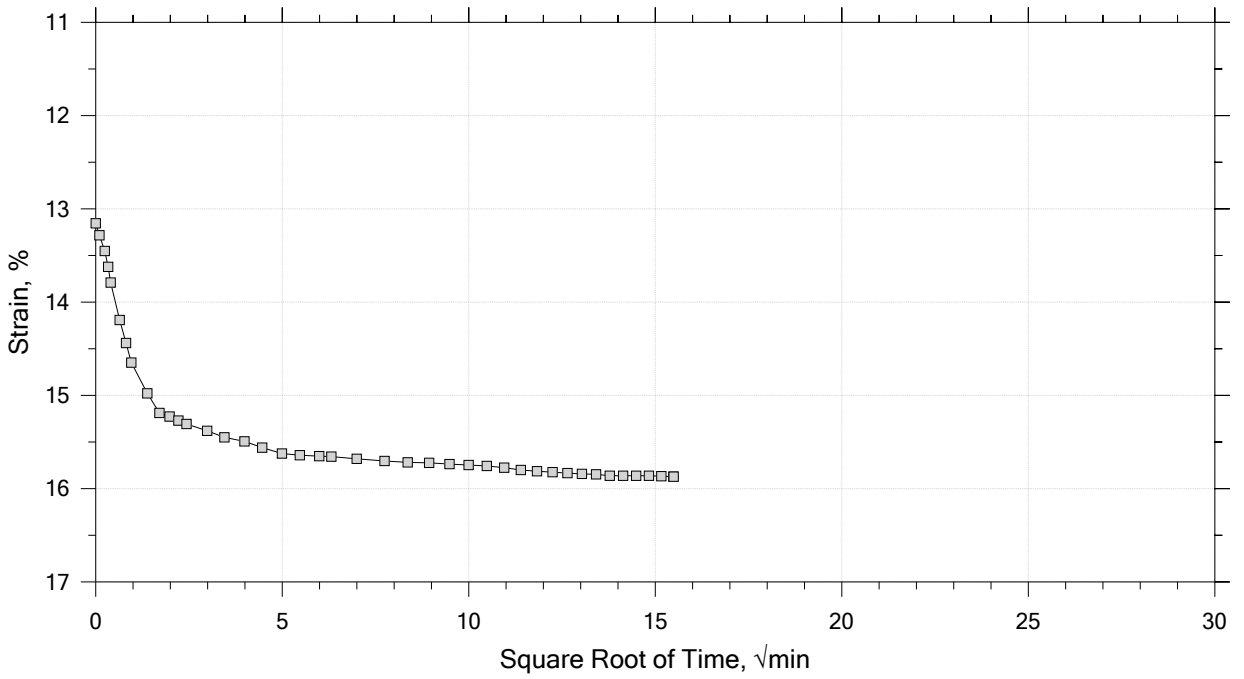


GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 16 of 16
Constant Load Step
Stress: 32 tsf





GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Specimen Diameter: 2.50 in	Estimated Specific Gravity: 2.78	Liquid Limit: 29
Initial Height: 1.00 in	Initial Void Ratio: 0.904	Plastic Limit: 18
Final Height: 0.84 in	Final Void Ratio: 0.602	Plasticity Index: 11

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	D2548	RING		A-2425
Mass Container, gm	8.31	106.46	106.46	8.19
Mass Container + Wet Soil, gm	192.31	257.93	249.27	148.73
Mass Container + Dry Soil, gm	143.3	223.85	223.85	123.71
Mass Dry Soil, gm	134.99	117.39	117.39	115.52
Water Content, %	36.31	29.04	21.66	21.66
Void Ratio	---	0.90	0.60	---
Degree of Saturation, %	---	89.25	100.00	---
Dry Unit Weight, pcf	---	91.101	108.29	---

Note: Specific Gravity and Void Ratios are calculated assuming the degree of saturation equals 100% at the end of the test. Therefore, values may not represent actual values for the specimen.

GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Log of Time Coefficients

Step	Applied Stress tsf	Final Displacement in	Void Ratio	Strain at End %	Log T50 min	Cv ft²/s	Mv 1/tsf	k ft/day	Ca %
1	0.0668	0.003617	0.897	0.362	1.000	5.68e-06	5.41e-02	8.29e-04	0.00e+00
2	0.125	0.007270	0.890	0.727	0.000	0.00e+00	6.28e-02	0.00e+00	0.00e+00
3	0.250	0.01701	0.872	1.70	0.940	5.92e-06	7.79e-02	1.24e-03	0.00e+00
4	0.500	0.02470	0.857	2.47	0.782	6.99e-06	3.08e-02	5.80e-04	0.00e+00
5	1.00	0.03344	0.840	3.34	0.000	0.00e+00	1.75e-02	0.00e+00	0.00e+00
6	2.00	0.04582	0.817	4.58	0.514	1.02e-05	1.24e-02	3.42e-04	0.00e+00
7	4.00	0.06206	0.786	6.21	0.481	1.06e-05	8.12e-03	2.33e-04	0.00e+00
8	2.00	0.05934	0.791	5.93	0.000	0.00e+00	1.36e-03	0.00e+00	0.00e+00
9	1.00	0.05637	0.797	5.64	0.000	0.00e+00	2.97e-03	0.00e+00	0.00e+00
10	0.500	0.05318	0.803	5.32	0.000	0.00e+00	6.38e-03	0.00e+00	0.00e+00
11	1.00	0.05432	0.801	5.43	0.000	0.00e+00	2.27e-03	0.00e+00	0.00e+00
12	2.00	0.05724	0.795	5.72	0.000	0.00e+00	2.92e-03	0.00e+00	0.00e+00
13	4.00	0.06521	0.780	6.52	1.122	4.48e-06	3.99e-03	4.81e-05	0.00e+00
14	8.00	0.08547	0.741	8.55	0.656	7.43e-06	5.06e-03	1.01e-04	0.00e+00
15	16.0	0.1190	0.677	11.9	0.704	6.52e-06	4.19e-03	7.38e-05	0.00e+00
16	32.0	0.1587	0.602	15.9	0.718	5.89e-06	2.48e-03	3.94e-05	0.00e+00

GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		
	Displacement at End of Increment		

One-Dimensional Consolidation by ASTM D2435 - Method B

Square Root of Time Coefficients

Step	Applied Stress tsf	Final Displacement in	Void Ratio	Strain at End %	Sq.Rt. T90 min	Cv ft²/s	Mv 1/tsf	k ft/day
1	0.0668	0.003617	0.897	0.362	5.450	4.49e-06	5.41e-02	6.55e-04
2	0.125	0.007270	0.890	0.727	3.548	6.84e-06	6.28e-02	1.16e-03
3	0.250	0.01701	0.872	1.70	8.243	2.90e-06	7.79e-02	6.10e-04
4	0.500	0.02470	0.857	2.47	4.283	5.49e-06	3.08e-02	4.56e-04
5	1.00	0.03344	0.840	3.34	6.981	3.31e-06	1.75e-02	1.56e-04
6	2.00	0.04582	0.817	4.58	7.085	3.19e-06	1.24e-02	1.07e-04
7	4.00	0.06206	0.786	6.21	5.085	4.32e-06	8.12e-03	9.46e-05
8	2.00	0.05934	0.791	5.93	1.618	1.34e-05	1.36e-03	4.91e-05
9	1.00	0.05637	0.797	5.64	1.641	1.33e-05	2.97e-03	1.06e-04
10	0.500	0.05318	0.803	5.32	5.358	4.09e-06	6.38e-03	7.04e-05
11	1.00	0.05432	0.801	5.43	1.910	1.15e-05	2.27e-03	7.05e-05
12	2.00	0.05724	0.795	5.72	1.622	1.35e-05	2.92e-03	1.06e-04
13	4.00	0.06521	0.780	6.52	3.907	5.53e-06	3.99e-03	5.95e-05
14	8.00	0.08547	0.741	8.55	4.346	4.83e-06	5.06e-03	6.59e-05
15	16.0	0.1190	0.677	11.9	4.521	4.37e-06	4.19e-03	4.95e-05
16	32.0	0.1587	0.602	15.9	3.276	5.55e-06	2.48e-03	3.72e-05

GeoTesting EXPRESS	Project: MA DOT	Location: Springfield, MA	Project No.: GTX-309910
	Boring No.: BB-5	Tested By: trm	Checked By: mcm
	Sample No.: ST-4	Test Date: 7/5/19	Depth: 37-39
	Test No.: IP-3B	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System E, Swell Pressure = 0.0668 tsf		
	Displacement at End of Increment		

PO Box 572455 / Salt Lake City UT 84157-2455 / USA
TEL +1 801 262 2448 · FAX +1 801 262 9870 · www.TEi-TS.com

GEOTESTING EXPRESS INCORPORATED
125 NAGOG PARK
ACTON MA 01720-3451
USA

Analysis No.	TS-A1908029
Report Date	26 June 2019
Date Sampled	18 June 2019
Date Received	21 June 2019
Where Sampled	Acton, MA USA
Sampled By	Client

This is to attest that we have examined: Soil for Project Name: MA DOT Armory Street Bridges; Site Location: Springfield, MA; Job Number: GTX-309910

When examined to the applicable requirements of:

ASTM D 512-12 “Standard Test Methods for Chloride Ion in Water” Method B

ASTM D 516 -16 “Standard Test Method for Sulfate Ion in Water”

RESULTS:

ASTM D 512 – Chloride Method B

Sample		Results		Detection Limit
		ppm (mg/kg)	%[1]	
BB-3		22.	0.0022	10.
S-4	10 – 12’			
BB-8A		381.	0.0381	
S-2	25 – 27’			
BB-2A		139.	0.0139	
S-4	35 – 37’			

NOTE: [1]Percent by weight as received

Testing Services analytical Laboratory
3455 South 500 West
Salt Lake City, UT 84115-4234 USA
TEL: +1 801 262 2448
FAX: +1 801 262 9870

CERTIFICATE OF ANALYSIS

ASTM D 516 - Sulfate (soluble)

Sample		Results		Detection Limit
		ppm (mg/kg)	%[1]	
BB-3		12.	0.0012	10.
S-4	10 – 12’			
BB-8A		12.	0.0012	
S-2	25 – 27’			
BB-2A		<10.	<0.0010	
S-4	35 – 37’			

NOTE: [1]Percent by weight as received

END OF ANALYSIS

USEPA Laboratory ID UT00930

Merrill Gee P.E. – Engineer in Charge

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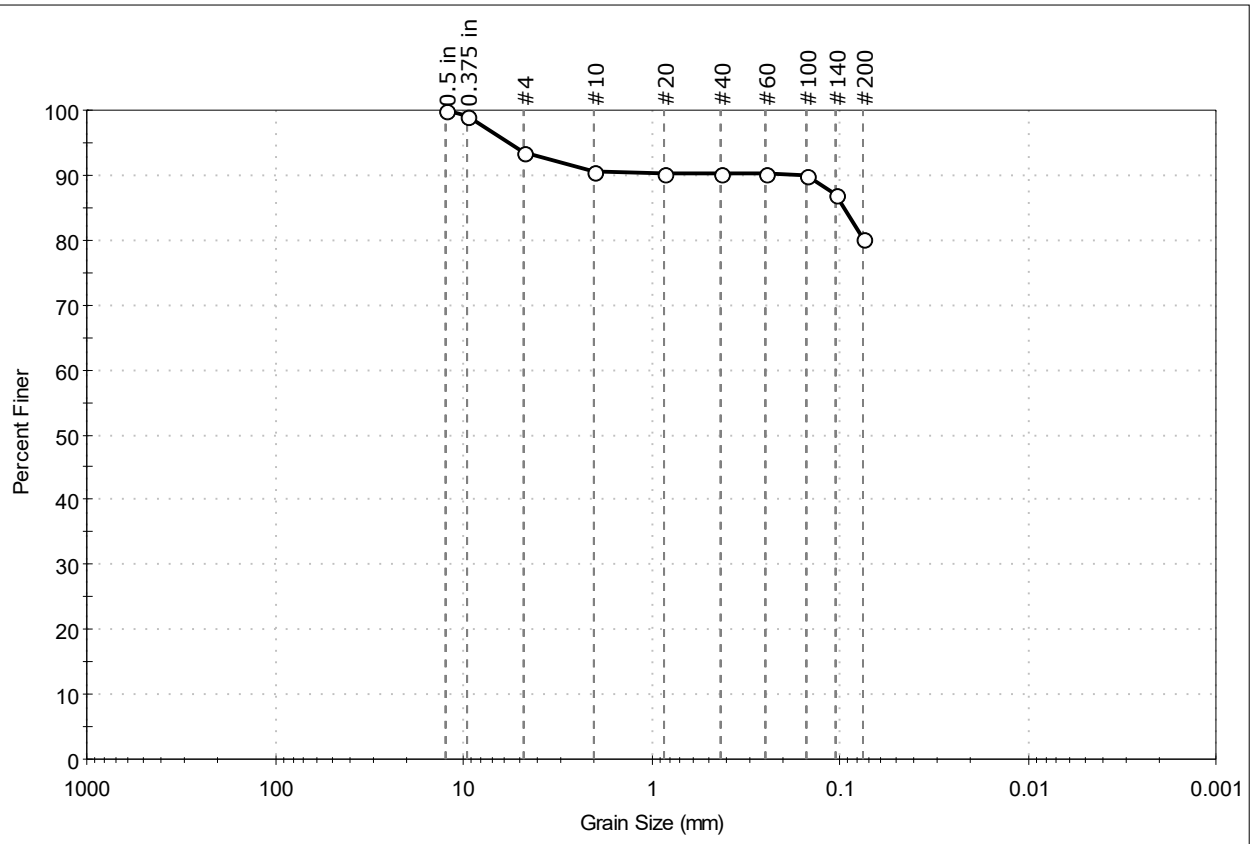
Client:	Nobis Engineering, Inc.				
Project:	MassDOT Armory St Bridges				
Location:	Springfield, MA			Project No:	GTX-316430
Boring ID:	WB-6	Sample Type:	jar	Tested By:	ckg
Sample ID:	S-14	Test Date:	12/05/22	Checked By:	ank
Depth :	59-61'	Test Id:	696501		
Test Comment:	---				
Visual Description:	Moist, gray silt with sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
--	6.6	13.1	80.3

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.5 in	12.50	100		
0.375 in	9.50	99		
#4	4.75	93		
#10	2.00	91		
#20	0.85	90		
#40	0.42	90		
#60	0.25	90		
#100	0.15	90		
#140	0.11	87		
#200	0.075	80		

Coefficients

D_{85} = 0.0956 mm D_{30} = N/A
D_{60} = N/A D_{15} = N/A
D_{50} = N/A D_{10} = N/A
C_u = N/A C_c = N/A

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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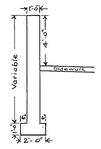
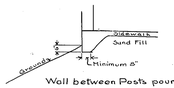
APPENDIX D – Plans Provided by Tetra Tech

Note "B"
Top Surface of all Walls floated Granolithic Paving to comply with specifications for Wearing Surface of Sidewalks

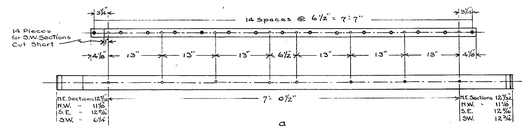
"Section "F"-"F"

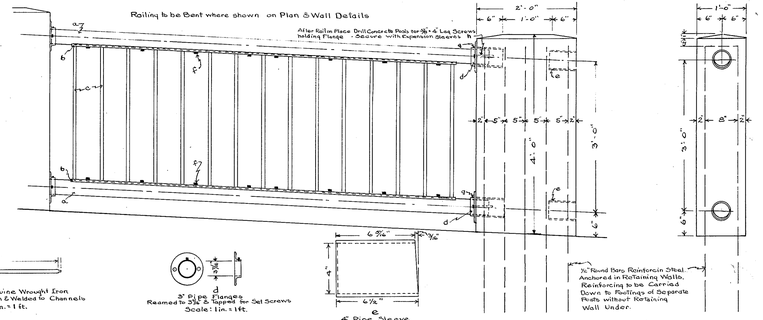


Section "G"-"G" at Posts



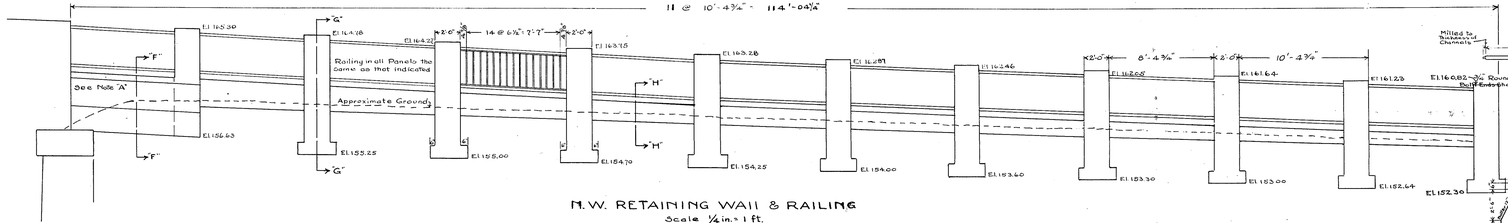
Wall between Posts poured with Sidewalk - Forms on Outside Face Only
Section "M"-"M" Between Posts



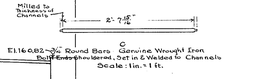


½" Round Bars Reinforcing Steel Anchored in Retaining Walls. Reinforcing to be Carried Down to Footings of Separate Posts without Fastening Wall Under.

Detail of Fence Posts & Rail Assembly
Scale: 1 in. = 1 ft.



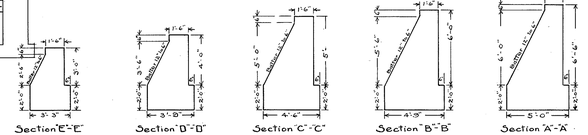
N.W. RETAINING WALL & RAILING
Scale 1/4 in. = 1 ft.



c
Scale: 1 in. = 1 ft.

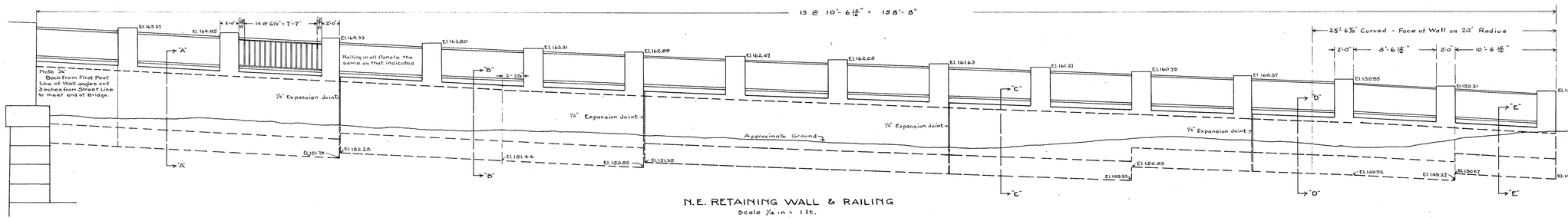
d
3" Pipe Flanges
Reamed to 3⅝" & Tapped for Set Screws
Scale: 1 in. = 1 ft.

e
4" Pipe Sleeve
Open End Cut on Angle
Scale: 3 in. = 1 ft.



BILL OF MATERIALS FOR PIPE RAILING				
Quan.	Style	Length	Material	Mark
30	3" Pipe	8'-01⅝"	Genuine Wrought Iron	a
22	"	8'-10⅜"	"	a
10	"	8'-1 1⅜"	"	a
14	"	6'-1 1½"	"	a
42	2" Channels	7'-8⅜"	Standard	b
14	"	7'-8⅜"	"	b
583	½" Round Bars	2'-8⅛"	Genuine Wrought Iron	c
104	3 Pipe Flanges	Stk.	Mal Iron	d
104	4" Pipe Sleeves	6 7/8"	Wrought Iron	e
606	½" Tap Bolts	1"	Standard	f
152	Set Screws	¼"	Standard	g
304	Lag Screws	4"	Standard	h

Quantities figured for 38 Sections including four different Lengths - All Exposed Metal Surfaces to have One Shop Coat of Red Lead.



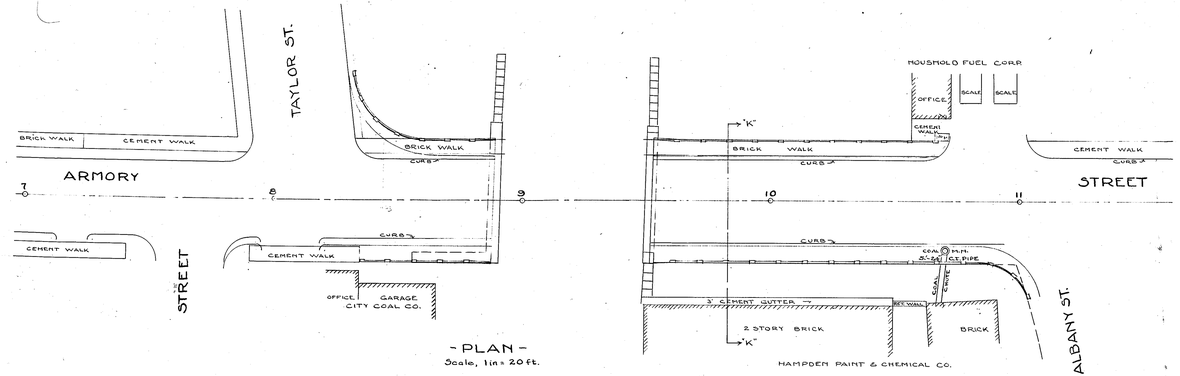
N.E. RETAINING WALL & RAILING
Scale 1/4 in. = 1 ft.

SPRINGFIELD, MASS.
DEPARTMENT OF STREETS & ENGINEERING
APPROACHES TO ARMORY ST. BRIDGE
OVER NEW YORK, NEW HAVEN & HARTFORD RAILROAD
SHEET TWO OF TWO SHEETS
SCALE: AS INDICATED SEPTEMBER 1934

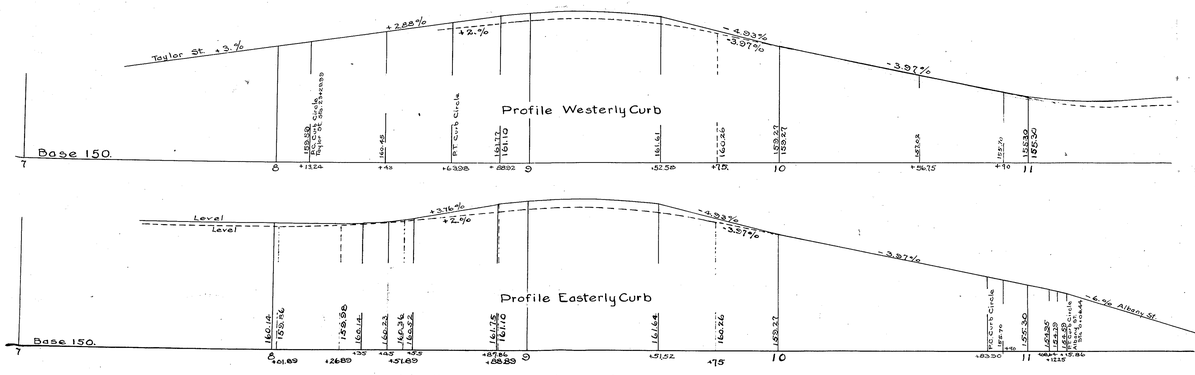
BRANCH BROOK

SE-15

2 Sheets

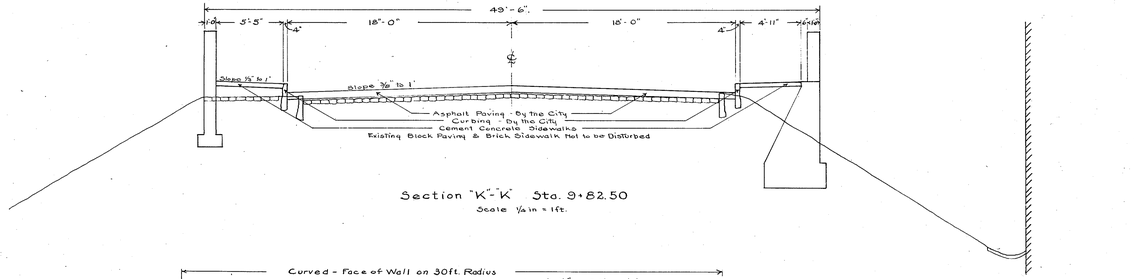


- PLAN -
Scale, 1in = 20 ft.

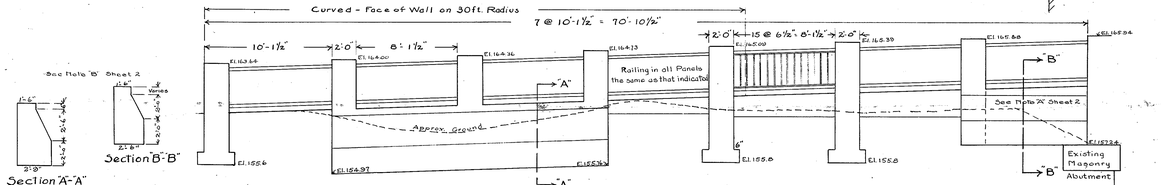


Profile Scales { Hor. 1in = 20 ft. / Vert. 1in = 4 ft.

Stationing Referred to Armory St and Measured Along Curb Lines
Dotted Lines in Orange - Roadway Crown Grades



Section "K"-"K" Sta. 9+82.50
Scale ¼ in = 1ft.



Section "A"-"A"

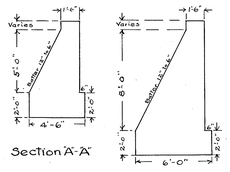
Section "B"-"B"

For Sections Separate Post Footings
See Sheet 2

S. W. RETAINING WALL & RAILING
Scale : ¼ in. = 1ft.

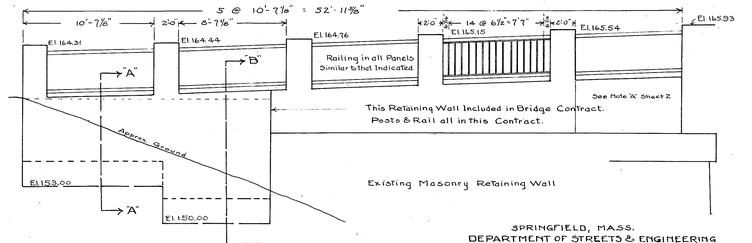
Commonwealth of Massachusetts
Hampden, ss. June 19, 1935
On the petition of the Board of Aldermen of the City of Springfield for authority to build a new bridge to carry Armory Street over the tracks of the N.Y.N.H.&H.R.R. Co. This plan is filed with the final decree and made a part thereof.

Charles N. Bray
Maurice G. Burkhead
Francis M. O'Keefe
County Commissioners
Assoc. Commissioner



Section "A"-"A"

Section "B"-"B"



S. E. RETAINING WALL & RAILING
Scale ¼" = 1'

SPRINGFIELD, MASS.
DEPARTMENT OF STREETS & ENGINEERING
APPROACHES TO ARMORY ST. BRIDGE
OVER NEW YORK, NEW HAVEN & HARTFORD RAILROAD
SHEET ONE OF TWO SHEETS
SCALE : AS INDICATED SEPTEMBER 1934

APPENDIX E.1 – Effective Stress, Max Past Pressure, and OCR Calculations

Armory Street over Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 94184.100

Calculated by: SAK Date: 07/24/2019
Checked by: BTW Date: 08/01/2019

Calculations for engineering properties of the Varved Silt and Clay.

Objective: Estimate the compression and recompression indexes, coefficient of consolidation, coefficient of secondary compression, effective stress, maximum past pressure, and over-consolidation ratio of the Varved Silt and Clay layers.

References:

1) An Introduction to Geotechnical Engineering by Robert D. Holtz and Williams D. Kovacs (1981).
2) Subsurface explorations observed by Nobis in 2019.
3) 1-Dimensional Consolidation tests performed by GeoTesting Express of Acton, MA.
4) Geologic and Engineering Properties of Connecticut Valley Varved Clay by DeGroot, D.J. and Lutenegger, A.J. (2002).

Assumptions: 1) Soil and groundwater conditions encountered in the Nobis borings are representative of subsurface conditions at the site.

Summary:

Sample	Max Past Pressure (psf)	Overconsolidation Ratio (OCR)	Compression Index ($C_{C\varepsilon}$)	Recompression Index ($C_{R\varepsilon}$)
BB-1 ST-1	6,000	-	-	-
BB-5 ST-3	**8,833**	**4.7**	0.021	0.088
BB-5 ST-4	**10,167**	**4.5**	0.029	0.122
		Average:	**0.025**	**0.10**

Coefficient of Secondary Compression ($C_{\alpha\varepsilon}$) = $C_{R\varepsilon}$ x 0.028 = **0.0028**

Calculated by: SAK Date: 07/24/2019
Checked by: BTW Date: 08/01/2019

Solution:

Evaluation of Maximum Past Pressure

1 Boring BB-1, ST-1

Load (psf)	Strain (%)	Increment Strain	Void Ratio	Work	Total Work
0	0	0	0	0	0
0	0	0	0	0	0.0
125	1.4	0.014	0.479	0.875	0.9
250	2.28	0.0088	0.466	1.65	2.5
500	2.78	0.005	0.459	1.875	4.4
1000	3.32	0.0054	0.45	4.05	8.5
2000	3.94	0.0062	0.441	9.3	17.8
4000	4.56	0.0062	0.432	18.6	36.4
8000	5.26	0.007	0.421	42	78.4
4000	5.1	-0.0016	0.424	-9.6	68.8
2000	4.95	-0.0015	0.426	-4.5	64.3
1000	4.87	0.0155	0.427	15.5	24.0
2000	5.05	0.0018	0.425	2.7	26.7
4000	5.2	0.0015	0.422	4.5	31.2
8000	5.52	0.0065	0.417	29.25	53.2
16000	6.25	0.0099	0.406	118.8	197.2
32000	7.29	0.0104	0.391	249.6	446.8

Due to apparent sample disturbance, BB-1, ST-1 not used for design.

MassDOT Armory Street over
Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 94184.00

Calculated by: SAK Date: 07/24/2019
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2 Boring BB-5, ST-3

Load (psf)	Strain (%)	Increment Strain	Void Ratio	Work	Total Work	CR	RR
0	0	0	0	0	0		
125	0.213	0.00213	0.839	0.133125	0.1		
250	0.508	0.00295	0.833	0.553125	0.7		
500	1.03	0.00522	0.824	1.9575	2.6		0.021
1000	1.65	0.0062	0.812	4.65	7.3		
2000	2.4	0.0075	0.798	11.25	18.5		
4000	3.45	0.0105	0.779	31.5	50.0		
8000	4.81	0.0136	0.754	81.6	131.6		
4000	4.58	-0.0023	0.758	-13.8	117.8		
2000	4.41	-0.0017	0.761	-5.1	112.7		
1000	4.15	-0.0026	0.766	-3.9	108.8		
2000	4.38	0.0023	0.762	3.45	112.3		
4000	4.62	0.0024	0.757	7.2	119.5		
8000	5.18	0.0056	0.747	33.6	153.1		
16000	6.82	0.0164	0.717	196.8	349.9		
32000	9.22	0.0464	0.673	835.2	953.0	0.0877	
64000	12.1	0.0288	0.62	1382.4	2335.4		

3 Boring BB-5, ST-4

Load (psf)	Strain (%)	Increment Strain	Void Ratio	Work	Total Work	CR	RR
0	0	0	0	0	0		
134	0.362	0.00362	0.897	0.24254	0.2		
250	0.727	0.00365	0.89	0.7008	0.9		
500	1.7	0.00973	0.872	3.64875	4.6		0.0289
1000	2.47	0.0077	0.857	5.775	10.4		
2000	3.34	0.0087	0.84	13.05	23.4		
4000	4.58	0.0124	0.817	37.2	60.6		
8000	6.21	0.0163	0.786	97.8	158.4		
4000	5.93	-0.0028	0.791	-16.8	141.6		
2000	5.64	-0.0029	0.797	-8.7	132.9		
1000	5.32	-0.0032	0.803	-4.8	128.1		
2000	5.43	0.0011	0.801	1.65	129.8		
4000	5.72	0.0029	0.795	8.7	138.5		
8000	6.52	0.008	0.78	48	186.5		
16000	8.55	0.0203	0.741	243.6	430.1		
32000	11.9	0.0597	0.677	1074.6	1216.2	0.1221	
64000	15.9	0.04	0.602	1920	3136.2		

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Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 94184.00

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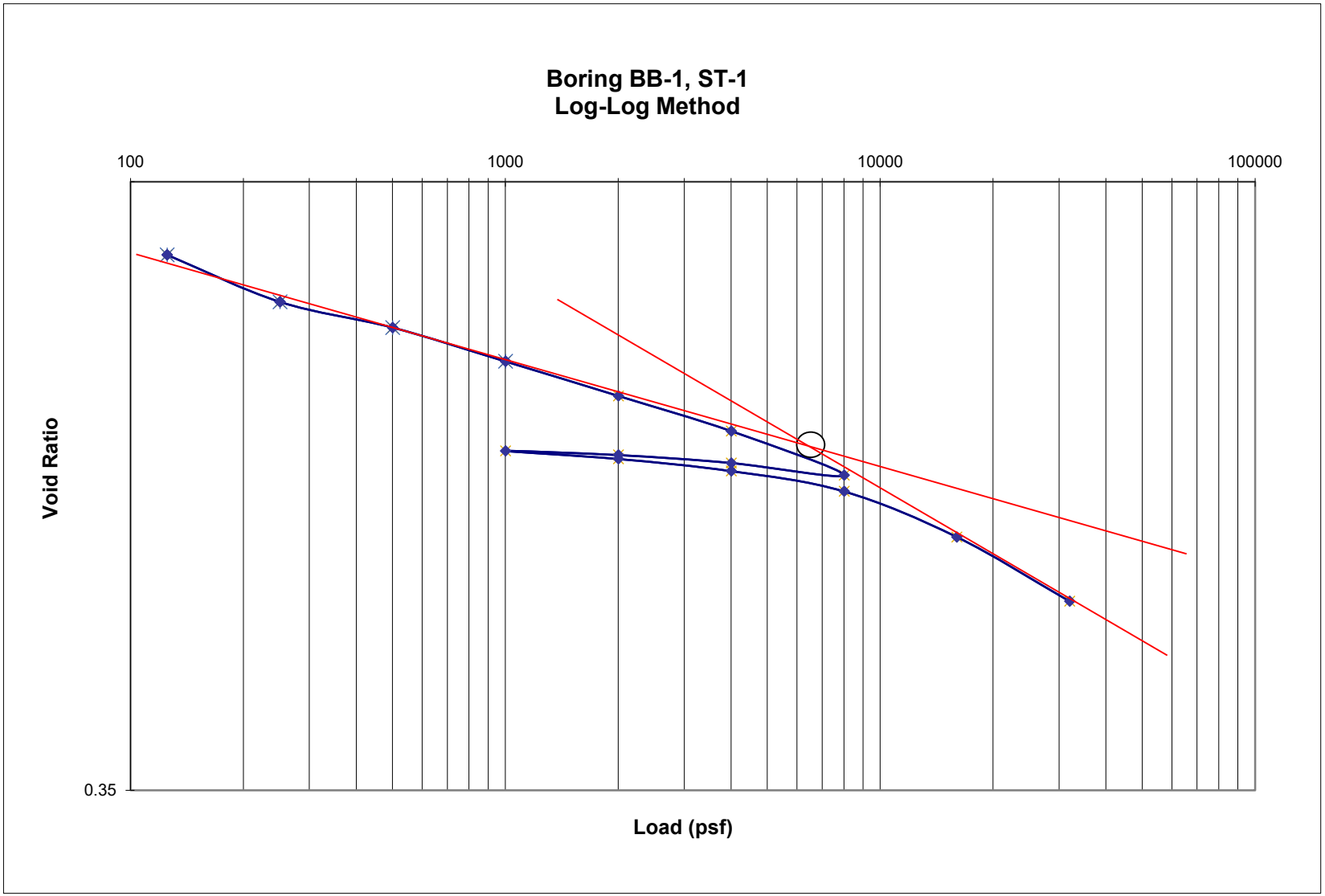

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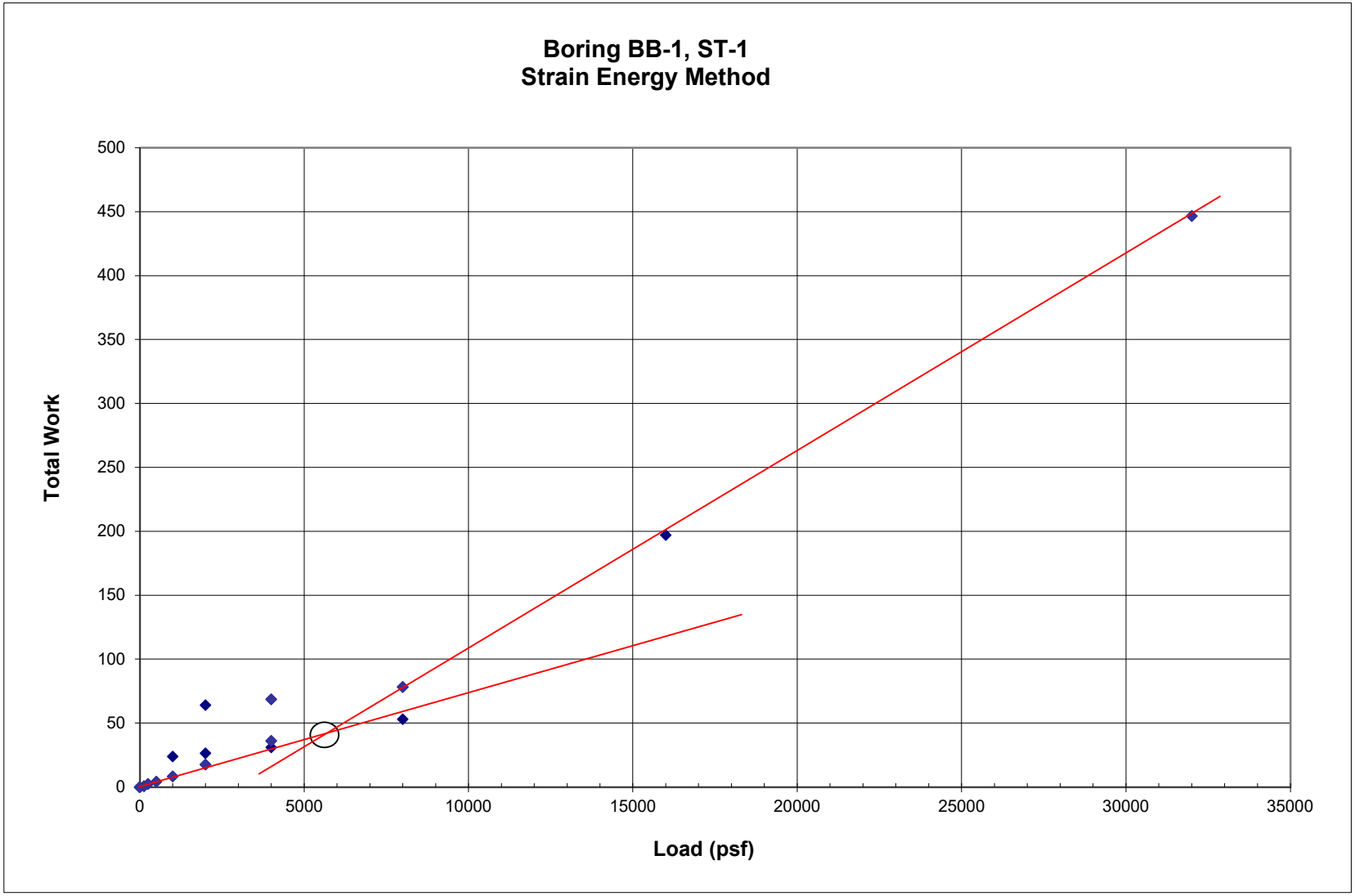

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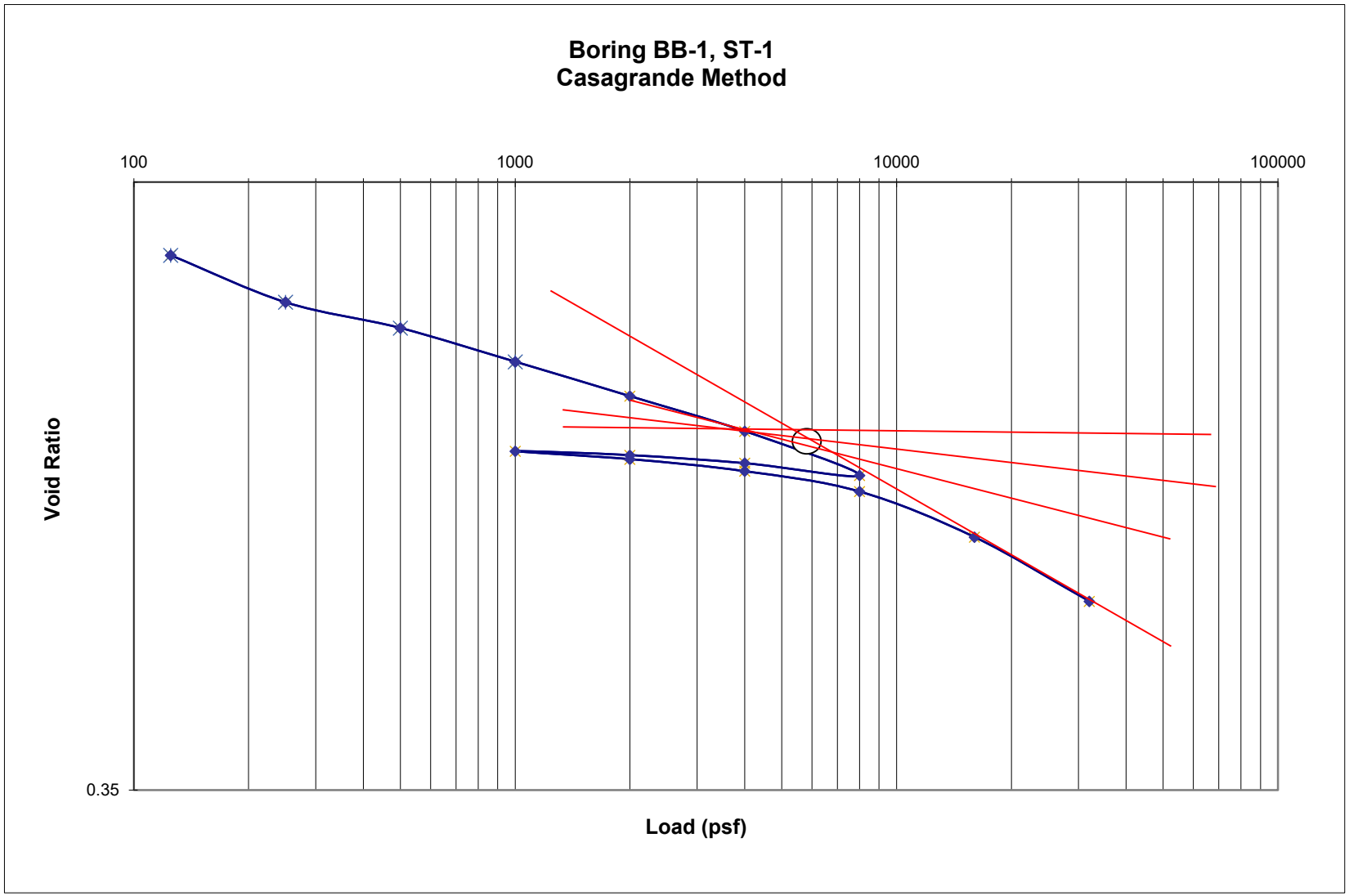

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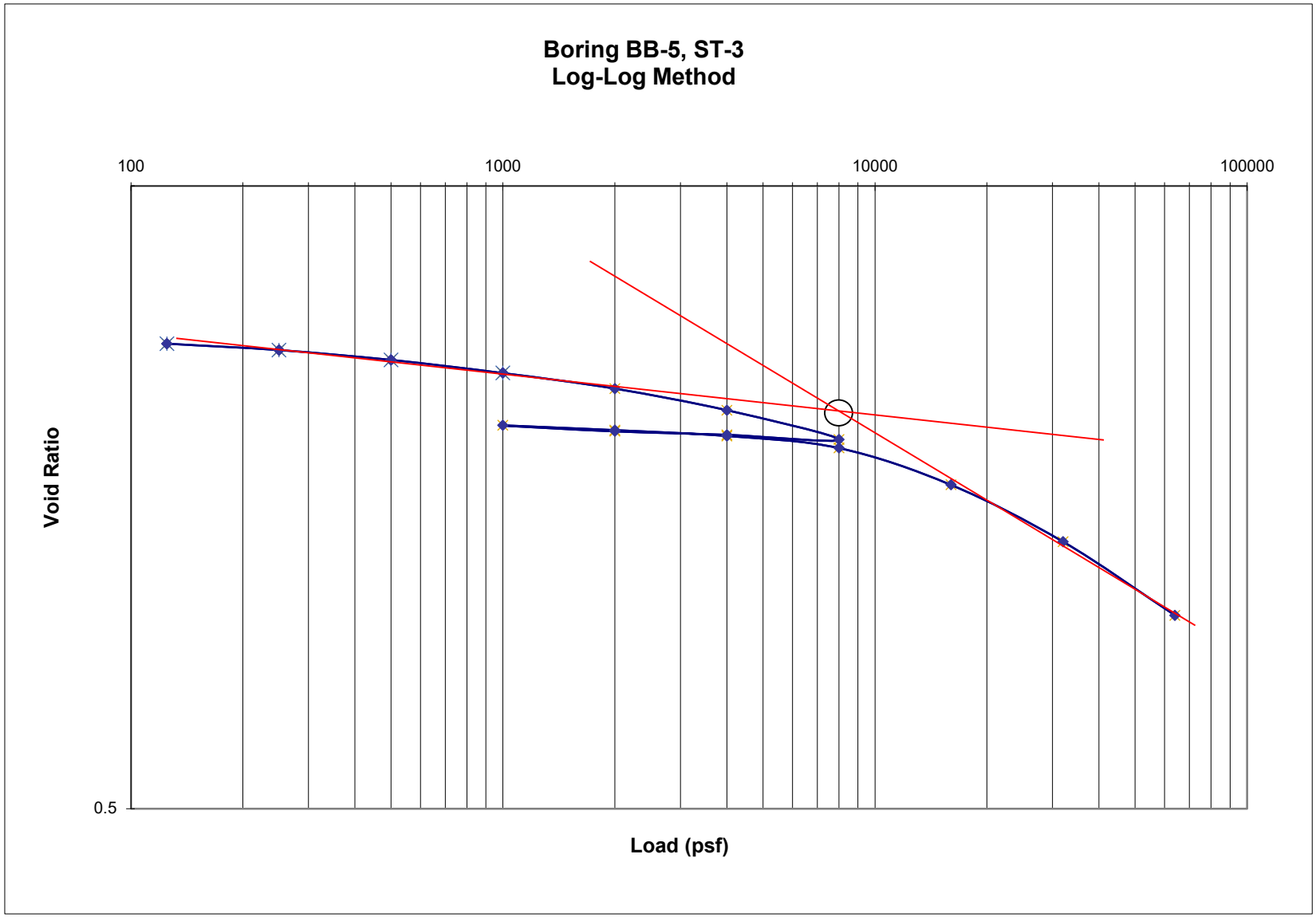

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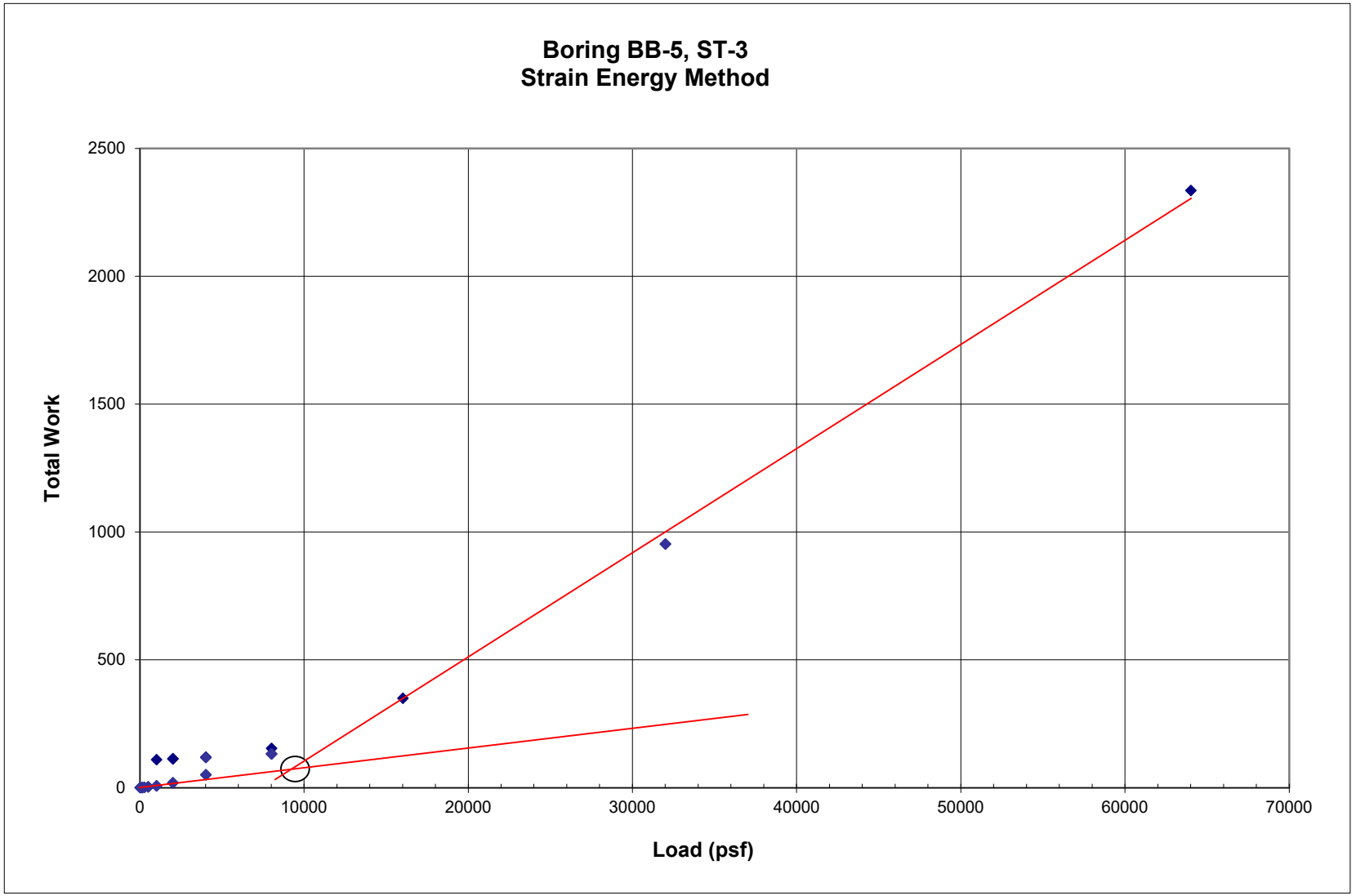

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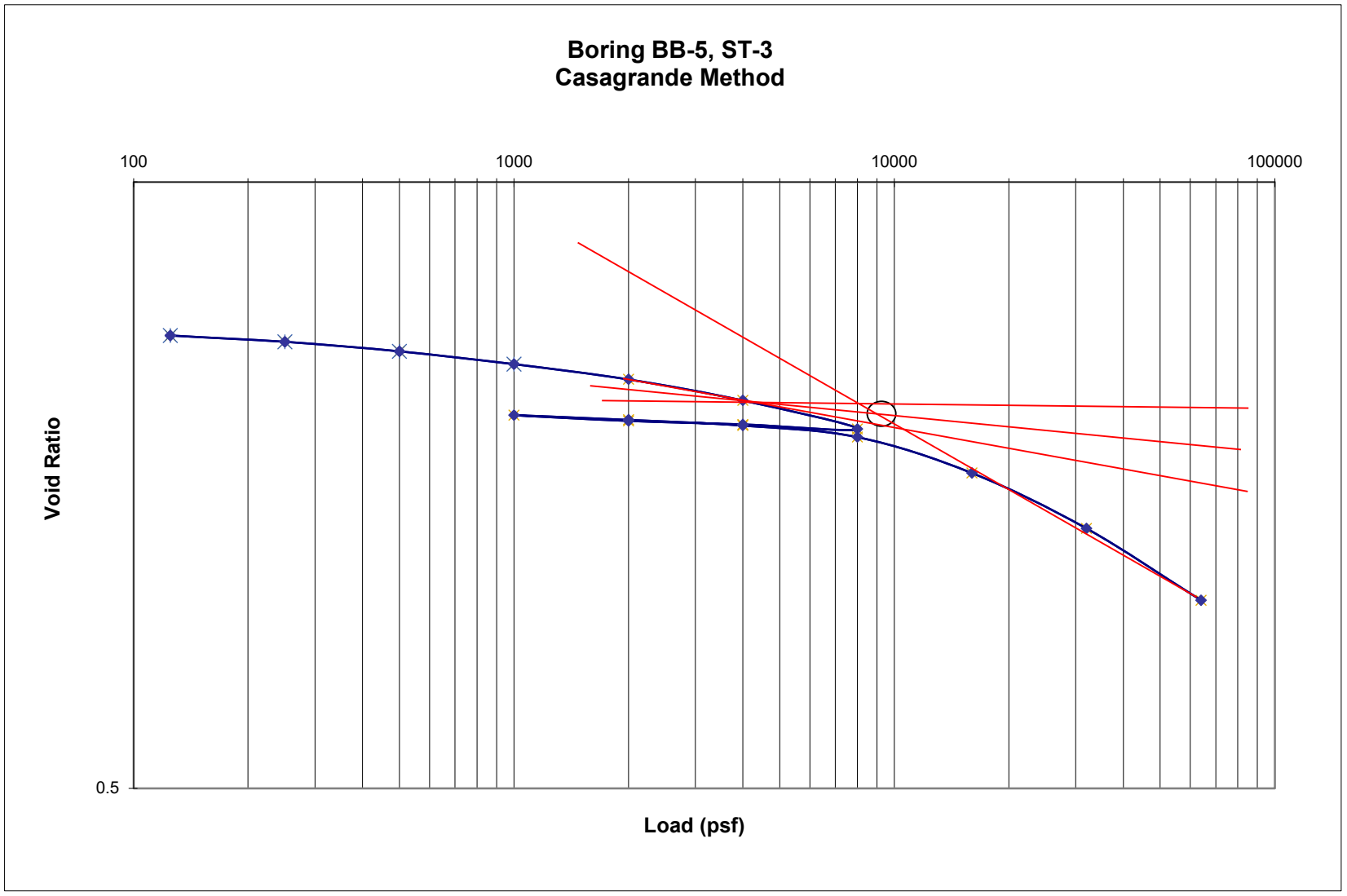

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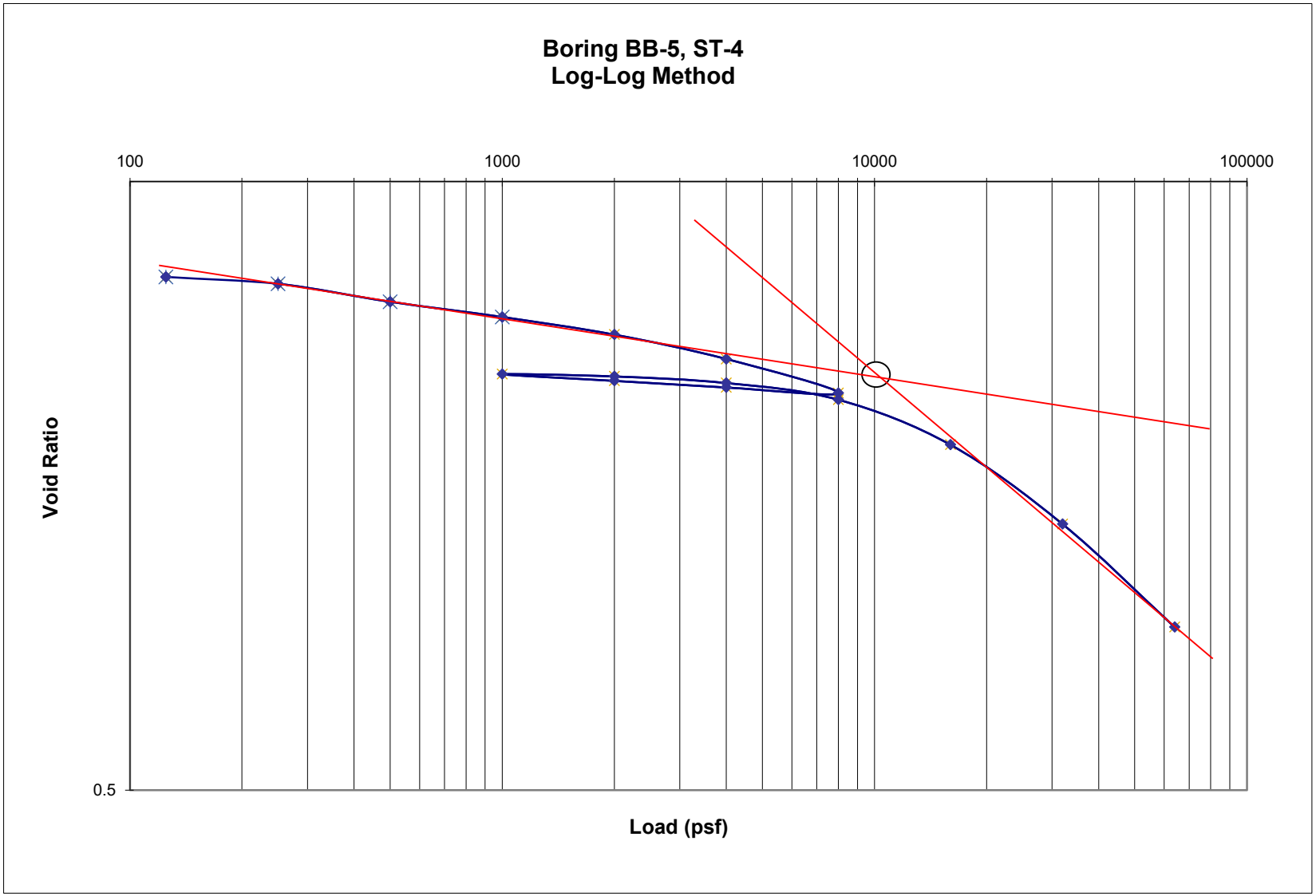

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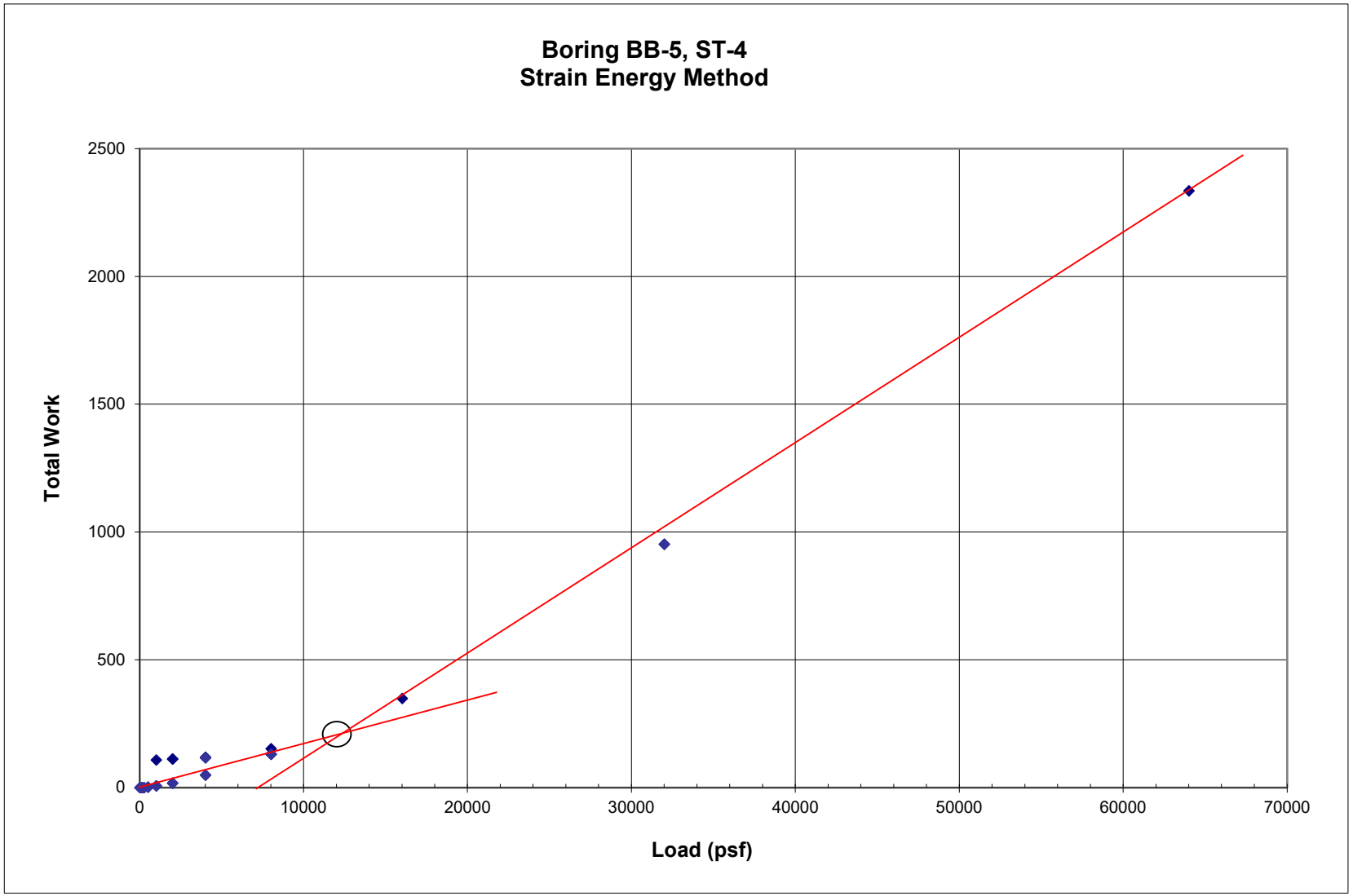

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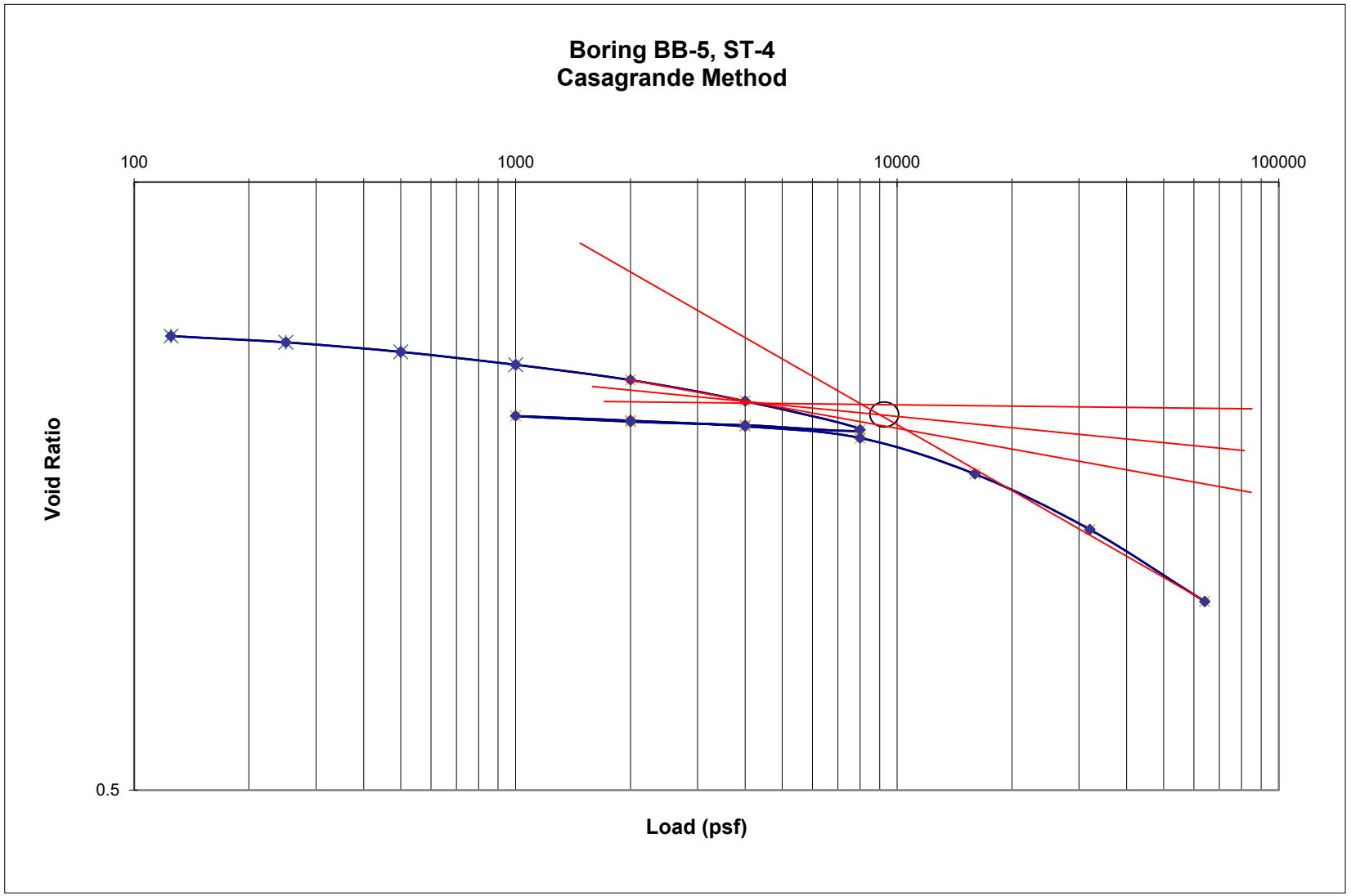

MassDOT Armory Street over Abandoned CSX Spur
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		Estimate of Maximum Past Pressure (psf)			
Boring	Sample	Log-Log	Strain Energy	Casagrande	Average
BB-1*	ST-1	6500	5500	6000	6000
BB-5	ST-3	8000	9500	9000	8833
BB-5	ST-4	10000	11000	9500	10167

* Due to apparent sample disturbance, BB-1, ST-1 not used for design. The average values for BB-5 ST-3 and ST-4 shall be used.

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MassDOT Armory Street over
Abandoned CSX Spur
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Calculated by: SAK Date: 07/24/2019
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$$stress - pore\ pressure = effective\ stress$$

$$\sigma - \mu = \sigma'$$

$$Overconsolidation\ Ratio = \frac{maximum\ past\ pressure}{effective\ stress}$$

$$OCR = \frac{\sigma'_m}{\sigma'}$$

1. Stress, pore pressure, and effective stress of BB-5, ST-3 and ST-4.

	H (ft bgs)	σ (psf)	μ (psf)	σ' (psf)	σ'_m (psf)	OCR	
	0	0	0	**0**			
Fill	2	230	0	**230**			
Fill	5	575	187	**388**			
Fill	8.2	943	387	**556**			
Varved	15	1759	811	**948**			
Varved	31	3679	1810	**1869**	**8833**	**4.725**	← OCR of ST-3
Varved	38	4519	2246	**2273**	**10167**	**4.474**	← OCR of ST-4
Varved	39	4639	2309	**2330**			
Varved	55	6559	3307	**3252**			

2. Stress, pore pressure, and effective stress of BB-1, ST-1.

	H (ft bgs)	σ (psf)	μ (psf)	σ' (psf)	Column1	OCR
	0	0	0	**0**		
Fill	12.5	1438	0	**1438**		
Fill	13	1495	31	**1464**		
Varved	16	1855	218	**1637**		
Varved	23	2695	655	**2040**	**6000**	**3**
Varved	28	3295	967	**2328**		
Varved	45	5335	2028	**3307**		
Glacial Till	59	7225	2902	**4323**		

Soil Type	Unit weight
Fill	115
Varved	120
Glacial Till	135

APPENDIX E.2 – Seismic Site Classification

Armory Street Over Abandoned CSX Spur
Springfield, Massachusetts
Project No. 94184.100

Calculated by: SK Date: 6/26/2019
Checked by: KAK Date: 7/18/2019

Seismic site classification for the proposed replacement of the Armory Street bridge over the the abandoned CSX Spur in Springfield.

Objective: Evaluate seismic site classification for the proposed bridge replacement.

References:
1) AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition, 2015 Revisions.
2) Boring Logs observed by Nobis, April 2019 to May 2019.
3) MassDOT LRFD Bridge Manual, 2020.

Solution: AASHTO, Section 3.4 was used to determine the seismic site classification for the proposed bridge reconstruction at Armory Street, as follows:

Step 1: Check for the four categories of Site Class F as described in attached AASHTO Site Classification, as follows:

1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils (per Article 6.8), quick and highly sensitive clays, collapsible weakly cemented soils.
2. Peats and/or highly organic clays (H>10 ft [3m] of peat and/or highly organic clay, where H = thickness of soil).
3. Very high plasticity clays (H>25 ft [7.6m] with PI >75).
4. Very thick soft/medium stiff clays (H > 120 ft [37m]).

Soil conditions for Site Class F were not shown on the Nobis boring logs.

Step 2: Check for Site Class E described as a soil profile with N-Bar less than 15 blows/ft or any profile with more than 10-ft of soft clay defined as soil with PI >20, ω>=40%, and Su <0.5 ksf (25 kPa). See attached AASHTO Table 3.4.2.1-1 Site Class Definitions.

Soil conditions for Site Class E were shown on boring BB-2A.

Step 3: Categorize the site using one of three methods as described in AASHTO Section 3.4.2.1.

Method 2 (N-bar Method) was used to determine the average Standard Penetration Test (SPT) blow count (blows/ft) for the upper 100 ft of the soil profile using the Nobis borings. See attached Table 3.4.2.1-1. The Nobis borings were performed in general accordance with ASTM D1586. Samples were obtained using a 1-3/8" diameter sampler driven with a 140-lb automatic hammer dropping a distance of 30 inches. The uncorrected SPT-N values were used tyo calculate N-bar according to equation 3.4.2.2-2 from Reference 1.

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Armory Street Over Abandoned CSX Spur
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Table: Summary of Seismic Site Classification from Reference No. 2.

Boring No.	N_{bar} (bpf)	Site Class	Comments
BB-1	**16**	**Site Class D - Stiff Soil**	Boring terminated at 71.0 ft bgs in Bedrock.
BB-2A	**11**	**Site Class E**	Boring terminated at 92.5 ft bgs in Bedrock.
BB-5	**23**	**Site Class D - Stiff Soil**	Boring terminated at 70.5 ft bgs in Bedrock.
BB-6	**17**	**Site Class D - Stiff Soil**	Boring terminated at 84.0 ft bgs in Bedrock.

Conclusion:

Based on the Nobis boring logs, average SPT N-bar for the site ranges from 11 to 23 bpf with a average value of 16.8 bpf. The seismic site classification for the proposed bridge reconstruction site is **Site Class E**. The calculated average N-bar values for the borings are summarized in the table above. See attached tables presenting the value of SPT-N vs. depth for the respective borings. This site is a **SEISMIC DESIGN CATEGORY A**.

Sample Calculation: Consider Boring BB-2A

Determine the SPT N-bar: Use the average SPT-N value of each layer provided in the table toward the end of this report.

$$\overline{N} = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{N_i}}$$

(3.4.2.2-2, Reference 1)

$$\overline{N} = \frac{20' + 5.8' + 24.2' + 25' + 5' + 2.5' + 17.5'}{\frac{20'}{21} + \frac{5.8'}{3} + \frac{24.2'}{5} + \frac{25'}{21} + \frac{5'}{59} + \frac{2.5'}{100} + \frac{17.5'}{100}} = 11\ bpf$$

Determine the site class for this boring using the Site Definitions, Table 3.4.2.1-1 in Reference 1

Boring BB-2A is classified as **Site Class E** as its standard penetration resistance of 11 bpf is below 15 bpf, which is required to reach Site Class D.

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Armory Street Over Abandoned CSX Spur
Springfield, Massachusetts
Project No. 94184.100

Calculated by: SK Date: 6/26/2019
Checked by: KAK Date: 7/18/2019

Data from Boring BB-1

Layer	Depth Range Start [ft]	Depth Range End [ft]	Thickness (d_i) [ft]	SPT-N blows/ft	d_i/N_i	Comments
1	0	12.5	12.5	4	3.333	Urban Fill
2	12.5	16	3.5	12	0.292	Subsoil (Fill)
3	16	28	12	14	0.889	Varved Clayey Silt
4	28	45	17	16	1.063	Varved Silt with Clay & Sand
5	45	59	14	40	0.350	Glacial Till
6	59	61	2	100	0.020	Weathered Bedrock
7	61	100	39	100	0.390	Bedrock
SUM			**100**		**6.336**	

N bar	**16**	**Site Class D - Stiff Soil**

Data from Boring BB-2A

Layer	Depth Range Start [ft]	Depth Range End [ft]	Thickness (d_i) [ft]	SPT-N blows/ft	d_i/N_i	Comments
1	0	20	20	9	2.222	Embankment Fill
2	20	25.8	5.8	3	1.933	Varved Silt and Clay
3	25.8	50	24.2	5	5.042	Varved Silt and Clay
4	50	75	25	21	1.190	Varved Silt with Sand
5	75	80	5	59	0.085	Glacial Till
6	80	82.5	2.5	100	0.025	Weathered Bedrock
7	82.5	100	17.5	100	0.175	Bedrock
SUM			**100**		**10.672**	

N bar	**9**	**Site Class E**

Data from Boring BB-5

Layer	Depth Range Start [ft]	Depth Range End [ft]	Thickness (d_i) [ft]	SPT-N blows/ft	d_i/N_i	Comments
1	0	15	15	12	1.220	Urban Fill
2	15	35	20	12	1.702	Varved Silt and Clay
3	35	39	4	8	0.500	Silty Clay
4	39	55	16	35	0.462	Silt
5	55	60	5	35	0.143	Glacial Till
6	60	60.5	0.5	100	0.005	Weathered Bedrock
7	60.5	100	39.5	100	0.395	Bedrock
SUM			**100**		**4.427**	

N bar	**23**	**Site Class D - Stiff Soil**

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Armory Street Over Abandoned CSX Spur
Springfield, Massachusetts
Project No. 94184.100

Calculated by: SK Date: 6/26/2019
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Data from Boring BB-6

Layer	Depth Range		Thickness (d_i)	SPT-N	d_i/N_i	Comments
	Start [ft]	End [ft]	[ft]	blows/ft		
1	0	11	11	8	1.375	Urban Fill
2	11	23.5	12.5	13	1.000	Varved Clayey Silt
3	23.5	36	12.5	16	0.781	Varved Sandy Silt
4	36	46	10	10	1.000	Varved Silt and Clay
5	46	51	5	12	0.417	Varved Sandy Silt
6	51	62.5	11.5	12	1.000	Silt
7	62.5	69.6	7.1	72	0.099	Glacial Till
8	69.6	74	4.4	100	0.044	Weathered Bedrock
9	74	100	26	100	0.260	Bedrock
SUM			**100**		**5.976**	

N bar	**17**

Site Class D - Stiff Soil

Step 4: According to Reference No. 3, special consideration must be given to structures which are considered Critical Bridges. These include:

1. Bridges on or over the following National Highway System (NHS) routes:
   a. Eisenhower Interstate System.
   b. Only those routes that are defined as OTHER NHS Routes and are denoted by red lines on the FHWA HEPGIS website map. Designers are cautioned not to assume that the term OTHER means everything else that is on the NHS. OTHER NHS Routes is a specific category of NHS routes that are separate from and are not to be confused with Intermodal Connectors, Unbuilt NHS Routes and MAP-21 NHS Principal Arterials. These last three categories of NHS routes are not considered Critical and Essential Bridges for the purposes of this Bridge Manual unless they meet the definition set forth in bullet 2 below.
   c. All STRAHNET Routes and Connectors including Non-Interstate STRAHNET Routes, Major STRAHNET Connector, and Intermodal/STRAHNET Connector.

2. On designated emergency evacuations routes.

Armory Street does not fall within the "National Highway System" and therefore will not be considered a critical/essential bridge per Section 3.1.2.

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Armory Street Over Abandoned CSX Spur
Springfield, Massachusetts
Project No. 94184.100
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Calculated by: SK Date: 6/26/2019
Checked by: KAK Date: 7/18/2019

Table 3.4.2.1-1—Site Class Definitions

Site Class	Soil Type and Profile
A	Hard rock with measured shear wave velocity, $\overline{v}_s > 5000$ ft/sec
B	Rock with 2500 ft/sec $< \overline{v}_s < 5000$ ft/sec
C	Very dense soil and soil rock with 1200 ft/sec $< \overline{v}_s < 2500$ ft/sec, or with either $\overline{N} > 50$ blows/ft or $\overline{s}_u > 2.0$ ksf
D	Stiff soil with 600 ft/sec $< \overline{v}_s < 1200$ ft/sec, or with either 15 blows/ft $< \overline{N} < 50$ blows/ft or 1.0 ksf $< \overline{s}_u < 2.0$ ksf
E	Soil profile with $\overline{v}_s < 600$ ft/sec, or with either $\overline{N} < 15$ blows/ft or $\overline{s}_u < 1.0$ ksf, or any profile with more than 10 ft of soft clay defined as soil with $PI > 20$, $w > 40\%$, and $\overline{s}_u < 0.5$ ksf
F	Soils requiring site-specific ground motion response evaluations, such as: • Peats or highly organic clays ($H > 10$ ft of peat or highly organic clay, where H = thickness of soil) • Very high plasticity clays ($H > 25$ ft with $PI > 75$) • Very thick soft/medium stiff clays ($H > 120$ ft)

Exceptions:

Where the soil properties are not known in sufficient detail to determine the site class, a site investigation shall be undertaken sufficient to determine the site class. Site Class E or F should not be assumed unless the authority having jurisdiction determines that Site Class E or F could be present at the site or in the event that Site Class E or F is established by geotechnical data.

where:

$\overline{v}_s$ = average shear wave velocity for the upper 100 ft of the soil profile as defined in Article 3.4.2.2

$\overline{N}$ = average standard penetration test (SPT) blow count (blows/ft) (ASTM D 1586) for the upper 100 ft of the soil profile as defined in Article 3.4.2.2

$\overline{s}_u$ = average undrained shear strength in ksf (ASTM D 2166 or D 2850) for the upper 100 ft of the soil profile as defined in Article 3.4.2.2

PI = plasticity index (ASTM D 4318)

w = moisture content (ASTM D 2216)

nobis

Armory Street Over Abandoned
CSX Spur
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Calculated by: SK Date: 6/26/2019
Checked by: KAK Date: 7/18/2019

Determination of Seismic Design Parameters using Reference 1 and Reference 3.

***Site Class**	E	Section 3.4, based on above calculation
***PGA**	0.059	Based on USGS 1000 year map contours (Reference 1)
***0.2 Sec (S_S)**	0.13	
***0.1 Sec (S_1)**	0.038	
*F_{PGA}	2.5	Table 3.4.2.3-1
*F_a	2.5	Table 3.4.2.3-1
*F_v	3.5	Table 3.4.2.3-2
A_s	0.148	EQ 3.4.1-1
S_{DS}	0.325	EQ 3.4.1-2
S_{D1}	0.133	EQ 3.4.1-3
***SDC**	A	Table 3.5-1

*Input required

Table 3.4.2.3-1—Values of F_{pga} and F_a as a Function of Site Class and Mapped Peak Ground Acceleration or Short-Period Spectral Acceleration Coefficient

Site Class	Mapped Peak Ground Acceleration or Spectral Response Acceleration Coefficient at Short Periods				
	$PGA \le 0.10$ $S_s \le 0.25$	$PGA = 0.20$ $S_s = 0.50$	$PGA = 0.30$ $S_s = 0.75$	$PGA = 0.40$ $S_s = 1.00$	$PGA \ge 0.50$ $S_s \ge 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	[a]	[a]	[a]	[a]	[a]

Note: Use straight line interpolation for intermediate values of PGA and S_s, where PGA is the peak ground acceleration and S_s is the spectral acceleration coefficient at 0.2 sec obtained from the ground motion maps.

[a] Site-specific response geotechnical investigation and dynamic site response analyses should be considered (Article 3.4.3).

Table 3.4.2.3-2—Values of F_v as a Function of Site Class and Mapped 1-sec Period Spectral Acceleration Coefficient

Site Class	Mapped Spectral Response Acceleration Coefficient at 1-sec Periods				
	$S_1 \le 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \ge 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	[a]	[a]	[a]	[a]	[a]

Note: Use straight line interpolation for intermediate values of S_1, where S_1 is the spectral acceleration coefficient at 1.0 sec obtained from the ground motion maps.

[a] Site-specific response geotechnical investigation and dynamic site response analyses should be considered (Article 3.4.3).

$$A_s = F_{pga} PGA \qquad (3.4.1\text{-}1)$$

$$S_{DS} = F_a S_s \qquad (3.4.1\text{-}2)$$

$$S_{D1} = F_v S_1 \qquad (3.4.1\text{-}3)$$

Table 3.5-1—Partitions for Seismic Design Categories A, B, C, and D

Value of $S_{D1} = F_v S_1$	SDC
$S_{D1} < 0.15$	A
$0.15 \le S_{D1} < 0.30$	B
$0.30 \le S_{D1} < 0.50$	C
$0.50 \le S_{D1}$	D

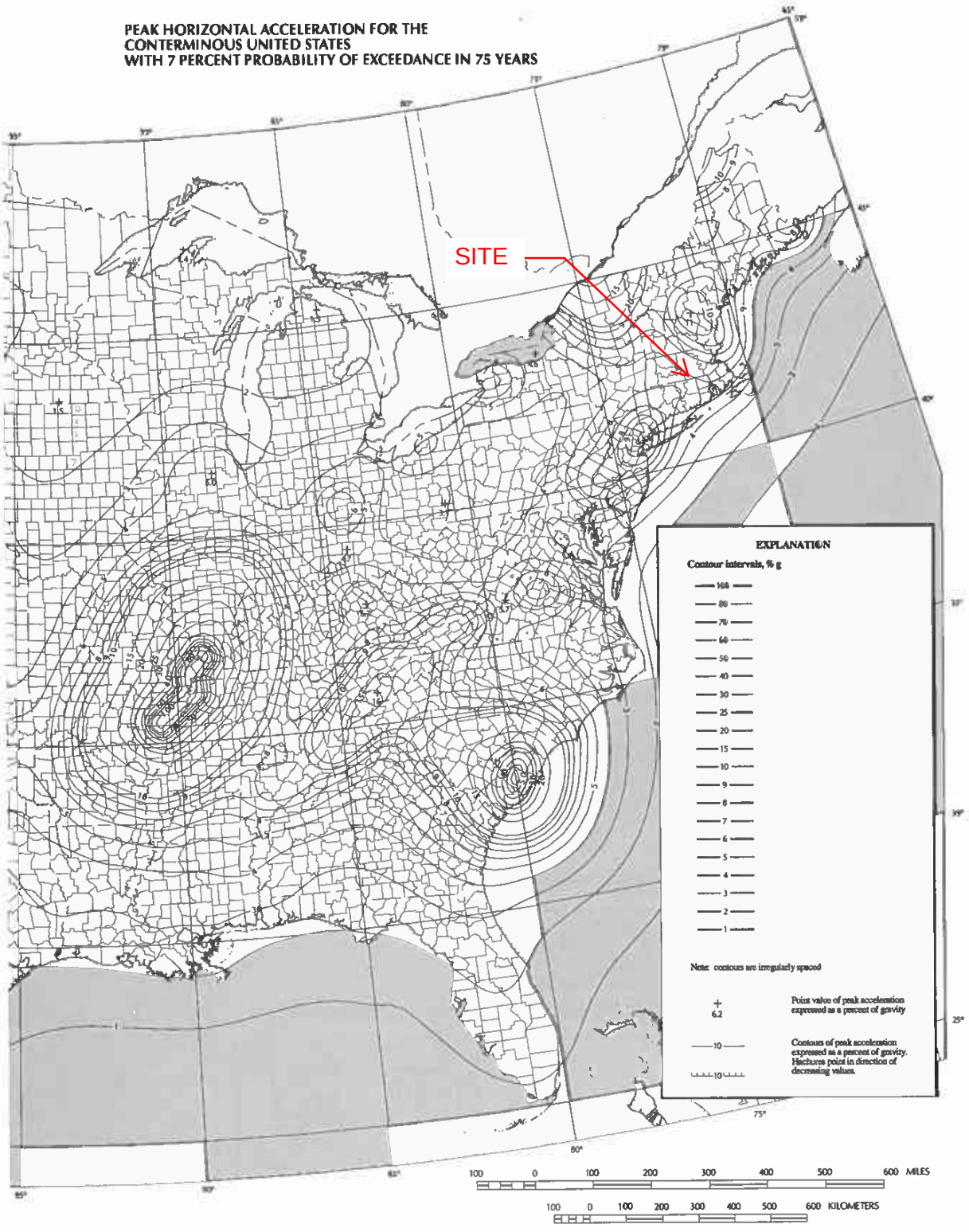

Figure 3.4.1-2b—Horizontal Peak Ground Acceleration Coefficient for the Conterminous United States (*PGA*) with Seven Percent Probability of Exceedance in 75 yr (Approx. 1000-yr Return Period)

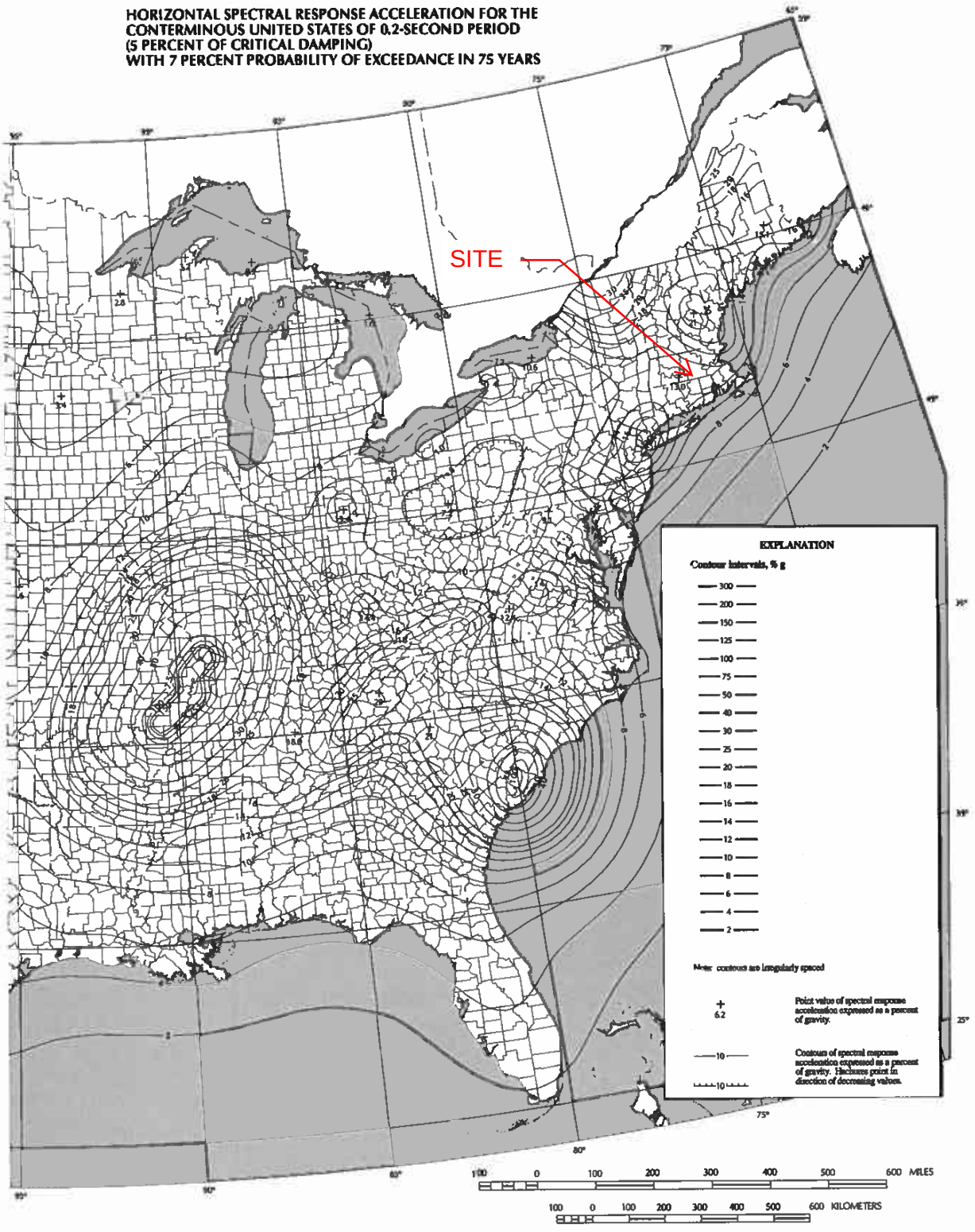

Figure 3.4.1-3b—Horizontal Response Spectral Acceleration Coefficient for the Conterminous United States at Period of 0.2-sec (S_s) with Seven Percent Probability of Exceedance in 75 yr (Approx. 1000-yr Return Period) and Five Percent Critical Damping

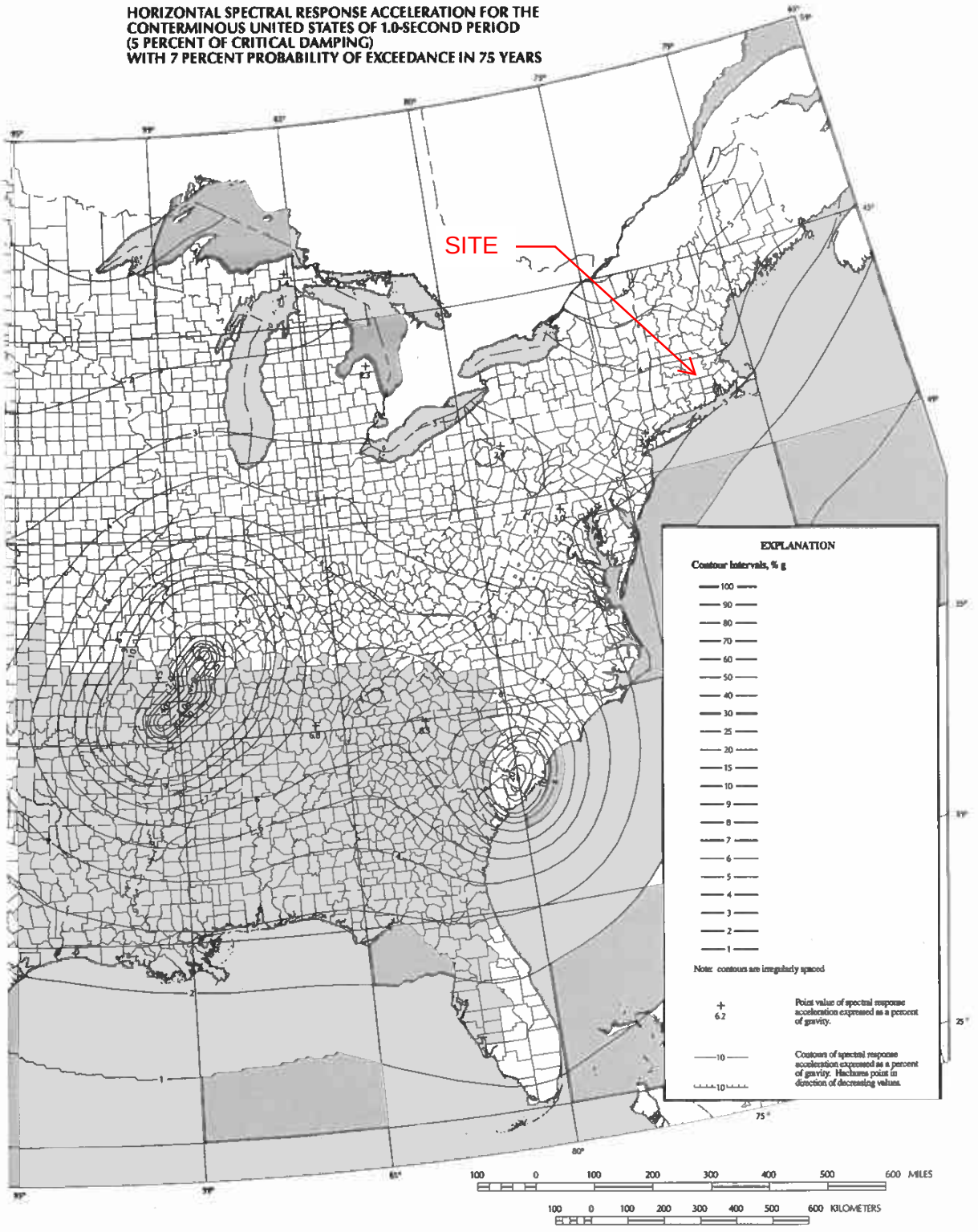

Figure 3.4.1-4b—Horizontal Response Spectral Acceleration Coefficient for the Conterminous United States at Period of 1.0-sec (S_1) with Seven Percent Probability of Exceedance in 75 yr (Approx. 1000-yr Return Period) and Five Percent Critical Damping

APPENDIX E.3 – Bearing Resistance for the Existing Abutments

nobis

MassDOT Armory Street over Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 94184.100

Calculated by: SAK Date: 01/20/2021
Checked by: BTW Date: 02/09/2021
Revision: 2

Bearing Resistance Calculation for the Existing Abutments of Bridge No. S-24-026.

Objective: Estimate bearing resistance for the existing abutments bearing on reworked silt and clay.

References:
1) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
2) Subsurface explorations observed by Nobis in 2019 and 2022.
3) Drawings in AutoCAD format provided by Tetra Tech on January 20, 2021.

Assumptions:
1) Soil and groundwater conditions encountered in the Nobis borings are representative of subsurface conditions at the site.
2) Geometry and elevations of north abutment of S-24-026 used for calculations.

Solution:

Bearing Soil Properties/Subsurface Information

Unit Weight of Bearing Soil (γ):	120	pcf	Estimated
Unit Weight of Soil Above Footing (γ):	115	pcf	Estimated
Cohesion of Bearing Soil (c):	130	psf	Estimated
Friction Angle of Bearing Soil (ϕ'):	22	degrees	Estimated

Soil Description: Native, soft to stiff, brown to gray, Clayey Silt and/or Silt with varying amounts of fine sand.

Footing Elevation:	132.5	ft, NAVD88	References 3 (S-24-026)
Ground Surface (GS) Elevation:	138	ft, NAVD88	Reference 2 and 3 (S-24-026)
Groundwater Elevation:	131	ft, NAVD88	Reference 2

Footing Geometry

Footing Depth (D_f):	5.5	ft	Reference 3
Groundwater Depth Below GS:	7	ft	Reference 2
Width (B):	7.5	ft	Assumed from Reference 2
Length (L):	48.0	ft	Assumed from Reference 3
Width Eccentricity (e_B):	1.3	ft	Assumed, see Note 2
Length Eccentricity (e_L):	0	ft	Assumed
Effective Width (B'):	5.0	ft	
Effective Length (L'):	48	ft	

Notes:
1) Bearing resistance calculation can be found on page 2.
2) Width eccentricity (e_B) is assumed to be B/6.

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MassDOT Armory Street over Abandoned CSX Spur
Springfield, Massachusetts
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Calculated by: SAK Date: 01/20/2021
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Revision: 1

Bearing Resistance Calculation

Factored Bearing Resistance: $q_R = q_n * \phi_b$ — Eq. 10.6.3.1.1-1

Resistance Factor (ϕ_b) =	0.45	Tb. 10.5.5.2.2-1

Nominal Resistance (q_n) =

$q_n = c*N_{cm} + \gamma*D_f*N_m*C_{wq} + 0.5*\gamma*B'*N_{\gamma m}*C_{w\gamma}$ — Eq. 10.6.3.1.2a-1

$N_{qm} = N_q*s_q*d_q*i_q$ — Eq. 10.6.3.1.2a-3

Bearing Capacity Factor (N_q)	7.8	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_q)	1.04	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_q)	1.0	Assumed
Depth Correction Factor (d_q)	1.0	Tb. 10.6.3.1.2a-4
N_{qm} =	8.13	

$N_{cm} = N_c*s_c*i_c$ — Eq. 10.6.3.1.2a-2

Bearing Capacity Factor (N_c)	16.9	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_c)	1.05	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_c)	1.0	Assumed
N_{cm} =	17.71	

$N_{\gamma m} = N_\gamma*s_\gamma*i_\gamma$ — Eq. 10.6.3.1.2a-4

Bearing Capacity Factor (N_γ)	7.1	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_γ)	0.96	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_γ)	1.0	Assumed
$N_{\gamma m}$=	6.80	

Groundwater Coefficients — Tb. 10.6.3.1.2a-2

(C_{wq})	1.00
($C_{w\gamma}$)	0.77

q_n=	**9.0 ksf**
q_R=	**4.1 ksf**

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MassDOT Armory Street over
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Calculated by: SAK Date: 01/20/2021
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Revision: 1

$$N1 = C_N N \qquad (10.4.6.2.4\text{-}1)$$

$N1$ = *SPT* blow count corrected for overburden pressure, σ'_v (blows/ft)

C_N = $[0.77 \log_{10}(40/\sigma'_v)]$, and $C_N < 2.0$

σ'_v = vertical effective stress (ksf)

N = uncorrected *SPT* blow count (blows/ft)

Table 10.6.2.4.2-1—Elastic Shape and Rigidity Factors, EPRI (1983)

L/B	Flexible, β_z (average)	β_z Rigid
Circular	1.04	1.13
1	1.06	1.08
2	1.09	1.10
3	1.13	1.15
5	1.22	1.24
10	1.41	1.41

Table 10.6.3.1.2a-1—Bearing Capacity Factors N_c (Prandtl, 1921), N_q (Reissner, 1924), and N_γ (Vesic, 1975)

ϕ_f	N_c	N_q	N_γ	ϕ_f	N_c	N_q	N_γ
0	5.14	1.0	0.0	23	18.1	8.7	8.2
1	5.4	1.1	0.1	24	19.3	9.6	9.4
2	5.6	1.2	0.2	25	20.7	10.7	10.9
3	5.9	1.3	0.2	26	22.3	11.9	12.5
4	6.2	1.4	0.3	27	23.9	13.2	14.5
5	6.5	1.6	0.5	28	25.8	14.7	16.7
6	6.8	1.7	0.6	29	27.9	16.4	19.3
7	7.2	1.9	0.7	30	30.1	18.4	22.4
8	7.5	2.1	0.9	31	32.7	20.6	26.0
9	7.9	2.3	1.0	32	35.5	23.2	30.2
10	8.4	2.5	1.2	33	38.6	26.1	35.2
11	8.8	2.7	1.4	34	42.2	29.4	41.1
12	9.3	3.0	1.7	35	46.1	33.3	48.0
13	9.8	3.3	2.0	36	50.6	37.8	56.3
14	10.4	3.6	2.3	37	55.6	42.9	66.2
15	11.0	3.9	2.7	38	61.4	48.9	78.0
16	11.6	4.3	3.1	39	67.9	56.0	92.3
17	12.3	4.8	3.5	40	75.3	64.2	109.4
18	13.1	5.3	4.1	41	83.9	73.9	130.2
19	13.9	5.8	4.7	42	93.7	85.4	155.6
20	14.8	6.4	5.4	43	105.1	99.0	186.5
21	15.8	7.1	6.2	44	118.4	115.3	224.6
22	16.9	7.8	7.1	45	133.9	134.9	271.8

Table 10.6.3.1.2a-3—Shape Correction Factors s_c, s_γ, s_q

Factor	Friction Angle	Cohesion Term (s_c)	Unit Weight Term (s_γ)	Surcharge Term (s_q)
Shape Factors s_c, s_γ, s_q	$\phi_f = 0$	$1 + \left(\frac{B}{5L}\right)$	1.0	1.0
	$\phi_f > 0$	$1 + \left(\frac{B}{L}\right)\left(\frac{N_q}{N_c}\right)$	$1 - 0.4\left(\frac{B}{L}\right)$	$1 + \left(\frac{B}{L}\tan\phi_f\right)$

nobis

MassDOT Armory Street over Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 94184.100
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Calculated by: SAK Date: 01/20/2021
Checked by: BTW Date: 02/09/2021
Revision: 1

Table 10.6.3.1.2a-4—Depth Correction Factor d_q

Friction Angle, ϕ_f (degrees)	D_f/B	d_q
32	1	1.20
	2	1.30
	4	1.35
	8	1.40
37	1	1.20
	2	1.25
	4	1.30
	8	1.35
42	1	1.15
	2	1.20
	4	1.25
	8	1.30

Table C10.4.6.3-1—Elastic Constants of Various Soils (modified after U.S. Department of the Navy, 1982; Bowles, 1988)

Soil Type	Typical Range of Young's Modulus Values, E_s (ksi)	Poisson's Ratio, ν (dim)
Clay:		
Soft sensitive		0.4–0.5 (undrained)
Medium stiff	0.347–2.08	
to stiff	2.08–6.94	
Very stiff	6.94–13.89	
Loess	2.08–8.33	0.1–0.3
Silt	0.278–2.78	0.3–0.35
Fine Sand:		
Loose	1.11–1.67	0.25
Medium dense	1.67–2.78	
Dense	2.78–4.17	
Sand:		
Loose	1.39–4.17	0.20–0.36
Medium dense	4.17–6.94	
Dense	6.94–11.11	0.30–0.40
Gravel:		
Loose	4.17–11.11	0.20–0.35
Medium dense	11.11–13.89	
Dense	13.89–27.78	0.30–0.40

Estimating E_s from *SPT N* Value	
Soil Type	E_s (ksi)
Silts, sandy silts, slightly cohesive mixtures	$0.056\ N1_{60}$
Clean fine to medium sands and slightly silty sands	$0.097\ N1_{60}$
Coarse sands and sands with little gravel	$0.139\ N1_{60}$
Sandy gravel and gravels	$0.167\ N1_{60}$
Estimating E_s from q_c (static cone resistance)	
Sandy soils	$0.028q_c$

For $\phi_f = 0$:

$$i_c = 1 - (nH/cBLN_c) \quad (10.6.3.1.2a\text{-}5)$$

For $\phi_f > 0$:

$$i_c = i_q - [(1 - i_q)/(N_q - 1)] \quad (10.6.3.1.2a\text{-}6)$$

in which:

$$i_q = \left[1 - \frac{H}{(V + cBL\cot\phi_f)}\right]^n \quad (10.6.3.1.2a\text{-}7)$$

$$i_\gamma = \left[1 - \frac{H}{V + cBL\cot\phi_f)}\right]^{(n+1)} \quad (10.6.3.1.2a\text{-}8)$$

c = cohesion, taken as undrained shear strength (ksf)

N_c = cohesion term (undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

N_q = surcharge (embedment) term (drained or undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

N_γ = unit weight (footing width) term (drained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

γ = total (moist) unit weight of soil above or below the bearing depth of the footing (kcf)

D_f = footing embedment depth (ft)

B = footing width (ft)

$C_{wq}, C_{w\gamma}$ = correction factors to account for the location of the groundwater table as specified in Table 10.6.3.1.2a-2 (dim)

s_c, s_γ, s_q = footing shape correction factors as specified in Table 10.6.3.1.2a-3 (dim)

d_q = correction factor to account for the shearing resistance along the failure surface passing through cohesionless material above the bearing elevation as specified in Table 10.6.3.1.2a-4 (dim)

i_c, i_γ, i_q = load inclination factors determined from Eqs. 10.6.3.1.2a-5 or 10.6.3.1.2a-6, and 10.6.3.1.2a-7 and 10.6.3.1.2a-8 (dim)

$$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma \quad BN_{\gamma m} C_{w\gamma} \qquad (10.6.3.1.2a\text{-}1)$$

$$N_{cm} = N_c s_c i_c \qquad (10.6.3.1.2a\text{-}2)$$

$$N_{qm} = N_q s_q d_q i_q \qquad (10.6.3.1.2a\text{-}3)$$

$$N_\gamma m = N_\gamma s_\gamma i_\gamma \qquad (10.6.3.1.2a\text{-}4)$$

Table 10.5.5.2.2-1—Resistance Factors for Geotechnical Resistance of Shallow Foundations at the Strength Limit State

Method/Soil/Condition			Resistance Factor
Bearing Resistance	φ_b	Theoretical method (Munfakh et al., 2001), in clay	0.50
		Theoretical method (Munfakh et al., 2001), in sand, using *CPT*	0.50
		Theoretical method (Munfakh et al., 2001), in sand, using *SPT*	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footings on rock	0.45
		Plate Load Test	0.55
Sliding	φ_τ	Precast concrete placed on sand	0.90
		Cast-in-Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on Clay	0.85
		Soil on soil	0.90
	φ_{ep}	Passive earth pressure component of sliding resistance	0.50

APPENDIX E.4 – Earth Pressure Calculations for the Existing Abutments

Project No.:	94184	**Page:**	1 of 1
Project Title:	Armory Street over Abandoned CSX Spur		
Calculated by:	SAK	**Date:**	01/20/2021
Checked by:	BTW	**Date:**	02/08/2021

Earth Pressure Coefficient for Existing Abutments

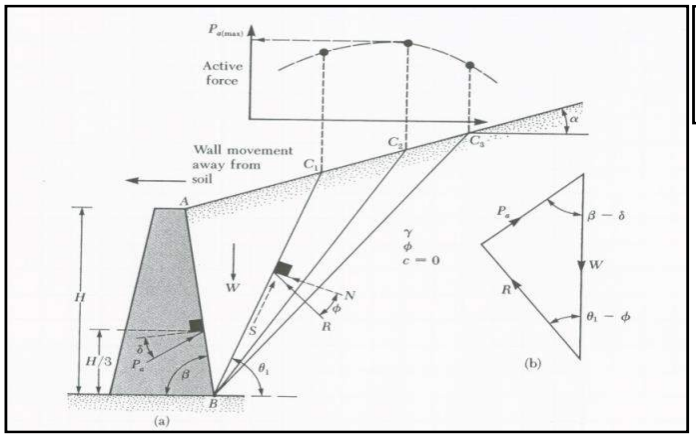
Objective: Calculate earth pressure coefficients for the existing abutments of the Armory Street bridge over the abandoned CSX spur.

Approach: Use Coulomb's method to calculate an active earth pressure coefficient and determine a design earth pressure coefficient in accordance with MassDOT LRFD Bridge Manual.

References:
1. Drawings in AutoCAD format provided by Tetra Tech on January 20, 2021.
2. MassDOT LRFD Bridge Manual, 2020.
3. Principles of Foundation Engineering, Second Edition, Das
4. AASHTO Bridge Design Specifications, 9th Edition, 2020.

Assumptions:
1. Retained soil is granular with an effective friction angle of 33°

Active Earth Pressure (Principles of Foundation Engineering, Second Edition, Das)



$$K_a = \text{Coulomb's active earth pressure coefficient} = \frac{\sin^2(\beta+\phi)}{\sin^2\beta\cdot\sin(\beta-\delta)\left[1+\sqrt{\frac{\sin(\phi+\delta)\cdot\sin(\phi-\alpha)}{\sin(\beta-\delta)\cdot\sin(\alpha+\beta)}}\right]^2}$$

α = backslope angle
β = wall batter angle
ϕ = soil friction angle
δ = soil/wall friction angle (= 2/3ϕ)

Evaluate Active Earth Pressure Coefficient

α	β	ϕ	δ
0	90	33	22

K_a = 0.26

Design Earth Pressures (from MassDOT LRFD Bridge Manual, Section 3.1.6)

Earth Pressure Coefficient = K_a

Earth Pressure Coefficient = 0.26 **(Use for Existing Abutments)**

APPENDIX E.5 – Global Slope Stability Calculations of Existing Abutments

Armory Street Over Abandoned CXS Spur
Bridge No. S-24-026
Springfield, Massachusetts

Discipline: Geotechnical

Title: Global Stability Analysis for the Existing Abutments

MassDOT Contract No. 115796

MassDOT Project File No. 609409

Design Basis/Assumptions:

Purpose: Perform global stability analyses on the existing granite block abutments.

Assumptions:

1) Engineering properties for existing fill, varved silt and clay, silt, glacial till, and bedrock encountered in the subsurface explorations (Reference 2).
2) Groundwater conditions the same or similar to those observed in the subsurface explorations by Nobis.
3) Surcharge loading of 250 psf (Reference 3).
4) Seismic loading 0.074 (As x 0.5 = 0.148g x 0.5) (Reference 4).

Approach:

Use the computer slope stability analysis software Slide2, by RocScience, Inc., to perform global stability analyses on the existing abutments based on the results of the subsurface explorations performed by Nobis and a longitudinal bridge section developed using information obtained from AutoCAD drawings provided by Tetra Tech (Reference 1).

References:

1) Topographic Survey and Bridge Plans and Profile (AutoCAD) drawing prepared by Tetra Tech, Inc. and provided to Nobis in January and February 2021.
2) Standard Penetration Test (SPT) data and subsurface explorations observed by Nobis.
3) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
4) Seismic site classification and seismic parameters developed by Nobis.

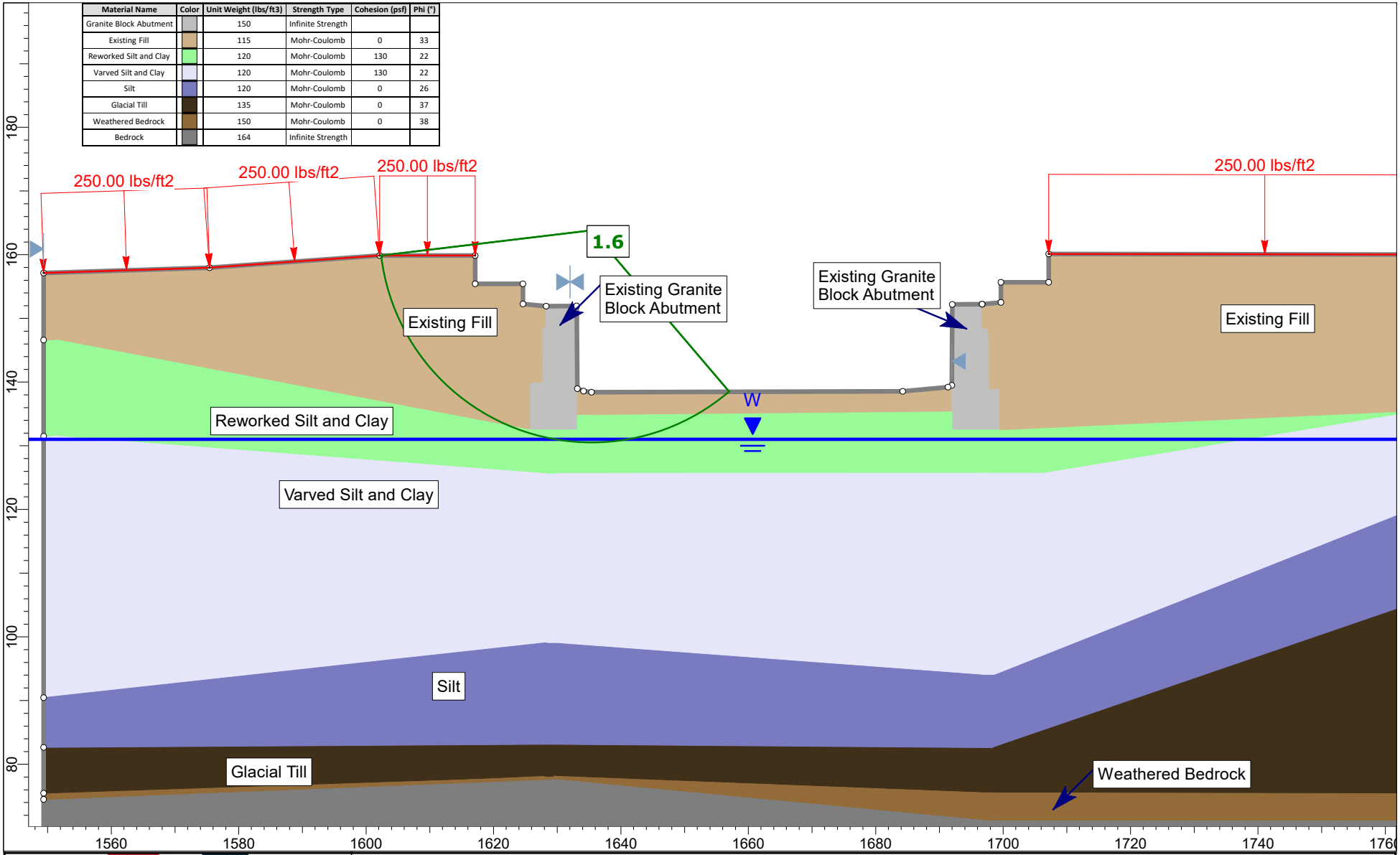
Remarks/Conclusions:

Based on the Slide2 analysis, the minimum factor of safety against global slope failure is at least 1.6 and 1.4 under static and seismic conditions, respectively, for the north abutment. The minimum factor of safety against global slope failure is at least 1.6 and 1.4 under static and seismic conditions, respectively, for the south abutment.

Originated By: Sarah Kurtzer Date: 02/08/2021

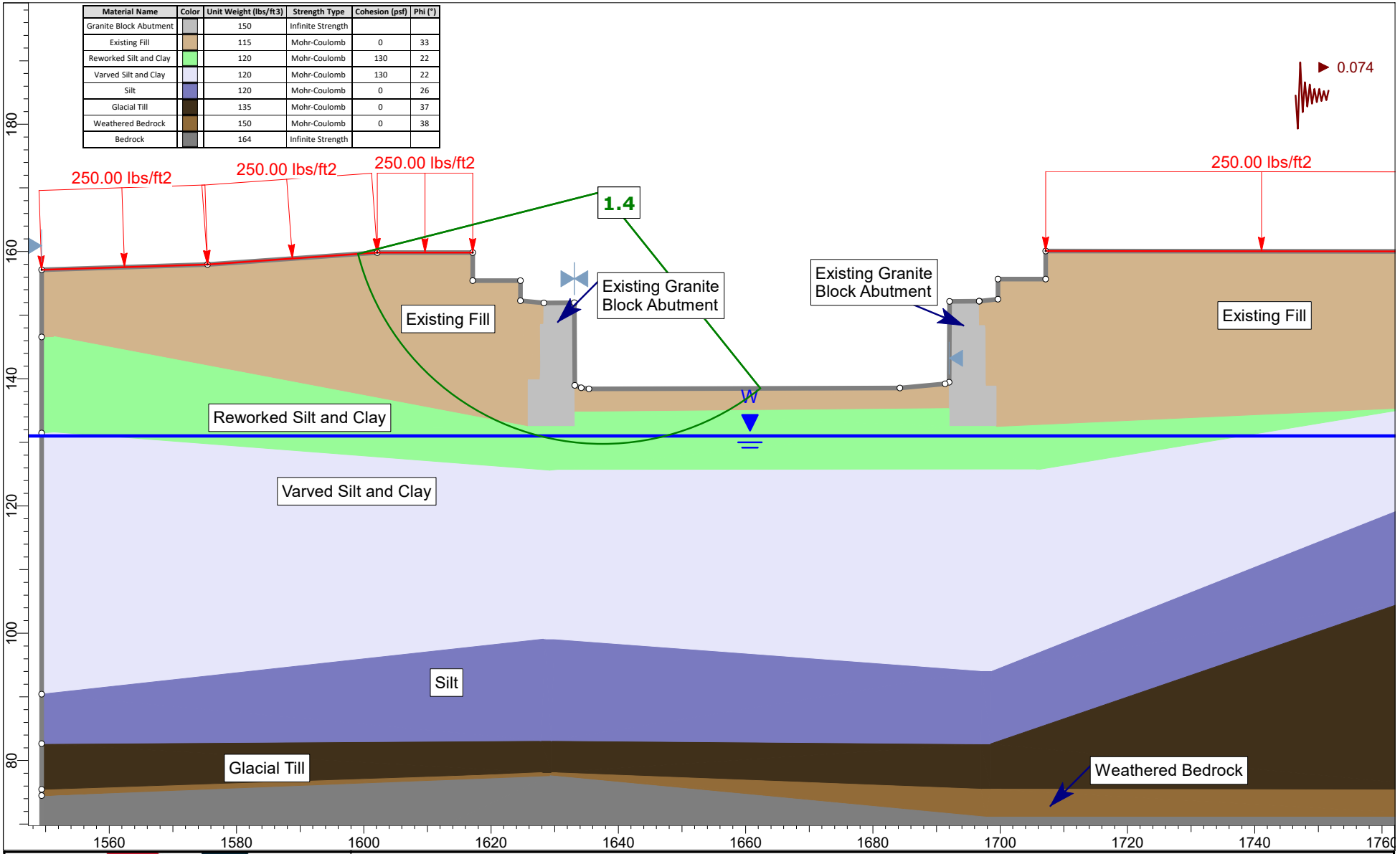
Reviewed By: Kurt Jelinek Date: 02/10/2021

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)
Granite Block Abutment		150	Infinite Strength		
Existing Fill		115	Mohr-Coulomb	0	33
Reworked Silt and Clay		120	Mohr-Coulomb	130	22
Varved Silt and Clay		120	Mohr-Coulomb	130	22
Silt		120	Mohr-Coulomb	0	26
Glacial Till		135	Mohr-Coulomb	0	37
Weathered Bedrock		150	Mohr-Coulomb	0	38
Bedrock		164	Infinite Strength		



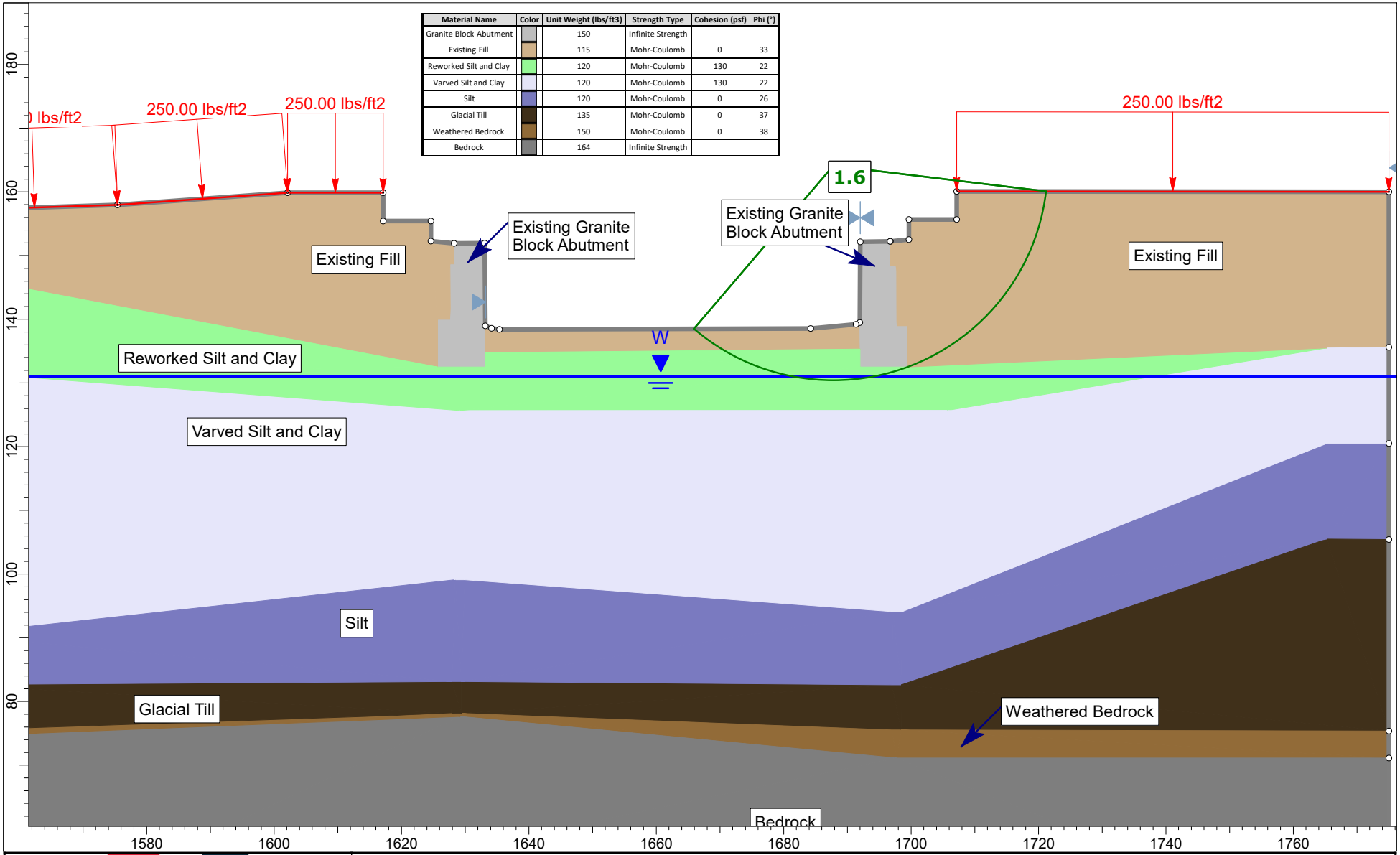
Project	Armory Street Over CSX Mainline and Abandoned Spur - Springfield, MA		
Analysis Description	Global Slope Stability - S-24-026 - Static		North - Static
Drawn By	SAK	Scale 1:250	Company Nobis Group
Date	11/9/2023		File Name S-24-026.slmd

SLIDEINTERPRET 9.030

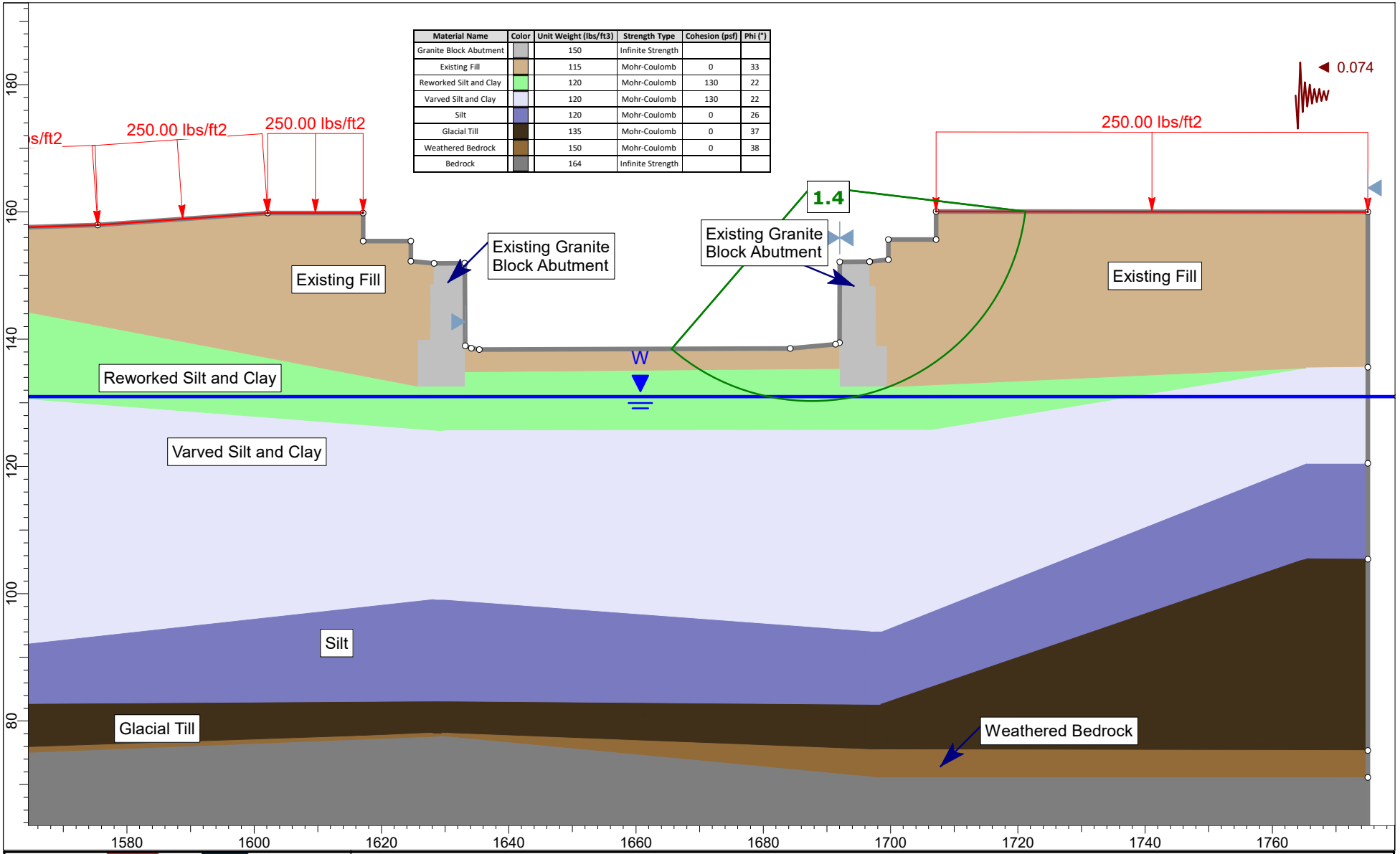


SLIDEINTERPRET 9.030

Project	Armory Street Over CSX Mainline and Abandoned Spur - Springfield, MA		
Analysis Description	Global Slope Stability - S-24-026 - Seismic		North - Seismic
Drawn By	SAK	Scale 1:250	Company Nobis Group
Date	11/9/2023		File Name S-24-026.slmd



SLIDEINTERPRET 9.030	*Project*	Armory Street Over CSX Mainline and Abandoned Spur - Springfield, MA	
	Analysis Description	Global Slope Stability - S-24-026	South - Static
	Drawn By SAK	*Scale* 1:250	*Company* Nobis Group
	Date 11/9/2023		*File Name* S-24-026.slmd



SLIDEINTERPRET 9.030 nobis	*Project* Armory Street Over CSX Mainline and Abandoned Spur - Springfield, MA		
	Analysis Description Global Slope Stability - S-24-026		South - Seismic
	Drawn By SAK	*Scale* 1:250	*Company* Nobis Group
	Date 11/9/2023		*File Name* S-24-026.slmd

APPENDIX E.6 – Axial-Lateral Micropile Analyses

Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for Proposed Abutments
Springfield, Massachusetts

Calculated by: RAC Date: 2/6/2025
Checked by: BTW Date: 2/25/2025

Purpose: Perform axial and lateral analyses for the proposed micropiles for the north and south abutments of the above-referenced project. See table and summary provided in Step 3 and 4 for results of the lateral and axial analyses, respectively. The Structural Engineer should evaluate the structural adequacy of the micropiles.

References:
1) FHWA-NHI-05-039 Micropile Manual, 2005.
2) MassDOT Bridge Design Manual, 2024.
3) Computer program GROUP, Version 2022, and associated user's manual, by Ensoft, Inc.
4) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
5) Loads provided by Tetra Tech via email on December 27, 2024.
6) Gravity Thrust Block diagrams with elevations provided by Tetra Tech on November 14, 2024.
7) Test borings observed by Nobis at the site in 2019.
8) Email and phone communications with design team.

Given:
1) Factored loads provided by Tetra Tech per Reference No. 5.
2) Pile cap geometry per References No. 5 and 6.
3) A pinned condition between the micropiles and the pile cap at both abutments per Reference No. 8.

Assumptions:
1) Compressive strength of grout (f'_c) is 5 ksi, and yield strength (F_y) of casing and rebar are 52 ksi and 60 ksi, respectively.
2) Micropiles will consist of casing with an outer diameter of 10.75-inch and 0.5-inch thick walls with a #8 sized center bar.
3) Structural engineer will verify the loads and the pile head condition used in analysis, and evaluate the structural resistance of the micropiles in accordance with AASHTO and MassDOT Bridge Design Manual.
4) Subsurface information from Reference 7 is representative of subsurface conditions at the proposed abutment.
5) A casing thickness loss of 1/16-in. in the top 3 feet due to corrosion and 50% loss (approx. 60% moment capacity) below the top 3 feet of the pile. No casing joints are located in top 3 feet of the micropiles.
6) A Pm of 0.5 to 1 was used from the bottom of the proposed pile cap to the existing ground surface in front of the abutment to represent the effect of the existing abutment on the proposed piles (i.e. 12 feet below the bottom of the pile cap).
7) The effects of nearby piles from the abutment extension/crash walls and return walls were ignored for the purposes of this analysis. P-multipliers (Pm) were calculated directly by Group for the micropiles of the abutments only.

Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for Proposed Abutments
Springfield, Massachusetts

Calculated by: RAC Date: 2/6/2025
Checked by: BTW Date: 2/25/2025

Solution:

Step 1: Soil Properties and Profile

Nobis used subsurface information from Borings BB-5 through BB-8 and BB-8A of Reference No. 7 to develop soil parameters in the table below. Stratigraphy was based on soils and bedrock conditions encountered at or near both abutments (worst case assumed). The depth datum was taken at the bottom of the proposed pile cap shown on Figure 7 (El. 151.5). Soil unit weight (γ_{moist}), angle of internal friction (ϕ), and cohesion were estimated based on field and laboratory testing and a study performed on Connecticut Valley Varved Clay entitled "Geology and Engineering Properties of Connecticut Valley Varved Clay" (DeGroot, D.J. and Lutenegger, A.J.). The groundwater table was taken at approximately El. 131. Soil modulus parameters (k) and strain factors for the varved silt/clay were determined using Tables 3.7 and 3.5 from Reference No. 2, respectively. Uniaxial Compressive Strength (U.C.S.) of rock was based on lab test data.

Soil Layer	Elevation (ft)	Depth (ft)	γ_{moist} (pcf)	ϕ (°)	k (pci)	Cohesion (psf)	Strain Factor (dims)	U.C.S (psi)
Fill	155.5 to 131	-4 to 21.5	115	33	25/20	-	-	-
Varved Silt & Clay	131 to 94	21.5 to 58.5	120	22	100	130	0.01	-
Silt	94 to 82.5	58.5 to 70	120	26	50	-	-	-
Glacial Till	82.5 to 75.4	70 to 77.1	135	37	125	-	-	-
Weathered Bedrock	75.4 to 71	77.1 to 81.5	150	38	150	-	-	-
Bedrock (Argillaceous Sandstone)	<71	>81.5	164	-	-	-	-	7,500

1) The design groundwater elevation is El. 131, bottom of the fill.

Step 2: Micropile and Pile Cap Properties

Micropile Cased (50%): micropile strength with 50% casing reduction due to threaded sections

Section Length:	82.5 ft*	Outer Diameter w/loss:	10.25 **in**	
Outside Diameter:	10.75 in	Casing Thickness w/loss:	0.25 **in**	
Casing Thickness:	0.5 in			
Percent of Casing loss to Thread:	50 %			
Yield Stress of Casing:	52 ksi			
Elastic modulus of Casing:	29000 ksi			
Center Bar:	# 8 bar	Area of Casing (A_{ct}):	**7.9 in^2**	
Yield Stress of Center Bar:	60 ksi	Area of Bar (A_b):	**0.8 in^2**	
Grout Compressive Strength:	5 ksi	Area of Grout (A_g):	**73.9 in^2**	

*Section length includes the 1-foot of embedment into bedrock required by the MassDOT Bridge Manual.

Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for Proposed Abutments
Springfield, Massachusetts

Calculated by: RAC Date: 2/6/2025
Checked by: BTW Date: 2/25/2025

Micropile Uncased: micropile strength with no casing (inside rock socket)

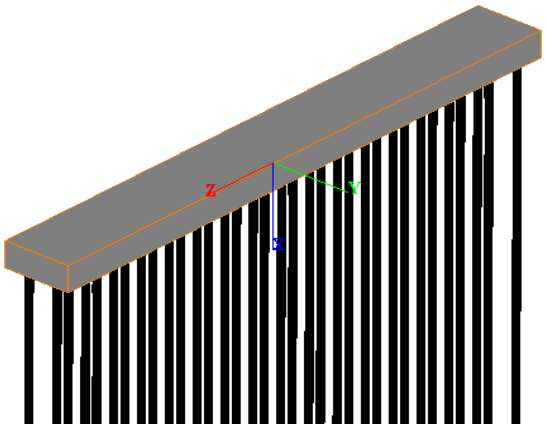
Section Length:	8	ft
Outside Diameter (before corrosion):	9.75	in
Center Bar:	# 8	bar
Yield Stress of Center Bar:	60	ksi
Grout Compressive Strength:	5	ksi

Area of Bar (A_b): **0.8 in^2**

Area of Grout (A_g): **73.9 in^2**

Pile Cap: See graphic.

Cap Length in Z-axis (Transverse):	70.68	ft
Cap Width in Y-axis (Longitudinal):	8	ft
Cap Thickness in X-axis (Vertical):	3	ft
Center-to-center spacing in Y-axis :	5	ft
Center-to-center spacing in Z-axis :	4	ft



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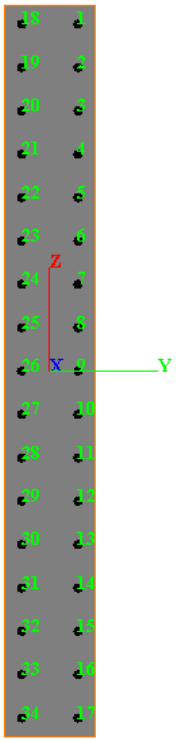

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Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for Proposed Abutments
Springfield, Massachusetts

Calculated by: RAC Date: 2/6/2025
Checked by: BTW Date: 2/25/2025

Step 3: Lateral Analysis

The software GROUP, version 2022 by Ensoft, Inc. was used for the lateral analyses. Pinned-head conditions were assumed between the micropiles and proposed pile caps. The Structural Engineer should evaluate the structural adequacy of the micropiles. The following table summarizes the results of the lateral analyses.

Results of Micropile Lateral Analyses for Proposed Abutments (per micropile)						
Abutment	**Load Case**	**Max Shear (kip)**	**Max Lateral Deflection (in)**	**Max Moment Below 3 Feet (kip*ft)^2**	**Max Axial Load (kip)**	**Min Axial Load (kip)**
North and South	Ser. I	6.6	0.23	15.8	75.0	60.0
	Str. I (Max)	9.3	0.33	22.9	105.0	85.0
	Str. I (Min)	6.7	0.24	16.4	90.0	75.0
	Ext. Event I	4.3	0.15	10.2	45.0	35.0

1) Depth of fixity is approximately 21 feet below the bottom of pile cap, and taken at the 2nd point of zero deflection
2) Maximum moment below the top 3 feet with loss of 50% casing due to threaded connections.

Step 4: Axial Analysis

Structural Resistance Factors			
Load Case	**Compression**	**Tension**	
Strength	**0.75**	**0.8**	Ref. No. 4 Tb. 10.5.5.2.5-2
Service	**1**	**1**	Ref. No. 4 Section 10.5.5.1
Extreme	**1**	**0.8**	Ref. No. 4 Section 10.5.5.3

Load Demand (from Group)		
Load Case	**Compression (kips)**	**Tension (kips)**
Strength	**105.0**	**0.0**
Service	**75.0**	**0.0**
Extreme	**45.0**	**0.0**

Geotechnical Resistance Factors			
Load Case	**Compression**	**Tension**	
Strength	**0.55**	**0.55**	Ref. No. 4 Tb. 10.5.5.2.5-1
Service	**1**	**1**	Ref. No. 4 Section 10.5.5.1
Extreme	**1**	**0.8**	Ref. No. 4 Section 10.5.5.3

Evaluate the structural resistance of the micropile for axial load only (negating lateral loads).

For micropile cased section (assuming 50% section):

Nominal axial compressive structural resistance (R_n): **648.7 kips** Ref. No. 4 Eq. 10.9.3.10.2a-2

Nominal axial tension structural resistance (R_n): **449.2 kips** Ref. No. 4 Eq. 10.9.3.10.3a-2

Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for Proposed Abutments
Springfield, Massachusetts

Calculated by: RAC Date: 2/6/2025
Checked by: BTW Date: 2/25/2025

For micropile uncased section:

Nominal axial compressive structural resistance (R_n):	**306.9**	**kips**	Ref. No. 4 Eq. 10.9.3.10.2b-2
Nominal axial tension structural resistance (R_n):	**47.1**	**kips**	Ref. No. 4 Eq. 10.9.3.10.3b-2

Evaluate the geotechnical resistance of the micropile for axial loads.

Grout-to-ground bond strength in Bedrock:	**11**	**ksf**	Ref. No. 4 Table C10.9.3.5.2-1
Minimum Rock Socket Length:	**8**	**feet**	assumption
Total Nominal grout-to-ground bond resistance:	**225**	**Kips**	Ref. No. 4 Eq. 10.9.3.5.2-1

Summary

Check to verify that a 8 foot rock socket is adequate based on the maximum factored axial load.

Geotechnical					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**123.5**	**105.0**	**123.5**	**0.0**	OK
Service	**224.6**	**75.0**	**224.6**	**0.0**	
Extreme	**224.6**	**45.0**	**179.7**	**0.0**	

Check to verify that the cased micropile is *adequate based on the maximum factored axial load (negating lateral loads).

Structural (cased): Check the strucural resistance of the micropile					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**486.6**	**105.0**	**359.4**	**0.0**	OK
Service	**648.7**	**75.0**	**449.2**	**0.0**	
Extreme	**648.7**	**45.0**	**359.4**	**0.0**	

*Structural engineer shall evaluate the structural adequacy of the micropiles.

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Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for Proposed Abutments
Springfield, Massachusetts

Calculated by: RAC Date: 2/6/2025
Checked by: BTW Date: 2/25/2025

Check to verify that the uncased micropile is *adequate based on the maximum factored axial load (negating lateral loads) and to verify that a plunge length is not needed.

Structural (uncased)					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**230.2**	**105.0**	**37.7**	**0.0**	OK
Service	**306.9**	**75.0**	**47.1**	**0.0**	
Extreme	**306.9**	**45.0**	**37.7**	**0.0**	

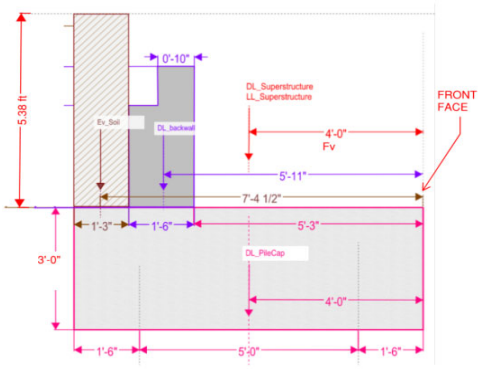
*Structural engineer shall evaluate the structural adequacy of the micropiles.

S-24-026 Active RR Revised Reactions: 12/27/2024

Proposed Width =	70.67 ft	70.68
Existing Span =	61.33 ft	
Existing & Proposed Span =	81.330 ft	

Loads Factors

	Load Factors	Service I	Strength I			Extreme Event I	
				max	min		
Vertical	Superstructure DL (DC)	1.00	γp	1.25	0.90		1.00
	Wearing Surface DL (DW)	1.00	γp	1.50	0.65		1.00
	Live Load (LL)	1.00		1.75	1.75	γEQ	0.00
	Pile Cap	1.00	γp	1.25	0.90		1.00
	Backwall	1.00	γp	1.25	0.90		1.00
	Earth (Ev)	1.00		1.35	1.00		1.00
	Approach Slab	1.00	γp	1.25	0.90		1.00
Horiz	Thermal Force (Tu)	1.00		1.20	0.50		0.00
	Breaking Force (BR)	1.00		1.75	1.75		0.00
	Horizontal Earth (EH_bw)	1.00	γp	1.35	0.90		1.00
	Horizontal Earth (EH_pc)	1.00	γp	1.35	0.90		1.00

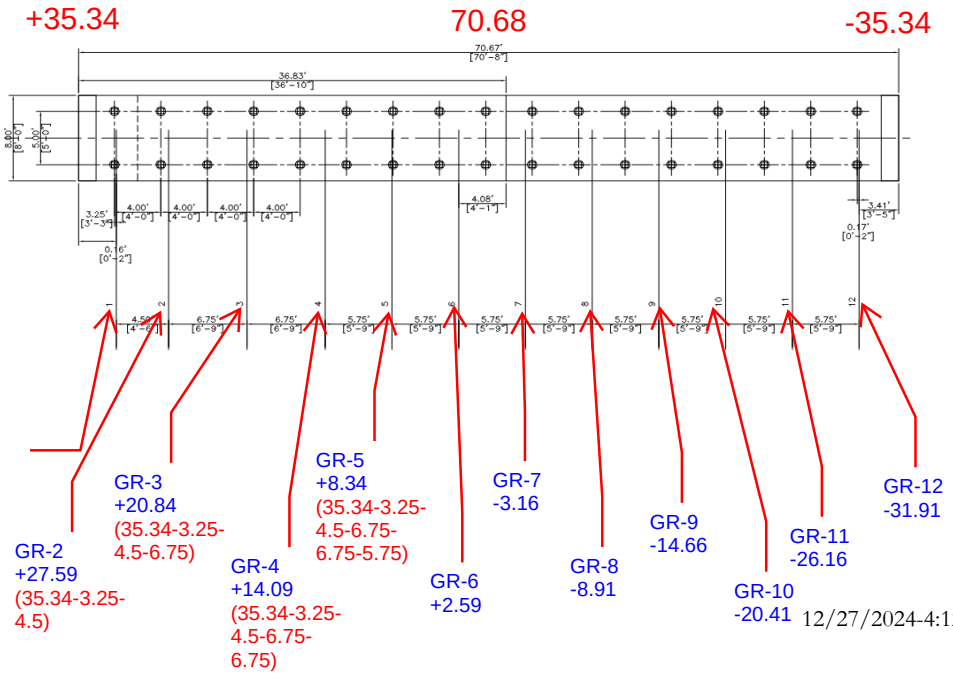


PROPOSED BRIDGE SEAT ELEVATIONS AT THE CL OF BRG.	
GR NO.	SOUTH
1	154.48
2	154.48
3	154.62
4	154.75
5	154.87
6	154.98
7	155.10
8	155.21
9	155.11
10	154.99
11	154.88
12	154.76

B.O. S. pile cap EL: 151.48

PROPOSED BRIDGE SEAT ELEVATIONS AT THE CL	
GR NO.	NORTH
1	154.23
2	154.23
3	154.37
4	154.51
5	154.62
6	154.74
7	154.85
8	154.97
9	154.86
10	154.74
11	154.63
12	154.51

B.O.N. pile cap EL: 151.23



Point Load at each Girder Bearing

Girder 1 Load 1 (-3.4,-4,+32.09)

Loads to be Applied to Substructure (Abutment)										
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap	Service I Force (k)	Strength I Max Force (k)	Strength I Min Force (k)	Extreme Event I Force (k)	
Vertical	DC	68.34	4.0			68.3	85.4	61.5	68.3	
	DW	5.9	4.0			110.7 5.9	158.0 8.8	129.1 3.8	74.2 5.9	
	LL	36.5	4.0			36.5	63.8	63.8	0.0	
Horiz.	Breaking Force (BR)	3.8			3.4	3.8	6.7	6.7	0.0	
	Thermal Force (Tu)	2.4			3.4	6.2 2.4	9.6 2.9	7.9 1.2	0.0 0.0	

Girder 2 Load 2 (-3.4,-4,+27.59)

Loads to be Applied to Substructure (Abutment)										
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap	Service I Force (k)	Strength I Max Force (k)	Strength I Min Force (k)	Extreme Event I Force (k)	
Vertical	DC	69.97	4.0			70.0	87.5	63.0	70.0	
	DW	5.9	4.0			157.1 5.9	238.4 8.8	208.9 3.	75.9 5.9	
	LL	81.2	4.0			81.2	142.1	142.1	0.0	
Horiz	Breaking Force (BR)	3.8			3.4	3.8	6.7	6.7	0.0	
	Thermal Force (Tu)	2.4			3.4	6.2 2.4	9.6 2.9	7.9 1.2	0.0 0.0	

Girder 3 Load 3 (-3.6,-4,+20.84)

Loads to be Applied to Substructure (Abutment)										
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap	Service I Force (k)	Strength I Max Force (k)	Strength I Min Force (k)	Extreme Event I Force (k)	
Vertical	DC	70.34	4.0			70.3	87.9	63.3	70.3	
	DW	5.8	4.0			161.3 5.8	245.7 8.8	216.1 3.8	76.1 5.8	
	LL	85.2	4.0			85.2	149.0	149.0	0.0	
Horiz	Breaking Force (BR)	3.8			3.6	3.8	6.7	6.7	0.0	
	Thermal Force (Tu)	2.4			3.6	6.2 2.4	9.6 2.9	7.9 1.2	0.0 0.0	

Girder 4 Load 4 (-3.7,-4,+14.09)

Loads to be Applied to Substructure (Abutment)										
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap	Service I Force (k)	Strength I Max Force (k)	Strength I Min Force (k)	Extreme Event I Force (k)	
Vertical	DC	68.35	4.0			68.4	85.4	61.5	68.4	
	DW	5.9	4.0			155.3 5.9	236.0 8.8	207.1 3.8	74.3 5.9	
	LL	81.0	4.0			81.0	141.8	141.8	0.0	
Horiz	Breaking Force (BR)	3.8			3.7	3.8	6.7	6.7	0.0	
	Thermal Force (Tu)	2.4			3.7	6.2 2.4	9.6 2.9	7.9 1.2	0.0 0.0	

Girder 5 Load 5 (-3.8,-4,+8.34)

Loads to be Applied to Substructure (Abutment)										
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap	Service I Force (k)	Strength I Max Force (k)	Strength I Min Force (k)	Extreme Event I Force (k)	
Vertical	DC	65.70	4.0			65.7	82.1	59.1	65.7	
	DW	5.9	4.0			148.7 5.9	225.8 8.8	197.8 3.8	71.6 5.9	
	LL	77.1	4.0			77.1	134.9	134.9	0.0	
Horiz	Breaking Force (BR)	3.8			3.8	3.8	6.7	6.7	0.0	.0
	Thermal Force (Tu)	2.4			3.8	6.2 2.4	9.6 2.9	7.9 1.2	0.0	.0

Girder 6 Load 6 (-3.9,-4,+2.59)

Loads to be Applied to Substructure (Abutment)										
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap	Service I Force (k)	Strength I Max Force (k)	Strength I Min Force (k)	Extreme Event I Force (k)	
Vertical	DC	63.95	4.0			64.0	79.9	57.6	64.0	
	DW	5.9	4.0			147.0 5.9	223.6 8.8	196.3 3.8	69.9 5.9	
	LL	77.1	4.0			77.1	134.9	134.9	0.0	
Horiz	Breaking Force (BR)	3.8			3.9	3.8	6.7	6.7	0.0	
	Thermal Force (Tu)	2.4			3.9	6.2 2.4	9.6 2.9	7.9 1.2	0.0	0.0

Girder 7 Load 7 (-4.0,-4,-3.16)

Loads to be Applied to Substructure (Abutment)										
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap	Service I Force (k)	Strength I Max Force (k)	Strength I Min Force (k)	Extreme Event I Force (k)	
Vertical	DC	63.95	4.0			64.0	79.9	57.6	64.0	
	DW	5.9	4.0			147.0 5.9	223.6 8.8	196.3 3.8	69.9 5.9	
	LL	77.1	4.0			77.1	134.9	134.9	0.0	
Horiz	Breaking Force (BR)	3.8			4.0	3.8	6.7	6.7	0.0	
	Thermal Force (Tu)	2.4			4.0	6.2 2.4	9.6 2.9	7.9 1.2	0.0	0.0

Girder 8 Load 8 (-4.2,-4,-8.91)

Loads to be Applied to Substructure (Abutment)										
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap	Service I Force (k)	Strength I Max Force (k)	Strength I Min Force (k)	Extreme Event I Force (k)	
Vertical	DC	65.70	4.0			65.7	82.1	59.1	65.7	
	DW	5.9	4.0			148.7 5.9	225.8 8.8	197.8 3.8	71.6 5.9	
	LL	77.1	4.0			77.1	134.9	134.9	0.0	
Horiz	Breaking Force (BR)	3.8			4.2	3.8	6.7	6.7	0.0	
	Thermal Force (Tu)	2.4			4.2	6.2 2.4	9.6 2.9	7.9 1.2	0.0	0.0

Girder 9 Load 9 (-4.1,-4,-14.66)

Loads to be Applied to Substructure (Abutment)											
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap		Service I Force (k)	Strength I Max Force (k)		Strength I Min Force (k)		Extreme Event I Force (k)
Vertical	DC	65.70	4.0				65.7	82.1		59.1		65.7
	DW	5.9	4.0			148.7	5.9	225.8	8.8	197.8	3.8	71.6 5.9
	LL	77.1	4.0				77.1	134.9		134.9		0.0
Horiz	Breaking Force (BR)	3.8			4.1		3.8	6.7		6.7		0.0
	Thermal Force (Tu)	2.4			4.1	6.2	2.4	9.6	2.9	7.9	1.2	0.0 0.0

Girder 10 Load 10 (-3.9,-4,-20.41)

Loads to be Applied to Substructure (Abutment)											
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap		Service I Force (k)	Strength I Max Force (k)		Strength I Min Force (k)		Extreme Event I Force (k)
Vertical	DC	65.70	4.0				65.7	82.1		59.1		65.7
	DW	5.9	4.0			148.7	5.9	225.8	8.8	197.8	3.8	71.6 5.9
	LL	77.1	4.0				77.1	134.9		134.9		0.0
Horiz	Breaking Force (BR)	3.8			3.9		3.8	6.7		6.7		0.0
	Thermal Force (Tu)	2.4			3.9	6.2	2.4	9.6	2.9	7.9	1.2	0.0 0.0

Girder 11 Load 11 (-3.8,-4,-26.16)

Loads to be Applied to Substructure (Abutment)											
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap		Service I Force (k)	Strength I Max Force (k)		Strength I Min Force (k)		Extreme Event I Force (k)
Vertical	DC	58.55	4.0				58.6	73.2		52.7		58.6
	DW	5.9	4.0			144.4	5.9	221.8	8.8	196.3	3.8	64.5 5.9
	LL	79.9	4.0				79.9	139.8		139.8		0.0
Horiz	Breaking Force (BR)	3.8			3.8		3.8	6.7		6.7		0.0
	Thermal Force (Tu)	2.4			3.8	6.2	2.4	9.6	2.9	7.9	1.2	0.0 0.0

Girder 12 Load 12 (-3.7,-4,-31.91)

Loads to be Applied to Substructure (Abutment)											
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap		Service I Force (k)	Strength I Max Force (k)		Strength I Min Force (k)		Extreme Event I Force (k)
Vertical	DC	54.61	4.0				54.6	68.3		49.1		54.6
	DW	5.9	4.0			110.8	5.9	165.1	8.8	140.9	3.8	60.5 5.9
	LL	50.3	4.0				50.3	88.0		88.0		0.0
Horiz	Breaking Force (BR)	3.8			3.7		3.8	6.7		6.7		0.0
	Thermal Force (Tu)	2.4			3.7	6.2	2.4	9.6	2.9	7.9	1.2	0.0 0.0

70.68 feet

Line Load along Abutment

Loads to be Applied to Substructure (Abutment)																	
Loads		Unfactored line Force (klf)		Fv Arm	Applied x ft from Bridge Seat		Applied x ft from Bot of Pile Cap		Service I Force (k)		Strength I Max Force (k)		Strength I Min Force (k)		Extreme Event I Force (k)	
Vertical	Load 13 End Diaphragm	1.25		4.0					84.8	1.2	113.0	1.6	77.8	1.1	84.8	1.2
	Load 14 Pile Cap	3.9		4.0					275.7	3.9	346.4	4.9	247.4	3.5	275.7	3.9
	Load 15 Backwall	1.2		6.0					84.8	1.2	106.0	1.5	77.8	1.1	84.8	1.2
	~~Earth (LW Ev)~~	~~0.5~~		~~7.4~~					~~0.5~~		~~0.6~~		~~0.5~~		~~0.5~~	
	Load 16 Earth (NW Ev)	0.9		7.4					63.6	0.9	84.8	1.2	63.6	0.9	63.6	0.9
	Approach Slab	0.0							0.0		0.0		0.0		0.0	
Horiz.	Horiz Earth (EH_bw NW)	Load 17	0.8		1.8		4.8		56.6	0.8	77.8	1.1	49.5	0.7	56.6	0.8
	~~Horiz Earth (EH_bw LW)~~		~~0.4~~		~~1.8~~		~~4.8~~		~~0.4~~		~~0.5~~		~~0.3~~		~~0.4~~	
	Horiz Earth (EH_pc NW)	Load 18	1.2		-1.6		1.4		84.8	1.2	113.0	1.6	77.8	1.1	84.8	1.2
	~~Horiz Earth (EH_pc LW)~~		~~0.4~~		~~1.5~~		~~1.5~~		~~0.4~~		~~0.6~~		~~0.4~~		~~0.4~~	

EH_bw: Earth pressure at backwall per ft
EH_pc: Earth pressure at pile cap per ft
Fv Arms are taken from the front face of the pile cap

LW fill width= 0 ft
NW fill width= 70.67 ft

Load 13 (-3,-4,0)

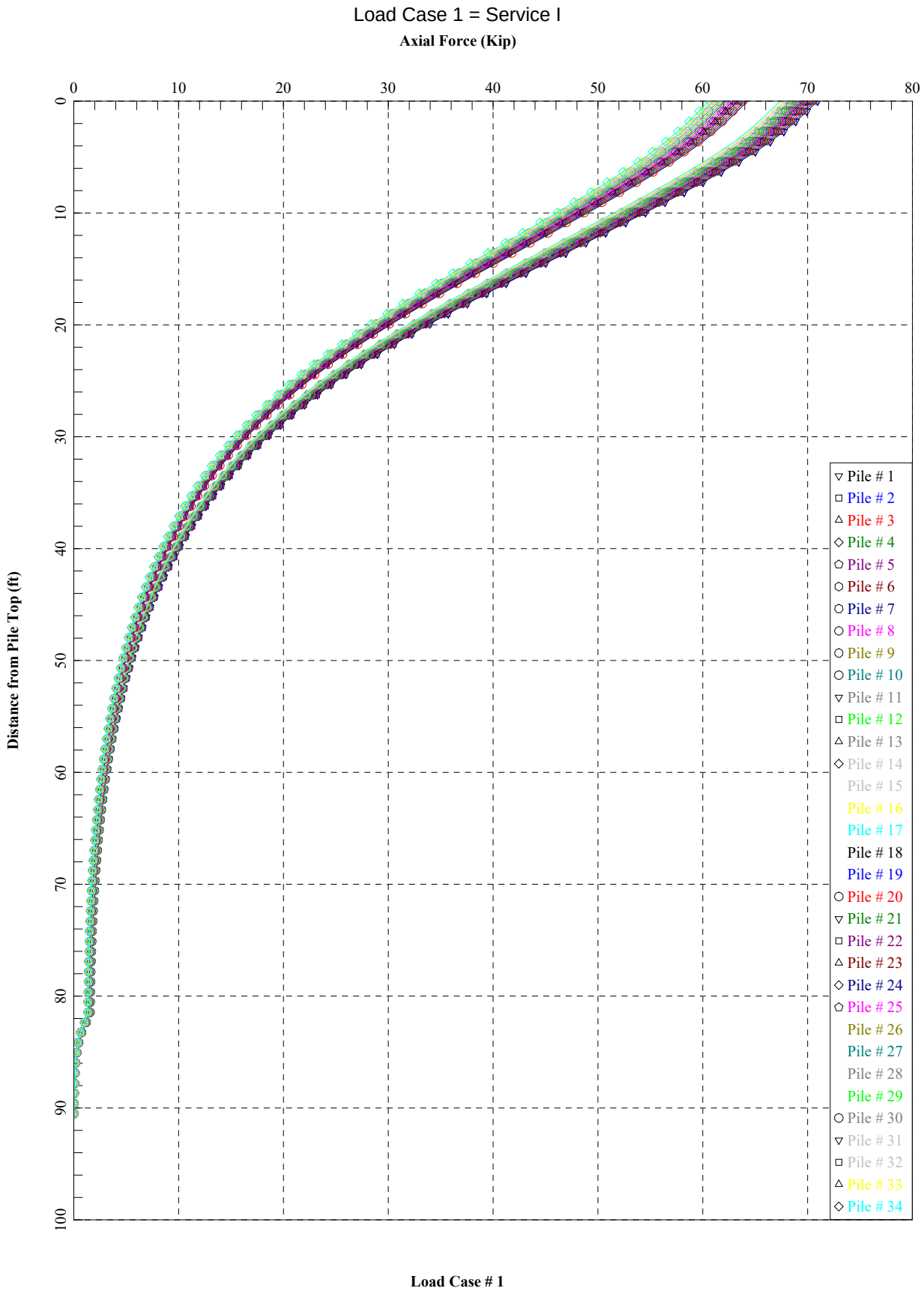
Load 14 (0,-4,0)

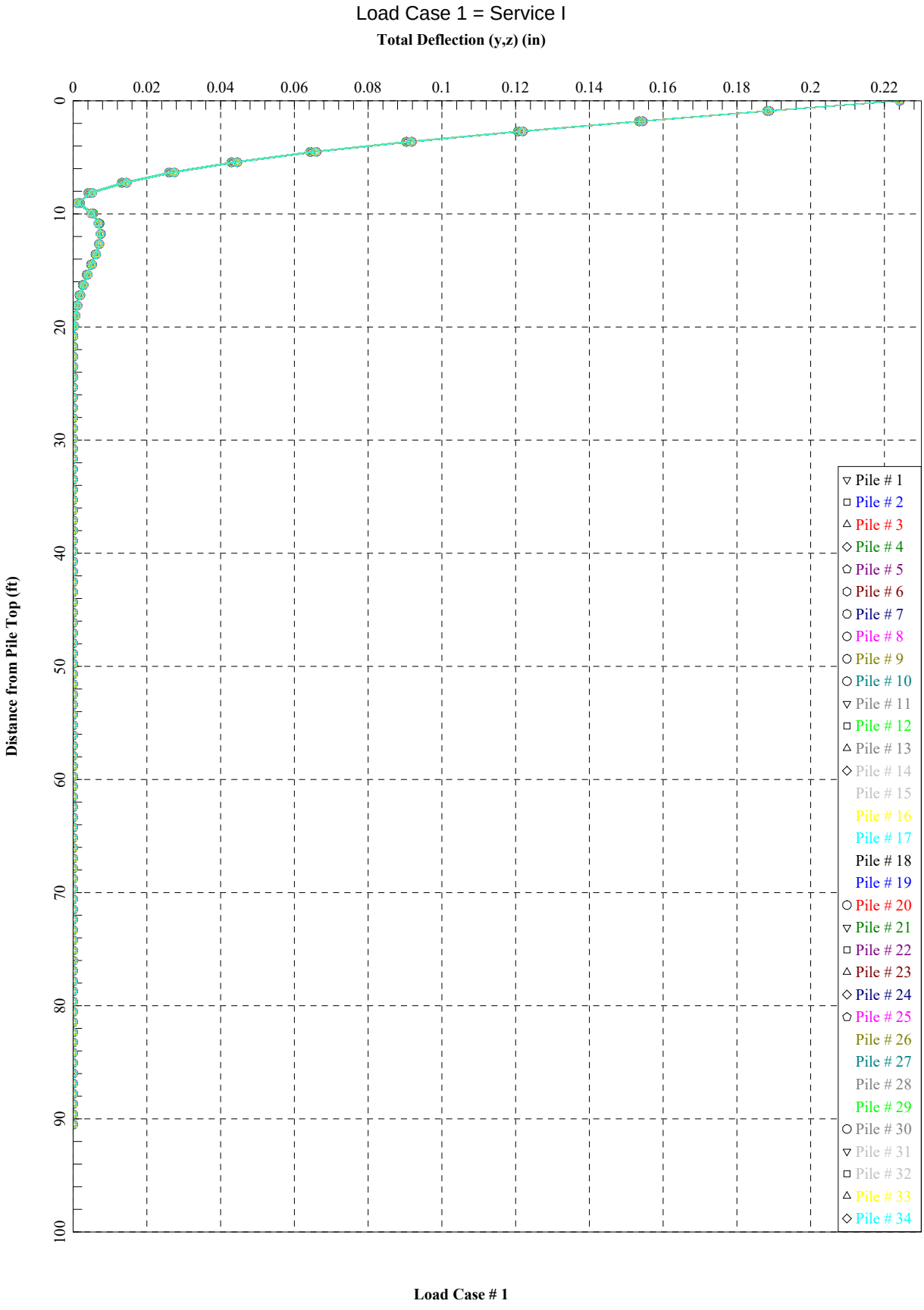
Load 15 (-3,-6,0)

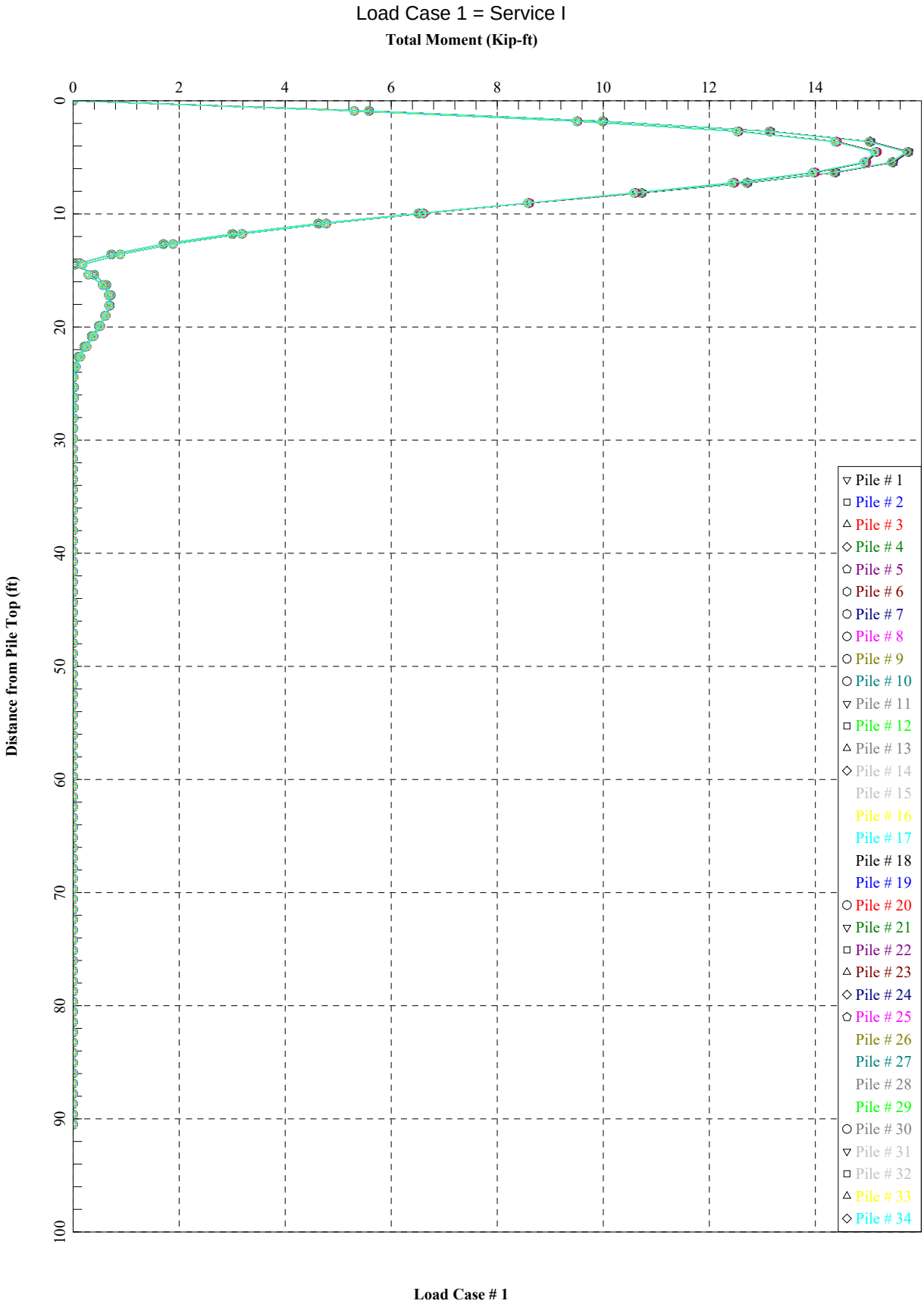
Load 16 (-3,-7.4,0)

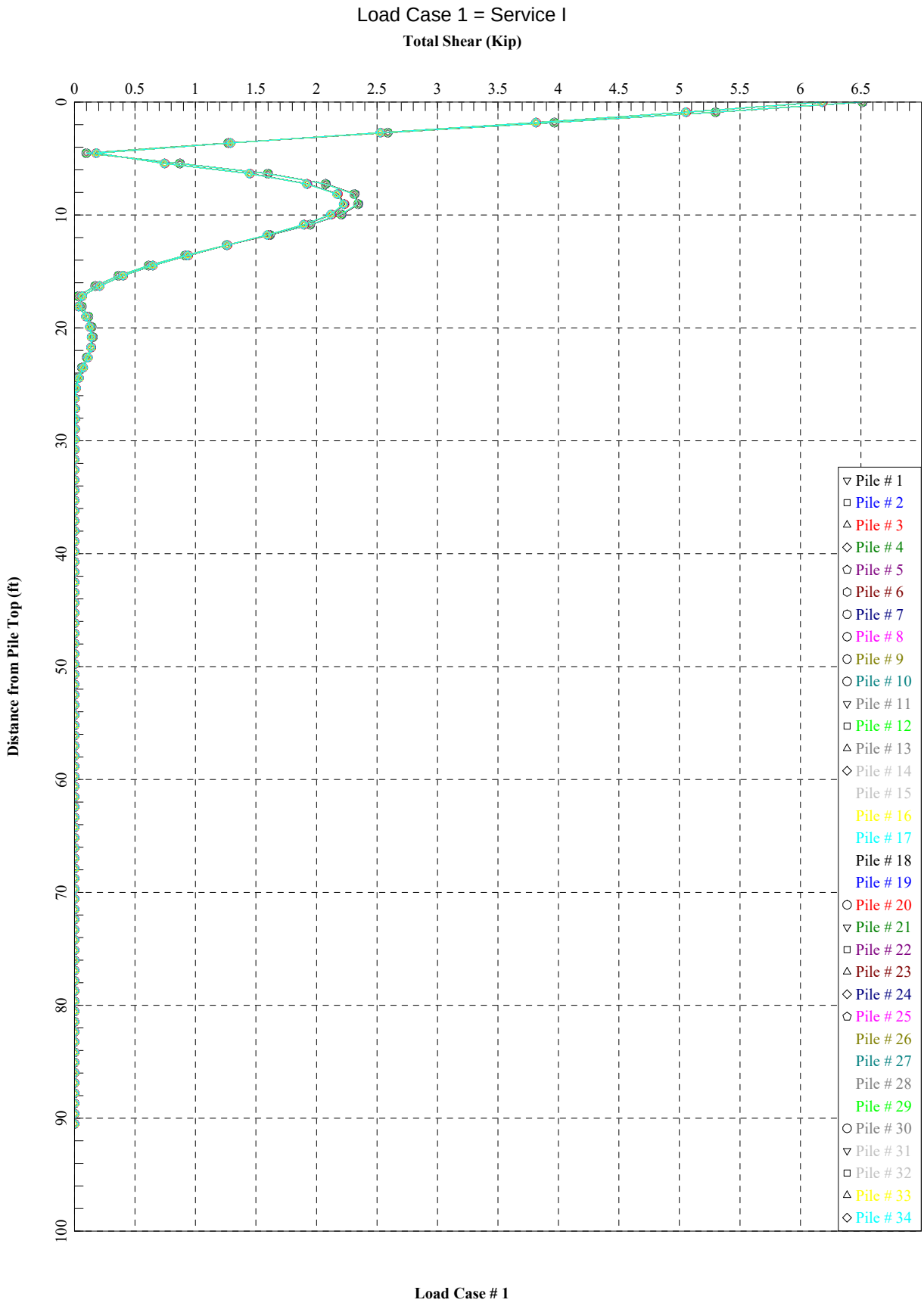
Load 17 (-4.8,-6.75,0)

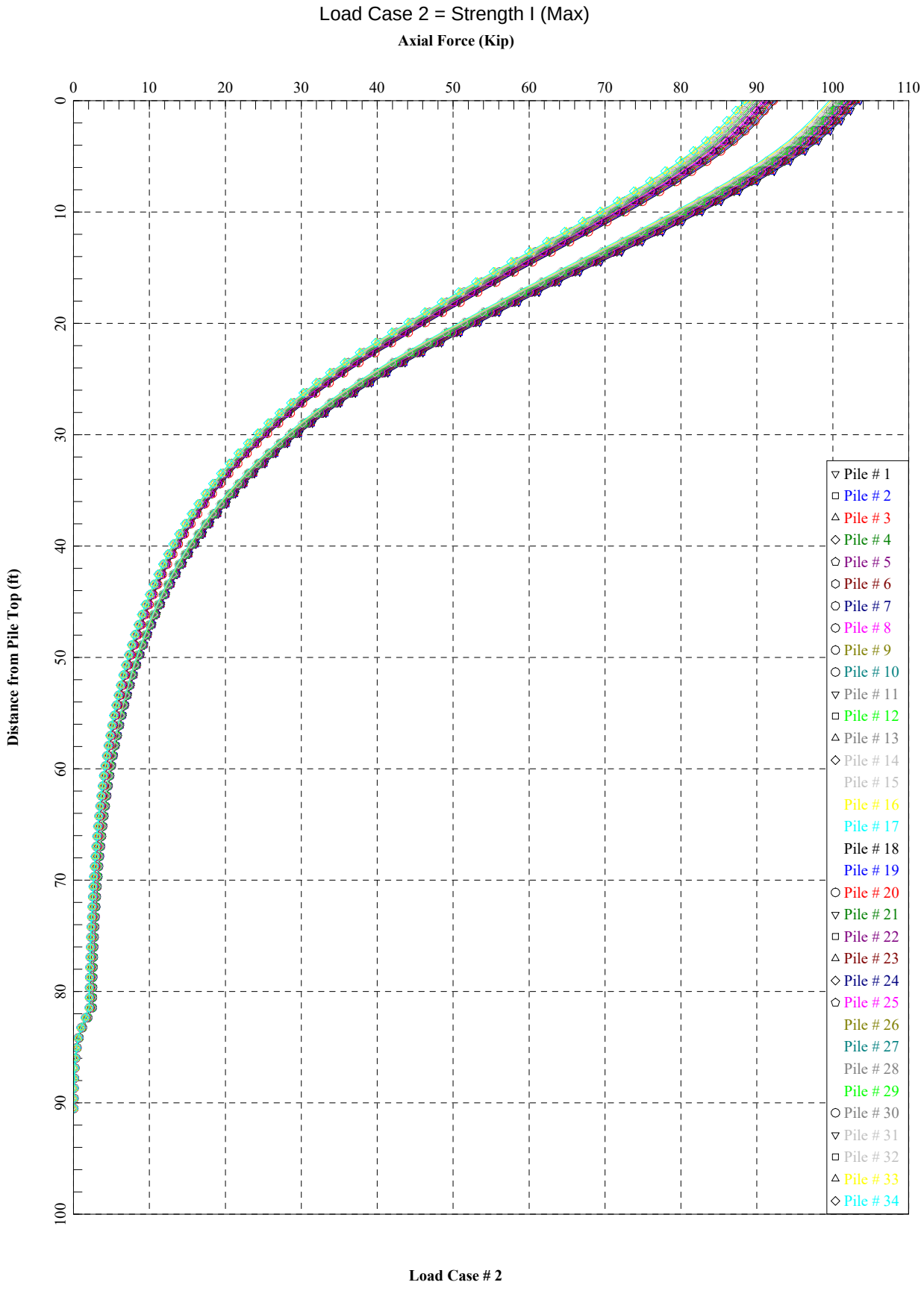
Load 18 (-1.4,-8,0)

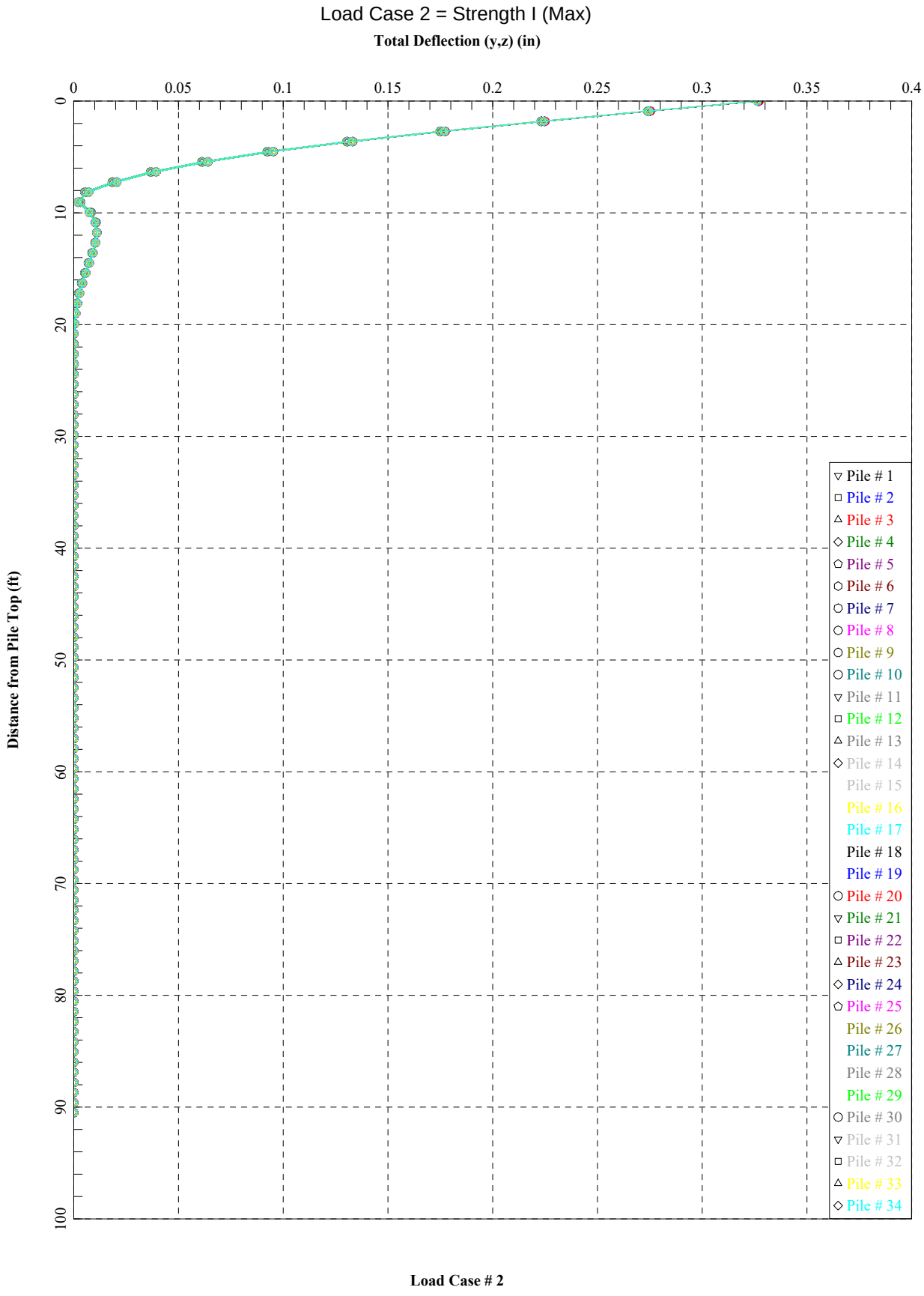

Load Case 1 = Service I
Axial Force (Kip)
0
10
20
30
40
50
60
70
80
Distance from Pile Top (ft)
0
10
20
30
40
50
60
70
80
90
100
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Pile # 19
Pile # 20
Pile # 21
Pile # 22
Pile # 23
Pile # 24
Pile # 25
Pile # 26
Pile # 27
Pile # 28
Pile # 29
Pile # 30
Pile # 31
Pile # 32
Pile # 33
Pile # 34
Load Case # 1

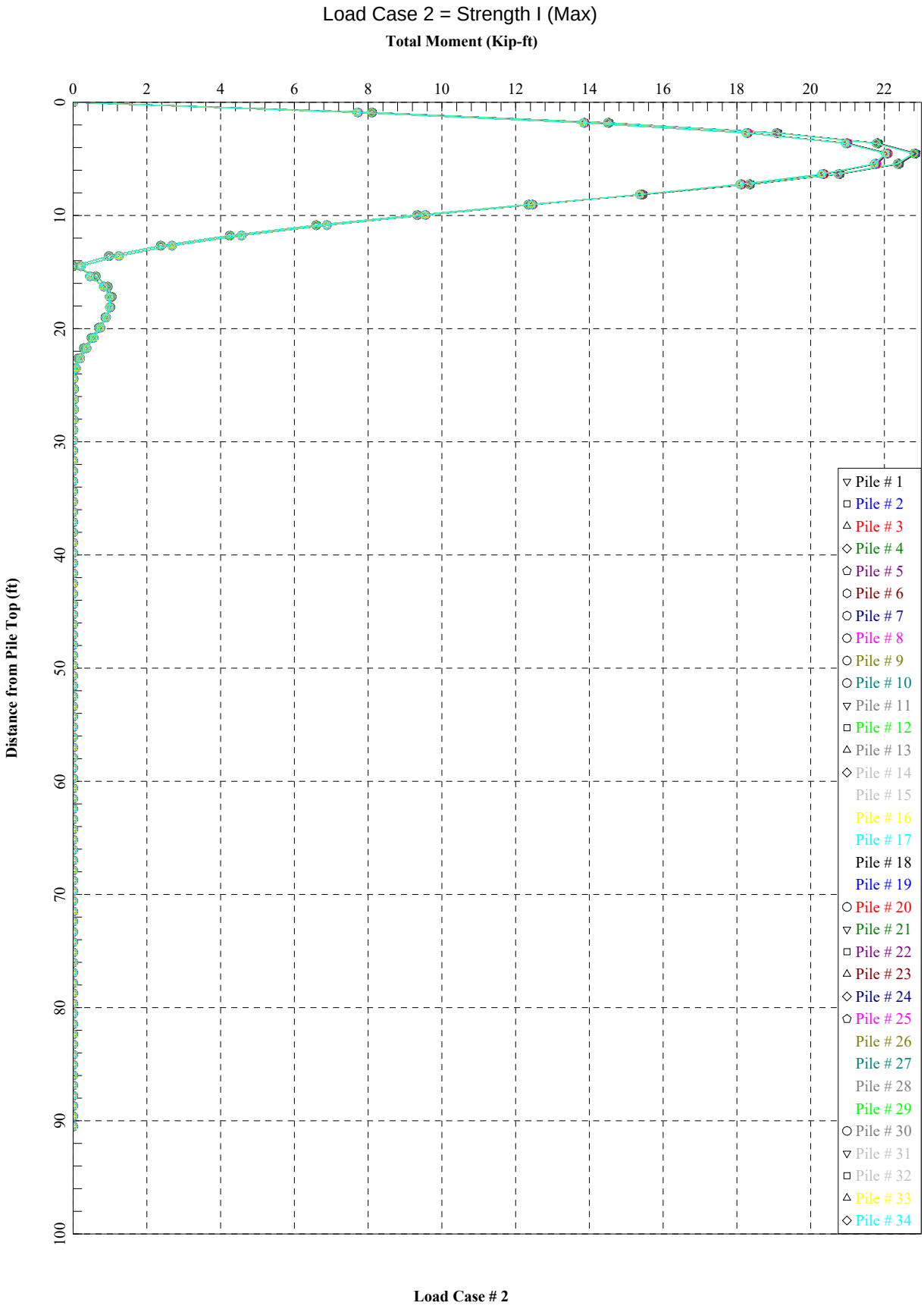

Load Case 1 = Service I
Total Deflection (y,z) (in)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
0.22
Distance from Pile Top (ft)
0
10
20
30
40
50
60
70
80
90
100
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Pile # 19
Pile # 20
Pile # 21
Pile # 22
Pile # 23
Pile # 24
Pile # 25
Pile # 26
Pile # 27
Pile # 28
Pile # 29
Pile # 30
Pile # 31
Pile # 32
Pile # 33
Pile # 34
Load Case # 1

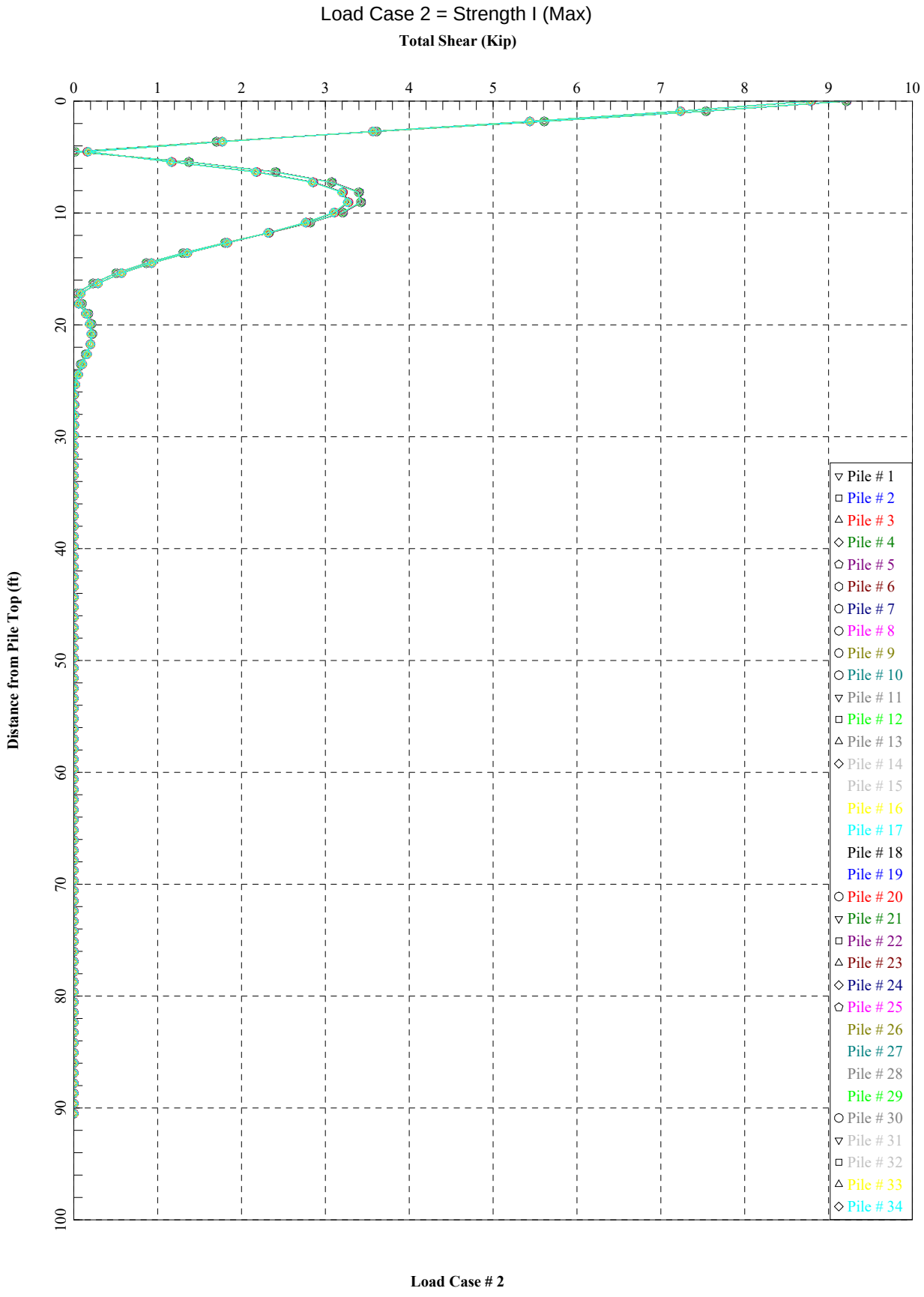

Load Case 1 = Service I
Total Moment (Kip-ft)
0
2
4
6
8
10
12
14
Distance from Pile Top (ft)
0
10
20
30
40
50
60
70
80
90
100
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Pile # 19
Pile # 20
Pile # 21
Pile # 22
Pile # 23
Pile # 24
Pile # 25
Pile # 26
Pile # 27
Pile # 28
Pile # 29
Pile # 30
Pile # 31
Pile # 32
Pile # 33
Pile # 34
Load Case # 1

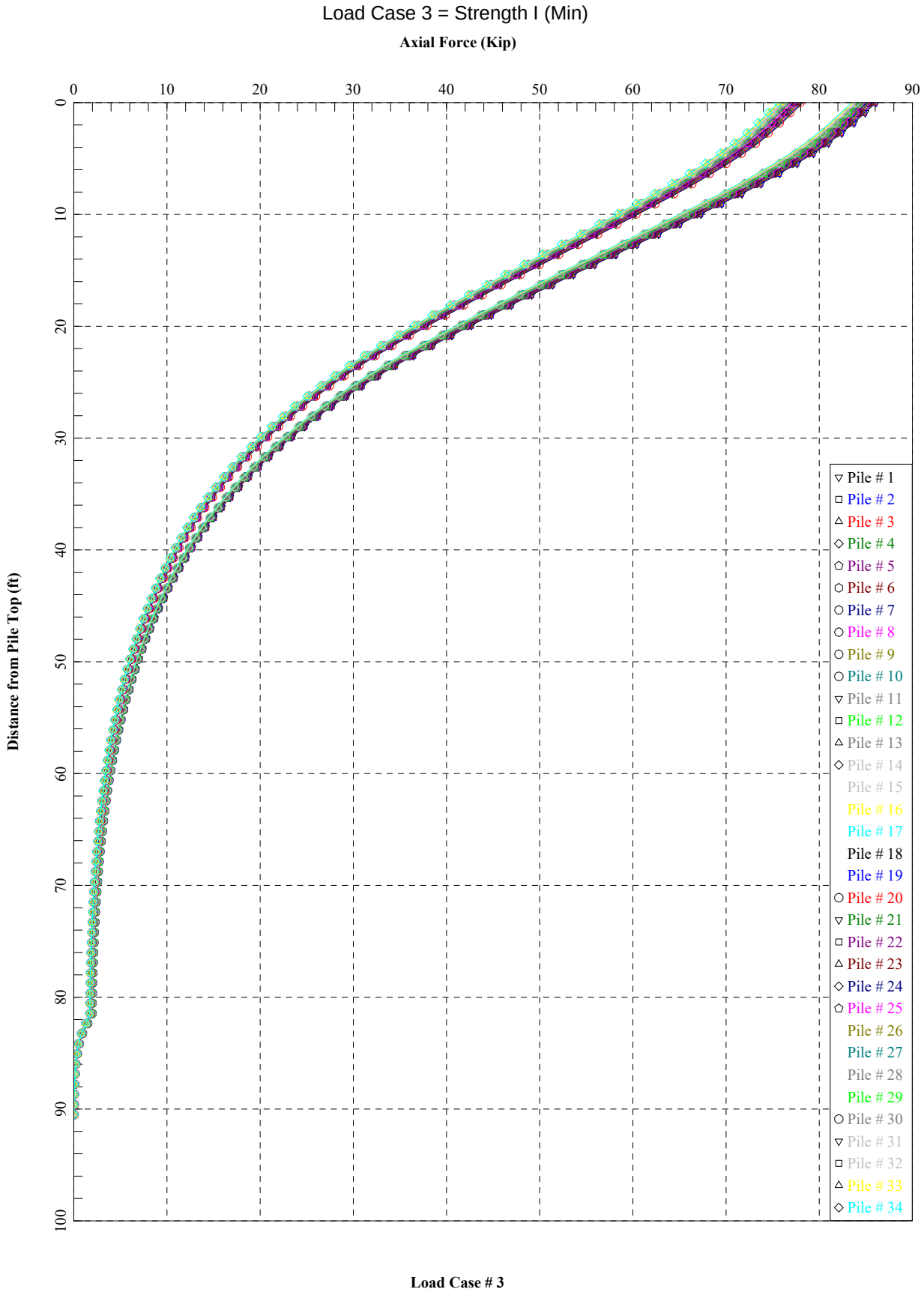

Load Case 1 = Service I
Total Shear (Kip)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
0
10
20
30
40
50
60
70
80
90
100
Distance from Pile Top (ft)
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Pile # 19
Pile # 20
Pile # 21
Pile # 22
Pile # 23
Pile # 24
Pile # 25
Pile # 26
Pile # 27
Pile # 28
Pile # 29
Pile # 30
Pile # 31
Pile # 32
Pile # 33
Pile # 34
Load Case # 1


Load Case 2 = Strength I (Max)
Axial Force (Kip)
0
10
20
30
40
50
60
70
80
90
100
110
Distance from Pile Top (ft)
0
10
20
30
40
50
60
70
80
90
100
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Pile # 19
Pile # 20
Pile # 21
Pile # 22
Pile # 23
Pile # 24
Pile # 25
Pile # 26
Pile # 27
Pile # 28
Pile # 29
Pile # 30
Pile # 31
Pile # 32
Pile # 33
Pile # 34
Load Case # 2

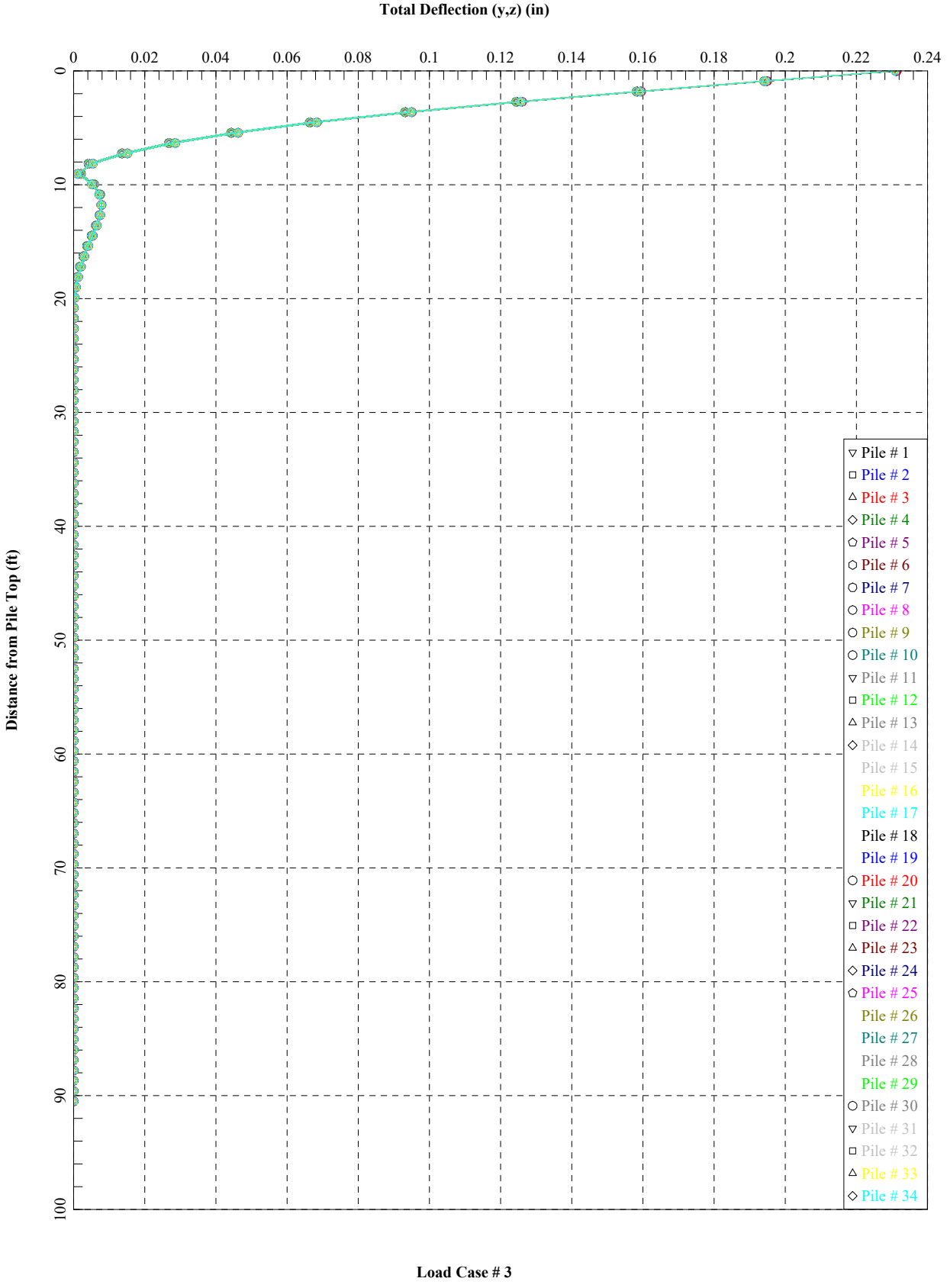

Load Case 2 = Strength I (Max)
Total Deflection (y,z) (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
10
20
30
40
50
60
70
80
90
100
Distance from Pile Top (ft)
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Pile # 19
Pile # 20
Pile # 21
Pile # 22
Pile # 23
Pile # 24
Pile # 25
Pile # 26
Pile # 27
Pile # 28
Pile # 29
Pile # 30
Pile # 31
Pile # 32
Pile # 33
Pile # 34
Load Case # 2

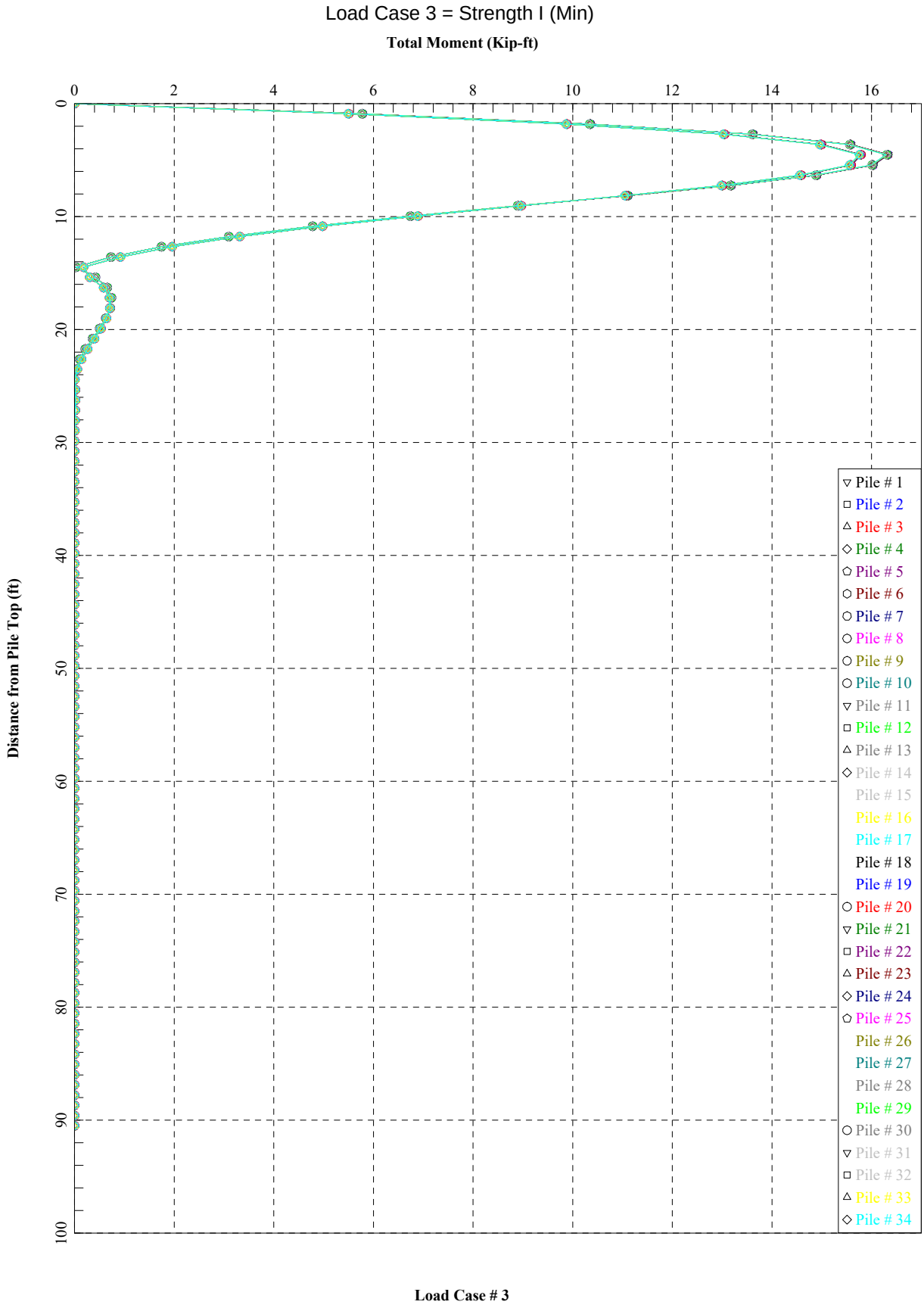

Load Case 2 = Strength I (Max)
Total Moment (Kip-ft)
0
2
4
6
8
10
12
14
16
18
20
22
Distance from Pile Top (ft)
0
10
20
30
40
50
60
70
80
90
100
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Pile # 19
Pile # 20
Pile # 21
Pile # 22
Pile # 23
Pile # 24
Pile # 25
Pile # 26
Pile # 27
Pile # 28
Pile # 29
Pile # 30
Pile # 31
Pile # 32
Pile # 33
Pile # 34
Load Case # 2


Load Case 2 = Strength I (Max)
Total Shear (Kip)
0
1
2
3
4
5
6
7
8
9
10
Distance from Pile Top (ft)
0
10
20
30
40
50
60
70
80
90
100
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Pile # 19
Pile # 20
Pile # 21
Pile # 22
Pile # 23
Pile # 24
Pile # 25
Pile # 26
Pile # 27
Pile # 28
Pile # 29
Pile # 30
Pile # 31
Pile # 32
Pile # 33
Pile # 34
Load Case # 2

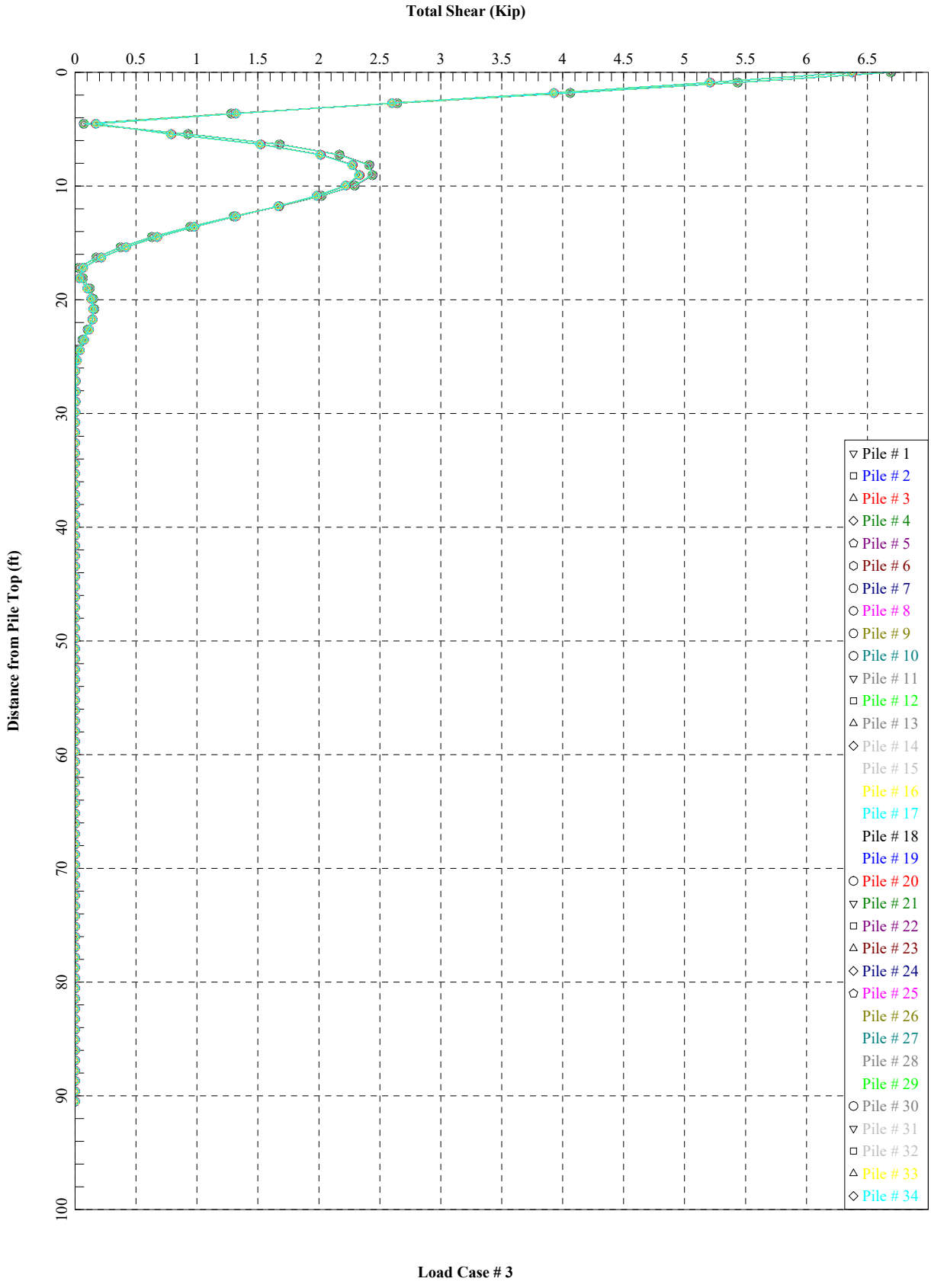

Load Case 3 = Strength I (Min)
Axial Force (Kip)
0
10
20
30
40
50
60
70
80
90
Distance from Pile Top (ft)
0
10
20
30
40
50
60
70
80
90
100
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Pile # 19
Pile # 20
Pile # 21
Pile # 22
Pile # 23
Pile # 24
Pile # 25
Pile # 26
Pile # 27
Pile # 28
Pile # 29
Pile # 30
Pile # 31
Pile # 32
Pile # 33
Pile # 34
Load Case # 3

Load Case 3 = Strength I (Min)

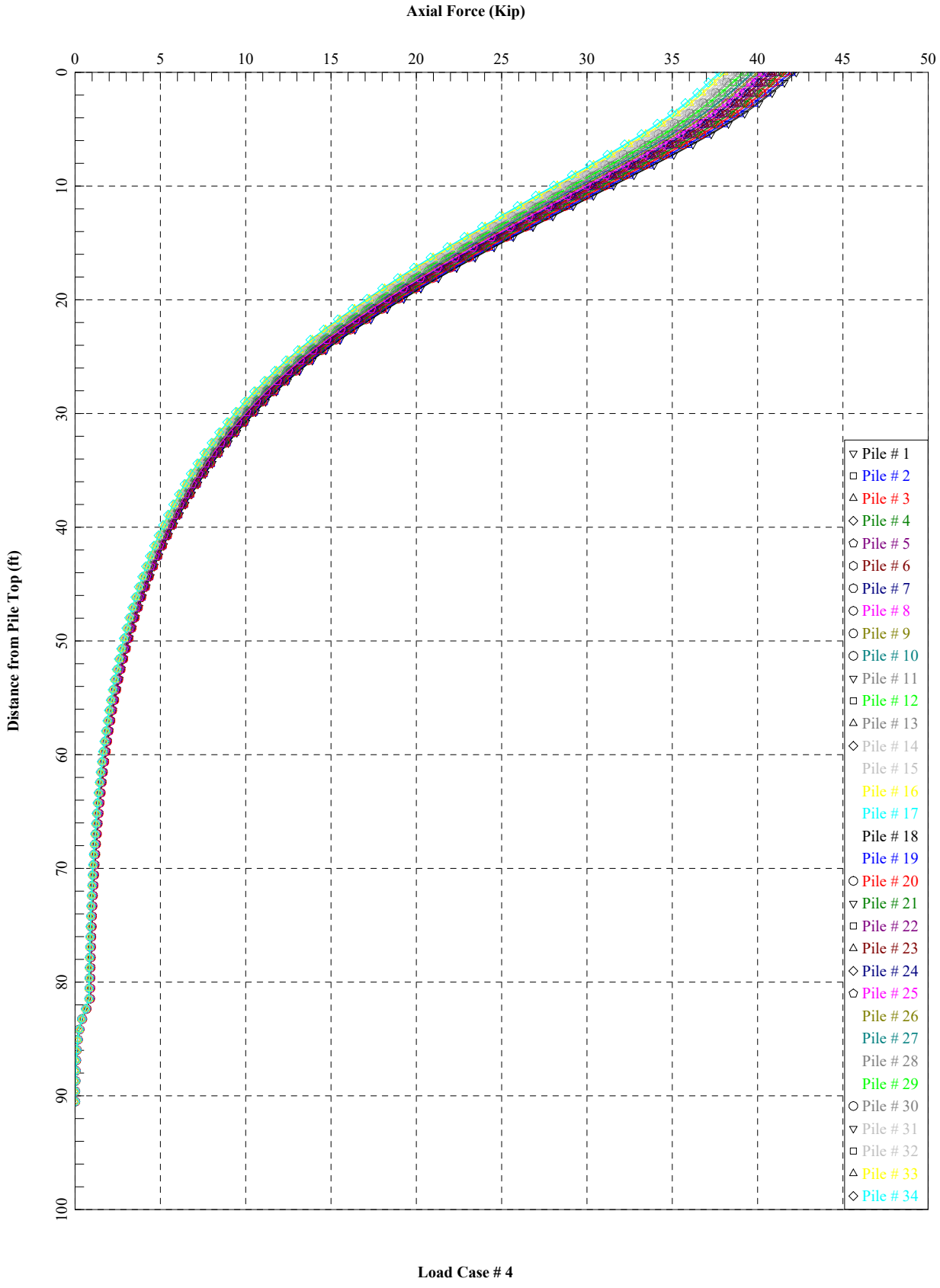



Load Case 3 = Strength I (Min)
Total Moment (Kip-ft)
0
2
4
6
8
10
12
14
16
Distance from Pile Top (ft)
0
10
20
30
40
50
60
70
80
90
100
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Pile # 19
Pile # 20
Pile # 21
Pile # 22
Pile # 23
Pile # 24
Pile # 25
Pile # 26
Pile # 27
Pile # 28
Pile # 29
Pile # 30
Pile # 31
Pile # 32
Pile # 33
Pile # 34
Load Case # 3

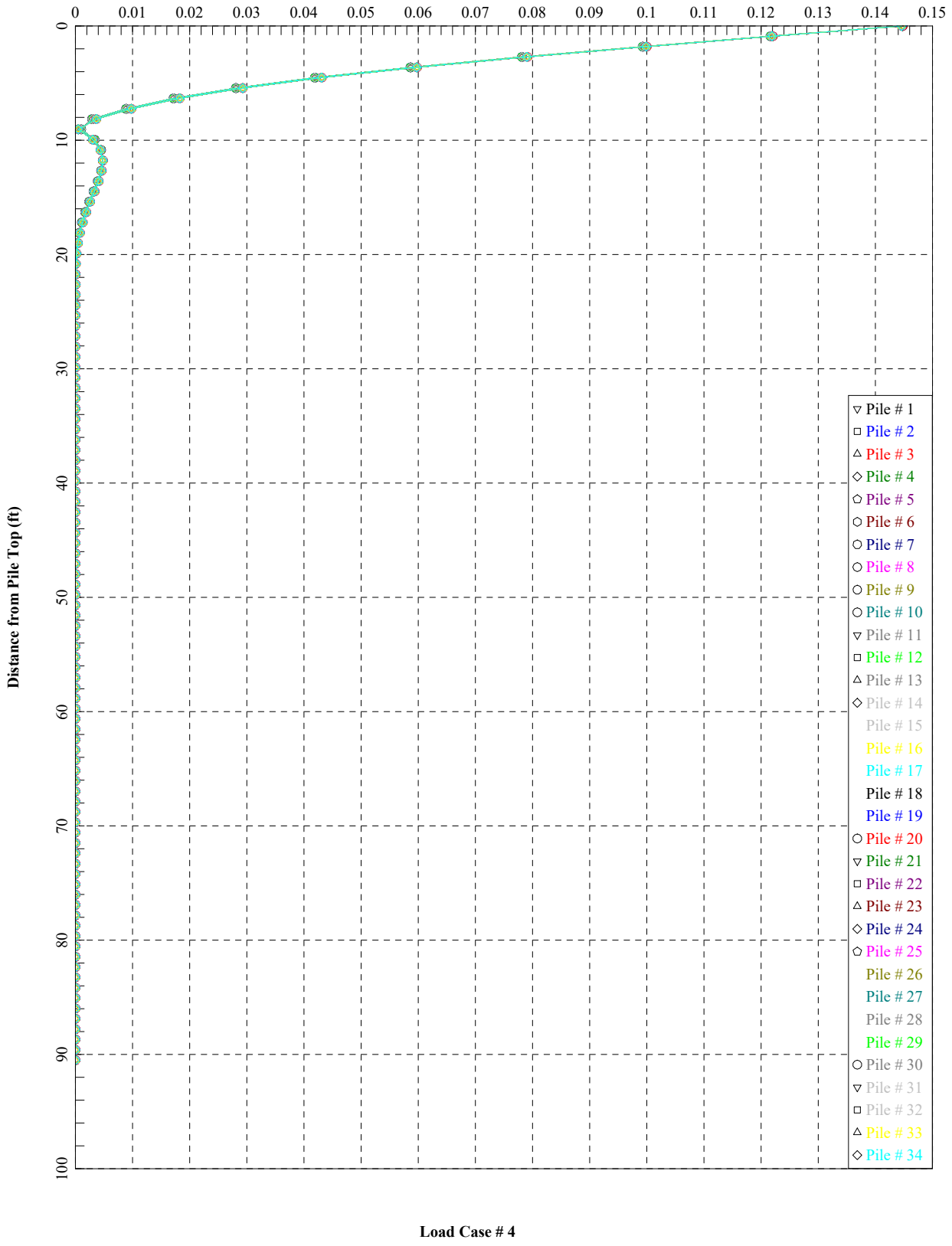
Load Case 3 = Strength I (Min)

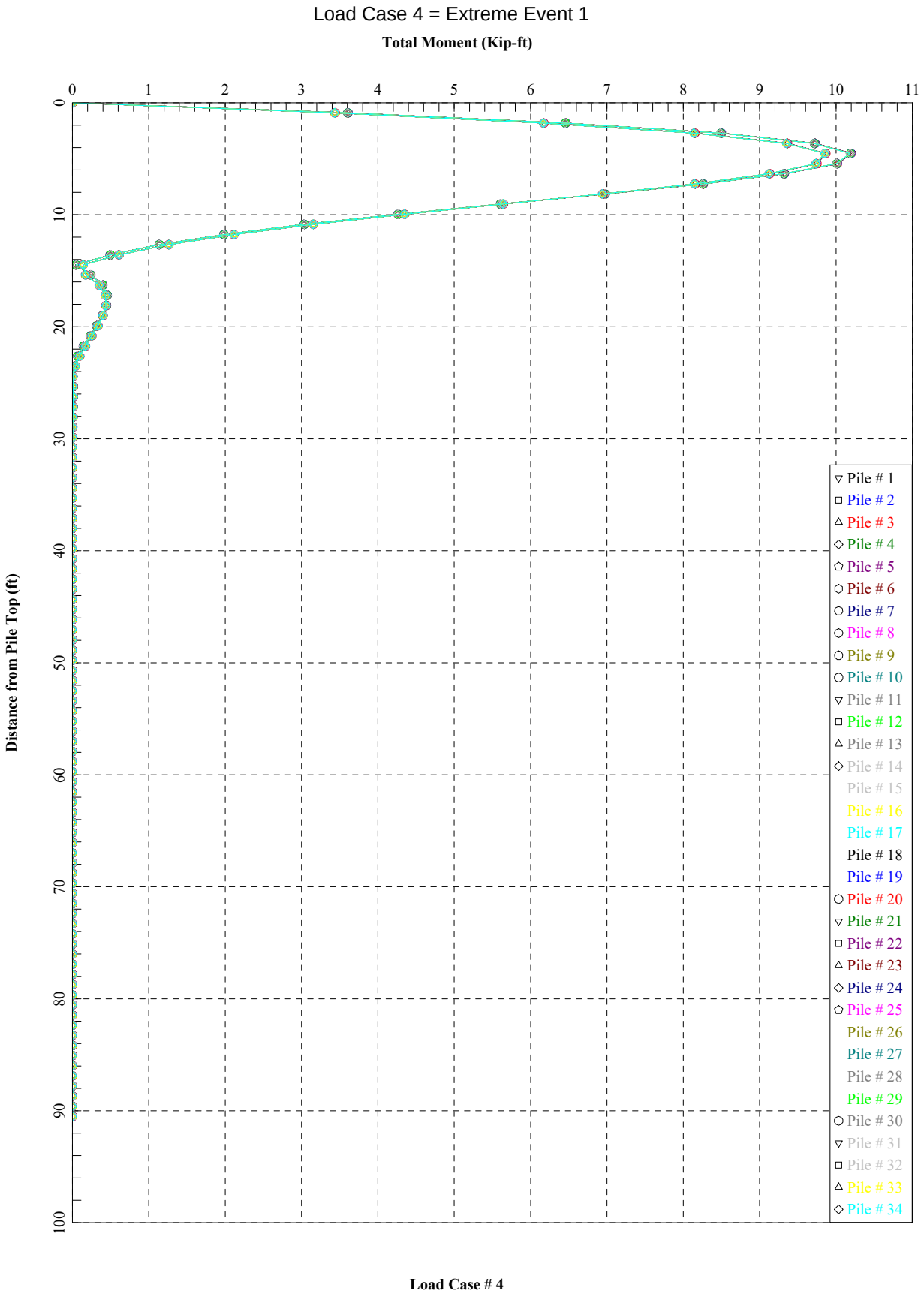


Load Case 4 = Extreme Event 1

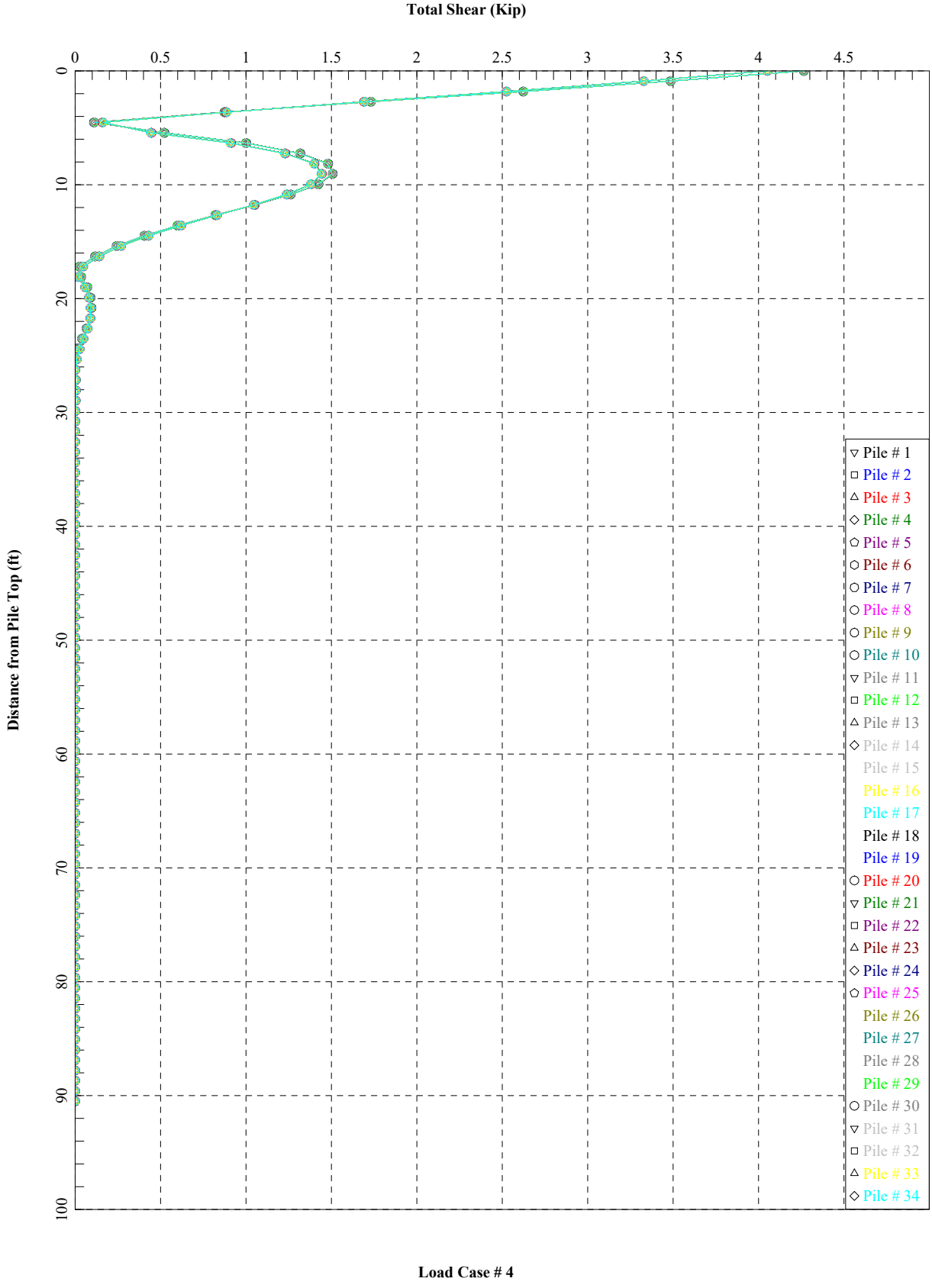


Load Case 4 = Extreme Event 1




Load Case 4 = Extreme Event 1
Total Moment (Kip-ft)
0
1
2
3
4
5
6
7
8
9
10
11
0
10
20
30
40
50
60
70
80
90
100
Distance from Pile Top (ft)
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Pile # 19
Pile # 20
Pile # 21
Pile # 22
Pile # 23
Pile # 24
Pile # 25
Pile # 26
Pile # 27
Pile # 28
Pile # 29
Pile # 30
Pile # 31
Pile # 32
Pile # 33
Pile # 34
Load Case # 4

Load Case 4 = Extreme Event 1



```
     ======================================================================

                    GROUP for Windows, Version 2022.12.4

                     Serial Number : 546958378

                     Analysis of A Group of Piles
                   Subjected to Axial and Lateral Loading

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     ======================================================================


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     Nobis Engineering, Inc.
     Lowell, MA, USA

     Path to file locations      : J:\094184.100-MassDOT Armory Street Bridges, Springfield\Calculations\Axial-Lateral Pile Analysis\S-24-026\Updated North
and South Abutment\Group\
     Name of input data file     : Proposed Pile Caps.gp12r
     Name of output echo file    : Proposed Pile Caps.gp12e
     Name of output results file : Proposed Pile Caps.gp12o
     Name of output summary file : Proposed Pile Caps.gp12t
     Name of plot output file    : Proposed Pile Caps.gp12p
     Name of runtime file        : Proposed Pile Caps.gp12r


     ------------------------------------------------------------------------
                          Time and Date of Analysis
     ------------------------------------------------------------------------

               Date:  February 26, 2025     Time:  10:13:44




                *****     INPUT INFORMATION     *****


     Armory Street over Abandoned CSX Spur - S-24-026 - Proposed Pile Caps (North & S

     ANALYSIS TYPE = 3D ANALYSIS

     ADJUST DEPTH FOR BATTER PILES

     GENERATE LOAD-DISP (AND T-R) CURVES BASED ON SOIL PROFILE

     EXTEND INTERPOLATION FOR L-DP (AND T-R) CURVES

     UNITS SYSTEM  = ENGL



     * TABLE B *  PILE CAP OPTIONS

     LENGTH,YY    ( FT ) =    8.000
     WIDTH, ZZ    ( FT ) =    70.68
     THICKNESS,XX ( FT ) =    5.000

     * PILE CAP DIMENSIONS ARE NOT CONSIDERED
       FOR THE PILE GROUP ANALYSIS




     * TABLE C *  LOAD AND CONTROL PARAMETERS


     ** LOAD CASES **


     NUMBER OF LOAD CASES :    4


     LOAD CASE    :     1
     CASE NAME    : Service I
     LOAD TYPE    : Dead, DL
     SCALE FACTOR :       1.0000

     * CONCENTRATED LOADS *

    NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
          LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
     1   1.11E+05  6.20E+03      0.00      0.00      0.00      0.00     -3.40     -4.00      32.1
     2   1.57E+05  6.20E+03      0.00      0.00      0.00      0.00     -3.40     -4.00      27.6
     3   1.61E+05  6.20E+03      0.00      0.00      0.00      0.00     -3.60     -4.00      20.8
```

4	1.55E+05	6.20E+03	0.00	0.00	0.00	0.00	-3.70	-4.00	14.1
5	1.49E+05	6.20E+03	0.00	0.00	0.00	0.00	-3.80	-4.00	8.34
6	1.47E+05	6.20E+03	0.00	0.00	0.00	0.00	-3.90	-4.00	2.59
7	1.47E+05	6.20E+03	0.00	0.00	0.00	0.00	-4.00	-4.00	-3.16
8	1.49E+05	6.20E+03	0.00	0.00	0.00	0.00	-4.20	-4.00	-8.91
9	1.49E+05	6.20E+03	0.00	0.00	0.00	0.00	-4.10	-4.00	-14.7
10	1.49E+05	6.20E+03	0.00	0.00	0.00	0.00	-3.90	-4.00	-20.4
11	1.44E+05	6.20E+03	0.00	0.00	0.00	0.00	-3.80	-4.00	-26.2
12	1.11E+05	6.20E+03	0.00	0.00	0.00	0.00	-3.70	-4.00	-31.9
13	8.48E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-4.00	0.00
14	2.76E+05	0.00	0.00	0.00	0.00	0.00	0.00	-4.00	0.00
15	8.48E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-6.00	0.00
16	6.36E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-7.40	0.00
17	0.00	5.66E+04	0.00	0.00	0.00	0.00	-4.80	-6.75	0.00
18	0.00	8.48E+04	0.00	0.00	0.00	0.00	-1.40	-8.00	0.00

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VER.LOAD X,LBS	HOR.LOAD Y,LBS	HOR.LOAD Z,LBS
2.23730E+06	2.15800E+05	0.00000

MOMENT X,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
-24552.0	8.87797E+06	1.03950E+08

* THE LOADING IS STATIC *

* CONTROL PARAMETERS *
TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT = 1.00000E-04
TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS = 1.00000E-04 IN
MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS = 100
MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS = 100
FACTOR TO APPLY THE LOAD IN INCREMENTS = 1.0000
MINIMUM FACTOR FOR LOAD INCREMENTS = 1.0000
INCLUDE VARIATION OF AXIAL LOAD AT PILES
* NOT FOR USER DEFINED LOAD SETTL. CURVE
- PRINT RESULTS AT PILE CAP

LOAD CASE : 2
CASE NAME : Strength I Max
LOAD TYPE : Dead, DL
SCALE FACTOR : 1.0000

* CONCENTRATED LOADS *

NL	VERT.LOAD LBS	HR.LOAD Y LBS	HR.LOAD Z LBS	MOMENT X LBS-IN	MOMENT Y LBS-IN	MOMENT Z LBS-IN	COORD X FT	COORD Y FT	COORD Z FT
1	1.58E+05	9.60E+03	0.00	0.00	0.00	0.00	-3.40	-4.00	32.1
2	2.38E+05	9.60E+03	0.00	0.00	0.00	0.00	-3.40	-4.00	27.6
3	2.46E+05	9.60E+03	0.00	0.00	0.00	0.00	-3.60	-4.00	20.8
4	2.36E+05	9.60E+03	0.00	0.00	0.00	0.00	-3.70	-4.00	14.1
5	2.26E+05	9.60E+03	0.00	0.00	0.00	0.00	-3.80	-4.00	8.34
6	2.24E+05	9.60E+03	0.00	0.00	0.00	0.00	-3.90	-4.00	2.59
7	2.24E+05	9.60E+03	0.00	0.00	0.00	0.00	-4.00	-4.00	-3.16
8	2.26E+05	9.60E+03	0.00	0.00	0.00	0.00	-4.20	-4.00	-8.91
9	2.26E+05	9.60E+03	0.00	0.00	0.00	0.00	-4.10	-4.00	-14.7
10	2.26E+05	9.60E+03	0.00	0.00	0.00	0.00	-3.90	-4.00	-20.4
11	2.22E+05	9.60E+03	0.00	0.00	0.00	0.00	-3.80	-4.00	-26.2
12	1.65E+05	9.60E+03	0.00	0.00	0.00	0.00	-3.70	-4.00	-31.9
13	1.13E+05	0.00	0.00	0.00	0.00	0.00	-3.00	-4.00	0.00
14	3.46E+05	0.00	0.00	0.00	0.00	0.00	0.00	-4.00	0.00
15	1.06E+05	0.00	0.00	0.00	0.00	0.00	-3.00	-6.00	0.00
16	8.48E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-7.40	0.00
17	0.00	7.78E+04	0.00	0.00	0.00	0.00	-4.80	-6.75	0.00
18	0.00	1.13E+05	0.00	0.00	0.00	0.00	-1.40	-8.00	0.00

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VER.LOAD X,LBS	HOR.LOAD Y,LBS	HOR.LOAD Z,LBS
3.26560E+06	3.06000E+05	0.00000

MOMENT X,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
-38016.0	1.01725E+07	1.51131E+08

* THE LOADING IS STATIC *

* CONTROL PARAMETERS *
TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT = 5.00000E-04
TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS = 5.00000E-04 IN
MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS = 100
MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS = 100
FACTOR TO APPLY THE LOAD IN INCREMENTS = 1.0000
MINIMUM FACTOR FOR LOAD INCREMENTS = 1.0000
INCLUDE VARIATION OF AXIAL LOAD AT PILES
* NOT FOR USER DEFINED LOAD SETTL. CURVE

- PRINT RESULTS AT PILE CAP

LOAD CASE : 3
CASE NAME : Strength I Min
LOAD TYPE : Dead, DL
SCALE FACTOR : 1.0000

* CONCENTRATED LOADS *

NL	VERT.LOAD LBS	HR.LOAD Y LBS	HR.LOAD Z LBS	MOMENT X LBS-IN	MOMENT Y LBS-IN	MOMENT Z LBS-IN	COORD X FT	COORD Y FT	COORD Z FT
1	1.29E+05	7.90E+03	0.00	0.00	0.00	0.00	-3.40	-4.00	32.1
2	2.09E+05	7.90E+03	0.00	0.00	0.00	0.00	-3.40	-4.00	27.6
3	2.16E+05	7.90E+03	0.00	0.00	0.00	0.00	-3.60	-4.00	20.8
4	2.07E+05	7.90E+03	0.00	0.00	0.00	0.00	-3.70	-4.00	14.1
5	1.98E+05	7.90E+03	0.00	0.00	0.00	0.00	-3.80	-4.00	8.34
6	1.96E+05	7.90E+03	0.00	0.00	0.00	0.00	-3.90	-4.00	2.59
7	1.96E+05	7.90E+03	0.00	0.00	0.00	0.00	-4.00	-4.00	-3.16
8	1.98E+05	7.90E+03	0.00	0.00	0.00	0.00	-4.20	-4.00	-8.91
9	1.98E+05	7.90E+03	0.00	0.00	0.00	0.00	-4.10	-4.00	-14.7
10	1.98E+05	7.90E+03	0.00	0.00	0.00	0.00	-3.90	-4.00	-20.4
11	1.96E+05	7.90E+03	0.00	0.00	0.00	0.00	-3.80	-4.00	-26.2
12	1.41E+05	7.90E+03	0.00	0.00	0.00	0.00	-3.70	-4.00	-31.9
13	7.78E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-4.00	0.00
14	2.47E+05	0.00	0.00	0.00	0.00	0.00	0.00	-4.00	0.00
15	7.78E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-6.00	0.00
16	6.36E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-7.40	0.00
17	0.00	4.95E+04	0.00	0.00	0.00	0.00	-4.80	-6.75	0.00
18	0.00	7.78E+04	0.00	0.00	0.00	0.00	-1.40	-8.00	0.00

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VER.LOAD X,LBS	HOR.LOAD Y,LBS	HOR.LOAD Z,LBS
2.74880E+06	2.22100E+05	0.00000

MOMENT X,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
-31284.0	6.42148E+06	1.27933E+08

* THE LOADING IS STATIC *

* CONTROL PARAMETERS *
TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT = 5.00000E-04
TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS = 5.00000E-04 IN
MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS = 100
MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS = 100
FACTOR TO APPLY THE LOAD IN INCREMENTS = 1.0000
MINIMUM FACTOR FOR LOAD INCREMENTS = 1.0000
INCLUDE VARIATION OF AXIAL LOAD AT PILES
* NOT FOR USER DEFINED LOAD SETTL. CURVE
- PRINT RESULTS AT PILE CAP

LOAD CASE : 4
CASE NAME : Extreme Event I
LOAD TYPE : Dead, DL
SCALE FACTOR : 1.0000

* CONCENTRATED LOADS *

NL	VERT.LOAD LBS	HR.LOAD Y LBS	HR.LOAD Z LBS	MOMENT X LBS-IN	MOMENT Y LBS-IN	MOMENT Z LBS-IN	COORD X FT	COORD Y FT	COORD Z FT
1	7.42E+04	0.00	0.00	0.00	0.00	0.00	-3.40	-4.00	32.1
2	7.59E+04	0.00	0.00	0.00	0.00	0.00	-3.40	-4.00	27.6
3	7.61E+04	0.00	0.00	0.00	0.00	0.00	-3.60	-4.00	20.8
4	7.43E+04	0.00	0.00	0.00	0.00	0.00	-3.70	-4.00	14.1
5	7.16E+04	0.00	0.00	0.00	0.00	0.00	-3.80	-4.00	8.34
6	6.99E+04	0.00	0.00	0.00	0.00	0.00	-3.90	-4.00	2.59
7	6.99E+04	0.00	0.00	0.00	0.00	0.00	-4.00	-4.00	-3.16
8	7.16E+04	0.00	0.00	0.00	0.00	0.00	-4.20	-4.00	-8.91
9	7.16E+04	0.00	0.00	0.00	0.00	0.00	-4.10	-4.00	-14.7
10	7.16E+04	0.00	0.00	0.00	0.00	0.00	-3.90	-4.00	-20.4
11	6.45E+04	0.00	0.00	0.00	0.00	0.00	-3.80	-4.00	-26.2
12	6.05E+04	0.00	0.00	0.00	0.00	0.00	-3.70	-4.00	-31.9
13	8.48E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-4.00	0.00
14	2.76E+05	0.00	0.00	0.00	0.00	0.00	0.00	-4.00	0.00
15	8.48E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-6.00	0.00
16	6.36E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-7.40	0.00
17	0.00	5.66E+04	0.00	0.00	0.00	0.00	-4.80	-6.75	0.00
18	0.00	8.48E+04	0.00	0.00	0.00	0.00	-1.40	-8.00	0.00

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VER.LOAD X,LBS	HOR.LOAD Y,LBS	HOR.LOAD Z,LBS
1.36060E+06	1.41400E+05	0.00000

MOMENT X,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN

0.00000 1.07811E+07 6.52541E+07

* THE LOADING IS STATIC *

* CONTROL PARAMETERS *
TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT = 5.00000E-04
TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS = 5.00000E-04 IN
MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS = 100
MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS = 100
FACTOR TO APPLY THE LOAD IN INCREMENTS = 1.0000
MINIMUM FACTOR FOR LOAD INCREMENTS = 1.0000
INCLUDE VARIATION OF AXIAL LOAD AT PILES
* NOT FOR USER DEFINED LOAD SETTL. CURVE
- PRINT RESULTS AT PILE CAP

* TABLE D * ARRANGEMENT OF PILE GROUPS

GROUP	CONN.Z-Z	CONN.Y-Y	PILE PROP	P-Y CURVE	L-S CURVE	T-R CURVE	R-F-L SET
1	PIN	PIN	1	0	1 G	1 G	1
2	PIN	PIN	1	0	1 G	1 G	1
3	PIN	PIN	1	0	1 G	1 G	1
4	PIN	PIN	1	0	1 G	1 G	1
5	PIN	PIN	1	0	1 G	1 G	1
6	PIN	PIN	1	0	1 G	1 G	1
7	PIN	PIN	1	0	1 G	1 G	1
8	PIN	PIN	1	0	1 G	1 G	1
9	PIN	PIN	1	0	1 G	1 G	1
10	PIN	PIN	1	0	1 G	1 G	1
11	PIN	PIN	1	0	1 G	1 G	1
12	PIN	PIN	1	0	1 G	1 G	1
13	PIN	PIN	1	0	1 G	1 G	1
14	PIN	PIN	1	0	1 G	1 G	1
15	PIN	PIN	1	0	1 G	1 G	1
16	PIN	PIN	1	0	1 G	1 G	1
17	PIN	PIN	1	0	1 G	1 G	1
18	PIN	PIN	1	0	1 G	1 G	1
19	PIN	PIN	1	0	1 G	1 G	1
20	PIN	PIN	1	0	1 G	1 G	1
21	PIN	PIN	1	0	1 G	1 G	1
22	PIN	PIN	1	0	1 G	1 G	1
23	PIN	PIN	1	0	1 G	1 G	1
24	PIN	PIN	1	0	1 G	1 G	1
25	PIN	PIN	1	0	1 G	1 G	1
26	PIN	PIN	1	0	1 G	1 G	1
27	PIN	PIN	1	0	1 G	1 G	1
28	PIN	PIN	1	0	1 G	1 G	1
29	PIN	PIN	1	0	1 G	1 G	1
30	PIN	PIN	1	0	1 G	1 G	1
31	PIN	PIN	1	0	1 G	1 G	1
32	PIN	PIN	1	0	1 G	1 G	1
33	PIN	PIN	1	0	1 G	1 G	1
34	PIN	PIN	1	0	1 G	1 G	1

GROUP	CorX,FT	CorY,FT	CorZ,FT	ALPHA,DEG	BETA,DEG	THETA,DEG	GROUND,FT	SPz,LBS-IN	SPy,LBS-IN
1	0.000	-1.500	32.00	0.000	90.00	0.000	-3.000	0.000	0.000
2	0.000	-1.500	28.00	0.000	90.00	0.000	-3.000	0.000	0.000
3	0.000	-1.500	24.00	0.000	90.00	0.000	-3.000	0.000	0.000
4	0.000	-1.500	20.00	0.000	90.00	0.000	-3.000	0.000	0.000
5	0.000	-1.500	16.00	0.000	90.00	0.000	-3.000	0.000	0.000
6	0.000	-1.500	12.00	0.000	90.00	0.000	-3.000	0.000	0.000
7	0.000	-1.500	8.000	0.000	90.00	0.000	-3.000	0.000	0.000
8	0.000	-1.500	4.000	0.000	90.00	0.000	-3.000	0.000	0.000
9	0.000	-1.500	0.000	0.000	90.00	0.000	-3.000	0.000	0.000
10	0.000	-1.500	-4.000	0.000	90.00	0.000	-3.000	0.000	0.000
11	0.000	-1.500	-8.000	0.000	90.00	0.000	-3.000	0.000	0.000
12	0.000	-1.500	-12.00	0.000	90.00	0.000	-3.000	0.000	0.000
13	0.000	-1.500	-16.00	0.000	90.00	0.000	-3.000	0.000	0.000
14	0.000	-1.500	-20.00	0.000	90.00	0.000	-3.000	0.000	0.000
15	0.000	-1.500	-24.00	0.000	90.00	0.000	-3.000	0.000	0.000
16	0.000	-1.500	-28.00	0.000	90.00	0.000	-3.000	0.000	0.000
17	0.000	-1.500	-32.00	0.000	90.00	0.000	-3.000	0.000	0.000
18	0.000	-6.500	32.00	0.000	90.00	0.000	-3.000	0.000	0.000
19	0.000	-6.500	28.00	0.000	90.00	0.000	-3.000	0.000	0.000
20	0.000	-6.500	24.00	0.000	90.00	0.000	-3.000	0.000	0.000
21	0.000	-6.500	20.00	0.000	90.00	0.000	-3.000	0.000	0.000
22	0.000	-6.500	16.00	0.000	90.00	0.000	-3.000	0.000	0.000
23	0.000	-6.500	12.00	0.000	90.00	0.000	-3.000	0.000	0.000
24	0.000	-6.500	8.000	0.000	90.00	0.000	-3.000	0.000	0.000
25	0.000	-6.500	4.000	0.000	90.00	0.000	-3.000	0.000	0.000
26	0.000	-6.500	0.000	0.000	90.00	0.000	-3.000	0.000	0.000
27	0.000	-6.500	-4.000	0.000	90.00	0.000	-3.000	0.000	0.000
28	0.000	-6.500	-8.000	0.000	90.00	0.000	-3.000	0.000	0.000
29	0.000	-6.500	-12.00	0.000	90.00	0.000	-3.000	0.000	0.000
30	0.000	-6.500	-16.00	0.000	90.00	0.000	-3.000	0.000	0.000
31	0.000	-6.500	-20.00	0.000	90.00	0.000	-3.000	0.000	0.000
32	0.000	-6.500	-24.00	0.000	90.00	0.000	-3.000	0.000	0.000
33	0.000	-6.500	-28.00	0.000	90.00	0.000	-3.000	0.000	0.000

```
 34       0.000     -6.500     -32.00      0.000      90.00      0.000     -3.000      0.000      0.000


* TABLE E *   PILE GEOMETRY AND PROPERTIES
              PILE TYPE = 1 - DRIVEN PILE
                        = 2 - DRILLED SHAFT

  PROP   SECTS   INC     PILE TYPE      LENGTH, FT
    1      3     100          2             90.500

* PILE SECTIONS *

  PROP    SECT      FROM,FT         TO,FT    CROSS SECT
    1       1        0.00000        3.00000       1
    1       2        3.00000        82.5000       2
    1       3        82.5000        90.5000       3

* PILE CROSS SECTIONS *

 CROSS SECTION       :     1
 SECTION NAME        : 10.75"
 TYPE                :  NONLINEAR
 CROSS SECTION TYPE  : ROUND CONC. SHAFT, CASING (AND STEEL SECTION)
 CONCRETE DIAMETER   :       9.75000 IN
 CONCRETE FC         :       5000.00 LBS/IN**2
 DIAMETER CASING     :       10.6250 IN
 THICKNESS CASING    :       0.43750 IN
 ES CASING           :   2.90000E+07 LBS/IN**2
 FY CASING           :       52000.0 LBS/IN**2
 EMBEDDED STEEL SECT : NONE
 NUMBER REBARS       :             1
 ES REINFORCEMENT    :   2.90000E+07 LBS/IN**2
 FY REINFORCEMENT    :       60000.0 LBS/IN**2
 REINF. LAYOUT       :       MANUAL
 REINF. A , D, COORDS:        IN^2             IN              IN              IN
 - REBAR    1        :       0.79000         1.00000         0.00000         0.00000
 EQ. YOUNG MODULUS   :   9.96202E+06 LBS/IN**2

 CROSS SECTION       :     2
 SECTION NAME        : 10.75"
 TYPE                :  NONLINEAR
 CROSS SECTION TYPE  : ROUND CONC. SHAFT, CASING (AND STEEL SECTION)
 CONCRETE DIAMETER   :       9.75000 IN
 CONCRETE FC         :       5000.00 LBS/IN**2
 DIAMETER CASING     :       10.2500 IN
 THICKNESS CASING    :       0.25000 IN
 ES CASING           :   2.90000E+07 LBS/IN**2
 FY CASING           :       52000.0 LBS/IN**2
 EMBEDDED STEEL SECT : NONE
 NUMBER REBARS       :             1
 ES REINFORCEMENT    :   2.90000E+07 LBS/IN**2
 FY REINFORCEMENT    :       60000.0 LBS/IN**2
 REINF. LAYOUT       :       MANUAL
 REINF. A , D, COORDS:        IN^2             IN              IN              IN
 - REBAR    1        :       0.79000         1.00000         0.00000         0.00000
 EQ. YOUNG MODULUS   :   8.54351E+06 LBS/IN**2

 CROSS SECTION       :     3
 SECTION NAME        : 9.75"
 TYPE                :  NONLINEAR
 CROSS SECTION TYPE  : ROUND CONC. SHAFT, CASING (AND STEEL SECTION)
 CONCRETE DIAMETER   :       9.75000 IN
 CONCRETE FC         :       5000.00 LBS/IN**2
 DIAMETER CASING     : NO CASING
 EMBEDDED STEEL SECT : NONE
 NUMBER REBARS       :             1
 ES REINFORCEMENT    :   2.90000E+07 LBS/IN**2
 FY REINFORCEMENT    :       60000.0 LBS/IN**2
 REINF. LAYOUT       :       MANUAL
 REINF. A , D, COORDS:        IN^2             IN              IN              IN
 - REBAR    1        :       0.79000         1.00000         0.00000         0.00000
 EQ. YOUNG MODULUS   :   6.39161E+06 LBS/IN**2

* PILE CROSS SECTIONS PROPERTIES *

          NONLINEAR SECTIONS

SECT    DIAM,IN   PERIM,IN AREA,IN**2   Iz,IN**4   Iy,IN**4  GJ,LBS-IN**2   EIz IND  EIy IND   Mn,LBS-IN    Vn,LBS
  1      10.625     33.379     88.664     0.0000     0.0000   5.4901E+09      0        0         0.0000     0.0000
  2      10.250     32.201     82.516     0.0000     0.0000   3.6218E+09      0        0         0.0000     0.0000
  3      9.7500     30.631     74.662     0.0000     0.0000   1.4303E+09      0        0         0.0000     0.0000


 * TABLE F *   SOIL DATA


 SOILS INFORMATION

     GROUND SURFACE          =     -3.00000  FT
```

6 LAYER(S) OF SOIL

LAYER 1
THE SOIL IS A SAND

		TOP OF LAYER	BOTTOM OF LAYER
X COORDINATE	(FT)	-3.00000	21.5000
EFFECTIVE UNIT WEIGHT	(LBS/FT**3)	115.000	115.000
FRICTION ANGLE	(DEGREES)	33.0000	33.0000
P-Y SUBGRADE MODULUS	(LBS/IN**3)	25.0000	25.0000
ULTIMATE UNIT SIDE FRICTION	(LBS/FT**2)	11.5000 (S)	2343.55 (S)
ULTIMATE UNIT TIP RESISTANCE	(LBS/FT**2)	0.00000	0.00000

LAYER 2
THE SOIL IS A SILT

		TOP OF LAYER	BOTTOM OF LAYER
X COORDINATE	(FT)	21.5000	58.5000
EFFECTIVE UNIT WEIGHT	(LBS/FT**3)	57.6000	57.6000
UNDRAINED COHESION, C	(LBS/FT**2)	130.000	130.000
FRICTION ANGLE	(DEGREES)	22.0000	22.0000
P-Y SUBGRADE MODULUS	(LBS/IN**3)	100.000	100.000
STRAIN AT 50% STRESS		1.00000E-02	1.00000E-02
ULTIMATE UNIT SIDE FRICTION	(LBS/FT**2)	2415.05 (S)	2255.38 (S)
ULTIMATE UNIT TIP RESISTANCE	(LBS/FT**2)	0.00000	0.00000

LAYER 3
THE SOIL IS A SAND

		TOP OF LAYER	BOTTOM OF LAYER
X COORDINATE	(FT)	58.5000	70.0000
EFFECTIVE UNIT WEIGHT	(LBS/FT**3)	57.6000	57.6000
FRICTION ANGLE	(DEGREES)	26.0000	26.0000
P-Y SUBGRADE MODULUS	(LBS/IN**3)	50.0000	50.0000
ULTIMATE UNIT SIDE FRICTION	(LBS/FT**2)	2183.88 (S)	1944.58 (S)
ULTIMATE UNIT TIP RESISTANCE	(LBS/FT**2)	0.00000	0.00000

LAYER 4
THE SOIL IS A SAND

		TOP OF LAYER	BOTTOM OF LAYER
X COORDINATE	(FT)	70.0000	77.1000
EFFECTIVE UNIT WEIGHT	(LBS/FT**3)	72.6000	72.6000
FRICTION ANGLE	(DEGREES)	37.0000	37.0000
P-Y SUBGRADE MODULUS	(LBS/IN**3)	125.000	125.000
ULTIMATE UNIT SIDE FRICTION	(LBS/FT**2)	1944.58 (S)	1787.54 (S)
ULTIMATE UNIT TIP RESISTANCE	(LBS/FT**2)	0.00000	0.00000

LAYER 5
THE SOIL IS A SAND

		TOP OF LAYER	BOTTOM OF LAYER
X COORDINATE	(FT)	77.1000	81.5000
EFFECTIVE UNIT WEIGHT	(LBS/FT**3)	87.6000	87.6000
FRICTION ANGLE	(DEGREES)	38.0000	38.0000
P-Y SUBGRADE MODULUS	(LBS/IN**3)	150.000	150.000
ULTIMATE UNIT SIDE FRICTION	(LBS/FT**2)	1787.54 (S)	1686.79 (S)
ULTIMATE UNIT TIP RESISTANCE	(LBS/FT**2)	0.00000	0.00000

LAYER 6
THE LAYER IS A VUGGY LIMESTONE

		TOP OF LAYER	BOTTOM OF LAYER
X COORDINATE	(FT)	81.5000	100.000
EFFECTIVE UNIT WEIGHT	(LBS/FT**3)	101.600	101.600
UNIAXIAL COMPRESSIVE STRENGTH	(LBS/IN**2)	7500.00	7500.00
ULTIMATE UNIT SIDE FRICTION	(LBS/FT**2)	1.08000E+05 (S)	1.08000E+05 (S)
ULTIMATE UNIT TIP RESISTANCE	(LBS/FT**2)	9.72000E+06 (T)	9.72000E+06 (T)

Notes : Program estimated values for listed parameters
if zero input values were entered:
(S) ULTIMATE UNIT SIDE FRICTION for Drilled Shafts
(T) ULTIMATE UNIT TIP RESISTANCE for Drilled Shafts

* TABLE H * AXIAL LOAD VS DISPLACEMENT

AXIAL LOAD-DISPLACEMENT CURVES GENERATED INTERNALLY

NUM OF CURVES 1

CURVE 1 NUM OF POINTS 19

DISPLACEMENT, IN	AXIAL LOAD,LBS
-5.27905	-2.43555E+06
-4.28509	-2.43944E+06
-3.90549	-2.52001E+06
-3.65841	-2.62132E+06
-3.64011	-2.64304E+06
-3.18066	-2.37665E+06
-2.76808	-2.11369E+06
-1.68437	-1.39542E+06
-0.47327	-5.53514E+05
0.00000	0.00000
0.81536	7.96404E+05

2.35371	1.84355E+06
3.46394	2.55754E+06
4.00829	2.89709E+06
6.53896	4.45267E+06
7.89315	5.26696E+06
11.5779	7.31853E+06
12.2329	7.41504E+06
13.4853	7.57305E+06

DISPL. TIP , IN	AXIAL TIP ,LBS
-2.00000	-6.88103
-1.00000	-6.66926
-0.50000	-6.50779
-0.10000	-3.64897
-0.0500000	-2.50941
-1.00000E-02	-0.50188
-5.00000E-03	-0.25094
-1.00000E-03	-0.0501882
-1.00000E-04	-5.01882E-03
0.00000	0.00000
1.00000E-04	3747.15
1.00000E-03	37471.5
5.00000E-03	1.87357E+05
1.00000E-02	3.74715E+05
0.0500000	1.87357E+06
0.10000	2.72439E+06
0.50000	4.85884E+06
1.00000	4.97940E+06
2.00000	5.13751E+06

* TABLE I * TORS. MOM. VS ANGLE ROT.

TORQUE-ROTATION CURVES GENERATED INTERNALLY

NUM OF CURVES 1

CURVE 1 NUM OF POINTS 19

ROT. ANGLE,Rad.	TORS.MOMEN,LBS-IN
-3.89292	-1.29362E+07
-3.70690	-1.29428E+07
-3.66845	-1.31149E+07
-3.67834	-1.33808E+07
-3.68433	-1.34292E+07
-3.53393	-1.30079E+07
-3.39914	-1.26096E+07
-2.99507	-1.13910E+07
-2.40562	-9.55715E+06
0.00000	0.00000
2.40562	9.55715E+06
2.99507	1.13910E+07
3.39914	1.26096E+07
3.53393	1.30079E+07
3.68433	1.34292E+07
3.67834	1.33808E+07
3.66845	1.31149E+07
3.70690	1.29428E+07
3.89292	1.29362E+07

* TABLE J1 * REDUCTION FACTORS ALONG DEPTH

NUM OF SETS : 1

SET 1 NUM OF POINTS 2

DEPTH,FT	P-FACTOR	Y-FACTOR
0.00000	0.50000	1.00000
12.0000	1.00000	1.00000

* TABLE K * REDUCTION FACTORS

AVERAGE DIAMETER IS USED TO GET RATIO S/B

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS ALONG Y-DIRECTION
ESTIMATED ASSUMING MOVEMENT IN THE DIRECTION OF Y-FORCE (+)

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	1.0000	1.0000
3	1.0000	1.0000
4	1.0000	1.0000
5	1.0000	1.0000
6	1.0000	1.0000
7	1.0000	1.0000
8	1.0000	1.0000

9	1.0000	1.0000
10	1.0000	1.0000
11	1.0000	1.0000
12	1.0000	1.0000
13	1.0000	1.0000
14	1.0000	1.0000
15	1.0000	1.0000
16	1.0000	1.0000
17	1.0000	1.0000
18	0.9267	1.0000
19	0.9267	1.0000
20	0.9267	1.0000
21	0.9267	1.0000
22	0.9267	1.0000
23	0.9267	1.0000
24	0.9267	1.0000
25	0.9267	1.0000
26	0.9267	1.0000
27	0.9267	1.0000
28	0.9267	1.0000
29	0.9267	1.0000
30	0.9267	1.0000
31	0.9267	1.0000
32	0.9267	1.0000
33	0.9267	1.0000
34	0.9267	1.0000

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS ALONG Z-DIRECTION
ESTIMATED ASSUMING MOVEMENT IN THE DIRECTION OF Z-FORCE (+)

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	0.8513	1.0000
3	0.8513	1.0000
4	0.8513	1.0000
5	0.8513	1.0000
6	0.8513	1.0000
7	0.8513	1.0000
8	0.8513	1.0000
9	0.8513	1.0000
10	0.8513	1.0000
11	0.8513	1.0000
12	0.8513	1.0000
13	0.8513	1.0000
14	0.8513	1.0000
15	0.8513	1.0000
16	0.8513	1.0000
17	0.8513	1.0000
18	1.0000	1.0000
19	0.8513	1.0000
20	0.8513	1.0000
21	0.8513	1.0000
22	0.8513	1.0000
23	0.8513	1.0000
24	0.8513	1.0000
25	0.8513	1.0000
26	0.8513	1.0000
27	0.8513	1.0000
28	0.8513	1.0000
29	0.8513	1.0000
30	0.8513	1.0000
31	0.8513	1.0000
32	0.8513	1.0000
33	0.8513	1.0000
34	0.8513	1.0000

```
     ======================================================================

                    GROUP for Windows, Version 2022.12.4

                     Serial Number : 546958378

                     Analysis of A Group of Piles
                   Subjected to Axial and Lateral Loading

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     ======================================================================


     This program is licensed to :

     Nobis Engineering, Inc.
     Lowell, MA, USA

     Path to file locations      : J:\094184.100-MassDOT Armory Street Bridges, Springfield\Calculations\Axial-Lateral Pile Analysis\S-24-026\Updated North
and South Abutment\Group\
     Name of input data file     : Proposed Pile Caps.gp12d
     Name of output echo file    : Proposed Pile Caps.gp12e
     Name of output results file : Proposed Pile Caps.gp12o
     Name of output summary file : Proposed Pile Caps.gp12t
     Name of plot output file    : Proposed Pile Caps.gp12p
     Name of runtime file        : Proposed Pile Caps.gp12r


     ----------------------------------------------------------------------
                         Time and Date of Analysis
     ----------------------------------------------------------------------

               Date:  February 26, 2025     Time:  10:13:44



                *****     COMPUTATION RESULTS     *****


     Armory Street over Abandoned CSX Spur - S-24-026 - Proposed Pile Caps (North & S



                *****     LOAD CASES RESULTS      *****


     LOAD CASE :     1
     CASE NAME : Service I
     LOAD TYPE : Dead, DL

       REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
       ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

            GROUP NO     P-FACTOR     Y-FACTOR

                1          1.0000       1.0000
                2          1.0000       1.0000
                3          1.0000       1.0000
                4          1.0000       1.0000
                5          1.0000       1.0000
                6          1.0000       1.0000
                7          1.0000       1.0000
                8          1.0000       1.0000
                9          1.0000       1.0000
               10          1.0000       1.0000
               11          1.0000       1.0000
               12          1.0000       1.0000
               13          1.0000       1.0000
               14          1.0000       1.0000
               15          1.0000       1.0000
               16          1.0000       1.0000
               17          1.0000       1.0000
               18          0.9267       1.0000
               19          0.9267       1.0000
               20          0.9267       1.0000
               21          0.9267       1.0000
               22          0.9267       1.0000
               23          0.9267       1.0000
               24          0.9267       1.0000
               25          0.9267       1.0000
               26          0.9267       1.0000
               27          0.9267       1.0000
               28          0.9267       1.0000
               29          0.9267       1.0000
               30          0.9267       1.0000
```

31	0.9267	1.0000
32	0.9267	1.0000
33	0.9267	1.0000
34	0.9267	1.0000

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD, LBS	HOR. LOAD Y, LBS	HOR. LOAD Z, LBS
2.23730E+06	2.15800E+05	0.00000

MOMENT X ,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
-24552.0	8.87797E+06	1.03950E+08

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0272884	0.22404	-1.78525E-05

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
-3.77714E-07	1.95341E-06	-4.65150E-05

NUMBER OF GLOBAL ITERATIONS = 4

LOAD CASE : 2
CASE NAME : Strength I Max
LOAD TYPE : Dead, DL

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	1.0000	1.0000
3	1.0000	1.0000
4	1.0000	1.0000
5	1.0000	1.0000
6	1.0000	1.0000
7	1.0000	1.0000
8	1.0000	1.0000
9	1.0000	1.0000
10	1.0000	1.0000
11	1.0000	1.0000
12	1.0000	1.0000
13	1.0000	1.0000
14	1.0000	1.0000
15	1.0000	1.0000
16	1.0000	1.0000
17	1.0000	1.0000
18	0.9267	1.0000
19	0.9267	1.0000
20	0.9267	1.0000
21	0.9267	1.0000
22	0.9267	1.0000
23	0.9267	1.0000
24	0.9267	1.0000
25	0.9267	1.0000
26	0.9267	1.0000
27	0.9267	1.0000
28	0.9267	1.0000
29	0.9267	1.0000
30	0.9267	1.0000
31	0.9267	1.0000
32	0.9267	1.0000
33	0.9267	1.0000
34	0.9267	1.0000

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD, LBS	HOR. LOAD Y, LBS	HOR. LOAD Z, LBS
3.26560E+06	3.06000E+05	0.00000

MOMENT X ,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
-38016.0	1.01725E+07	1.51131E+08

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0424297	0.32665	-7.07253E-05

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
-1.49544E-06	2.51773E-06	-8.55091E-05

NUMBER OF GLOBAL ITERATIONS = 4

LOAD CASE : 3
CASE NAME : Strength I Min
LOAD TYPE : Dead, DL

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	1.0000	1.0000
3	1.0000	1.0000
4	1.0000	1.0000
5	1.0000	1.0000
6	1.0000	1.0000
7	1.0000	1.0000
8	1.0000	1.0000
9	1.0000	1.0000
10	1.0000	1.0000
11	1.0000	1.0000
12	1.0000	1.0000
13	1.0000	1.0000
14	1.0000	1.0000
15	1.0000	1.0000
16	1.0000	1.0000
17	1.0000	1.0000
18	0.9267	1.0000
19	0.9267	1.0000
20	0.9267	1.0000
21	0.9267	1.0000
22	0.9267	1.0000
23	0.9267	1.0000
24	0.9267	1.0000
25	0.9267	1.0000
26	0.9267	1.0000
27	0.9267	1.0000
28	0.9267	1.0000
29	0.9267	1.0000
30	0.9267	1.0000
31	0.9267	1.0000
32	0.9267	1.0000
33	0.9267	1.0000
34	0.9267	1.0000

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD, LBS	HOR. LOAD Y, LBS	HOR. LOAD Z, LBS
2.74880E+06	2.22100E+05	0.00000

MOMENT X ,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
-31284.0	6.42148E+06	1.27933E+08

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0341982	0.23109	-4.40319E-05

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
-9.31478E-07	1.49430E-06	-5.71849E-05

NUMBER OF GLOBAL ITERATIONS = 4

LOAD CASE : 4
CASE NAME : Extreme Event I

LOAD TYPE : Dead, DL

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	1.0000	1.0000
3	1.0000	1.0000
4	1.0000	1.0000
5	1.0000	1.0000
6	1.0000	1.0000
7	1.0000	1.0000
8	1.0000	1.0000
9	1.0000	1.0000
10	1.0000	1.0000
11	1.0000	1.0000
12	1.0000	1.0000
13	1.0000	1.0000
14	1.0000	1.0000
15	1.0000	1.0000
16	1.0000	1.0000
17	1.0000	1.0000
18	0.9267	1.0000
19	0.9267	1.0000
20	0.9267	1.0000
21	0.9267	1.0000
22	0.9267	1.0000
23	0.9267	1.0000
24	0.9267	1.0000
25	0.9267	1.0000
26	0.9267	1.0000
27	0.9267	1.0000
28	0.9267	1.0000
29	0.9267	1.0000
30	0.9267	1.0000
31	0.9267	1.0000
32	0.9267	1.0000
33	0.9267	1.0000
34	0.9267	1.0000

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD, LBS	HOR. LOAD Y, LBS	HOR. LOAD Z, LBS
1.36060E+06	1.41400E+05	0.00000

MOMENT X ,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
0.00000	1.07811E+07	6.52541E+07

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0148610	0.14470	-1.46671E-05

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
-3.10573E-07	2.19571E-06	-6.86345E-07

NUMBER OF GLOBAL ITERATIONS = 4

Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for Proposed Abutments (West)
Springfield, Massachusetts

Calculated by: RAC Date: 2/6/2025
Checked by: BTW Date: 2/26/2025

Purpose: Perform axial and lateral analyses for the proposed micropiles for the north and south abutments (west side of construction staging) of the above-referenced project. See table and summary provided in Step 3 and 4 for results of the lateral and axial analyses, respectively. The Structural Engineer should evaluate the structural adequacy of the micropiles.

References:
1) FHWA-NHI-05-039 Micropile Manual, 2005.
2) MassDOT Bridge Design Manual, 2020.
3) Computer program GROUP, Version 2022, and associated user's manual, by Ensoft, Inc.
4) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
5) Loads provided by Tetra Tech via email on December 27, 2024.
6) Gravity Thrust Block diagrams with elevations provided by Tetra Tech on November 14, 2024.
7) Test borings observed by Nobis at the site in 2019 and 2022.
8) Email and phone communications with design team.

Given:
1) Factored loads provided by Tetra Tech per Reference No. 5.
2) Pile cap geometry for West Side of Construction Staging per References No. 5 and No. 6.
3) A pinned condition between the micropiles and the pile cap at both abutments per Reference No. 8.

Assumptions:
1) Compressive strength of grout (f'_c) is 5 ksi, and yield strength (F_y) of casing and rebar are 52 ksi and 60 ksi, respectively.
2) Micropiles will consist of casing with an outer diameter of 10.75-inch and 0.5-inch thick walls with a #8 sized center bar.
3) Structural engineer will verify the loads and the pile head condition used in analysis, and evaluate the structural resistance of the micropiles in accordance with AASHTO and MassDOT Bridge Design Manual.
4) Subsurface information from Reference 7 is representative of subsurface conditions at the proposed abutment.
5) A casing thickness loss of 1/16-in. in the top 3 feet due to corrosion and 50% loss (approx. 60% moment capacity) below the top 3 feet of the pile. No casing joints are located in top 3 feet of the micropiles.
6) A Pm of 0.5 to 1 was used from the bottom of the proposed pile cap to the existing ground surface in front of the abutment to represent the effect of the existing abutment on the proposed piles (i.e. to a depth of 12 feet below bottom of pile cap).
7) The effects of nearby piles from the abutment extension/crash walls and return walls were ignored for the purposes of this analysis. P-multipliers (Pm) were calculated directly by Group for the micropiles of the abutments only.

Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for Proposed Abutments (West)
Springfield, Massachusetts

Calculated by: RAC Date: 2/6/2025
Checked by: BTW Date: 2/26/2025

Solution:

Step 1: Soil Properties and Profile

Nobis used subsurface information from Borings BB-5 through BB-8 and BB-8A of Reference No. 7 to develop soil parameters in the table below. Stratigraphy was based on soils and bedrock conditions encountered at or near both abutments (worst case assumed). The depth datum was taken at the bottom proposed pile cap shown on Figure 7 (El. 151.5). Soil unit weight (γ_{moist}), angle of internal friction (ϕ), and cohesion were estimated based on field and laboratory testing and a study performed on Connecticut Valley Varved Clay entitled "Geology and Engineering Properties of Connecticut Valley Varved Clay" (DeGroot, D.J. and Lutenegger, A.J.). The groundwater table was taken at approximately El. 131. Soil modulus parameters (k) and strain factors for the varved silt/clay were determined using Tables 3.7 and 3.5 from Reference No. 3, respectively. Uniaxial Compressive Strength (U.C.S.) of rock was based on lab test data.

Soil Layer	Elevation (ft)	Depth (ft)	γ_{moist} (pcf)	ϕ (^{o})	k (pci)	Cohesion (psf)	Strain Factor (dims)	U.C.S (psi)
Fill	155.5 to 131	-4 to 21.5	115	33	25/20	-	-	-
Varved Silt & Clay	131 to 94	21.5 to 58.5	120	22	100	130	0.01	-
Silt	94 to 82.5	58.5 to 70	120	26	50	-	-	-
Glacial Till	82.5 to 75.4	70 to 77.1	135	37	125	-	-	-
Weathered Bedrock	75.4 to 71	77.1 to 81.5	150	38	150	-	-	-
Bedrock (Argillaceous Sandstone)	<71	>81.5	164	-	-	-	-	7,500

1) The design groundwater elevation is El. 131, bottom of the fill.

Step 2: Micropile and Pile Cap Properties

Micropile Cased (50%): micropile strength with 50% casing reduction due to threaded sections

Section Length:	82.5	ft	Outer Diameter w/loss:	10.25	**in**
Outside Diameter:	10.75	in	Casing Thickness w/loss:	0.25	**in**
Casing Thickness:	0.5	in			
Percent of Casing loss to Thread:	50	%			
Yield Stress of Casing:	52	ksi			
Elastic modulus of Casing:	29000	ksi			
Center Bar:	# 8	bar	Area of Casing (A_{ct}):	**7.9**	**in^2**
Yield Stress of Center Bar:	60	ksi	Area of Bar (A_b):	**0.8**	**in^2**
Grout Compressive Strength:	5	ksi	Area of Grout (A_g):	**73.9**	**in^2**

Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for Proposed Abutments (West)
Springfield, Massachusetts

Calculated by: RAC Date: 2/6/2025
Checked by: BTW Date: 2/26/2025

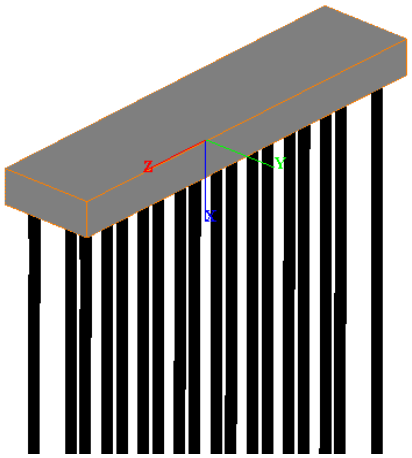
Micropile Uncased: micropile strength with no casing (inside rock socket)

Section Length:	8	ft
Outside Diameter (before corrosion):	9.75	in
Center Bar:	# 8	bar
Yield Stress of Center Bar:	60	ksi
Grout Compressive Strength:	5	ksi

Area of Bar (A_b): **0.8 in^2**
Area of Grout (A_g): **73.9 in^2**

Pile Cap: See graphic.

Cap Length in Z-axis (Transverse):	36.84	ft
Cap Width in Y-axis (Longitudinal):	8	ft
Cap Thickness in X-axis (Vertical):	3	ft
Center-to-center spacing in Y-axis :	5	ft
Center-to-center spacing in Z-axis :	4	ft



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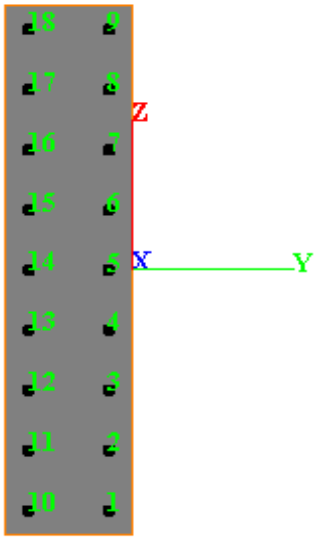

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nobis

Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for Proposed Abutments (West)
Springfield, Massachusetts

Calculated by: RAC Date: 2/6/2025
Checked by: BTW Date: 2/26/2025

Step 3: Lateral Analysis

The software GROUP, version 2022 by Ensoft, Inc. was used for the lateral analyses. Pinned-head conditions were assumed between the micropiles and proposed pile caps. The Structural Engineer should evaluate the structural adequacy of the micropiles. The following table summarizes the results of the lateral analyses.

Results of Micropile Lateral Analyses for Proposed Abutments (West Side) (per micropile)

Abutment	Load Case	Max Shear (kip)	Max Lateral Deflection (in)	Max Moment Below 3 Feet (kip*ft)^2	Max Axial Load (kip)	Min Axial Load (kip)
North and South	Ser. I	7.1	0.22	16.0	75.0	50.0
	Str. I (Max)	10.0	0.31	22.9	105.0	75.0
	Str. I (Min)	7.4	0.23	16.7	90.0	65.0
	Ext. Event I	4.8	0.15	10.6	45.0	30.0

1) Depth of fixity is approximately 21 feet below the bottom of pile cap, and taken at the 2nd point of zero deflection
2) Maximum moment below the top 3 feet with loss of 50% casing due to threaded connections.

Step 4: Axial Analysis

Structural Resistance Factors			
Load Case	Compression	Tension	
Strength	**0.75**	**0.8**	Ref. No. 4 Tb. 10.5.5.2.5-2
Service	**1**	**1**	Ref. No. 4 Section 10.5.5.1
Extreme	**1**	**0.8**	Ref. No. 4 Section 10.5.5.3

Load Demand (from Group)		
Load Case	Compression (kips)	Tension (kips)
Strength	**105.0**	**0.0**
Service	**75.0**	**0.0**
Extreme	**45.0**	**0.0**

Geotechnical Resistance Factors			
Load Case	Compression	Tension	
Strength	**0.55**	**0.55**	Ref. No. 4 Tb. 10.5.5.2.5-1
Service	**1**	**1**	Ref. No. 4 Section 10.5.5.1
Extreme	**1**	**0.8**	Ref. No. 4 Section 10.5.5.3

Evaluate the structural resistance of the micropile for axial load only (negating lateral loads).

For micropile cased section (assuming 50% section):

Nominal axial compressive structural resistance (R_n): **648.7 kips** Ref. No. 4 Eq. 10.9.3.10.2a-2

Nominal axial tension structural resistance (R_n): **449.2 kips** Ref. No. 4 Eq. 10.9.3.10.3a-2

Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for Proposed Abutments (West)
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For micropile uncased section:

Nominal axial compressive structural resistance (R_n):	**306.9**	**kips**	Ref. No. 4 Eq. 10.9.3.10.2b-2
Nominal axial tension structural resistance (R_n):	**47.1**	**kips**	Ref. No. 4 Eq. 10.9.3.10.3b-2

Evaluate the geotechnical resistance of the micropile for axial loads.

Grout-to-ground bond strength in Bedrock:	**11**		Ref. No. 4 Table C10.9.3.5.2-1
Minimum Rock Socket Length:	**8**	**feet**	assumption
Total Nominal grout-to-ground bond resistance:	**225**	**Kips**	Ref. No. 4 Eq. 10.9.3.5.2-1

Summary

Check to verify that a 8 foot rock socket is adequate based on the maximum factored axial load during contruction of the western portion.

Geotechnical					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**123.5**	**105.0**	**123.5**	**0.0**	OK
Service	**224.6**	**75.0**	**224.6**	**0.0**	
Extreme	**224.6**	**45.0**	**179.7**	**0.0**	

Check to verify that the cased micropile is *adequate based on the maximum factored axial load (negating lateral loads).

Structural (cased): Check the strucural resistance of the micropile					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**486.6**	**105.0**	**359.4**	**0.0**	OK
Service	**648.7**	**75.0**	**449.2**	**0.0**	
Extreme	**648.7**	**45.0**	**359.4**	**0.0**	

*Structural engineer shall evaluate the structural adequacy of the micropiles.

Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for Proposed Abutments (West)
Springfield, Massachusetts

Calculated by: RAC Date: 2/6/2025
Checked by: BTW Date: 2/26/2025

Check to verify that the uncased micropile is *adequate based on the maximum factored axial load (negating lateral loads) and to verify that a plunge length is not needed.

Structural (uncased)					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**230.2**	**105.0**	**37.7**	**0.0**	OK
Service	**306.9**	**75.0**	**47.1**	**0.0**	
Extreme	**306.9**	**45.0**	**37.7**	**0.0**	

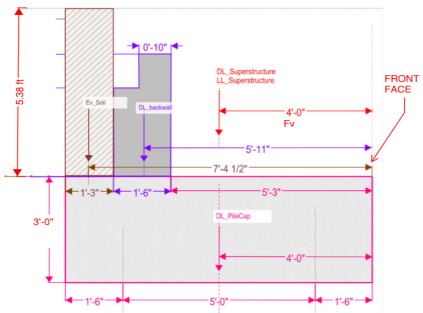
*Structural engineer shall evaluate the structural adequacy of the micropiles.

S-24-026 Active RR Revised Reactions: 12/27/2024

Proposed Width =	36.83 ft	36.84
Existing Span =	61.33 ft	
Existing & Proposed Span =	81.333 ft	

Loads Factors

	Load Factors	Service I		Strength I max	Strength I min	Extreme Event I	
Vertical	Superstructure DL (DC)	1.00	γp	1.25	0.90		1.00
	Wearing Surface DL (DW)	1.00	γp	1.50	0.65		1.00
	Live Load (LL)	1.00		1.75	1.75	γEQ	0.00
	Pile Cap	1.00	γp	1.25	0.90		1.00
	Backwall	1.00	γp	1.25	0.90		1.00
	Earth (Ev)	1.00		1.35	1.00		1.00
	Approach Slab	1.00	γp	1.25	0.90		1.00
Horiz	Thermal Force (Tu)	1.00		1.20	0.50		0.00
	Breaking Force (BR)	1.00		1.75	1.75		0.00
	Horizontal Earth (EH_bw)	1.00	γp	1.35	0.90		1.00
	Horizontal Earth (EH_pc)	1.00	γp	1.35	0.90		1.00

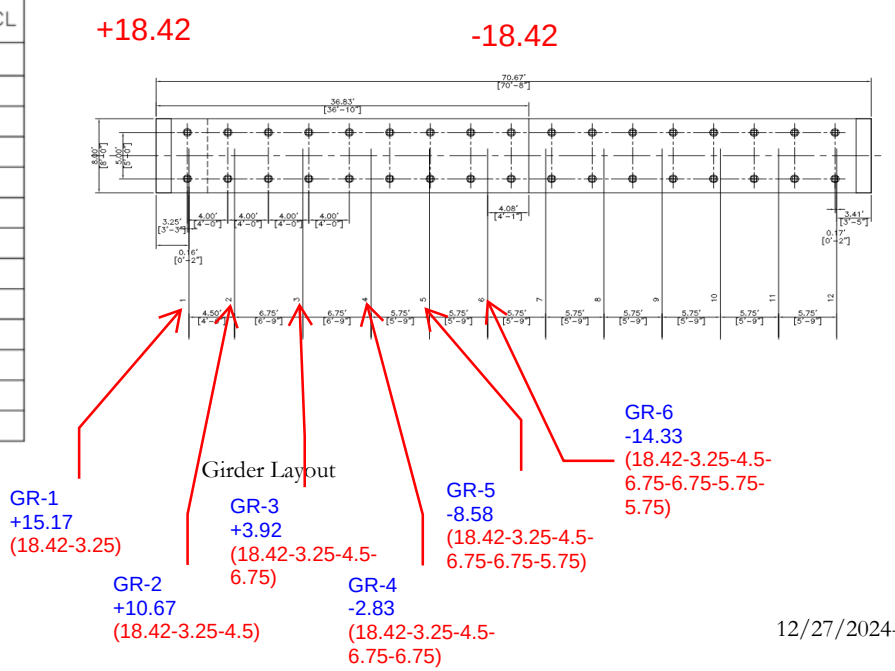


PROPOSED BRIDGE SEAT ELEVATIONS AT THE CL OF BRG.	
GR NO.	SOUTH
1	154.48
2	154.48
3	154.62
4	154.75
5	154.87
6	154.98
7	155.10
8	155.21
9	155.11
10	154.99
11	154.88
12	154.76

B.O. S. pile cap EL: 151.48

PROPOSED BRIDGE SEAT ELEVATIONS AT THE CL	
GR NO.	NORTH
1	154.23
2	154.23
3	154.37
4	154.51
5	154.62
6	154.74
7	154.85
8	154.97
9	154.86
10	154.74
11	154.63
12	154.51

B.O.N. pile cap EL: 151.23



Point Load at each Girder Bearing

Girder 1 Load 1 (-3.4,-4,+15.17)

Loads to be Applied to Substructure (Abut west)										
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap	Service I Force (k)	Strength I Max Force (k)	Strength I Min Force (k)	Extreme Event I Force (k)	
Vertical	DC	68.34	4.0			68.3	85.4	61.5	68.3	
	DW	0.0	4.0			104.8 0.0	149.2 0.0	125.3 0.0	68.3 0.0	
	LL	36.5	4.0			36.5	63.8	63.8		0.0
Horiz.	Breaking Force (BR)	3.6			3.4	3.6	6.3	6.3		0.0
	Thermal Force (Tu)	2.0			3.4	5.6 2.0	8.7 2.4	7.3 1.0	0.0	0.0

Girder 2 Load 2 (-3.4,-4,+10.67)

Loads to be Applied to Substructure (Abut west)										
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap	Service I Force (k)	Strength I Max Force (k)	Strength I Min Force (k)	Extreme Event I Force (k)	
Vertical	DC	69.97	4.0			70.0	87.5	63.0	70.0	
	DW	0.0	4.0			151.2 0.0	229.6 0.0	205.1 0.	70.0	0.0
	LL	81.2	4.0			81.2	142.1	142.1		0.0
Horiz	Breaking Force (BR)	3.6			3.4	3.6	6.3	6.3		0.0
	Thermal Force (Tu)	2.0			3.4	5.6 2.0	8.7 2.4	7.3 1.0	0.0	0.0

Girder 3 Load 3 (-3.6,-4,+3.92)

Loads to be Applied to Substructure (Abut west)										
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap	Service I Force (k)	Strength I Max Force (k)	Strength I Min Force (k)	Extreme Event I Force (k)	
Vertical	DC	70.34	4.0			70.3	87.9	63.3	70.3	
	DW	0.0	4.0			155.5 0.0	236.9 0.0	212.3 0.0	70.3	0.0
	LL	85.2	4.0			85.2	149.0	149.0		0.0
Horiz	Breaking Force (BR)	3.6			3.6	3.6	6.3	6.3		0.0
	Thermal Force (Tu)	2.0			3.6	5.6 2.0	8.7 2.4	7.3 1.0	0.0	0.0

Girder 4 Load 4 (-3.7,-4,-2.83)

Loads to be Applied to Substructure (Abut west)										
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap	Service I Force (k)	Strength I Max Force (k)	Strength I Min Force (k)	Extreme Event I Force (k)	
Vertical	DC	68.35	4.0			68.4	85.4	61.5	68.4	
	DW	0.0	4.0			149.4 0.0	227.3 0.0	203.3 0.0	68.4	0.0
	LL	81.0	4.0			81.0	141.8	141.8		0.0
Horiz	Breaking Force (BR)	3.6			3.7	3.6	6.3	6.3		0.0
	Thermal Force (Tu)	2.0			3.7	5.6 2.0	8.7 2.4	7.3 1.0	0.0	0.0

Girder 5 Load 5 (-3.8,-4,-8.58)

Loads to be Applied to Substructure (Abut west)																
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap		Service I Force (k)		Strength I Max Force (k)		Strength I Min Force (k)		Extreme Event I Force (k)	
Vertical	DC	65.70	4.0				65.7		82.1		59.1		65.7	
	DW	0.0	4.0			142.8	0.0	217.0	0.0	194.0	0.0	65.7	0.0	
	LL	77.1	4.0				77.1		134.9		134.9		0.0	
Horiz	Breaking Force (BR)	3.6			3.8		3.6		6.3		6.3		0.0	
	Thermal Force (Tu)	2.0			3.8	5.6	2.0	8.7	2.4	7.3	1.0	0.0	0.0	

Load 6 (-3.9,-4,-14.33)

Girder 6 **Added additional DC - wider slab+CF-PL3**

Loads to be Applied to Substructure (Abut west)																
Loads		Unfactored Force (k)	Fv Arm	Applied x ft from Bridge Seat	Applied x ft from Bot of Pile Cap		Service I Force (k)		Strength I Max Force (k)		Strength I Min Force (k)		Extreme Event I Force (k)	
Vertical	DC	95.67	4.0				95.7		119.6		86.1		95.7	
	DW	0.0	4.0			172.8	0.0	254.5	0.0	221.0	0.0	95.7	0.0	
	LL	77.1	4.0				77.1		134.9		134.9		0.0	
Horiz	Breaking Force (BR)	3.6			3.9		3.6		6.3		6.3		0.0	
	Thermal Force (Tu)	2.0			3.9	5.6	2.0	8.7	2.4	7.3	1.0	0.0	0.0	

Line Load along Abutment

Loads to be Applied to Substructure (Abut west)																
Loads		Unfactored line Force (klf)	Fv Arm	Applied x ft from Bridge Seat		Applied x ft from Bot of Pile Cap		Service I Force (k)		Strength I Max Force (k)		Strength I Min Force (k)		Extreme Event I Force (k)	
Vertical	Load 7 End Diaphragm	1.25	4.0					44.2	1.2	59.0	1.6	40.6	1.1	44.2	1.2
	Load 8 Pile Cap	3.9	4.0					143.7	3.9	180.5	4.9	129.0	3.5	143.7	3.9
	Load 9 Backwall	1.2	6.0					44.2	1.2	55.3	1.5	40.6	1.1	44.2	1.2
	~~Earth (LW Ev)~~	~~0.5~~	~~7.4~~					~~0.5~~		~~0.6~~		~~0.5~~		~~0.5~~	
	Load 10 Earth (NW Ev)	0.9	7.4					33.2	0.9	44.2	1.2	33.2	0.9	33.2	0.9
	~~Approach Slab~~	~~0.0~~						~~0.0~~		~~0.0~~		~~0.0~~		~~0.0~~	
Horiz.	Horiz Earth (EH_bw NW)	Load 11 0.8		1.8		4.8		29.5	0.8	40.6	1.1	25.8	0.7	29.5	0.8
	~~Horiz Earth (EH_bw LW)~~	~~0.4~~		~~1.8~~		~~4.8~~		~~0.4~~		~~0.5~~		~~0.3~~		~~0.4~~	
	Horiz Earth (EH_pc NW)	Load 12 1.2		-1.6		1.4		44.2	1.2	59.0	1.6	40.6	1.1	44.2	1.2
	~~Horiz Earth (EH_pc, LW)~~	~~0.4~~		~~-1.5~~		~~1.5~~		~~0.4~~		~~0.6~~		~~0.4~~		~~0.4~~	

EH_bw: Earth pressure at backwall per ft
EH_pc: Earth pressure at pile cap per ft
Fv Arms are taken from the front face of the pile cap

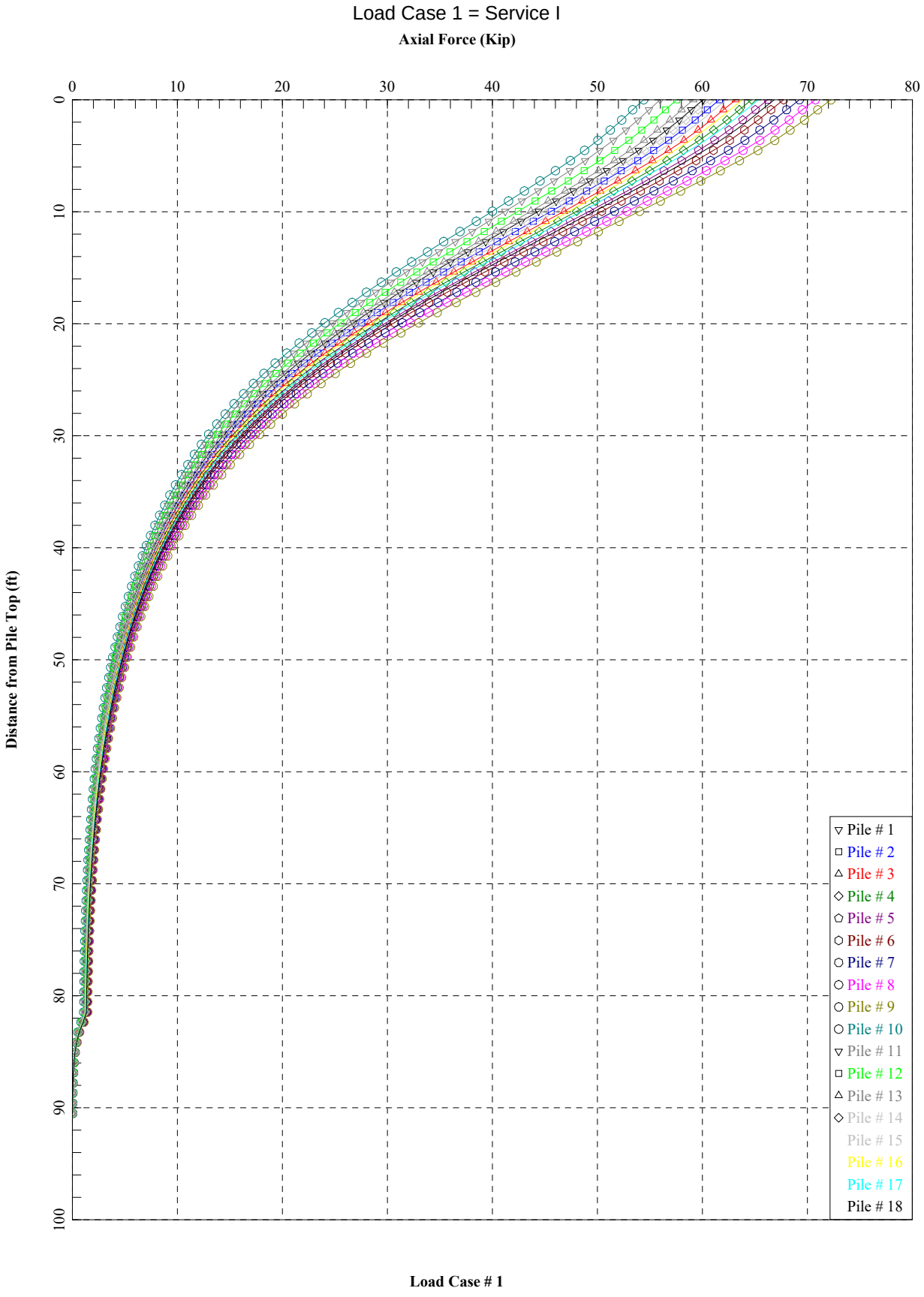
LW fill width= 0 ft

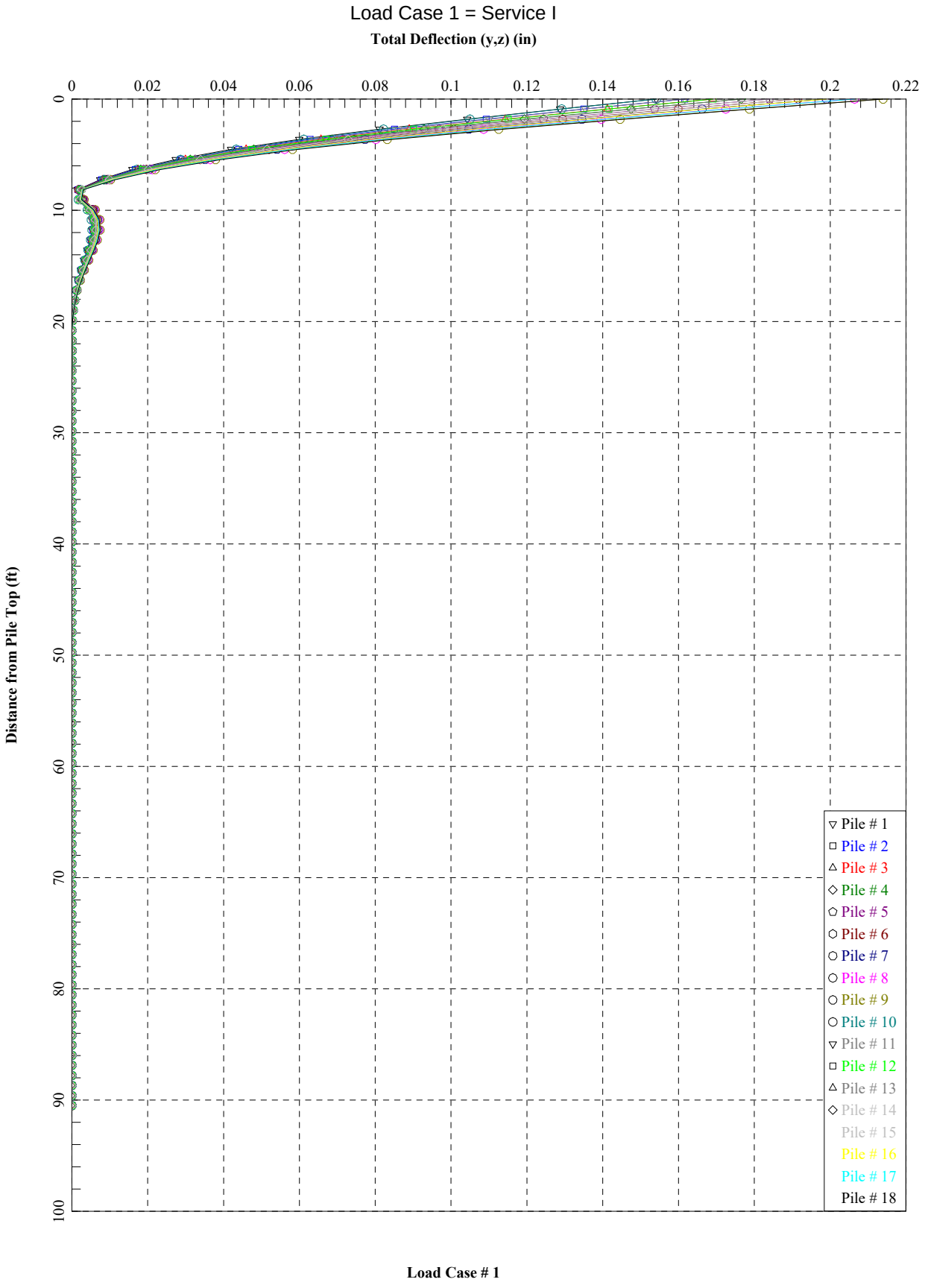
NW fill width= 36.83 ft

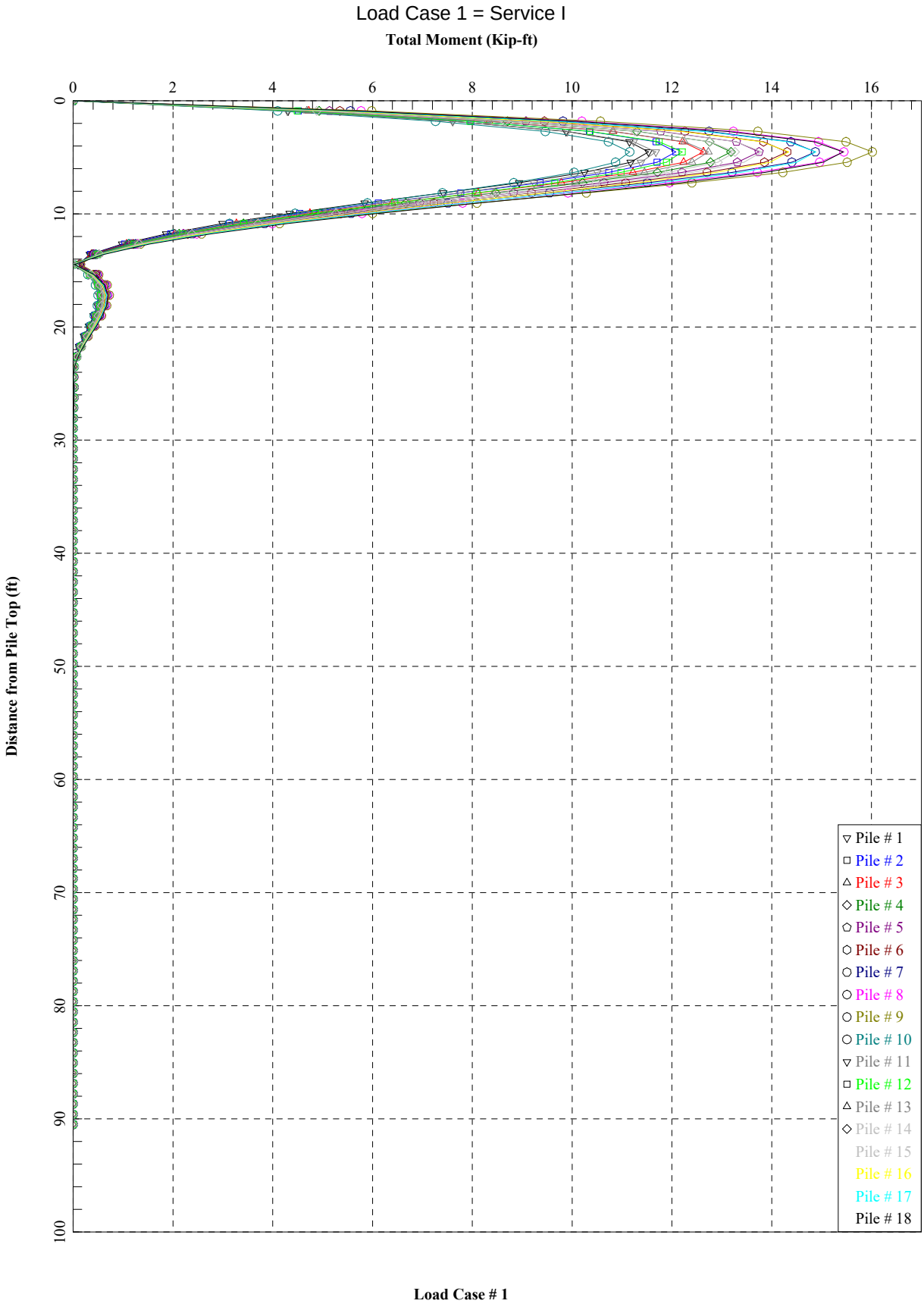
36.84

Load 7 (-3,-4,0)
Load 8 (0,-4,0)
Load 9 (-3,-6,0)
Load 10 (-3,-7.4,0)

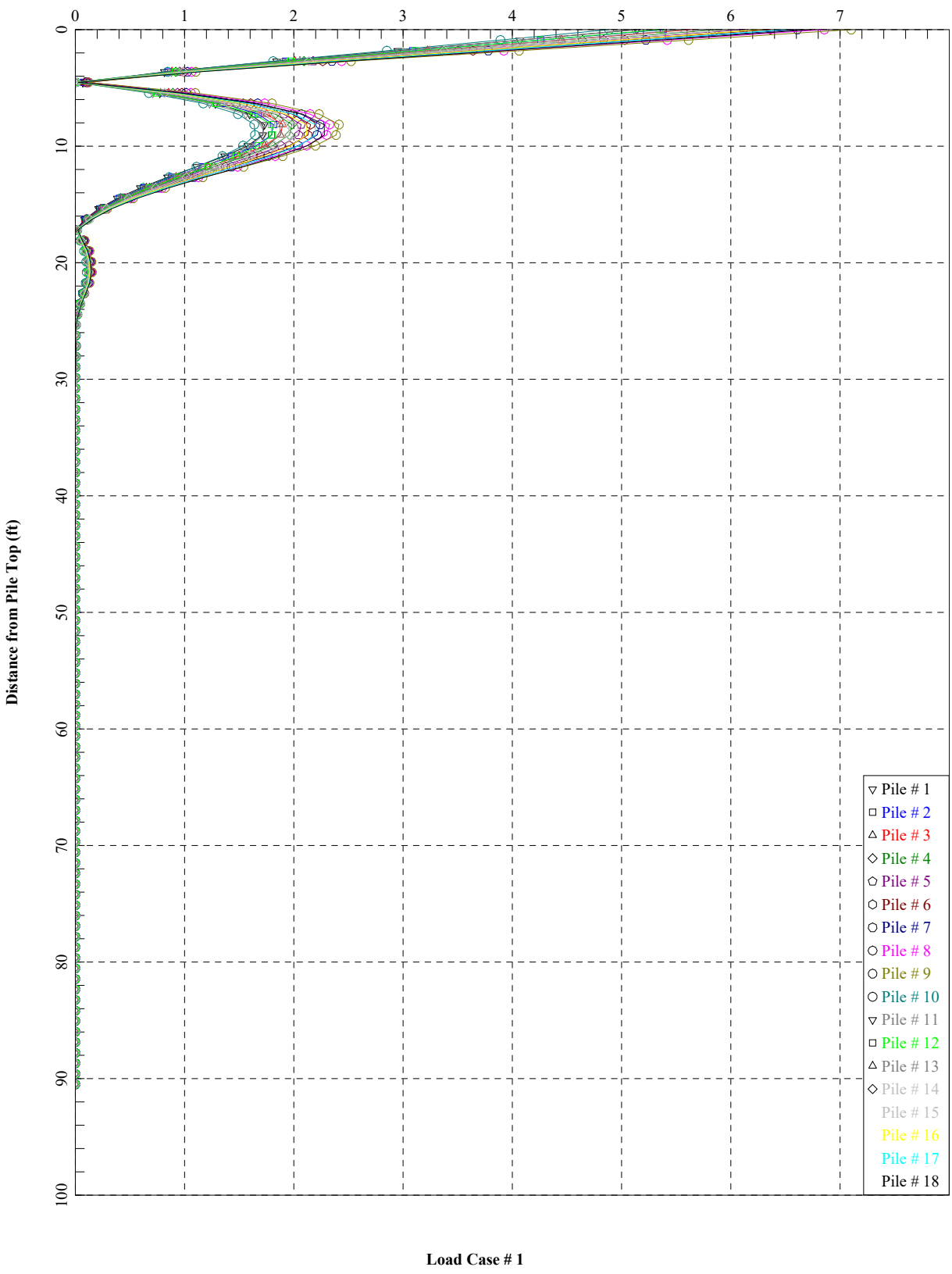
Load 11 (-4.8,-6.75,0)
Load 12 (-1.4,-8,0)

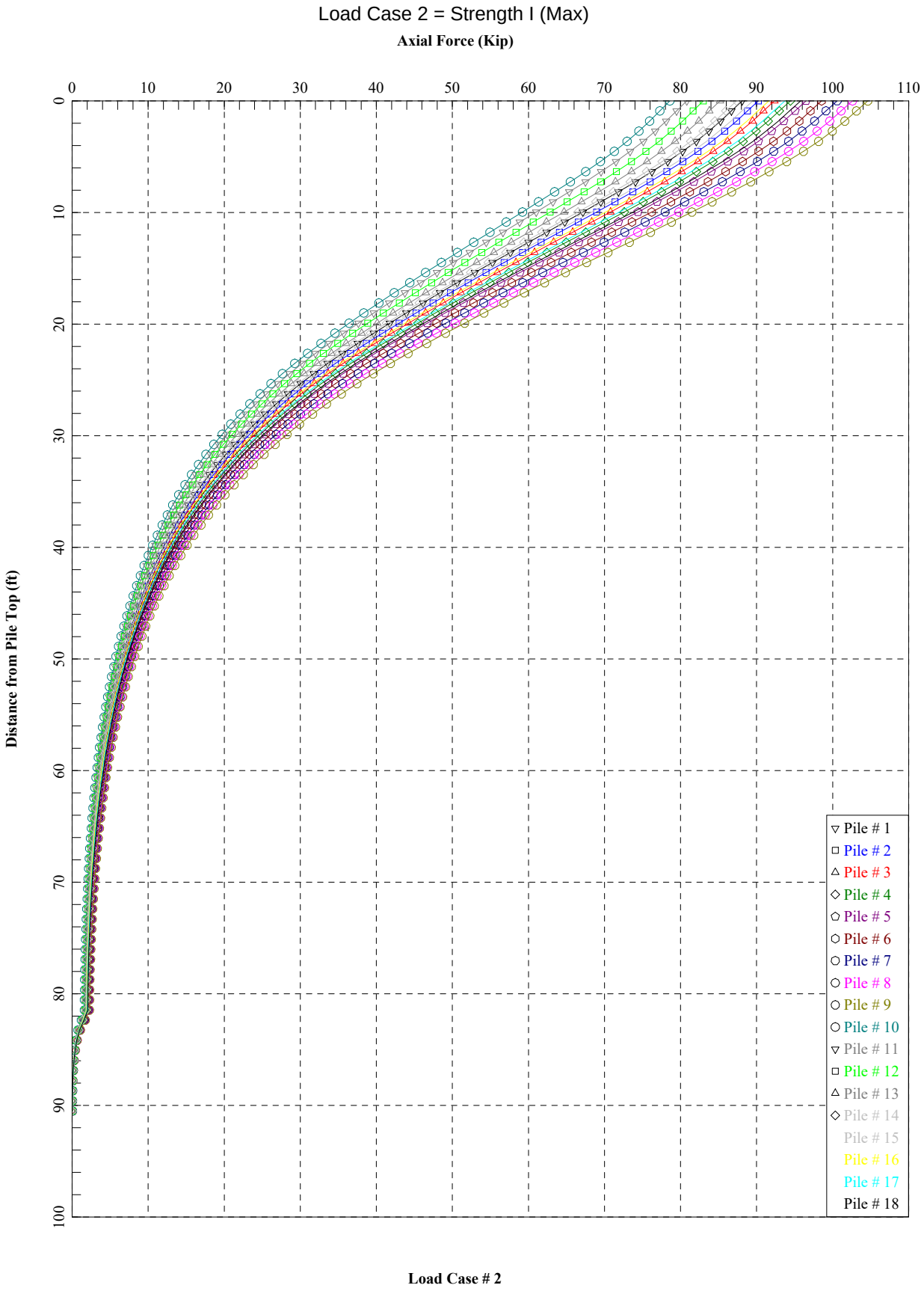

Load Case 1 = Service I
Axial Force (Kip)
0
10
20
30
40
50
60
70
80
Distance from Pile Top (ft)
0
10
20
30
40
50
60
70
80
90
100
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Load Case # 1

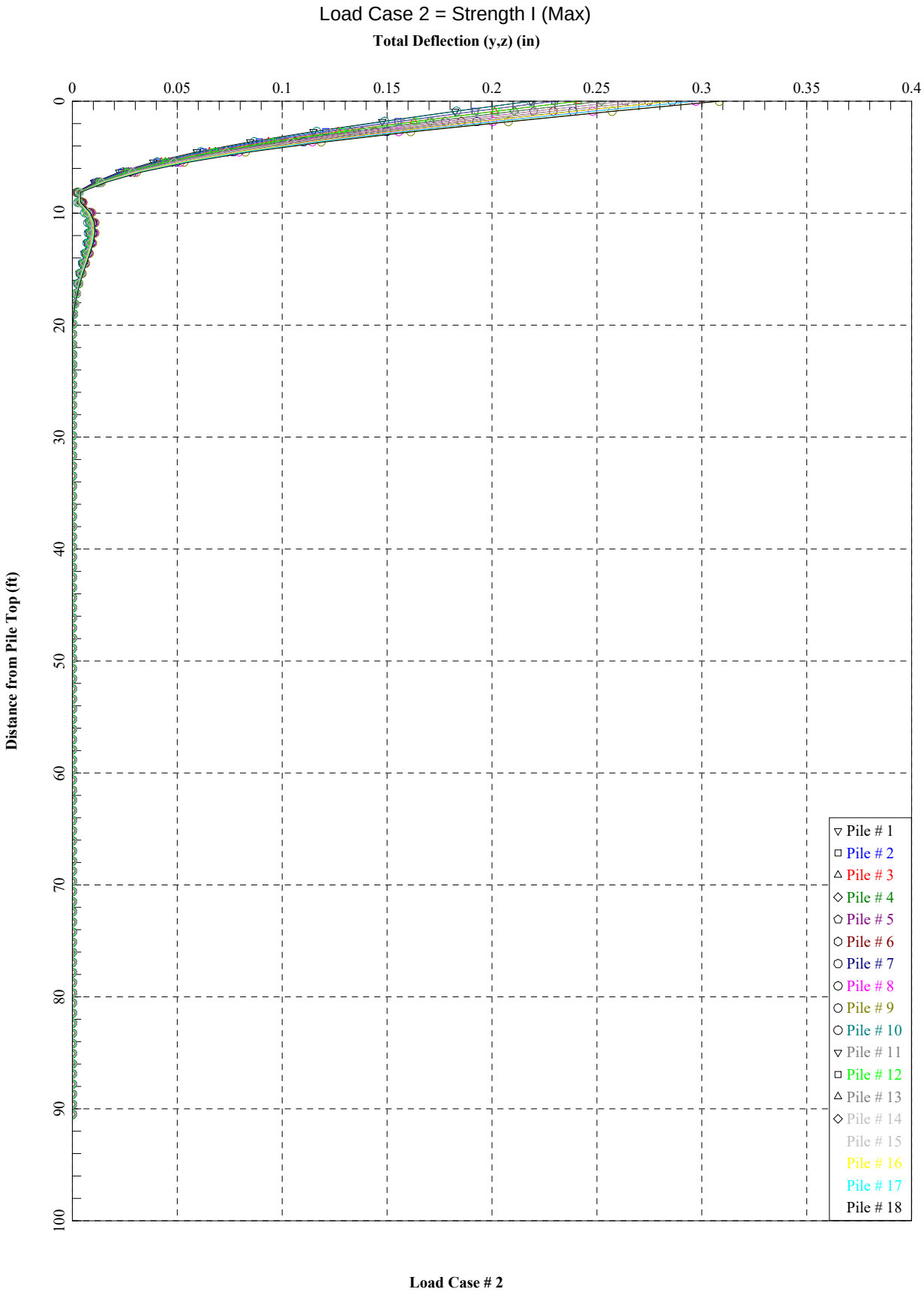

Load Case 1 = Service I
Total Deflection (y,z) (in)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
0.22
Distance from Pile Top (ft)
0
10
20
30
40
50
60
70
80
90
100
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Load Case # 1


Load Case 1 = Service I
Total Moment (Kip-ft)
Distance from Pile Top (ft)
Load Case # 1
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18

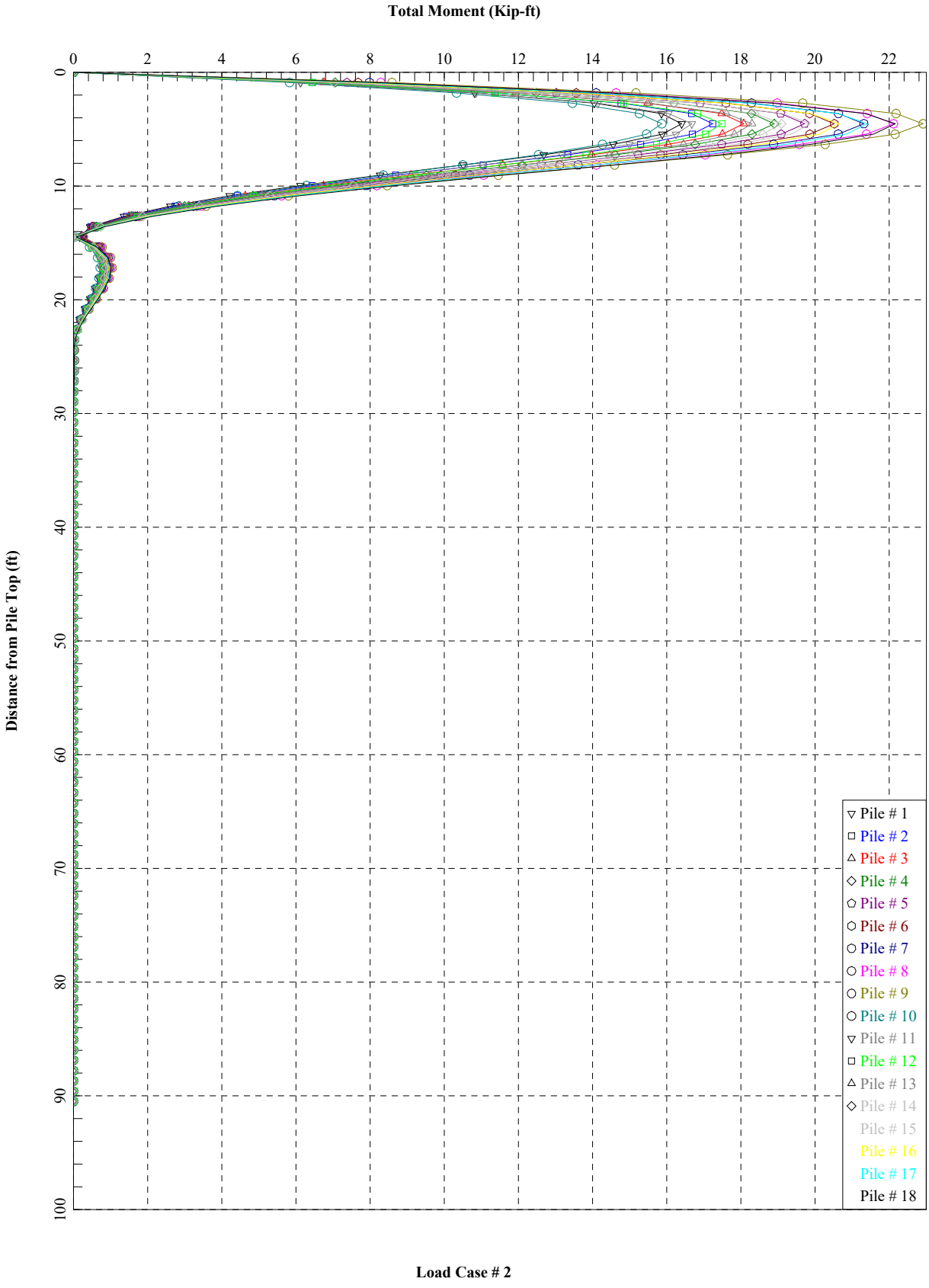
Load Case 1 = Service I



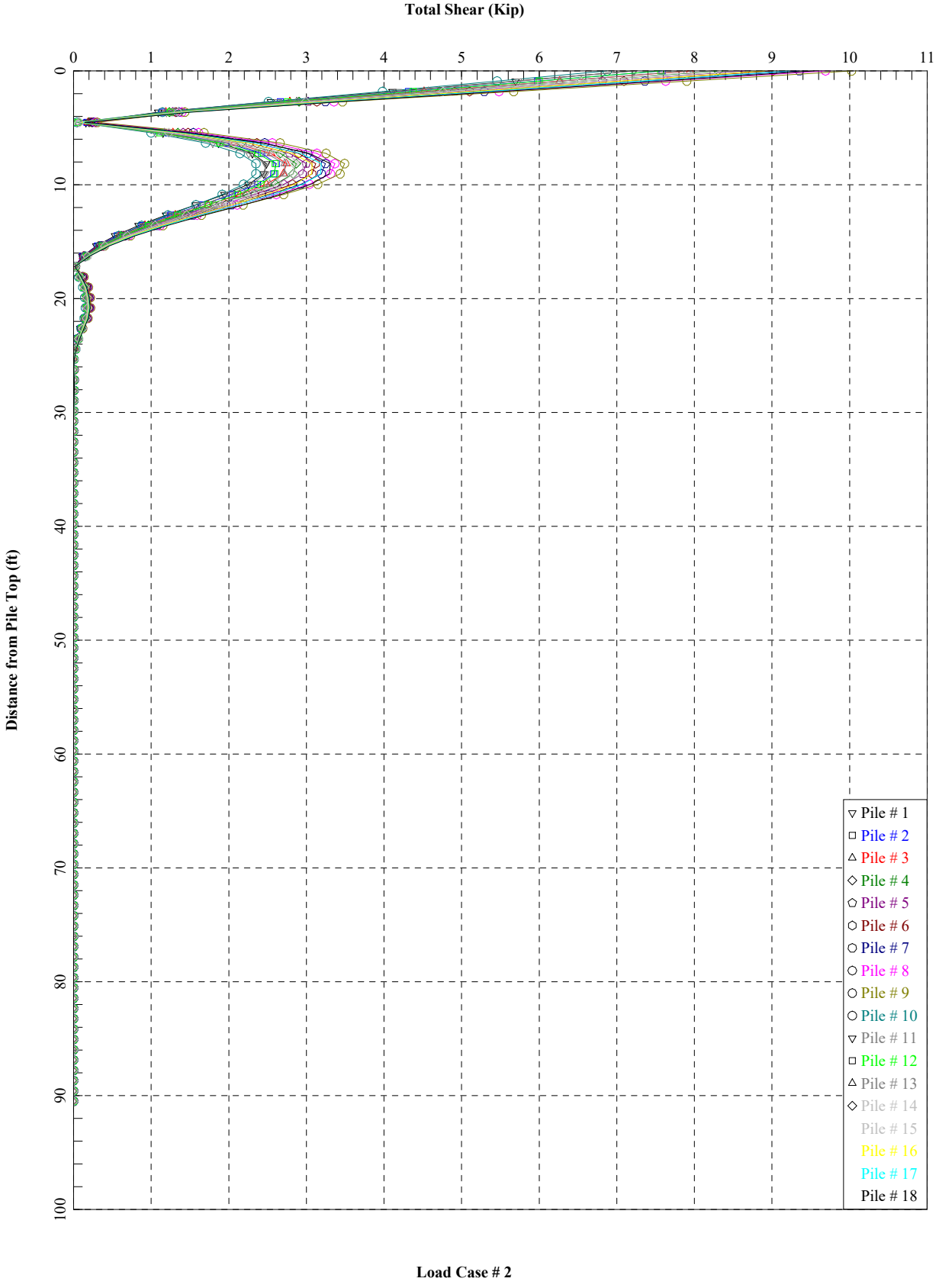

Load Case 2 = Strength I (Max)
Axial Force (Kip)
0
10
20
30
40
50
60
70
80
90
100
110
Distance from Pile Top (ft)
0
10
20
30
40
50
60
70
80
90
100
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Load Case # 2

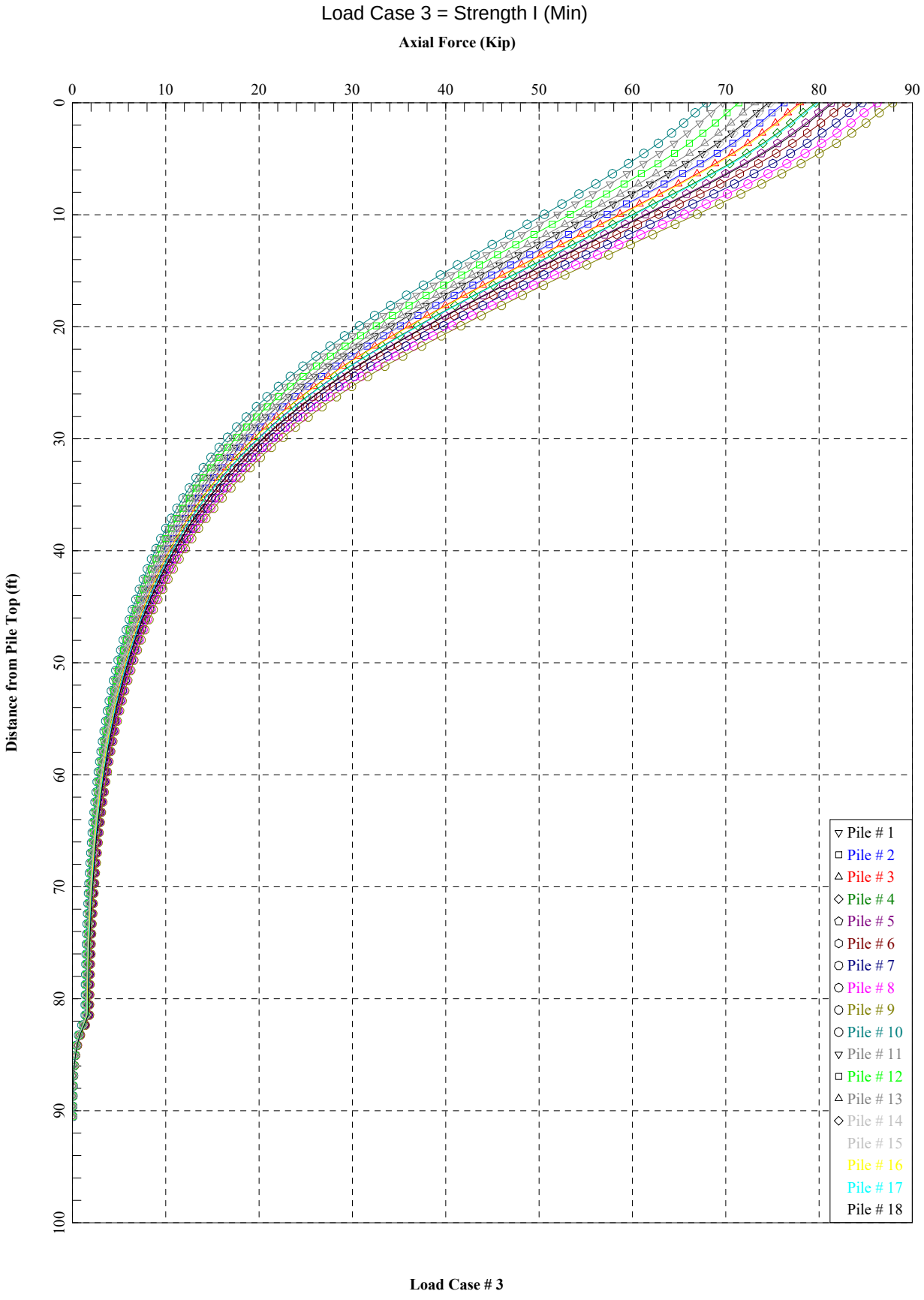

Load Case 2 = Strength I (Max)
Total Deflection (y,z) (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0
10
20
30
40
50
60
70
80
90
100
Distance from Pile Top (ft)
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Load Case # 2

Load Case 2 = Strength I (Max)

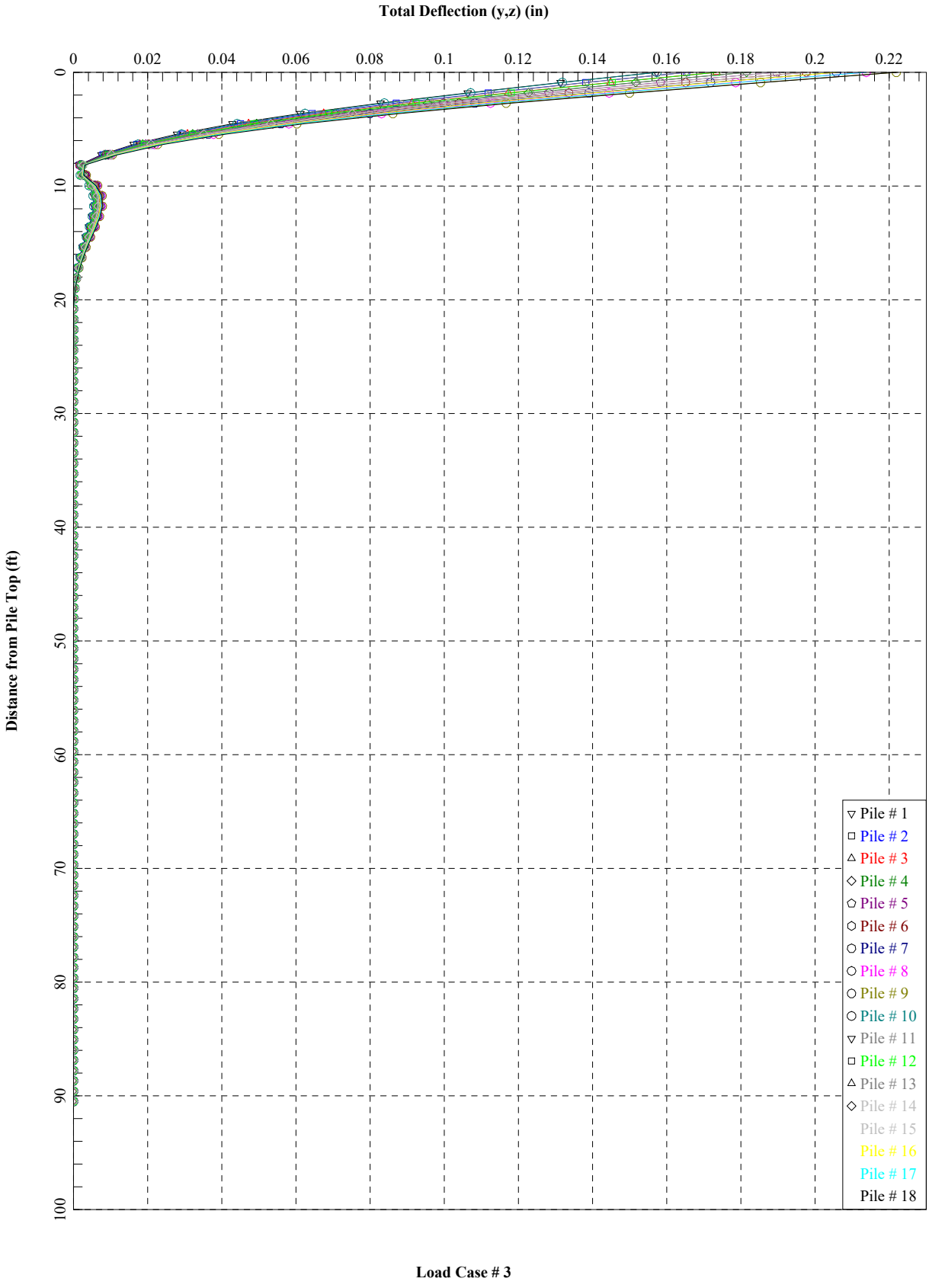


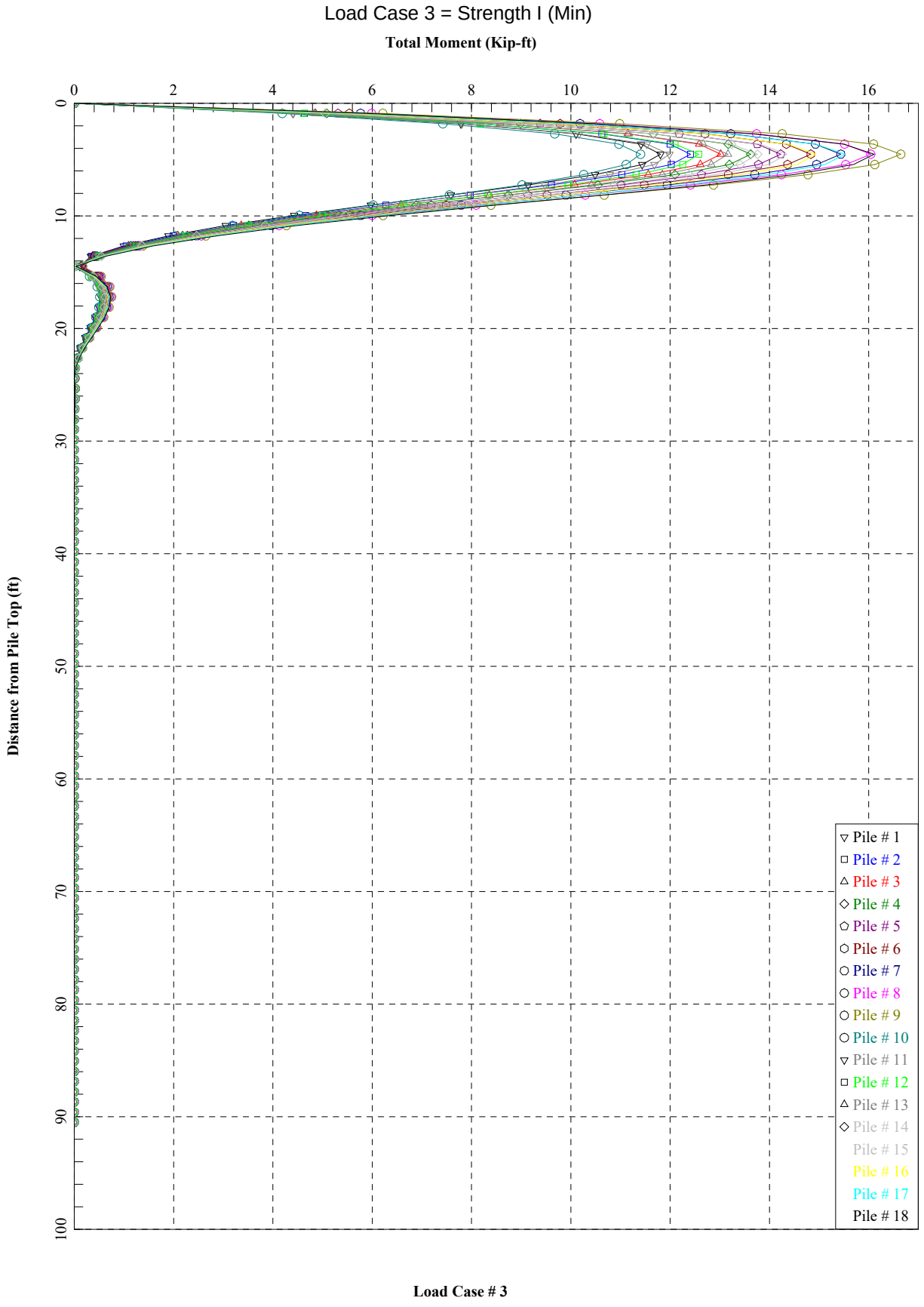
Load Case 2 = Strength I (Max)

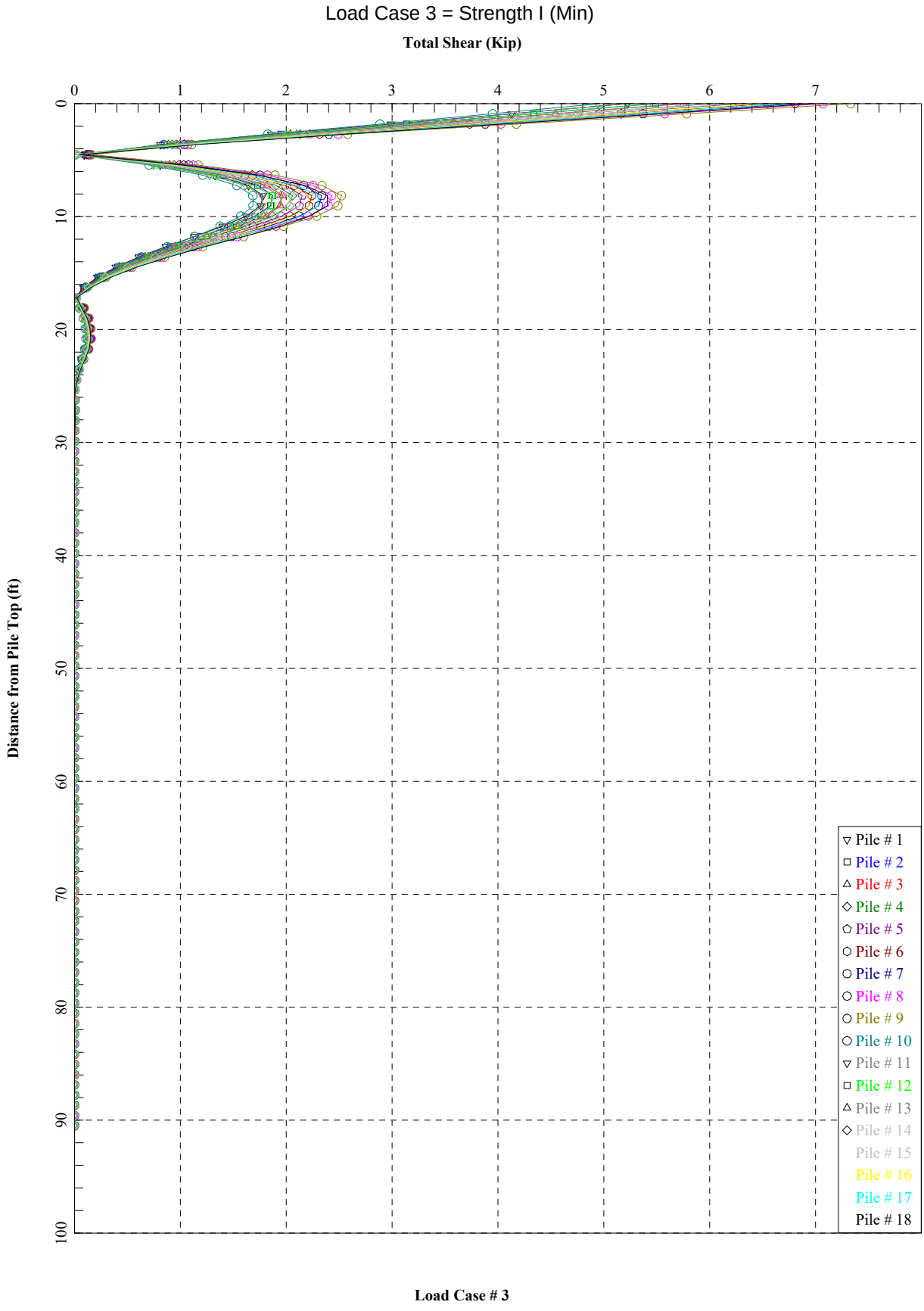


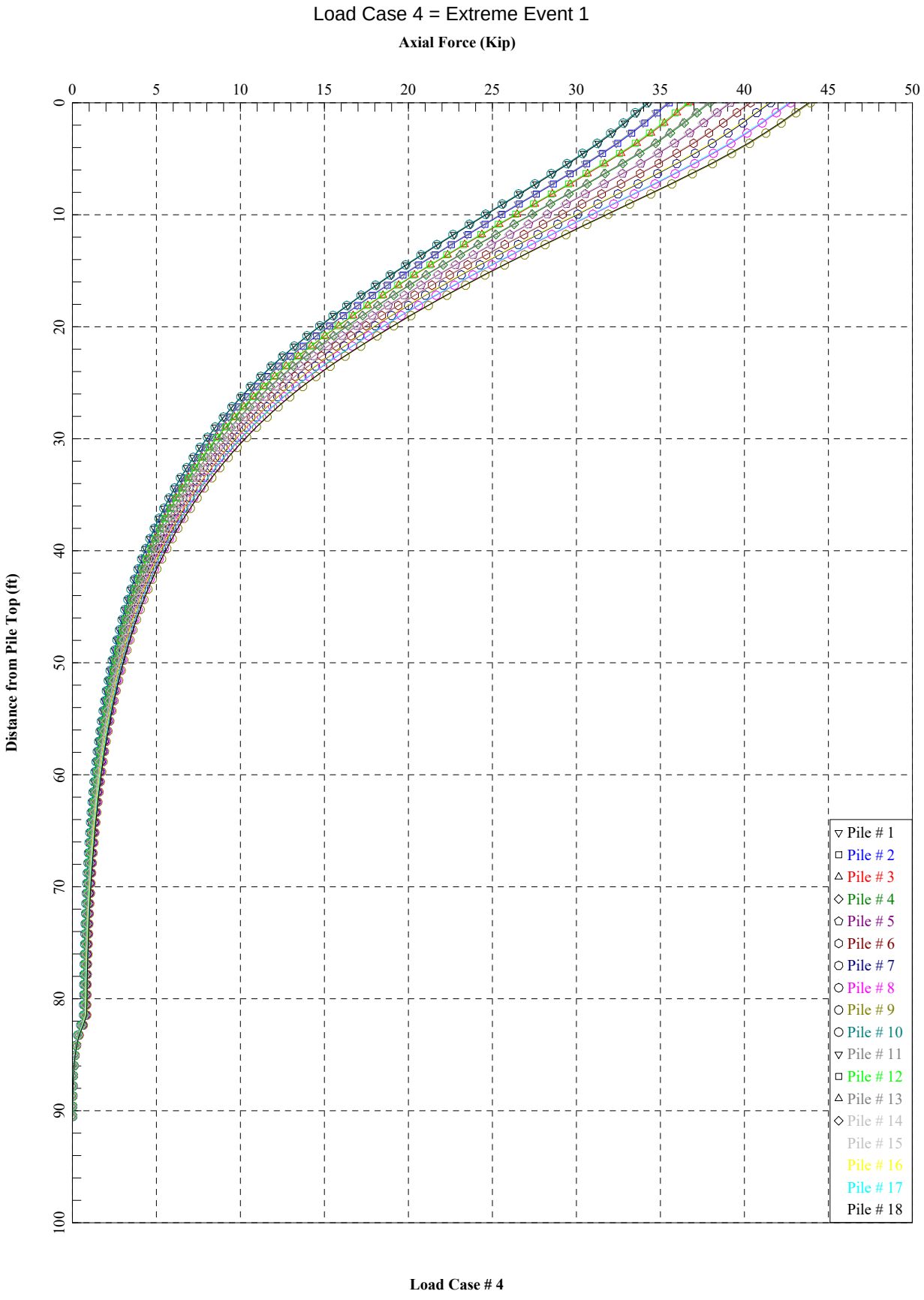

Load Case 3 = Strength I (Min)
Axial Force (Kip)
0
10
20
30
40
50
60
70
80
90
Distance from Pile Top (ft)
0
10
20
30
40
50
60
70
80
90
100
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Load Case # 3

Load Case 3 = Strength I (Min)

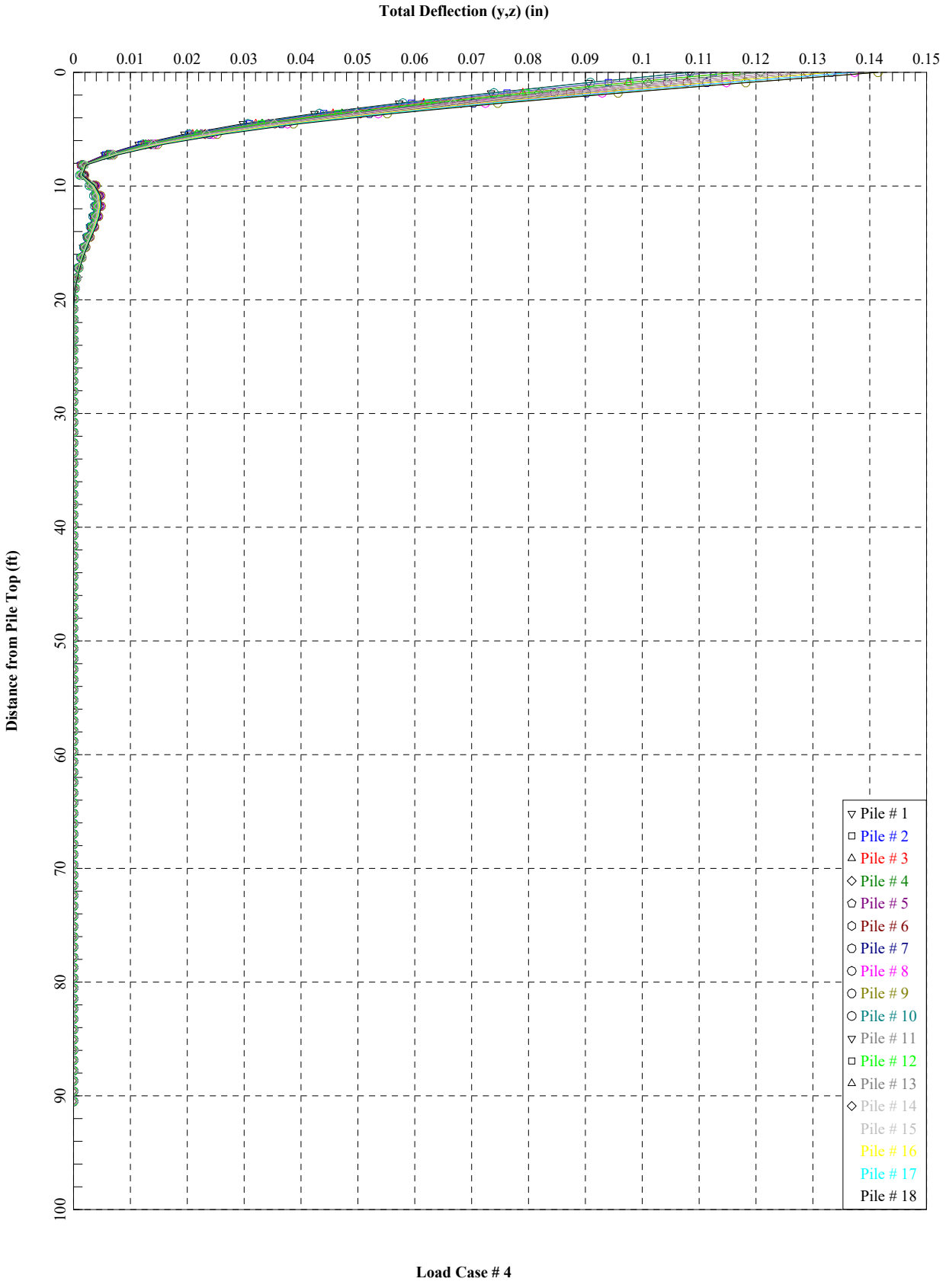



Load Case 3 = Strength I (Min)
Total Moment (Kip-ft)
0
2
4
6
8
10
12
14
16
0
10
20
30
40
50
60
70
80
90
100
Distance from Pile Top (ft)
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Load Case # 3

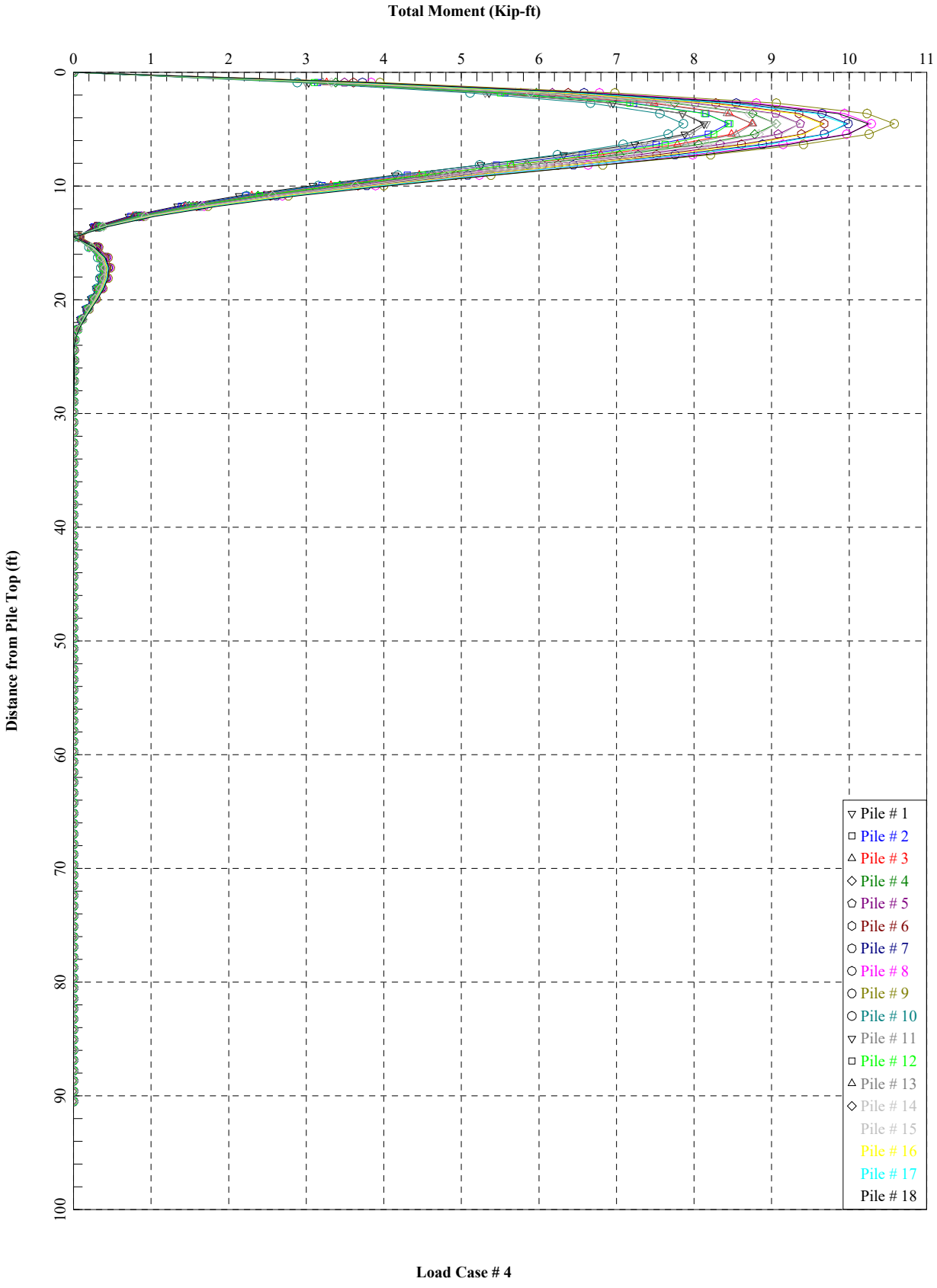

Load Case 3 = Strength I (Min)
Total Shear (Kip)
0
1
2
3
4
5
6
7
0
10
20
30
40
50
60
70
80
90
100
Distance from Pile Top (ft)
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Load Case # 3


Load Case 4 = Extreme Event 1
Axial Force (Kip)
0
5
10
15
20
25
30
35
40
45
50
Distance from Pile Top (ft)
0
10
20
30
40
50
60
70
80
90
100
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Pile # 11
Pile # 12
Pile # 13
Pile # 14
Pile # 15
Pile # 16
Pile # 17
Pile # 18
Load Case # 4

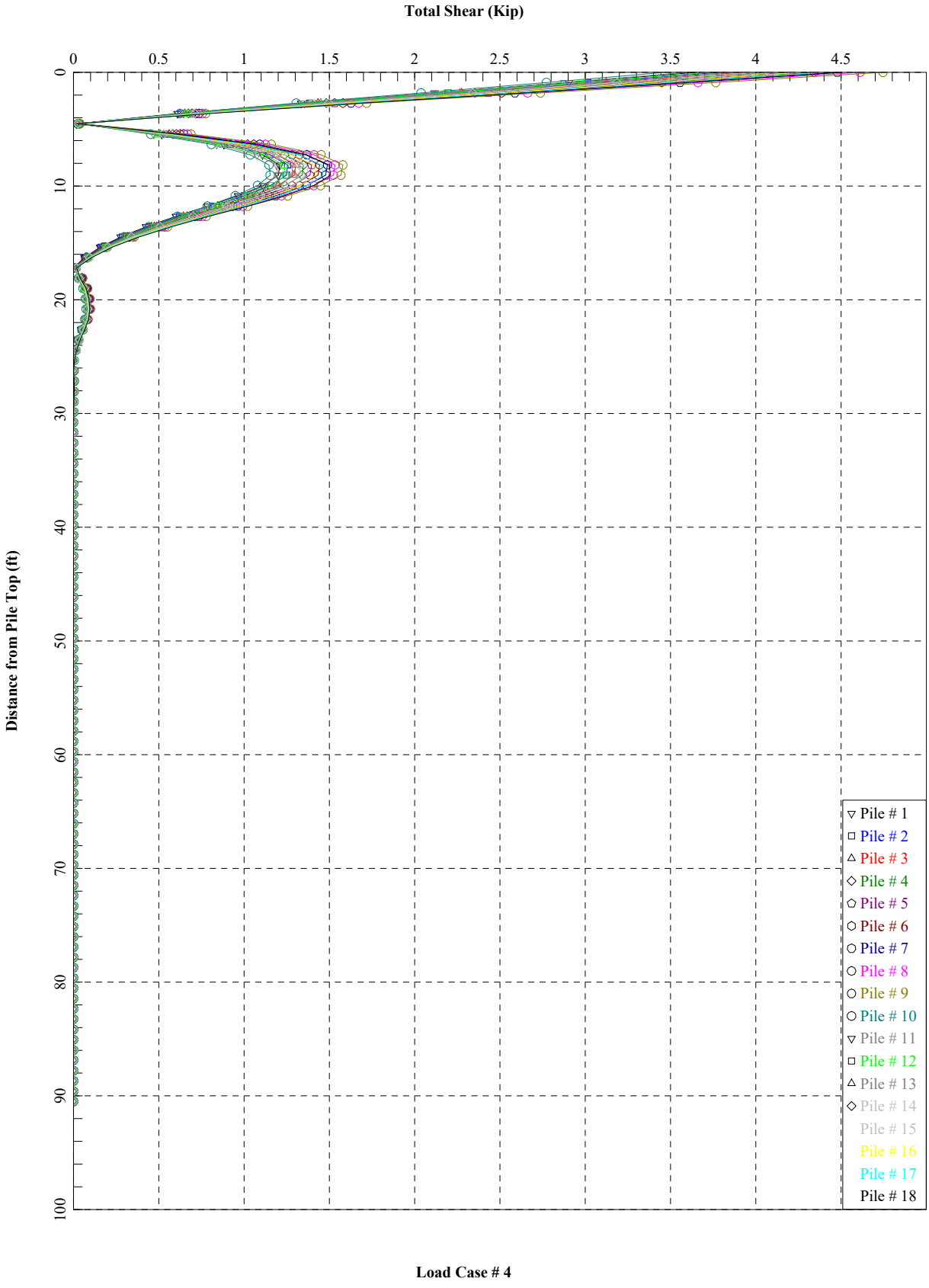
Load Case 4 = Extreme Event 1



Load Case 4 = Extreme Event 1



Load Case 4 = Extreme Event 1



```
     ======================================================================

                    GROUP for Windows, Version 2022.12.4

                     Serial Number : 546958378

                     Analysis of A Group of Piles
                   Subjected to Axial and Lateral Loading

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     ======================================================================


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     Nobis Engineering, Inc.
     Lowell, MA, USA

     Path to file locations      : J:\094184.100-MassDOT Armory Street Bridges, Springfield\Calculations\Axial-Lateral Pile Analysis\S-24-026\Updated North
and South Abutment\Group\
     Name of input data file     : Proposed Pile Caps - West.gp12r
     Name of output echo file    : Proposed Pile Caps - West.gp12e
     Name of output results file : Proposed Pile Caps - West.gp12o
     Name of output summary file : Proposed Pile Caps - West.gp12t
     Name of plot output file    : Proposed Pile Caps - West.gp12p
     Name of runtime file        : Proposed Pile Caps - West.gp12r


     ----------------------------------------------------------------------
                         Time and Date of Analysis
     ----------------------------------------------------------------------

               Date:  February 26, 2025     Time:  15:12:04




                *****     INPUT INFORMATION     *****


     Armory Street over Abandoned CSX Spur - S-24-026 - Proposed Pile Caps (North & S

     ANALYSIS TYPE = 3D ANALYSIS

     ADJUST DEPTH FOR BATTER PILES

     GENERATE LOAD-DISP (AND T-R) CURVES BASED ON SOIL PROFILE

     EXTEND INTERPOLATION FOR L-DP (AND T-R) CURVES

     UNITS SYSTEM  = ENGL



     * TABLE B *  PILE CAP OPTIONS

     LENGTH,YY    ( FT ) =    8.000
     WIDTH, ZZ    ( FT ) =    36.84
     THICKNESS,XX ( FT ) =    5.000

     * PILE CAP DIMENSIONS ARE NOT CONSIDERED
       FOR THE PILE GROUP ANALYSIS




     * TABLE C *  LOAD AND CONTROL PARAMETERS


     ** LOAD CASES **


     NUMBER OF LOAD CASES :    4


     LOAD CASE    :     1
     CASE NAME    : Service I
     LOAD TYPE    : Dead, DL
     SCALE FACTOR :       1.0000

     * CONCENTRATED LOADS *

    NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
          LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
     1   1.05E+05  5.60E+03      0.00      0.00      0.00      0.00     -3.40     -4.00      15.2
     2   1.51E+05  5.60E+03      0.00      0.00      0.00      0.00     -3.40     -4.00      10.7
     3   1.56E+05  5.60E+03      0.00      0.00      0.00      0.00     -3.60     -4.00      3.92
```

4	1.49E+05	5.60E+03	0.00	0.00	0.00	0.00	-3.70	-4.00	-2.83
5	1.43E+05	5.60E+03	0.00	0.00	0.00	0.00	-3.80	-4.00	-8.58
6	1.73E+05	5.60E+03	0.00	0.00	0.00	0.00	-3.90	-4.00	-14.3
7	4.42E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-4.00	0.00
8	1.44E+05	0.00	0.00	0.00	0.00	0.00	0.00	-4.00	0.00
9	4.42E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-6.00	0.00
10	3.32E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-7.40	0.00
11	0.00	2.95E+04	0.00	0.00	0.00	0.00	-4.80	-6.75	0.00
12	0.00	4.42E+04	0.00	0.00	0.00	0.00	-1.40	-8.00	0.00

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VER.LOAD X,LBS	HOR.LOAD Y,LBS	HOR.LOAD Z,LBS
1.14180E+06	1.07300E+05	0.00000

MOMENT X,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
-2.70144E+05	-3.73884E+06	5.33150E+07

* THE LOADING IS STATIC *

* CONTROL PARAMETERS *
- TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT = 1.00000E-04
- TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS = 1.00000E-04 IN
- MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS = 100
- MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS = 100
- FACTOR TO APPLY THE LOAD IN INCREMENTS = 1.0000
- MINIMUM FACTOR FOR LOAD INCREMENTS = 1.0000
- INCLUDE VARIATION OF AXIAL LOAD AT PILES
- * NOT FOR USER DEFINED LOAD SETTL. CURVE
- - PRINT RESULTS AT PILE CAP

LOAD CASE : 2
CASE NAME : Strength I Max
LOAD TYPE : Dead, DL
SCALE FACTOR : 1.0000

* CONCENTRATED LOADS *

NL	VERT.LOAD LBS	HR.LOAD Y LBS	HR.LOAD Z LBS	MOMENT X LBS-IN	MOMENT Y LBS-IN	MOMENT Z LBS-IN	COORD X FT	COORD Y FT	COORD Z FT
1	1.49E+05	8.70E+03	0.00	0.00	0.00	0.00	-3.40	-4.00	15.2
2	2.30E+05	8.70E+03	0.00	0.00	0.00	0.00	-3.40	-4.00	10.7
3	2.37E+05	8.70E+03	0.00	0.00	0.00	0.00	-3.60	-4.00	3.92
4	2.27E+05	8.70E+03	0.00	0.00	0.00	0.00	-3.70	-4.00	-2.83
5	2.17E+05	8.70E+03	0.00	0.00	0.00	0.00	-3.80	-4.00	-8.58
6	2.54E+05	8.70E+03	0.00	0.00	0.00	0.00	-3.90	-4.00	-14.3
7	5.90E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-4.00	0.00
8	1.80E+05	0.00	0.00	0.00	0.00	0.00	0.00	-4.00	0.00
9	5.53E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-6.00	0.00
10	4.42E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-7.40	0.00
11	0.00	4.06E+04	0.00	0.00	0.00	0.00	-4.80	-6.75	0.00
12	0.00	5.90E+04	0.00	0.00	0.00	0.00	-1.40	-8.00	0.00

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VER.LOAD X,LBS	HOR.LOAD Y,LBS	HOR.LOAD Z,LBS
1.65350E+06	1.51800E+05	0.00000

MOMENT X,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
-4.19688E+05	-6.12312E+06	7.68929E+07

* THE LOADING IS STATIC *

* CONTROL PARAMETERS *
- TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT = 5.00000E-04
- TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS = 5.00000E-04 IN
- MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS = 100
- MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS = 100
- FACTOR TO APPLY THE LOAD IN INCREMENTS = 1.0000
- MINIMUM FACTOR FOR LOAD INCREMENTS = 1.0000
- INCLUDE VARIATION OF AXIAL LOAD AT PILES
- * NOT FOR USER DEFINED LOAD SETTL. CURVE
- - PRINT RESULTS AT PILE CAP

LOAD CASE : 3
CASE NAME : Strength I Min
LOAD TYPE : Dead, DL
SCALE FACTOR : 1.0000

* CONCENTRATED LOADS *

NL	VERT.LOAD LBS	HR.LOAD Y LBS	HR.LOAD Z LBS	MOMENT X LBS-IN	MOMENT Y LBS-IN	MOMENT Z LBS-IN	COORD X FT	COORD Y FT	COORD Z FT

1	1.25E+05	7.30E+03	0.00	0.00	0.00	0.00	-3.40	-4.00	15.2
2	2.05E+05	7.30E+03	0.00	0.00	0.00	0.00	-3.40	-4.00	10.7
3	2.12E+05	7.30E+03	0.00	0.00	0.00	0.00	-3.60	-4.00	3.92
4	2.03E+05	7.30E+03	0.00	0.00	0.00	0.00	-3.70	-4.00	-2.83
5	1.94E+05	7.30E+03	0.00	0.00	0.00	0.00	-3.80	-4.00	-8.58
6	2.21E+05	7.30E+03	0.00	0.00	0.00	0.00	-3.90	-4.00	-14.3
7	4.06E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-4.00	0.00
8	1.29E+05	0.00	0.00	0.00	0.00	0.00	0.00	-4.00	0.00
9	4.06E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-6.00	0.00
10	3.32E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-7.40	0.00
11	0.00	2.58E+04	0.00	0.00	0.00	0.00	-4.80	-6.75	0.00
12	0.00	4.06E+04	0.00	0.00	0.00	0.00	-1.40	-8.00	0.00

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VER.LOAD X,LBS	HOR.LOAD Y,LBS	HOR.LOAD Z,LBS
1.40440E+06	1.10200E+05	0.00000

MOMENT X,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
-3.52152E+05	-5.82426E+06	6.56623E+07

* THE LOADING IS STATIC *

* CONTROL PARAMETERS *
- TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT = 5.00000E-04
- TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS = 5.00000E-04 IN
- MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS = 100
- MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS = 100
- FACTOR TO APPLY THE LOAD IN INCREMENTS = 1.0000
- MINIMUM FACTOR FOR LOAD INCREMENTS = 1.0000
- INCLUDE VARIATION OF AXIAL LOAD AT PILES
- * NOT FOR USER DEFINED LOAD SETTL. CURVE
- - PRINT RESULTS AT PILE CAP

LOAD CASE : 4
CASE NAME : Extreme Event I
LOAD TYPE : Dead, DL
SCALE FACTOR : 1.0000

* CONCENTRATED LOADS *

NL	VERT.LOAD LBS	HR.LOAD Y LBS	HR.LOAD Z LBS	MOMENT X LBS-IN	MOMENT Y LBS-IN	MOMENT Z LBS-IN	COORD X FT	COORD Y FT	COORD Z FT
1	6.83E+04	0.00	0.00	0.00	0.00	0.00	-3.40	-4.00	15.2
2	7.00E+04	0.00	0.00	0.00	0.00	0.00	-3.40	-4.00	10.7
3	7.03E+04	0.00	0.00	0.00	0.00	0.00	-3.60	-4.00	3.92
4	6.84E+04	0.00	0.00	0.00	0.00	0.00	-3.70	-4.00	-2.83
5	6.57E+04	0.00	0.00	0.00	0.00	0.00	-3.80	-4.00	-8.58
6	9.57E+04	0.00	0.00	0.00	0.00	0.00	-3.90	-4.00	-14.3
7	4.42E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-4.00	0.00
8	1.44E+05	0.00	0.00	0.00	0.00	0.00	0.00	-4.00	0.00
9	4.42E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-6.00	0.00
10	3.32E+04	0.00	0.00	0.00	0.00	0.00	-3.00	-7.40	0.00
11	0.00	2.95E+04	0.00	0.00	0.00	0.00	-4.80	-6.75	0.00
12	0.00	4.42E+04	0.00	0.00	0.00	0.00	-1.40	-8.00	0.00

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VER.LOAD X,LBS	HOR.LOAD Y,LBS	HOR.LOAD Z,LBS
7.03700E+05	73700.0	0.00000

MOMENT X,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
0.00000	-8.40864E+05	3.37512E+07

* THE LOADING IS STATIC *

* CONTROL PARAMETERS *
- TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT = 5.00000E-04
- TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS = 5.00000E-04 IN
- MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS = 100
- MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS = 100
- FACTOR TO APPLY THE LOAD IN INCREMENTS = 1.0000
- MINIMUM FACTOR FOR LOAD INCREMENTS = 1.0000
- INCLUDE VARIATION OF AXIAL LOAD AT PILES
- * NOT FOR USER DEFINED LOAD SETTL. CURVE
- - PRINT RESULTS AT PILE CAP

* TABLE D * ARRANGEMENT OF PILE GROUPS

GROUP	CONN.Z-Z	CONN.Y-Y	PILE PROP	P-Y CURVE	L-S CURVE	T-R CURVE	R-F-L SET
1	PIN	PIN	1	0	1 G	1 G	1
2	PIN	PIN	1	0	1 G	1 G	1

3	PIN	PIN	1	0	1 G	1 G	1
4	PIN	PIN	1	0	1 G	1 G	1
5	PIN	PIN	1	0	1 G	1 G	1
6	PIN	PIN	1	0	1 G	1 G	1
7	PIN	PIN	1	0	1 G	1 G	1
8	PIN	PIN	1	0	1 G	1 G	1
9	PIN	PIN	1	0	1 G	1 G	1
10	PIN	PIN	1	0	1 G	1 G	1
11	PIN	PIN	1	0	1 G	1 G	1
12	PIN	PIN	1	0	1 G	1 G	1
13	PIN	PIN	1	0	1 G	1 G	1
14	PIN	PIN	1	0	1 G	1 G	1
15	PIN	PIN	1	0	1 G	1 G	1
16	PIN	PIN	1	0	1 G	1 G	1
17	PIN	PIN	1	0	1 G	1 G	1
18	PIN	PIN	1	0	1 G	1 G	1

GROUP	CorX,FT	CorY,FT	CorZ,FT	ALPHA,DEG	BETA,DEG	THETA,DEG	GROUND,FT	SPz,LBS-IN	SPy,LBS-IN
1	0.000	-1.500	-16.92	0.000	90.00	0.000	-4.000	0.000	0.000
2	0.000	-1.500	-12.92	0.000	90.00	0.000	-4.000	0.000	0.000
3	0.000	-1.500	-8.920	0.000	90.00	0.000	-4.000	0.000	0.000
4	0.000	-1.500	-4.920	0.000	90.00	0.000	-4.000	0.000	0.000
5	0.000	-1.500	-0.920	0.000	90.00	0.000	-4.000	0.000	0.000
6	0.000	-1.500	3.080	0.000	90.00	0.000	-4.000	0.000	0.000
7	0.000	-1.500	7.080	0.000	90.00	0.000	-4.000	0.000	0.000
8	0.000	-1.500	11.08	0.000	90.00	0.000	-4.000	0.000	0.000
9	0.000	-1.500	15.08	0.000	90.00	0.000	-4.000	0.000	0.000
10	0.000	-6.500	-16.92	0.000	90.00	0.000	-4.000	0.000	0.000
11	0.000	-6.500	-12.92	0.000	90.00	0.000	-4.000	0.000	0.000
12	0.000	-6.500	-8.920	0.000	90.00	0.000	-4.000	0.000	0.000
13	0.000	-6.500	-4.920	0.000	90.00	0.000	-4.000	0.000	0.000
14	0.000	-6.500	-0.920	0.000	90.00	0.000	-4.000	0.000	0.000
15	0.000	-6.500	3.080	0.000	90.00	0.000	-4.000	0.000	0.000
16	0.000	-6.500	7.080	0.000	90.00	0.000	-4.000	0.000	0.000
17	0.000	-6.500	11.08	0.000	90.00	0.000	-4.000	0.000	0.000
18	0.000	-6.500	15.08	0.000	90.00	0.000	-4.000	0.000	0.000

* TABLE E * PILE GEOMETRY AND PROPERTIES
PILE TYPE = 1 - DRIVEN PILE
= 2 - DRILLED SHAFT

PROP	SECTS	INC	PILE TYPE	LENGTH, FT
1	3	100	2	90.500

* PILE SECTIONS *

PROP	SECT	FROM,FT	TO,FT	CROSS SECT
1	1	0.00000	3.00000	1
1	2	3.00000	82.5000	2
1	3	82.5000	90.5000	3

* PILE CROSS SECTIONS *

CROSS SECTION : 1
SECTION NAME : 10.75"
TYPE : NONLINEAR
CROSS SECTION TYPE : ROUND CONC. SHAFT, CASING (AND STEEL SECTION)
CONCRETE DIAMETER : 9.75000 IN
CONCRETE FC : 5000.00 LBS/IN**2
DIAMETER CASING : 10.6250 IN
THICKNESS CASING : 0.43750 IN
ES CASING : 2.90000E+07 LBS/IN**2
FY CASING : 52000.0 LBS/IN**2
EMBEDDED STEEL SECT : NONE
NUMBER REBARS : 1
ES REINFORCEMENT : 2.90000E+07 LBS/IN**2
FY REINFORCEMENT : 60000.0 LBS/IN**2
REINF. LAYOUT : MANUAL
REINF. A , D, COORDS: IN^2 IN IN IN
- REBAR 1 : 0.79000 1.00000 0.00000 0.00000
EQ. YOUNG MODULUS : 9.96202E+06 LBS/IN**2

CROSS SECTION : 2
SECTION NAME : 10.75"
TYPE : NONLINEAR
CROSS SECTION TYPE : ROUND CONC. SHAFT, CASING (AND STEEL SECTION)
CONCRETE DIAMETER : 9.75000 IN
CONCRETE FC : 5000.00 LBS/IN**2
DIAMETER CASING : 10.2500 IN
THICKNESS CASING : 0.25000 IN
ES CASING : 2.90000E+07 LBS/IN**2
FY CASING : 52000.0 LBS/IN**2
EMBEDDED STEEL SECT : NONE
NUMBER REBARS : 1
ES REINFORCEMENT : 2.90000E+07 LBS/IN**2
FY REINFORCEMENT : 60000.0 LBS/IN**2
REINF. LAYOUT : MANUAL
REINF. A , D, COORDS: IN^2 IN IN IN
- REBAR 1 : 0.79000 1.00000 0.00000 0.00000

```
 EQ. YOUNG MODULUS   :   8.54351E+06 LBS/IN**2

 CROSS SECTION       :     3
 SECTION NAME        : 9.75"
 TYPE                :  NONLINEAR
 CROSS SECTION TYPE  : ROUND CONC. SHAFT, CASING (AND STEEL SECTION)
 CONCRETE DIAMETER   :       9.75000 IN
 CONCRETE FC         :       5000.00 LBS/IN**2
 DIAMETER CASING     : NO CASING
 EMBEDDED STEEL SECT : NONE
 NUMBER REBARS       :              1
 ES REINFORCEMENT    :   2.90000E+07 LBS/IN**2
 FY REINFORCEMENT    :       60000.0 LBS/IN**2
 REINF. LAYOUT       :       MANUAL
 REINF. A , D, COORDS:        IN^2             IN              IN              IN
 - REBAR    1        :       0.79000         1.00000         0.00000         0.00000
 EQ. YOUNG MODULUS   :   6.39161E+06 LBS/IN**2

* PILE CROSS SECTIONS PROPERTIES *

         NONLINEAR SECTIONS

SECT    DIAM,IN   PERIM,IN AREA,IN**2   Iz,IN**4   Iy,IN**4  GJ,LBS-IN**2   EIz IND  EIy IND   Mn,LBS-IN    Vn,LBS
  1      10.625     33.379     88.664     0.0000     0.0000   5.4901E+09      0        0         0.0000     0.0000
  2      10.250     32.201     82.516     0.0000     0.0000   3.6218E+09      0        0         0.0000     0.0000
  3      9.7500     30.631     74.662     0.0000     0.0000   1.4303E+09      0        0         0.0000     0.0000


* TABLE F *   SOIL DATA


SOILS INFORMATION

    GROUND SURFACE          =     -4.00000  FT

    6 LAYER(S) OF SOIL

    LAYER  1
    THE SOIL IS A SAND
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       -4.00000          21.5000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       115.000           115.000
    FRICTION ANGLE                  (DEGREES)       33.0000           33.0000
    P-Y SUBGRADE MODULUS          (LBS/IN**3)       25.0000           25.0000
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)       11.5000 (S)       2399.62 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)       0.00000           0.00000

    LAYER  2
    THE SOIL IS A SILT
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       21.5000           58.5000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       57.6000           57.6000
    UNDRAINED COHESION, C         (LBS/FT**2)       130.000           130.000
    FRICTION ANGLE                  (DEGREES)       22.0000           22.0000
    P-Y SUBGRADE MODULUS          (LBS/IN**3)       100.000           100.000
    STRAIN AT 50% STRESS                           1.00000E-02       1.00000E-02
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)       2471.12 (S)       2262.72 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)       0.00000           0.00000

    LAYER  3
    THE SOIL IS A SAND
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       58.5000           70.0000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       57.6000           57.6000
    FRICTION ANGLE                  (DEGREES)       26.0000           26.0000
    P-Y SUBGRADE MODULUS          (LBS/IN**3)       50.0000           50.0000
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)       2191.22 (S)       1939.35 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)       0.00000           0.00000

    LAYER  4
    THE SOIL IS A SAND
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       70.0000           77.1000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       72.6000           72.6000
    FRICTION ANGLE                  (DEGREES)       37.0000           37.0000
    P-Y SUBGRADE MODULUS          (LBS/IN**3)       125.000           125.000
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)       1939.35 (S)       1774.16 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)       0.00000           0.00000

    LAYER  5
    THE SOIL IS A SAND
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       77.1000           81.5000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       87.6000           87.6000
    FRICTION ANGLE                  (DEGREES)       38.0000           38.0000
    P-Y SUBGRADE MODULUS          (LBS/IN**3)       150.000           150.000
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)       1774.16 (S)       1668.06 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)       0.00000           0.00000

    LAYER  6
```

THE LAYER IS A VUGGY LIMESTONE

		TOP OF LAYER	BOTTOM OF LAYER
X COORDINATE	(FT)	81.5000	100.000
EFFECTIVE UNIT WEIGHT	(LBS/FT**3)	101.600	101.600
UNIAXIAL COMPRESSIVE STRENGTH	(LBS/IN**2)	7500.00	7500.00
ULTIMATE UNIT SIDE FRICTION	(LBS/FT**2)	1.08000E+05 (S)	1.08000E+05 (S)
ULTIMATE UNIT TIP RESISTANCE	(LBS/FT**2)	9.72000E+06 (T)	9.72000E+06 (T)

Notes : Program estimated values for listed parameters
if zero input values were entered:
(S) ULTIMATE UNIT SIDE FRICTION for Drilled Shafts
(T) ULTIMATE UNIT TIP RESISTANCE for Drilled Shafts

* TABLE H * AXIAL LOAD VS DISPLACEMENT

AXIAL LOAD-DISPLACEMENT CURVES GENERATED INTERNALLY

NUM OF CURVES 1

CURVE 1 NUM OF POINTS 19

DISPLACEMENT, IN	AXIAL LOAD,LBS
-5.28765	-2.45190E+06
-4.29369	-2.45579E+06
-3.91408	-2.53636E+06
-3.66702	-2.63768E+06
-3.64872	-2.65940E+06
-3.18928	-2.39302E+06
-2.77670	-2.13005E+06
-1.69300	-1.41180E+06
-0.48116	-5.69388E+05
0.00000	0.00000
0.82380	8.12686E+05
2.36234	1.85993E+06
3.47256	2.57390E+06
4.01690	2.91345E+06
6.54756	4.46902E+06
7.90174	5.28331E+06
11.5865	7.33488E+06
12.2415	7.43139E+06
13.4939	7.58940E+06

DISPL. TIP , IN	AXIAL TIP ,LBS
-2.00000	-6.88103
-1.00000	-6.66926
-0.50000	-6.50779
-0.10000	-3.64897
-0.0500000	-2.50941
-1.00000E-02	-0.50188
-5.00000E-03	-0.25094
-1.00000E-03	-0.0501882
-1.00000E-04	-5.01882E-03
0.00000	0.00000
1.00000E-04	3747.15
1.00000E-03	37471.5
5.00000E-03	1.87357E+05
1.00000E-02	3.74715E+05
0.0500000	1.87357E+06
0.10000	2.72439E+06
0.50000	4.85884E+06
1.00000	4.97940E+06
2.00000	5.13751E+06

* TABLE I * TORS. MOM. VS ANGLE ROT.

TORQUE-ROTATION CURVES GENERATED INTERNALLY

NUM OF CURVES 1

CURVE 1 NUM OF POINTS 19

ROT. ANGLE,Rad.	TORS.MOMEN,LBS-IN
-3.90170	-1.30222E+07
-3.71568	-1.30288E+07
-3.67723	-1.32009E+07
-3.68713	-1.34668E+07
-3.69311	-1.35152E+07
-3.54272	-1.30939E+07
-3.40792	-1.26956E+07
-3.00386	-1.14770E+07
-2.41441	-9.64313E+06
0.00000	0.00000
2.41441	9.64313E+06
3.00386	1.14770E+07
3.40792	1.26956E+07
3.54272	1.30939E+07
3.69311	1.35152E+07

3.68713	1.34668E+07
3.67723	1.32009E+07
3.71568	1.30288E+07
3.90170	1.30222E+07

* TABLE J1 * REDUCTION FACTORS ALONG DEPTH

NUM OF SETS : 1

SET 1 NUM OF POINTS 2

DEPTH,FT	P-FACTOR	Y-FACTOR
0.00000	0.50000	1.00000
12.0000	1.00000	1.00000

* TABLE K * REDUCTION FACTORS

AVERAGE DIAMETER IS USED TO GET RATIO S/B

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS ALONG Y-DIRECTION
ESTIMATED ASSUMING MOVEMENT IN THE DIRECTION OF Y-FORCE (+)

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	1.0000	1.0000
3	1.0000	1.0000
4	1.0000	1.0000
5	1.0000	1.0000
6	1.0000	1.0000
7	1.0000	1.0000
8	1.0000	1.0000
9	1.0000	1.0000
10	0.9267	1.0000
11	0.9267	1.0000
12	0.9267	1.0000
13	0.9267	1.0000
14	0.9267	1.0000
15	0.9267	1.0000
16	0.9267	1.0000
17	0.9267	1.0000
18	0.9267	1.0000

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS ALONG Z-DIRECTION
ESTIMATED ASSUMING MOVEMENT IN THE DIRECTION OF Z-FORCE (+)

GROUP NO	P-FACTOR	Y-FACTOR
1	0.8513	1.0000
2	0.8513	1.0000
3	0.8513	1.0000
4	0.8513	1.0000
5	0.8513	1.0000
6	0.8513	1.0000
7	0.8513	1.0000
8	0.8513	1.0000
9	1.0000	1.0000
10	0.8513	1.0000
11	0.8513	1.0000
12	0.8513	1.0000
13	0.8513	1.0000
14	0.8513	1.0000
15	0.8513	1.0000
16	0.8513	1.0000
17	0.8513	1.0000
18	1.0000	1.0000

```
     ======================================================================

                    GROUP for Windows, Version 2022.12.4

                     Serial Number : 546958378

                     Analysis of A Group of Piles
                   Subjected to Axial and Lateral Loading

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     ======================================================================


     This program is licensed to :

     Nobis Engineering, Inc.
     Lowell, MA, USA

     Path to file locations      : J:\094184.100-MassDOT Armory Street Bridges, Springfield\Calculations\Axial-Lateral Pile Analysis\S-24-026\Updated North
and South Abutment\Group\
     Name of input data file     : Proposed Pile Caps - West.gp12d
     Name of output echo file    : Proposed Pile Caps - West.gp12e
     Name of output results file : Proposed Pile Caps - West.gp12o
     Name of output summary file : Proposed Pile Caps - West.gp12t
     Name of plot output file    : Proposed Pile Caps - West.gp12p
     Name of runtime file        : Proposed Pile Caps - West.gp12r


     ------------------------------------------------------------------------
                         Time and Date of Analysis
     ------------------------------------------------------------------------

               Date:  February 26, 2025     Time:  15:12:04



                *****     COMPUTATION RESULTS     *****


     Armory Street over Abandoned CSX Spur - S-24-026 - Proposed Pile Caps (North & S



                *****     LOAD CASES RESULTS      *****


     LOAD CASE :     1
     CASE NAME : Service I
     LOAD TYPE : Dead, DL

       REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
       ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

            GROUP NO     P-FACTOR     Y-FACTOR

                1           1.0000       1.0000
                2           0.9998       1.0000
                3           0.9998       1.0000
                4           0.9998       1.0000
                5           0.9998       1.0000
                6           0.9998       1.0000
                7           0.9998       1.0000
                8           0.9998       1.0000
                9           0.9998       1.0000
               10           0.9268       1.0000
               11           0.9266       1.0000
               12           0.9266       1.0000
               13           0.9266       1.0000
               14           0.9266       1.0000
               15           0.9266       1.0000
               16           0.9266       1.0000
               17           0.9266       1.0000
               18           0.9266       1.0000


     * TABLE L *   COMPUTATION ON PILE CAP


     * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *


           VERT. LOAD, LBS    HOR. LOAD Y, LBS   HOR. LOAD Z, LBS
             1.14180E+06        1.07300E+05           0.00000
```

```
     MOMENT X ,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
       -2.70144E+05       -3.73884E+06        5.33150E+07


* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *


       VERTICAL ,IN      HORIZONTAL Y,IN     HORIZONTAL Z,IN
          0.0250335            0.18570       -7.35830E-03

     ANGLE ROT. X,RAD    ANGLE ROT. Y,RAD    ANGLE ROT. Z,RAD
       -1.55762E-04        1.25987E-05       -3.61474E-05


     NUMBER OF GLOBAL ITERATIONS =    4



LOAD CASE :     2
CASE NAME : Strength I Max
LOAD TYPE : Dead, DL

  REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
  ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

       GROUP NO     P-FACTOR     Y-FACTOR

           1           1.0000       1.0000
           2           0.9998       1.0000
           3           0.9998       1.0000
           4           0.9998       1.0000
           5           0.9998       1.0000
           6           0.9998       1.0000
           7           0.9998       1.0000
           8           0.9998       1.0000
           9           0.9998       1.0000
          10           0.9268       1.0000
          11           0.9266       1.0000
          12           0.9266       1.0000
          13           0.9266       1.0000
          14           0.9266       1.0000
          15           0.9266       1.0000
          16           0.9266       1.0000
          17           0.9266       1.0000
          18           0.9266       1.0000


* TABLE L *   COMPUTATION ON PILE CAP


* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *


      VERT. LOAD, LBS    HOR. LOAD Y, LBS   HOR. LOAD Z, LBS
        1.65350E+06        1.51800E+05            0.00000

     MOMENT X ,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
       -4.19688E+05       -6.12312E+06        7.68929E+07


* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *


       VERTICAL ,IN      HORIZONTAL Y,IN     HORIZONTAL Z,IN
          0.0384134            0.26592         -0.0110603

     ANGLE ROT. X,RAD    ANGLE ROT. Y,RAD    ANGLE ROT. Z,RAD
       -2.34026E-04        1.92514E-05       -6.70204E-05


     NUMBER OF GLOBAL ITERATIONS =    4



LOAD CASE :     3
CASE NAME : Strength I Min
LOAD TYPE : Dead, DL

  REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
  ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

       GROUP NO     P-FACTOR     Y-FACTOR

           1           1.0000       1.0000
           2           0.9998       1.0000
           3           0.9998       1.0000
           4           0.9998       1.0000
           5           0.9998       1.0000
           6           0.9998       1.0000
           7           0.9998       1.0000
```

8	0.9998	1.0000
9	0.9998	1.0000
10	0.9268	1.0000
11	0.9266	1.0000
12	0.9266	1.0000
13	0.9266	1.0000
14	0.9266	1.0000
15	0.9266	1.0000
16	0.9266	1.0000
17	0.9266	1.0000
18	0.9266	1.0000

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD, LBS	HOR. LOAD Y, LBS	HOR. LOAD Z, LBS
1.40440E+06	1.10200E+05	0.00000

MOMENT X ,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
-3.52152E+05	-5.82426E+06	6.56623E+07

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0313725	0.19136	-7.95191E-03

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
-1.68311E-04	1.45304E-05	-4.48153E-05

NUMBER OF GLOBAL ITERATIONS = 3

LOAD CASE : 4
CASE NAME : Extreme Event I
LOAD TYPE : Dead, DL

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	0.9999	1.0000
3	0.9999	1.0000
4	0.9999	1.0000
5	0.9999	1.0000
6	0.9999	1.0000
7	0.9999	1.0000
8	0.9999	1.0000
9	0.9999	1.0000
10	0.9268	1.0000
11	0.9266	1.0000
12	0.9266	1.0000
13	0.9266	1.0000
14	0.9266	1.0000
15	0.9266	1.0000
16	0.9266	1.0000
17	0.9266	1.0000
18	0.9266	1.0000

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD, LBS	HOR. LOAD Y, LBS	HOR. LOAD Z, LBS
7.03700E+05	73700.0	0.00000

MOMENT X ,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
0.00000	-8.40864E+05	3.37512E+07

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0140566	0.12584	-4.07165E-03

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD

```
  -8.62411E-05        9.18822E-06       -5.99108E-07

NUMBER OF GLOBAL ITERATIONS =    3
```

Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for North/South Abutment Crash Wall
Springfield, Massachusetts

Calculated by: RAC Date: 1/28/2025
Checked by: BTW Date: 2/27/2025

Purpose: Perform axial and lateral analyses for the proposed micropiles for the above-referenced project. See table and summary provided in Step 3 and 4 for results of the lateral and axial analyses, respectively. The Structural Engineer should evaluate the structural adequacy of the micropiles.

References:
1) FHWA-NHI-05-039 Micropile Manual, 2005.
2) MassDOT Bridge Design Manual, 2024.
3) Computer program GROUP, Version 2022, and associated user's manual, by Ensoft, Inc.
4) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
5) Loads provided by Tetra Tech via email on December 10, 2024.
6) Sketch of crash wall and micropile geometry provided by Tetra Tech via email on December 13, 2024.
7) Test borings observed by Nobis at the site in 2019 and 2022.
8) Email and phone communications with design team.

Given:
1) Factored loads provided by Tetra Tech per Reference No. 5.
2) Pile cap geometry per References No. 5 and 6.
3) A pinned pile head conditions at North Abutment Crash Wall micropiles.

Assumptions:
1) F'c of grout is 5 ksi, Fy of casing and rebar are 52 ksi and 60 ksi, respectively.
2) Micropiles will consist of casing with an outer diameter of 10.75-inch and 0.5-inch thick walls with a #8 sized center bar.
3) Structural engineer will verify the loads and the pile head condition used in analysis, and evaluate the structural resistance of the micropiles in accordance with AASHTO.
4) Subsurface information from Reference 7 is representative of subsurface conditions.
5) Pile cap geometry with 10 micropiles was considered (2 rows of 5). See Step 2.
6) A casing thickness loss of 1/16-inch in the top 3 feet due to corrosion and 50% loss below the top 3 feet of the pile are used. No casing joints are located in the top 3 feet of the micropiles.
7) The effects of nearby piles from the abutments and abutment return walls were ignored for the purposes of this analysis. P-multipliers (Pm) were calculated directly by Group for the micropiles of the abutment extenson/crash walls only.

Solution:

Step 1: Soil Properties and Profile

Nobis used subsurface information from Borings BB-5 through BB-8 and BB-8A of Reference No. 7 to develop soil parameters in the table below. The datum was taken at the bottom of pile cap (El. 129.25). Soil unit weight (γ_{moist}) soil angle of internal friction (ϕ) and cohesions were estimated based on field and laboratory testing and a study performed on Connecticut Valley Varved Clay entitled “Geology and Engineering Properties of Connecticut Valley Varved Clay” (DeGroot, D.J. and Lutenegger, A.J.). The groundwater table was taken at approximately El. 128. Soil modulus parameters (k) and strain factor for the varved silt/clay were determined using Table 3.7 and Table 3.5 from Reference No. 3, respectively. Uniaxial Compressive Strength (U.C.S.) of rock was based on lab test data.

Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for North/South Abutment Crash Wall
Springfield, Massachusetts

Calculated by: RAC Date: 1/28/2025
Checked by: BTW Date: 2/27/2025

Soil Layer	Elevation (ft)	Depth (ft)	γ_{moist} (pcf)	ϕ (^{o})	k (pci)	U.C.S. (psi)	Cohesion (psf)	Strain Fact. (dims)
Fill	133.25 to 128	-4 to 1.5	115	33	25/20	-	-	-
Varved Silt & Clay	128 to 91	1.5 to 38.5	120	22	100	-	130	0.01
Silt	91 to 79.5	38.5 to 50	120	26	50	-	-	-
Glacial Till	79.5 to 72.4	50 to 57.1	135	37	125	-	-	-
W. Bedrock	72.4 to 68	57.1 to 61.5	150	38	150	-	-	-
Bedrock	<68	>61.5	164	-	-	7,500	-	-

1) Assumed 25 pci for fill above water table and 20 pci for fill below water table.

Step 2: Micropile and Pile Cap Properties

Micropile Cased (50%): micropile strength with 50% casing reduction due to threaded sections

Section Length:	62.5	ft*	Outer Diameter w/loss:	10.25	**in**
Outside Diameter:	10.75	in	Casing Thickness w/loss:	0.25	**in**
Casing Thickness:	0.5	in			
Percent of Casing loss to Thread:	50	%			
Yield Stress of Casing:	52	ksi			
Elastic modulus of Casing:	29000	ksi			
Center Bar:	# 8	bar	Area of Casing (A_{ct}):	**7.9**	**in^2**
Yield Stress of Center Bar:	60	ksi	Area of Bar (A_b):	**0.8**	**in^2**
Grout Compressive Strength:	5	ksi	Area of Grout (A_g):	**73.9**	**in^2**

*Section length includes the 1-foot of embedment into bedrock required by the MassDOT Bridge Manual.

Micropile Uncased: micropile strength with no casing (inside rock socket)

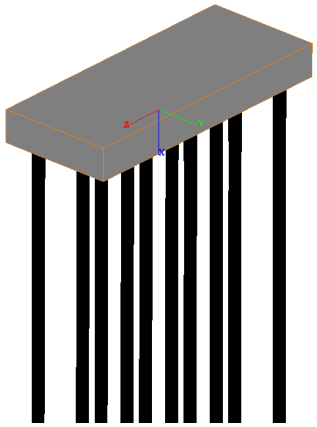
Section Length:	8	ft			
Outside Diameter (before corrosion):	9.75	in			
Center Bar:	# 8	bar			
Yield Stress of Center Bar:	60	ksi	Area of Bar (A_b):	**0.8**	**in^2**
Grout Compressive Strength:	5	ksi	Area of Grout (A_g):	**73.9**	**in^2**

Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for North/South Abutment Crash Wall
Springfield, Massachusetts

Calculated by: RAC Date: 1/28/2025
Checked by: BTW Date: 2/27/2025

Pile Cap: See graphic.

Cap Length in Z-axis (Transverse):	20.5 ft
Cap Width in Y-axis (Longitudinal):	8.5 ft
Cap Thickness in X-axis (Vertical):	2.5 ft
Center-to-center spacing in Z-axis :	4.375 ft
Center-to-center spacing in Y-axis :	5.25 ft



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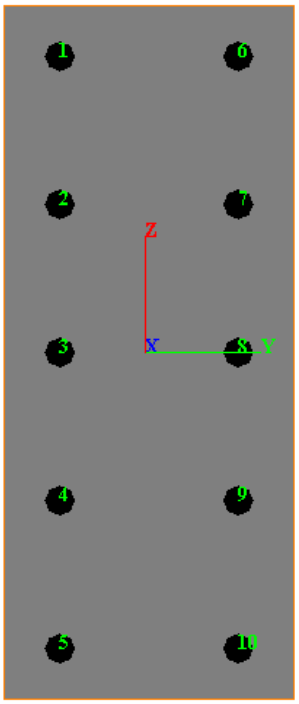

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Step 3: Lateral Analysis

The Computer Program GROUP, version 2022 by Ensoft, Inc. was used for the lateral analyses. Pinned-head conditions were assumed between the micropiles and the proposed abutment extensions/crash walls. The analyses (GROUP) used the provided loads including the effects of regular fill from Tetra Tech. Non-linear EI was assumed in all analyses. Structural engineer shall evaluate the structural adequacy of the micropiles.

Results of Micropile Lateral Analyses for Proposed Abutment Extension/Crash Walls (per micropile)

Structure	Load Case	Max Shear (kip)	Max Deflection (in)	Max Moment Below 3 Feet (kip*ft)[2]	Max Axial Load (kip)	Min Axial Load (kip)
Abutment Extension/ Crash Wall	Ser. I	11.7	0.15	24.0	85.0	-20.0
	Str. I (Max)	15.8	0.22	33.0	110.0	-30.0
	Str. I (Min)	10.6	0.13	21.4	75.0	-20.0
	Ext. I (I)[3]	14.8	0.20	30.3	80.0	-20.0
	Ext. I (II)[4]	16.2	0.23	33.4	75.0	-15.0

1) Depth of fixity is approximately 14 feet below the bottom of pile cap, and taken at the 2nd point of zero deflection.
2) Maximum moment below the top 3 feet with loss of 50% casing due to threaded connections.
3) Extreme I (I) is 50% Inertial + 100% P_{ae}
4) Extreme I (II) is 100% Inertial + 50% P_{ae}

Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for North/South Abutment Crash Wall
Springfield, Massachusetts

Calculated by: RAC Date: 1/28/2025
Checked by: BTW Date: 2/27/2025

Step 4: Axial Analysis

Structural Resistance Factors			
Load Case	**Compression**	**Tension**	
Strength	**0.75**	**0.8**	Ref. No. 4 Tb. 10.5.5.2.5-2
Service	**1**	**1**	Ref. No. 4 Section 10.5.5.1
Extreme	**1**	**0.8**	Ref. No. 4 Section 10.5.5.3

Load Demand (from Group)		
Load Case	**Compression (kips)**	**Tension (kips)**
Strength	**110.0**	**-30.0**
Service	**85.0**	**-20.0**
Extreme	**80.0**	**-20.0**

Geotechnical Resistance Factors			
Load Case	**Compression**	**Tension**	
Strength	**0.55**	**0.55**	Ref. No. 4 Tb. 10.5.5.2.5-1
Service	**1**	**1**	Ref. No. 4 Section 10.5.5.1
Extreme	**1**	**0.8**	Ref. No. 4 Section 10.5.5.3

Evaluate the structural resistance of the micropile for axial load only (negating lateral loads).

For micropile cased section (assuming 50% section):

Nominal axial compressive structural resistance (R_n):	**648.7 kips**	Ref. No. 4 Eq. 10.9.3.10.2a-2
Nominal axial tension structural resistance (R_n):	**449.2 kips**	Ref. No. 4 Eq. 10.9.3.10.3a-2

For micropile uncased section:

Nominal axial compressive structural resistance (R_n):	**306.9 kips**	Ref. No. 4 Eq. 10.9.3.10.2b-2
Nominal axial tension structural resistance (R_n):	**47.1 kips**	Ref. No. 4 Eq. 10.9.3.10.3b-2

Evaluate the geotechnical resistance of the micropile for axial loads.

Grout-to-ground bond strength in Bedrock:	**11 ksf**	Ref. No. 4 Table C10.9.3.5.2-1
Minimum Rock Socket Length:	**8 feet**	assumption
Total Nominal grout-to-ground bond resistance:	**225 Kips**	Ref. No. 4 Eq. 10.9.3.5.2-1

Armory Street over Abandoned CSX Spur
Bridge No. S-24-026
Micropiles for North/South Abutment Crash Wall
Springfield, Massachusetts

Calculated by: RAC Date: 1/28/2025
Checked by: BTW Date: 2/27/2025

Summary

Check to verify that a 8 foot rock socket is adequate based on the maximum factored axial load

Geotechnical					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**123.5**	**110.0**	**123.5**	**30.0**	OK
Service	**224.6**	**85.0**	**224.6**	**20.0**	
Extreme	**224.6**	**80.0**	**179.7**	**20.0**	

Check to verify that the cased micropile is *adequate based on the maximum factored axial load (negating lateral loads).

Structural (cased): Check the strucural resistance of the micropile					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**486.6**	**110.0**	**359.4**	**30.0**	OK
Service	**648.7**	**85.0**	**449.2**	**20.0**	
Extreme	**648.7**	**80.0**	**359.4**	**20.0**	

*Structural engineer shall evaluate the structural adequacy of the micropiles.

Check to verify that the uncased micropile is *adequate based on the maximum factored axial load (negating lateral loads) and to verify that a plunge length is not needed.

Structural (uncased)					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**230.2**	**110.0**	**37.7**	**30.0**	OK
Service	**306.9**	**85.0**	**47.1**	**20.0**	
Extreme	**306.9**	**80.0**	**37.7**	**20.0**	

*Structural engineer shall evaluate the structural adequacy of the micropiles.

JOB:	Armory Street Bridge No S-24-026			SHEET NO.	
SUBJECT:	North Abutment Crash Wall			FILE NO.	
COMP. BY:	AJF	DATE: 12/10/2024	CHK. BY:	DATE:	

CONSTANTS

Type of Wall: Wing / Retaining Wall
Type of Backwall: Independent
Type of Foundation: Pile Supported
Footing Constructed on Tremie? N
Type of Backfill: Lightweight fill
Type of Lateral Soil Pressure: Temporary Condition: Active
Permanent Condition: At-Rest
Method for Calculating Active Earth Pressure: Rankine
Include Lateral Load on Backwall in Case IB? Y
Pile Information: Pile Type: Metal Shell 12" OD
Testing: Gates Dynamic Formula
Include: Lateral load from EPS conc cap? N/A
Pile Shading for Lateral Resistance? N
Pile Reaction for Top Fnd Reinf.? Y
Earth Load for Bottom Fnd Reinf.? Y

Pile Properties:	Default		Overwrite		Final	
Nom. Pile Resistance:	250	K/Pile		K/Pile	250	K/Pile
Resistance Factor:	0.50				0.50	
Factored Pile Resist.:	125	K/Pile		K/Pile	125	K/Pile
Pile Width/Diameter:	12	in		in	12	in
Lateral Pile Resistance:			10	K/Pile	10	K/Pile

Soil Properties:	Default		Overwrite		Final	
Backfill weight, w:	0.120	Kcf	0.125	Kcf	0.125	Kcf
Angle (beta):	0	degrees		degrees	0	degrees
Angle (phi):	30	degrees	33	degrees	33	degrees
Angle (delta):	17	degrees		degrees	17	degrees
Angle (theta):					90	degrees
Active Coeff, K_a:	0.295		0.350		0.350	
At-Rest Coeff, K_o:	0.455		0.460		0.460	
Seismic Coeff, K_{AE}:			0.333			
Seismic Coeff, K_{h0}:			0.225			

Lightweight Fill Properties:	Default		Overwrite		Final	
Lightweight Concrete Weight, w:		Kcf	0.023	Kcf	0.023	Kcf
Lateral Lightweight Concrete Load:		Ksf	0.008	Ksf	0.008	Ksf
Seismic Lateral Lightweight Concrete Load:		Ksf	0.008	Ksf	0.008	Ksf

Structural Material Properties:	Default		Overwrite		Final	
Concrete Strength, f'c:	3	Ksi	4	Ksi	4	Ksi
Concrete Weight, w:	0.150	Kcf		Kcf	0.150	Kcf
	0.145	Kcf		Kcf	0.145	Kcf
Concrete Modulus of Elasticity, Ec:					3987	Ksi
Concrete Modulus of Rupture, fr:					0.48	Ksi
Max Aggregate Size	1.5	in		in	1.500	in
Rebar Strength, Fy:	60	Ksi		Ksi	60	Ksi
Rebar Modulus of Elasticity, Es:					29000	Ksi
Modular Ratio, n:					7	

Miscellaneous Properties: Unit Weight of Water: 0.0624 Kcf

Reinforcement Centerline:	Default		Overwrite		Final	
Wall Back Face:	3	in		in	3	in
Footing Top:	4	in		in	4	in
Footing Bottom:	9	in	14	in	14	in
Wall Increment:	0.50	Ft	1.00	Ft	1.00	Ft

Reinforcement Epoxy Coated? Footing: Y Wall: Y

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Crash Wall FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

INPUT AND SUMMARY OF RESULTS

Superstructure Bearing Loads:		Vertical Loads: maximum	Vertical Loads: minimum	Horizontal Loads: maximum	Horizontal Loads: minimum	
Self-Weight (Temporary)	DC1:	0.00		0.00		K/Ft
Self-Weight (Permanent)	DC1:	0.00		0.00		K/Ft
Superimposed Dead Loads	DC2:	0.00		0.00		K/Ft
Wearing Surface / Utilities	DW:	0.00		0.00		K/Ft
Post-Tensioning, Creep, Shrinkage	PS+CR+SH:	0.00	0.00	0.00	0.00	K/Ft
Thermal Contraction	TU:	0.00		0.00		K/Ft
Thermal Expansion	TU:	0.00		0.00		K/Ft
Live Loads	LL:	0.00		0.00		K/Ft
Braking	BR:			0.00		K/Ft
Wind on Structure (Service I)	WS:	0.00		0.00		K/Ft
Wind on Structure (Strength III)	WS:	0.00		0.00		K/Ft
Wind on Structure (Strength V)	WS:	0.00		0.00		K/Ft
Wind on Live Load (Service I)	WL:	0.00		0.00		K/Ft
Wind on Live Load (Strength V)	WL:	0.00		0.00		K/Ft

Approach Equivalent Live Loads:

Depth of equiv fill - temporary	HE =	0.000	Ft
Depth of equiv fill - permanent		0.000	Ft

Wind Load on Wall (wing/retaining walls):

Service I wind load:	0.000	Ksf
Strength III wind load:	0.000	Ksf
Strength V wind load:	0.000	Ksf

Backfill Dimensions:

Temp height of soil (from bott of ftg)	HT =		Ft
Height of EPS concrete cap	HC =	0.000	Ft
Height of lightweight fill	HFF =	21.500	Ft
Add Height of lightweight fill		8.125	Ft
Height of soil below lightweight fill		0.000	Ft
Soil depth at toe	HP =		Ft
Height of water table	HWT =	0.000	Ft

Abutment Stem Wall Dimensions:

Bearing distance	BD =	0.000	Ft
Bearing height	BH =	0.000	Ft
Height of backwall/upper wall	HB =	6.125	Ft
Height of upper wall above grade	HG =	0.000	Ft
Thickness of backwall/upper wall	TB =	0.000	Ft
Location of backwall/upper wall	DB =	0.000	Ft
Height of stem wall	HW =	19.000	Ft
Thickness of stem wall	TW =	3.500	Ft
Railing height on wingwall	HR =	0.000	Ft

Abutment Footing Dimensions:

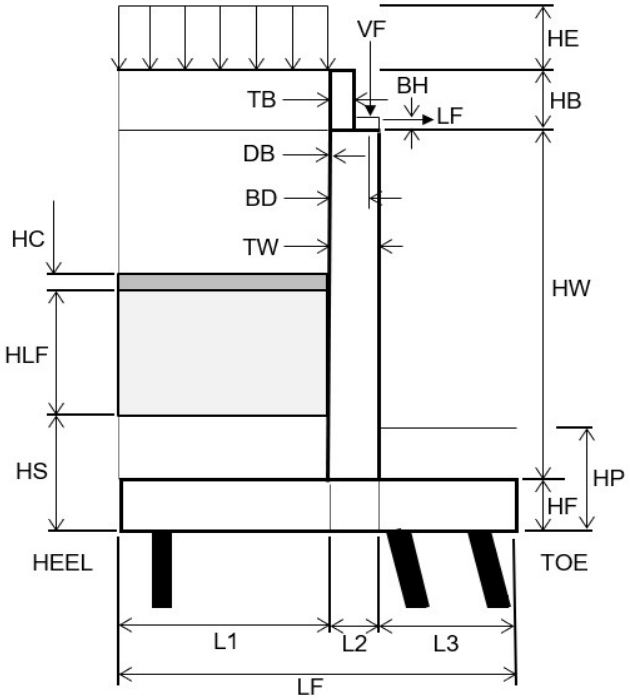
Height of footing	HF =	2.500	Ft
Total length of footing	LF =	8.500	Ft
Length of footing at toe	L3 =	0.920	Ft
Pile location - First pile from heel:		1.750	Ft

Pile Spacing Dimensions:

Pile Row:	Toe	1	2	3	4	5	Heel	
Piles Present in this Row?		Y	N	N	N	Y		
Pile Distance from Toe:		1.50				6.75		Ft
Longitudinal Pile Spacing:		5.500				5.500		Ft
Battered Piles in this Row?		N	N	N	N	N		
Pile Batter:								to 1
Percent of Piles Battered:								

JOB:	Armory Street Bridge No S-24-026					SHEET NO.	
SUBJECT:	North Abutment Crash Wall					FILE NO.	
COMP. BY:	AJF	DATE:	12/10/2024	CHK. BY:		DATE:	

INPUT AND SUMMARY OF RESULTS - CONTINUED



L1= 4.080 L2= 3.500 L3= 0.920 Ft

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Crash Wall FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

VERTICAL LOAD CALCULATIONS:

Load No.		Load Description	Unfactored Loads Width Ft	Height Ft	Unit Wt. Kcf	Maximum K/Ft	Minimum K/Ft	Centroid Y from Heel Ft	Moment Arm from CL Ftg Ft
1A	DC	Footing Heel Dead Load	4.08 x	2.50 x	0.150 =	1.53	1.53	2.040	-2.210
1A	DC	Footing Mid Dead Load	3.50 x	2.50 x	0.150 =	1.31	1.31	5.830	1.580
1A	DC	Footing Toe Dead Load	0.92 x	2.50 x	0.150 =	0.35	0.35	8.040	3.790
1B	DC	Stem Wall Dead Load	3.50 x	19.00 x	0.150 =	9.98	9.98	5.830	1.580
1C	DC	Backwall Dead Load	0.00 x	6.13 x	0.150 =	0.00	0.00	0.000	0.000
1C	DC	Backwall Dead Load (Case IB)	0.00 x	6.13 x	0.150 =	0.00	0.00	0.000	0.000
2A	EV	Soil Vertical Load Temp							
2A	EV	Soil Vertical Load 1	4.08 x	0.00 x	0.150 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 2	4.08 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 2 (Case IB)	0.00 x	6.13 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 3	0.00 x	6.13 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 4	0.92 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Load (below lightwt fill)	4.08 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00	0.000	0.000
4A	DC1	Super Dead Load Permanent	0.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
4B	DC2	Superimposed Dead Load			=	0.00	0.00	0.000	0.000
4C	DW	Wearing Surface / Utilities			=	0.00	0.00	0.000	0.000
5	LS	Temp LL Surcharge	4.08 x	0.00 x	0.125 =	0.00	0.00	2.040	0.000
5	LS	Equiv LL Surcharge	4.08 x	0.00 x	0.125 =	0.00	0.00	2.040	0.000
6	LL	Superstructure Live Load			=	0.00	0.00	0.000	0.000
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00	0.000	0.000
7B	TU	Thermal Contraction			=	0.00	0.00	0.000	0.000
7C	TU	Thermal Expansion			=	0.00	0.00	0.000	0.000
8A	EV	Lightweight Fill below Bearing	4.08 x	19.00 x	0.023 =	1.78	1.78	2.040	-2.210
8B	EV	Lightweight Fill above Bearing	4.08 x	0.00 x	0.023 =	0.00	0.00	0.000	0.000
9A	EV	EPS Concrete Cap below Brg	4.08 x	0.00 x	0.150 =	0.00	0.00	0.000	0.000
9B	EV	EPS Concrete Cap above Brg	4.08 x	0.00 x	0.150 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Heel	4.08 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Mid	3.50 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Toe	0.92 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00	0.000	0.000
	WS	Wind on Structure (Str III)			=	0.00	0.00	0.000	0.000
	WS	Wind on Structure (Str V)			=	0.00	0.00	0.000	0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00	0.000	0.000
	WL	Wind on Live Load (Str V)			=	0.00	0.00	0.000	0.000

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Crash Wall FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

VERTICAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Extreme Event I Load Factors Max	Extreme Event I Load Factors Min
1A	DC	Footing Heel Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1A	DC	Footing Mid Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1A	DC	Footing Toe Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1B	DC	Stem Wall Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1C	DC	Backwall Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1C	DC	Backwall Dead Load (Case IB)	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
2A	EV	Soil Vertical Load Temp	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2A	EV	Soil Vertical Load 1	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 2	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 2 (Case IB)	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 3	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 4	1.00	1.00	1.35	0.00	1.35	0.00	1.00	1.00
2B	EV	Soil Load (below lightwt fill)	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface / Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5	LS	Temp LL Surcharge	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5	LS	Equiv LL Surcharge	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	1.00	1.00
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	0.50	0.50	0.50	0.50	1.00	1.00
8A	EV	Lightweight Fill below Bearing	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
8B	EV	Lightweight Fill above Bearing	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
9A	EV	EPS Concrete Cap below Brg	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
9B	EV	EPS Concrete Cap above Brg	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
10	WA	Buoyancy Heel	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	WA	Buoyancy Mid	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	WA	Buoyancy Toe	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Crash Wall FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

HORIZONTAL LOAD CALCULATIONS:

3	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Soil above bearing elevation
3	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Soil below bearing elevation
3	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Soil under lightweight fill
5	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Temporary live load surcharge
5	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Equivalent live load surcharge
8		0.008	Ksf	Lightweight Fill
9A	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap below Bearing
9B	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap above Bearing
9C	19.00 ft x 0.023 kcf x 0.350 =	0.153	Ksf	Lightweight Fill below Bearing Surcharge
9D	0.00 ft x 0.023 kcf x 0.350 =	0.000	Ksf	Lightweight Fill above Bearing Surcharge
9E	0.00 ft x 0.150 kcf x 0.350 =	0.000	Ksf	EPS Concrete Cap below Bearing Surcharge
9F	0.00 ft x 0.150 kcf x 0.350 =	0.000	Ksf	EPS Concrete Cap above Bearing Surcharge

Load No.		Load Description	Unfactored Loads Height Ft	Load Ksf		Maximum K/Ft	Minimum K/Ft		Moment Arm Ft
3	EH	Soil Lateral Load 1	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
3A	EH	Soil Lateral Load 2	0.00 x	0.000	=	0.00	0.00		0.000
3A	EH	Soil Lateral Load 2 (Case IB)	0.00 x	0.000	=	0.00	0.00		0.000
3B	EH	Soil Lateral Load 3	21.50 x	0.000		0.00	0.00		13.292
3B	EH	Soil Lateral Load 3 (Case IB)	0.00 x	0.000	/ 2 =	0.00	0.00		27.625
3C	EH	Soil Lateral Load 4	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
3D	EH	Soil Lateral Load 5	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6 (Case IB)	0.00 x	0.000	=	0.00	0.00		0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00		21.500
4A	DC1	Super Dead Load Permanent			=	0.00	0.00		21.500
4B	DC2	Superimposed Dead Loads			=	0.00	0.00		21.500
4C	DW	Wearing Surface + Utilities			=	0.00	0.00		21.500
5A	LS	Temp LL Surcharge 1	0.00 x	0.000	=	0.00	0.00		21.500
5B	LS	Temp LL Surcharge 2	6.13 x	0.000	=	0.00	0.00		24.563
5B	LS	Temp LL Surcharge 2 (Case IB)	6.13 x	0.000	=	0.00	0.00		24.563
5C	LS	Temp LL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
5A	LS	Equiv LL Surcharge 1	0.00 x	0.000	=	0.00	0.00		21.500
5B	LS	Equiv LL Surcharge 2	21.50 x	0.000	=	0.00	0.00		16.875
5C	LS	Equiv LL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
6A	LL	Superstructure Live Load			=	0.00	0.00		21.500
6B	BR	Braking (Contraction)			=	0.00	0.00		21.500
6C	BR	Braking (Expansion)			=	0.00	0.00		21.500
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00		21.500
7B	TU	Thermal Contraction			=	0.00	0.00		21.500
7C	TU	Thermal Expansion			=	0.00	0.00		21.500
8A	EH	Lightweight Fill below Bearing	21.50^2 x	0.008	/ 2 =	1.85	1.85		7.167
8B	EH	Lightweight Fill above Bearing	21.50 x	0.170	=	3.66	3.66		10.750
9A	EH	EPS Cap below Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9B	EH	EPS Cap above Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9C	EH	Lwt Fill below Brg Surcharge	0.00 x	0.153	=	0.00	0.00		0.000
9D	EH	Lwt Fill above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9E	EH	EPS Cap below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9F	EH	EPS Cap above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00		21.500
	WS	Wind on Structure (Str III)			=	0.00	0.00		21.500
	WS	Wind on Structure (Str V)			=	0.00	0.00		21.500
12B	WS	Wind on Stem Wall (Serv I)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str III)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str V)	0.00 x	0.000	=	0.00	0.00		0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00		21.500
	WL	Wind on Live Load (Str V)			=	0.00	0.00		21.500
13	EQ	Earthquake Load		0.23 x	14.95 =	3.36	3.36	-----	-----

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Crash Wall FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

HORIZONTAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Strength V Load Factors Max	Strength V Load Factors Min
3	EH	Soil Lateral Load 1	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3C	EH	Soil Lateral Load 4	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3D	EH	Soil Lateral Load 5	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Loads	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface + Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5A	LS	Temp LL Surcharge 1	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5B	LS	Temp LL Surcharge 2	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5B	LS	Temp LL Surcharge 2 (Case IB)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5C	LS	Temp LL Surcharge 3	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5A	LS	Equiv LL Surcharge 1	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5B	LS	Equiv LL Surcharge 2	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5C	LS	Equiv LL Surcharge 3	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6A	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6B	BR	Braking (Contraction)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6C	BR	Braking (Expansion)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
8A	EH	Lightweight Fill below Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
8B	EH	Lightweight Fill above Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9A	EH	EPS Cap below Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9B	EH	EPS Cap above Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9C	EH	Lwt Fill below Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9D	EH	Lwt Fill above Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9E	EH	EPS Cap below Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9F	EH	EPS Cap above Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12B	WS	Wind on Stem Wall (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Stem Wall (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Stem Wall (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
13	EQ	Earthquake Load	-----	-----	-----	-----	-----	-----	1.00	1.00

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Crash Wall FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

EARTHQUAKE HORIZONTAL LOAD CALCULATIONS:

3	0.00 ft x 0.125 kcf x 0.333 =	0.000	Ksf	Soil above bearing elevation
3	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Soil below bearing elevation
3	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Soil under lightweight fill
5	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Temporary live load surcharge
5	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Equivalent live load surcharge
8		0.008	Ksf	Lightweight Fill
9A	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap below Bearing
9B	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap above Bearing
9C	19.00 ft x 0.0077 ksf =	0.146	Ksf	Lightweight Fill below Bearing Surcharge
9D	0.00 ft x 0.0077 ksf =	0.000	Ksf	Lightweight Fill above Bearing Surcharge
9E	0.00 ft x 0.0077 ksf =	0.000	Ksf	EPS Concrete Cap below Bearing Surcharge
9F	0.00 ft x 0.0077 ksf =	0.000	Ksf	EPS Concrete Cap above Bearing Surcharge

Load No.		Load Description	Unfactored Loads Height Ft	Load Ksf		Maximum K/Ft	Minimum K/Ft		Moment Arm Ft
3	EH	Soil Lateral Load 1	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
3A	EH	Soil Lateral Load 2	0.00 x	0.000	=	0.00	0.00		0.000
3A	EH	Soil Lateral Load 2 (Case IB)	0.00 x	0.000	=	0.00	0.00		0.000
3B	EH	Soil Lateral Load 3	21.50 x	0.000		0.00	0.00		13.292
3B	EH	Soil Lateral Load 3 (Case IB)	0.00 x	0.000	/ 2 =	0.00	0.00		27.625
3C	EH	Soil Lateral Load 4	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
3D	EH	Soil Lateral Load 5	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6 (Case IB)	0.00 x	0.000	=	0.00	0.00		0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00		21.500
4A	DC1	Super Dead Load Permanent			=	0.00	0.00		21.500
4B	DC2	Superimposed Dead Loads			=	0.00	0.00		21.500
4C	DW	Wearing Surface + Utilities			=	0.00	0.00		21.500
5A	LS	Temp LL Surcharge 1	0.00 x	0.000	=	0.00	0.00		21.500
5B	LS	Temp LL Surcharge 2	6.13 x	0.000	=	0.00	0.00		24.563
5B	LS	Temp LL Surcharge 2 (Case IB)	6.13 x	0.000	=	0.00	0.00		24.563
5C	LS	Temp LL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
5A	LS	Equiv LL Surcharge 1	0.00 x	0.000	=	0.00	0.00		21.500
5B	LS	Equiv LL Surcharge 2	21.50 x	0.000	=	0.00	0.00		16.875
5C	LS	Equiv LL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
6A	LL	Superstructure Live Load			=	0.00	0.00		21.500
6B	BR	Braking (Contraction)			=	0.00	0.00		21.500
6C	BR	Braking (Expansion)			=	0.00	0.00		21.500
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00		21.500
7B	TU	Thermal Contraction			=	0.00	0.00		21.500
7C	TU	Thermal Expansion			=	0.00	0.00		21.500
8A	EH	Lightweight Fill below Bearing	21.50^2 x	0.0077	/ 2 =	1.78	1.78		7.167
8B	EH	Lightweight Fill above Bearing	21.50 x	0.162	=	3.49	3.49		10.750
9A	EH	EPS Cap below Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9B	EH	EPS Cap above Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9C	EH	Lwt Fill below Brg Surcharge	0.00 x	0.153	=	0.00	0.00		0.000
9D	EH	Lwt Fill above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9E	EH	EPS Cap below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9F	EH	EPS Cap above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00		21.500
	WS	Wind on Structure (Str III)			=	0.00	0.00		21.500
	WS	Wind on Structure (Str V)			=	0.00	0.00		21.500
12B	WS	Wind on Stem Wall (Serv I)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str III)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str V)	0.00 x	0.000	=	0.00	0.00		0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00		21.500
	WL	Wind on Live Load (Str V)			=	0.00	0.00		21.500
13	EQ	Earthquake Load		0.23 x	14.95 =	3.36	3.36	-----	-----

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Crash Wall FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

HORIZONTAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Strength V Load Factors Max	Strength V Load Factors Min
3	EH	Soil Lateral Load 1	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3C	EH	Soil Lateral Load 4	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3D	EH	Soil Lateral Load 5	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Loads	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface + Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5A	LS	Temp LL Surcharge 1	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5B	LS	Temp LL Surcharge 2	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5B	LS	Temp LL Surcharge 2 (Case IB)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5C	LS	Temp LL Surcharge 3	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5A	LS	Equiv LL Surcharge 1	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5B	LS	Equiv LL Surcharge 2	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5C	LS	Equiv LL Surcharge 3	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6A	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6B	BR	Braking (Contraction)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6C	BR	Braking (Expansion)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
8A	EH	Lightweight Fill below Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
8B	EH	Lightweight Fill above Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9A	EH	EPS Cap below Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9B	EH	EPS Cap above Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9C	EH	Lwt Fill below Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9D	EH	Lwt Fill above Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9E	EH	EPS Cap below Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9F	EH	EPS Cap above Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12B	WS	Wind on Stem Wall (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Stem Wall (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Stem Wall (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
13	EQ	Earthquake Load	-----	-----	-----	-----	-----	-----	1.00	1.00

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Crash Wall FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

CASE II **Strength I** **Live Load on Approach** 20.5 feet

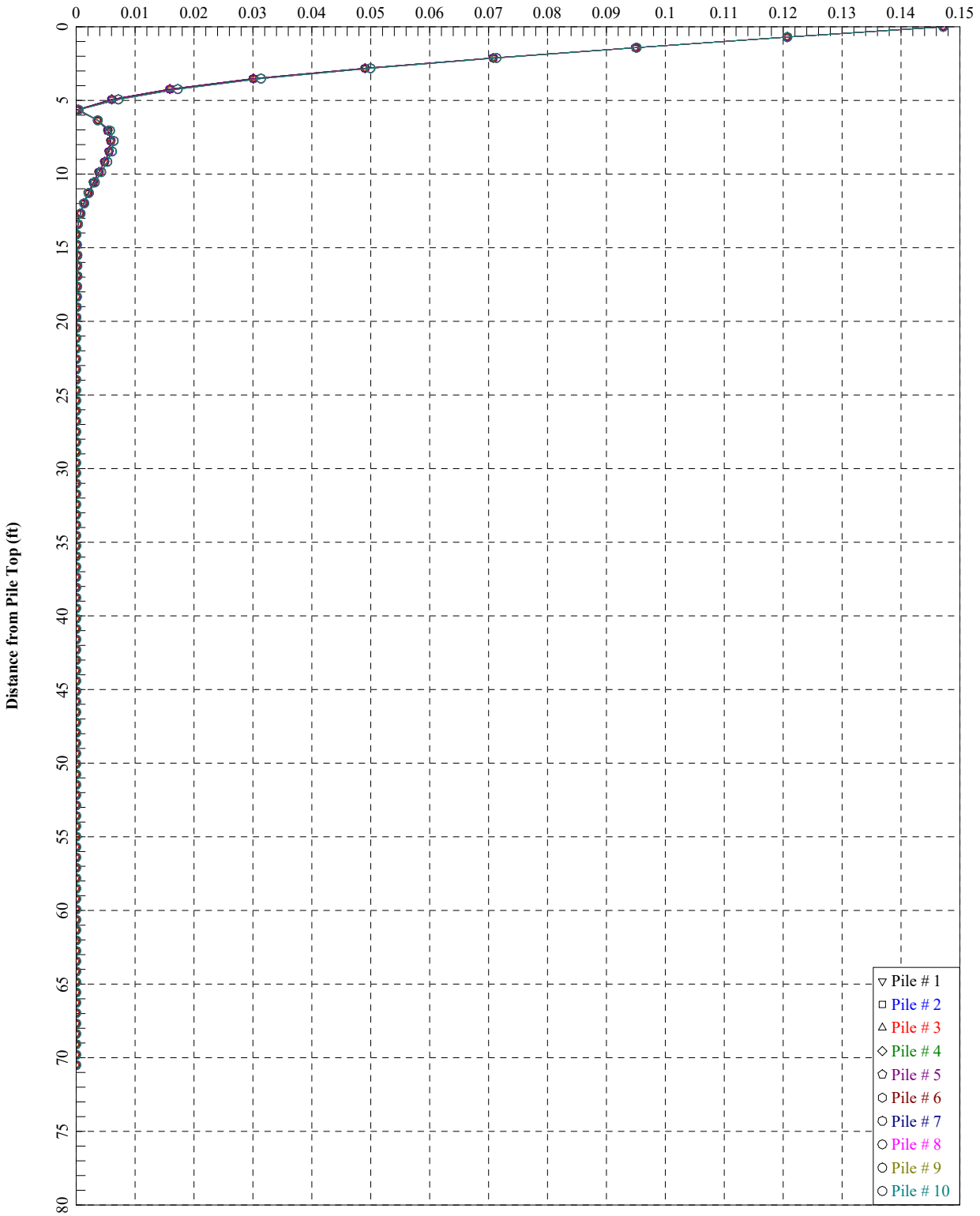
			SERVICE I		STRENGTH I MAX			STRENGTH I MIN		
Load No.		Load Description	Load	Moment	Factors	Load	Moment	Factors	Load	Moment
			K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft
VERTICAL LOADS:										
1A	DC	Footing Heel Dead Load	1.53	-3.38	1.25	1.91	-4.23	0.90	1.38	-3.04
1A	DC	Footing Mid Dead Load	1.31	2.07	1.25	1.64	2.59	0.90	1.18	1.87
1A	DC	Footing Toe Dead Load	0.35	1.31	1.25	0.43	1.63	0.90	0.31	1.18
1B	DC	Stem Wall Dead Load	9.98	15.76	1.25	12.47	19.70	0.90	8.98	14.18
1C	DC	Backwall Dead Load	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
2A	EV	Soil Vertical Load 1	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 2	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 3	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 4	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2C	EV	Soil Load (below lightwt fill)	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4B	DC2	Superimposed Dead Load	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4C	DW	Wearing Surface / Utilities	0.00	0.00	1.50	0.00	0.00	0.65	0.00	0.00
5	LS	Equiv LL Surcharge	0.00	0.00	1.75	0.00	0.00	1.75	0.00	0.00
8A	EV	Lightweight Fill below Bearing	1.78	-3.94	1.35	2.41	-5.32	1.00	1.78	-3.94
8B	EV	Lightweight Fill above Bearing	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
9A	EV	EPS Concrete Cap below Brg	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9B	EV	EPS Concrete Cap above Brg	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Heel	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Mid	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Toe	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
Total Vertical:		306.48	14.95	11.82	386.63	18.86	14.38	279.42	13.63	10.24
HORIZONTAL LOADS:										
3	EH	Soil Lateral Load 1	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3A	EH	Soil Lateral Load 2	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3B	EH	Soil Lateral Load 3	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3C	EH	Soil Lateral Load 4	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3D	EH	Soil Lateral Load 5	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3E	EH	Soil Lateral Load 6	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4B	DC2	Superimposed Dead Loads	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4C	DW	Wearing Surface + Utilities	0.00	0.00	1.50	0.00	0.00	0.65	0.00	0.00
5A	LS	Equiv LL Surcharge 1	0.00	0.00	1.75	0.00	0.00	1.75	0.00	0.00
5B	LS	Equiv LL Surcharge 2	0.00	0.00	1.75	0.00	0.00	1.75	0.00	0.00
5C	LS	Equiv LL Surcharge 3	0.00	0.00	1.75	0.00	0.00	1.75	0.00	0.00
8A	EH	Lightweight Fill below Bearing	1.85	13.25	1.35	2.50	17.89	0.90	1.66	11.93
8B	EH	Lightweight Fill above Bearing	3.66	39.39	1.35	4.95	53.17	0.90	3.30	35.45
9A	EH	EPS Cap below Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9B	EH	EPS Cap above Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9C	EH	Lwt Fill below Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9D	EH	Lwt Fill above Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9C	EH	EPS Cap below Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9D	EH	EPS Cap above Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
Total Horizontal:		112.96	5.51	52.64	152.52	7.44	71.06	101.68	4.96	47.37
Moment Grand Total:				64.46			85.44			57.62
				1321.43			1751.52			1181.21

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Crash Wall FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

CASE II **Extreme I** **Live Load on Approach**

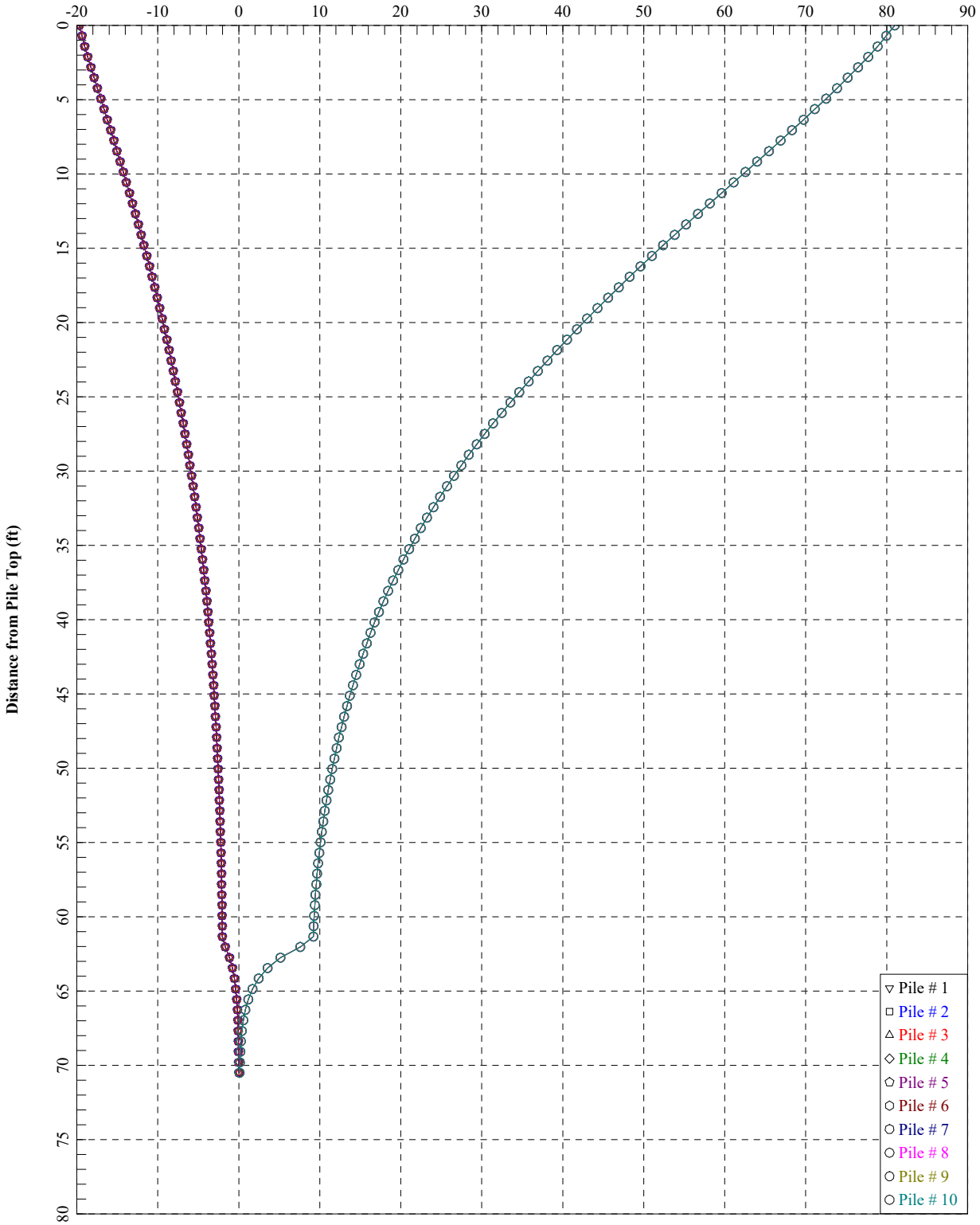
			SERVICE I		EXTREME I 50% Inertial + 100% PAE			EXTREME I 100% Inertial + 50% PAE		
Load No.		Load Description	Load	Moment	Factors	Load	Moment	Factors	Load	Moment
			K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft
VERTICAL LOADS:										
1A	DC	Footing Heel Dead Load	1.53	-3.38	1.00	1.53	-3.38	1.00	1.53	-3.38
	DC	Footing Mid Dead Load	1.31	2.07	1.00	1.31	2.07	1.00	1.31	2.07
	DC	Footing Toe Dead Load	0.35	1.31	1.00	0.35	1.31	1.00	0.35	1.31
1B	DC	Stem Wall Dead Load	9.98	15.76	1.00	9.98	15.76	1.00	9.98	15.76
	DC	Backwall Dead Load	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2A	EV	Soil Vertical Load 1	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	EV	Soil Vertical Load 2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	EV	Soil Vertical Load 4	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2C	EV	Soil Load (below lightwt fill)	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4B	DC2	Superimposed Dead Load	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4C	DW	Wearing Surface / Utilities	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5	LS	Equiv LL Surcharge	0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00
8A	EV	Lightweight Fill below Bearing	1.78	-3.94	1.00	1.78	-3.94	1.00	1.78	-3.94
8B	EV	Lightweight Fill above Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9A	EV	EPS Concrete Cap below Brg	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9B	EV	EPS Concrete Cap above Brg	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
10	WA	Buoyancy Heel	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	WA	Buoyancy Mid	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	WA	Buoyancy Toe	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
12A	WS	Wind on Structure (Serv I)	0.00	0.00						
	WS	Wind on Structure (Str V)								
Total Vertical:			14.95	11.82	306.48	14.95	11.82	306.48	14.95	11.82
HORIZONTAL LOADS:										
3	EH	Soil Lateral Load 1	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3A	EH	Soil Lateral Load 2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3B	EH	Soil Lateral Load 3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3C	EH	Soil Lateral Load 4	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3D	EH	Soil Lateral Load 5	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3E	EH	Soil Lateral Load 6	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4B	DC2	Superimposed Dead Loads	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4C	DW	Wearing Surface + Utilities	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5A	LS	Equiv LL Surcharge 1	0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00
5B	LS	Equiv LL Surcharge 2	0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00
5C	LS	Equiv LL Surcharge 3	0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00
8A	EH	Lightweight Fill below Bearing	1.78	12.75	1.00	1.78	12.75	1.00	1.45	10.40
8B	EH	Lightweight Fill above Bearing	3.49	37.47	1.00	3.49	37.47	1.00	2.84	30.55
9A	EH	EPS Cap below Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9B	EH	EPS Cap above Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9C	EH	Lwt Fill below Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9D	EH	Lwt Fill above Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9C	EH	EPS Cap below Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9D	EH	EPS Cap above Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
12A	WS	Wind on Structure (Serv I)	0.00	0.00						
	WS	Wind on Structure (Str V)								
12B	WS	Wind on Stem Wall (Serv I)	0.00	0.00						
	WS	Wind on Stem Wall (Str V)								
13	EQ	Earthquake Load	3.36	0.00	1.00	1.68	0.00	1.00	3.36	0.00
Total Horizontal:			8.63	50.23	142.48	6.95	50.23	157.03	7.66	40.95
Moment Grand Total:				62.05			62.05			52.77
							1272.03			1081.79

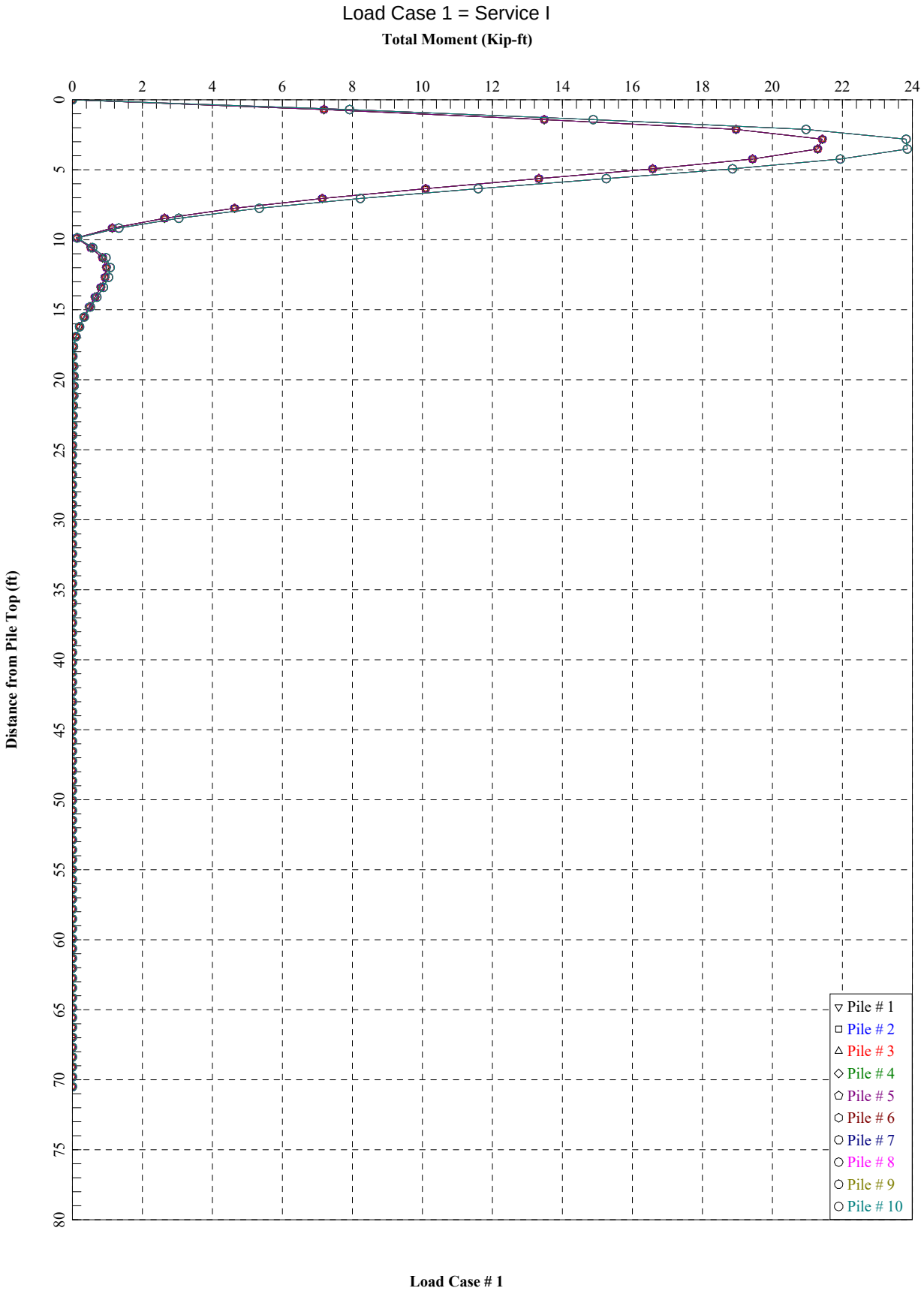
Load Case 1 = Service I



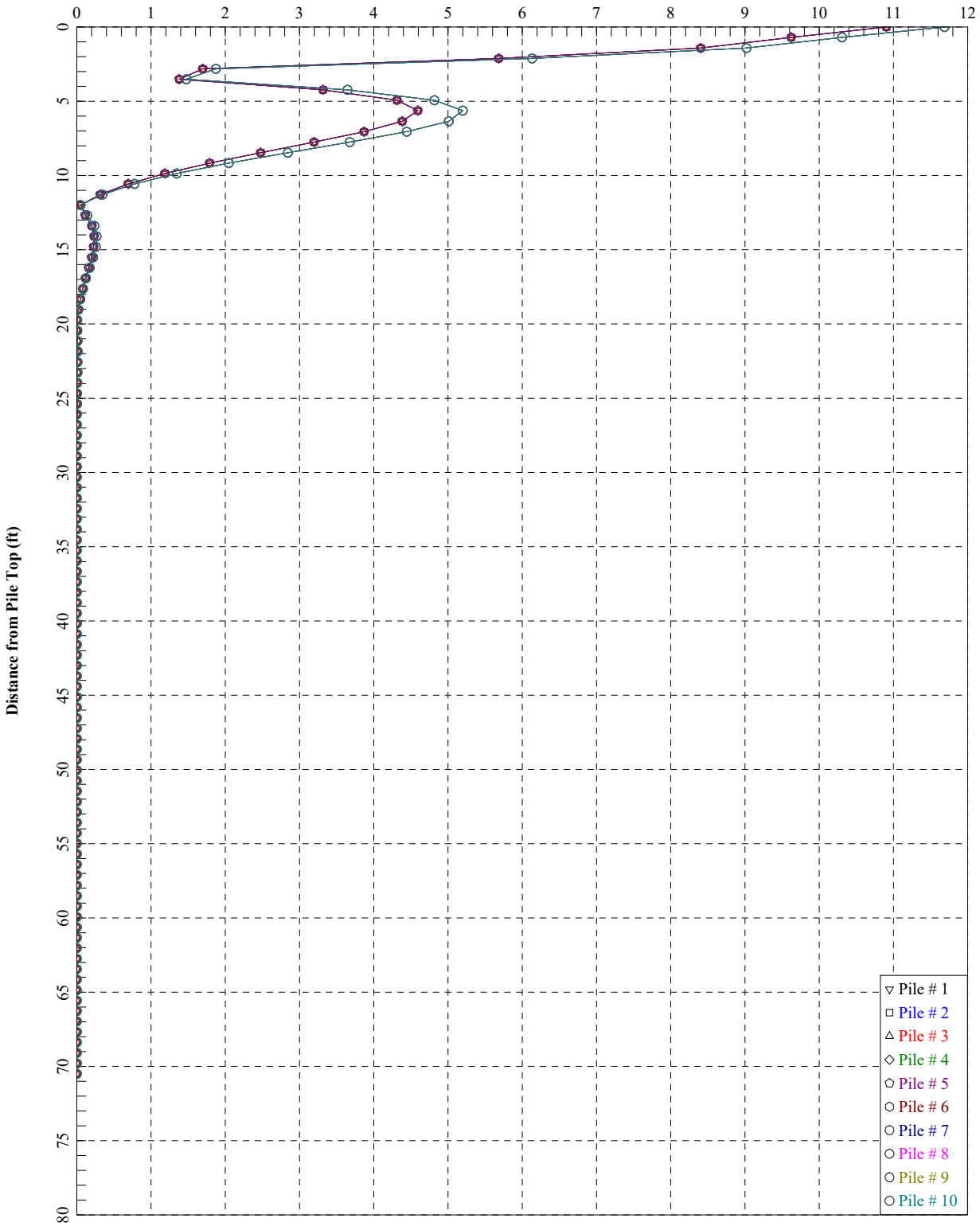
Load Case # 1

Load Case 1 = Service I

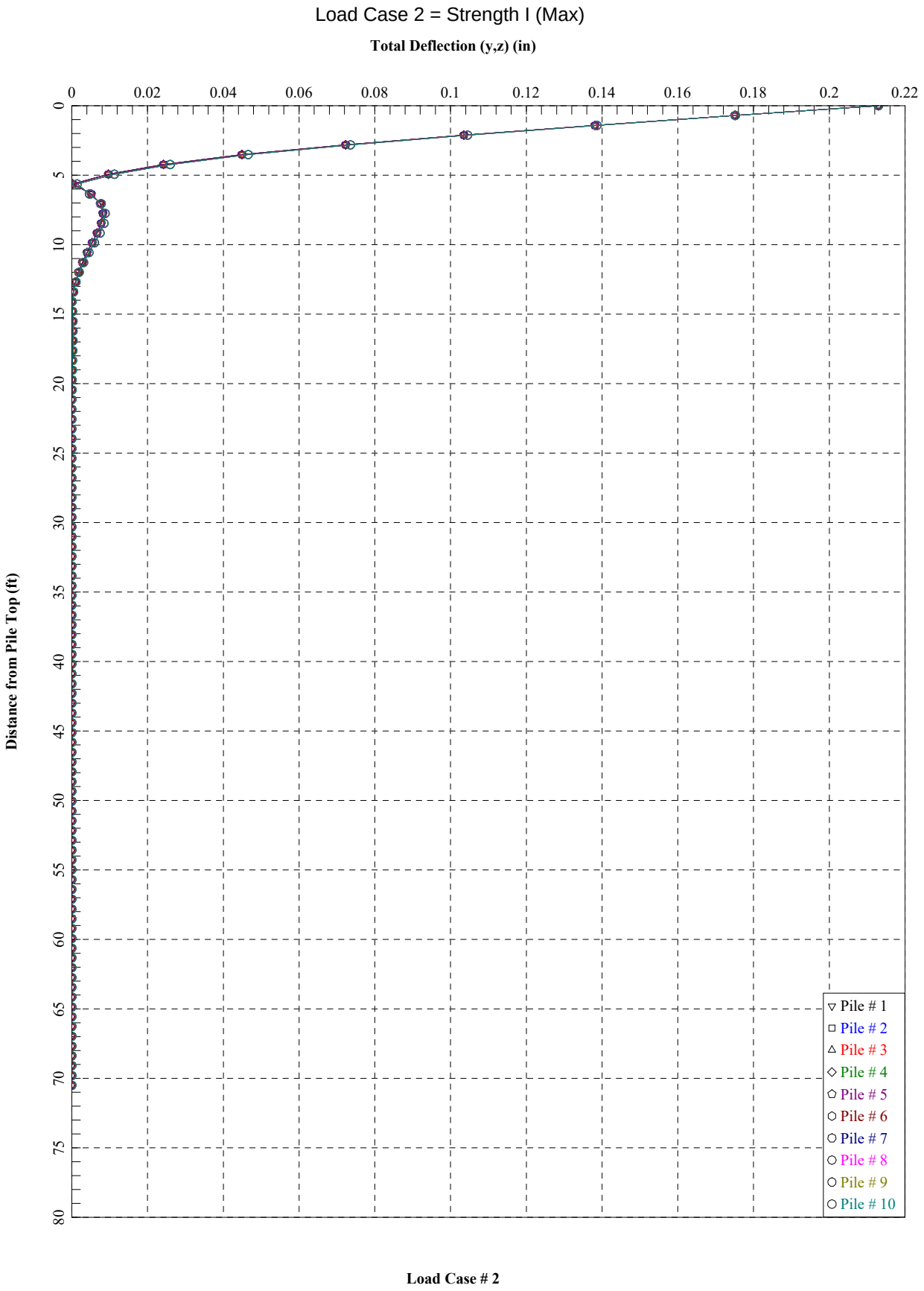



Load Case 1 = Service I
Total Moment (Kip-ft)
Distance from Pile Top (ft)
Load Case # 1
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10

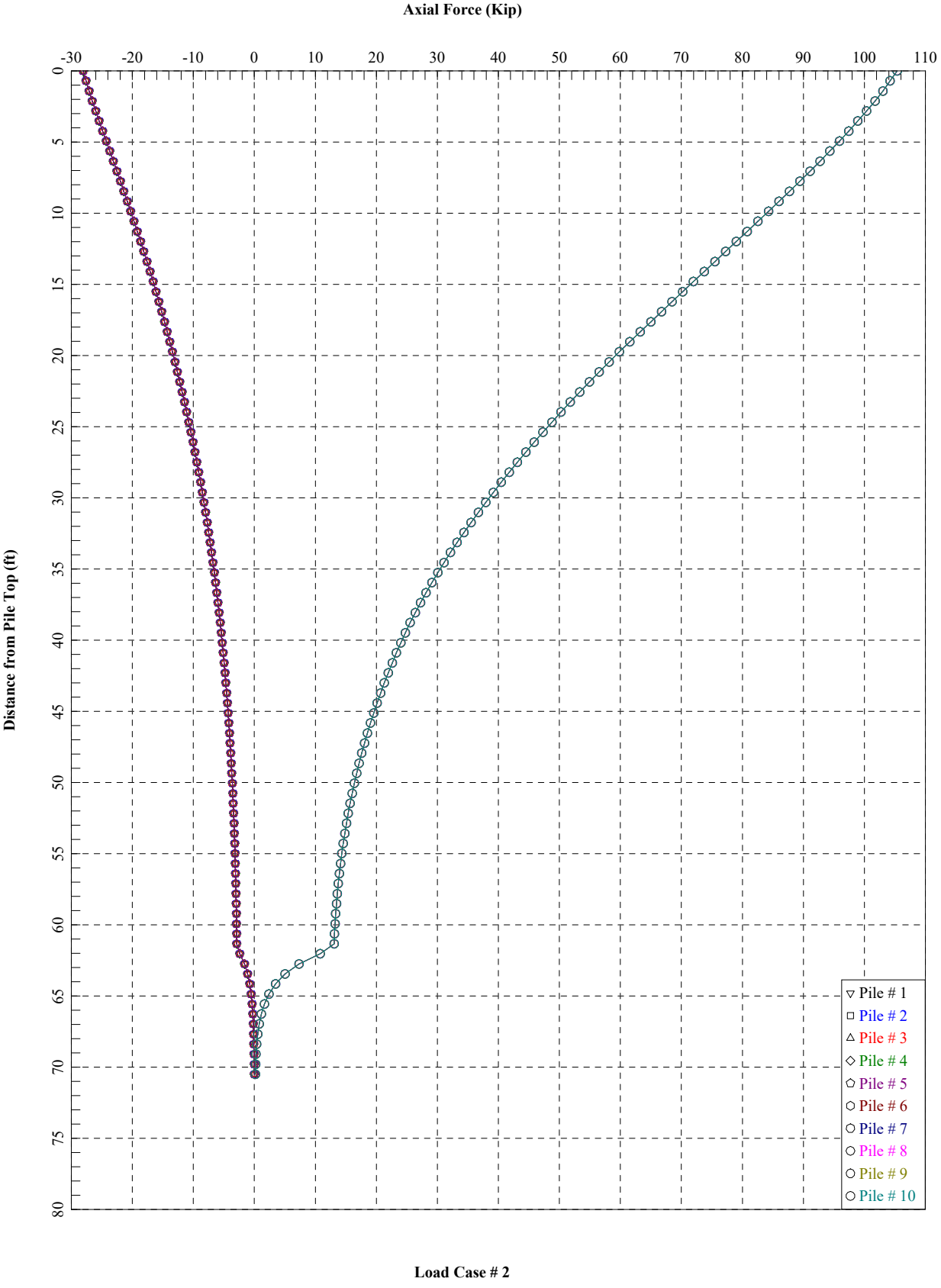
Load Case 1 = Service I



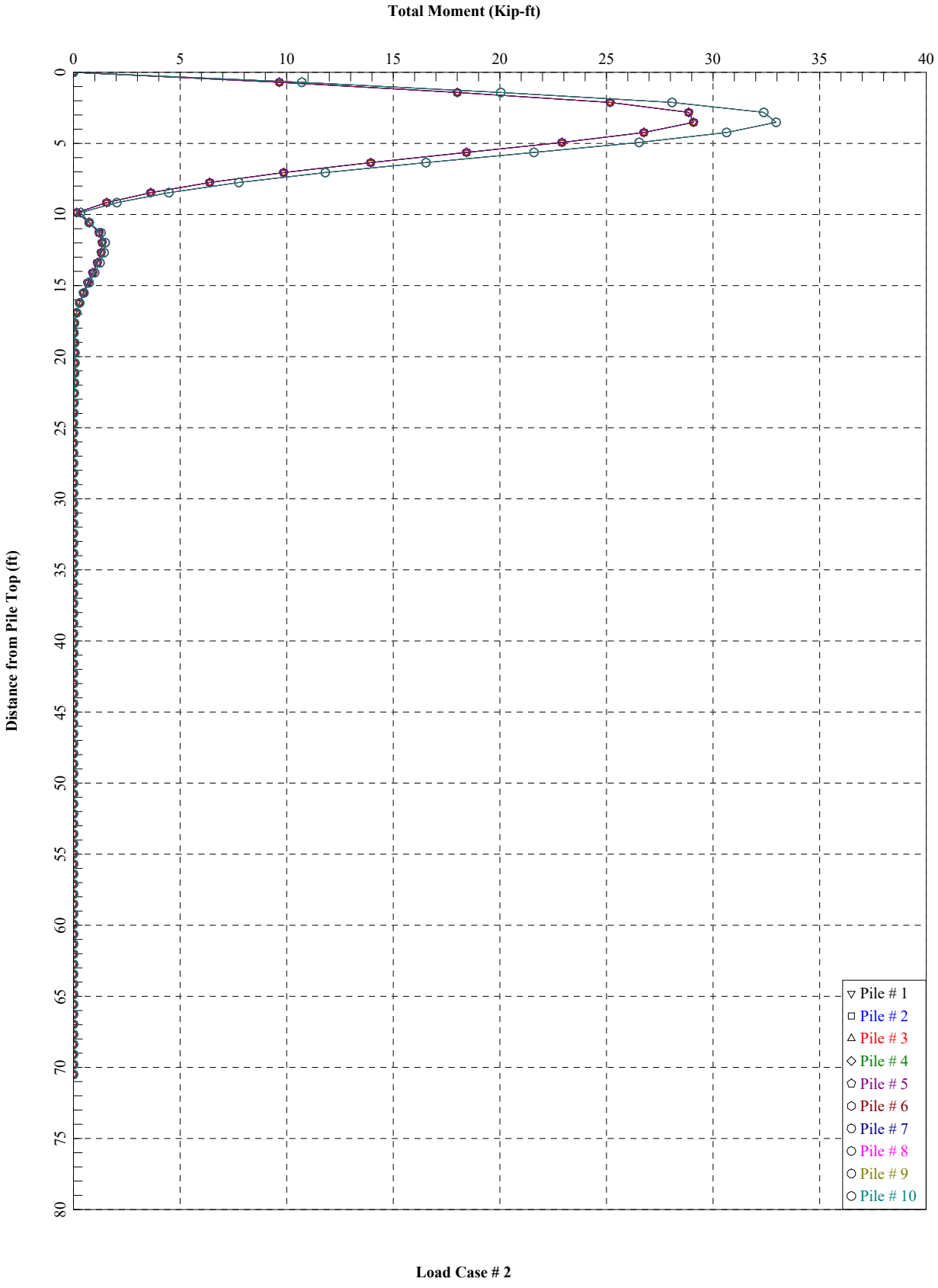
Load Case # 1

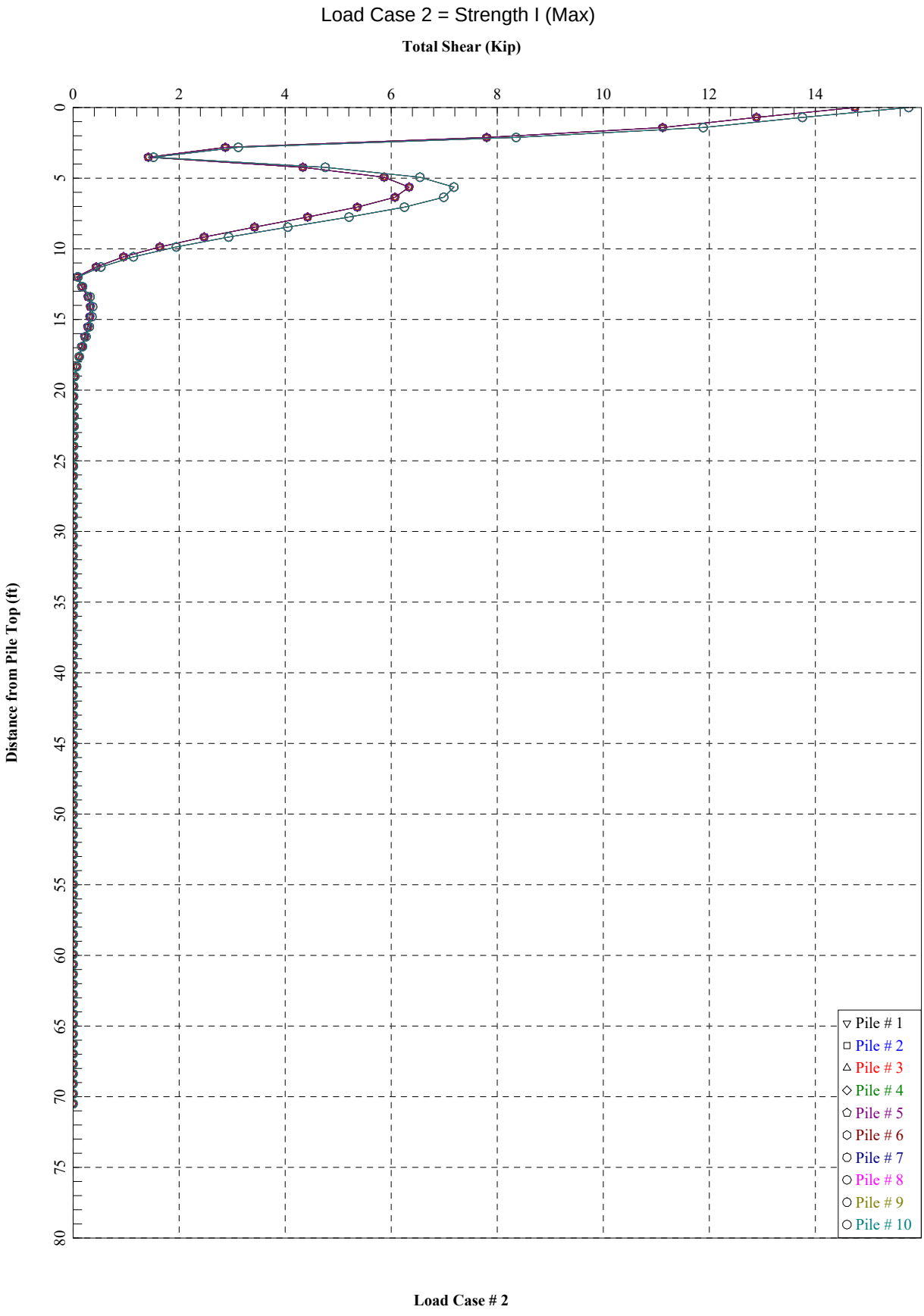

Load Case 2 = Strength I (Max)
Total Deflection (y,z) (in)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
0.22
Distance from Pile Top (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Load Case # 2

Load Case 2 = Strength I (Max)

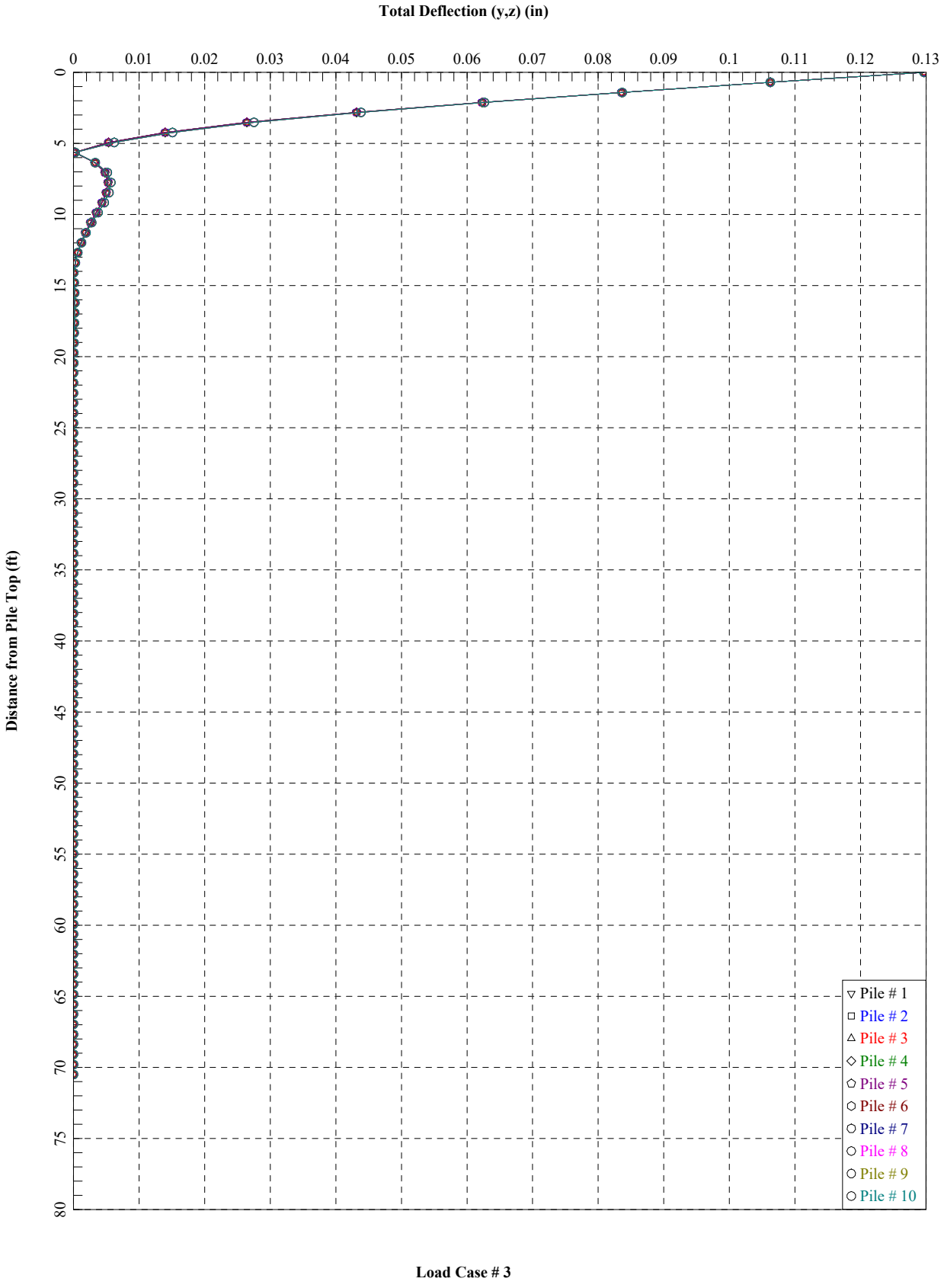


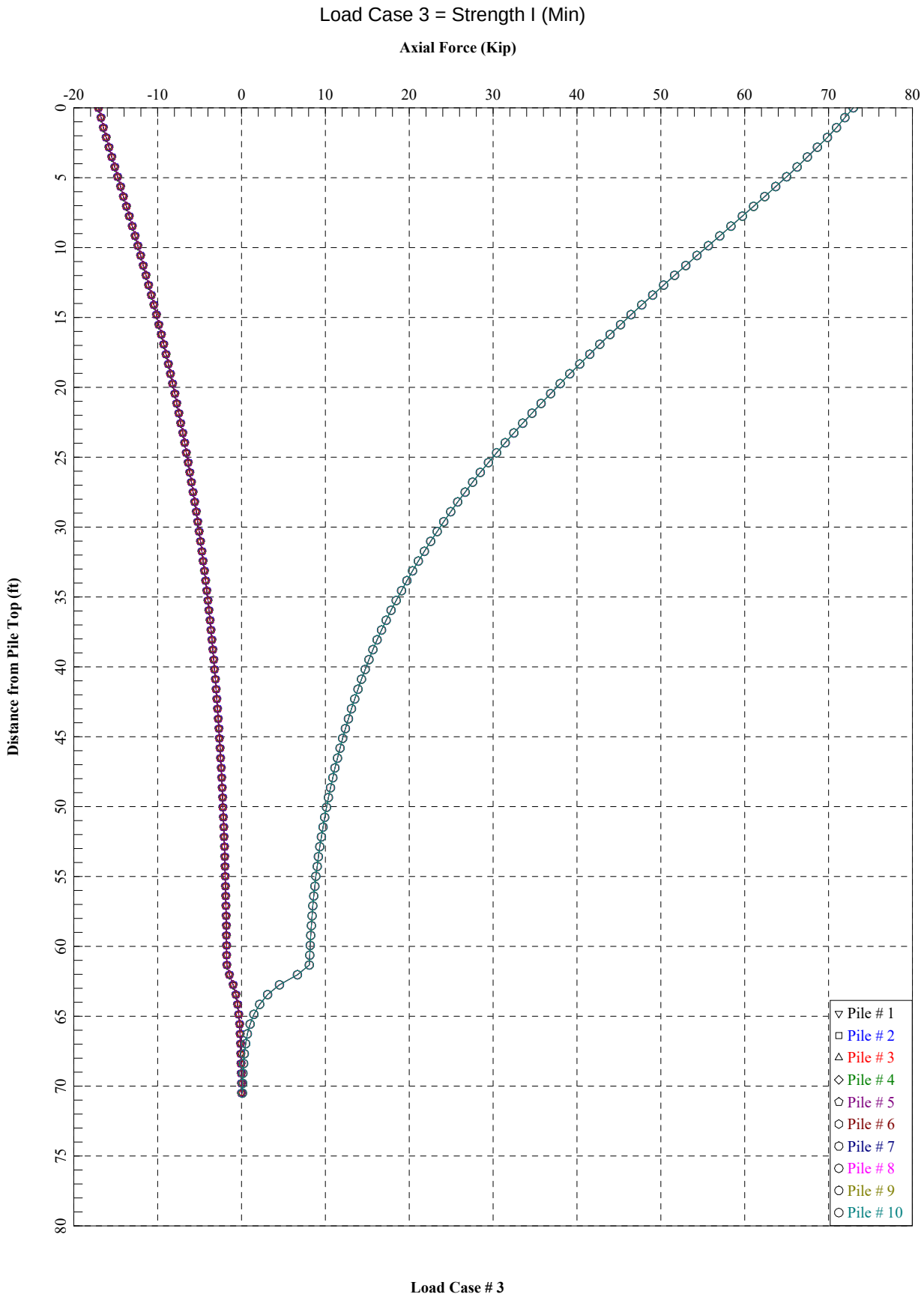
Load Case 2 = Strength I (Max)



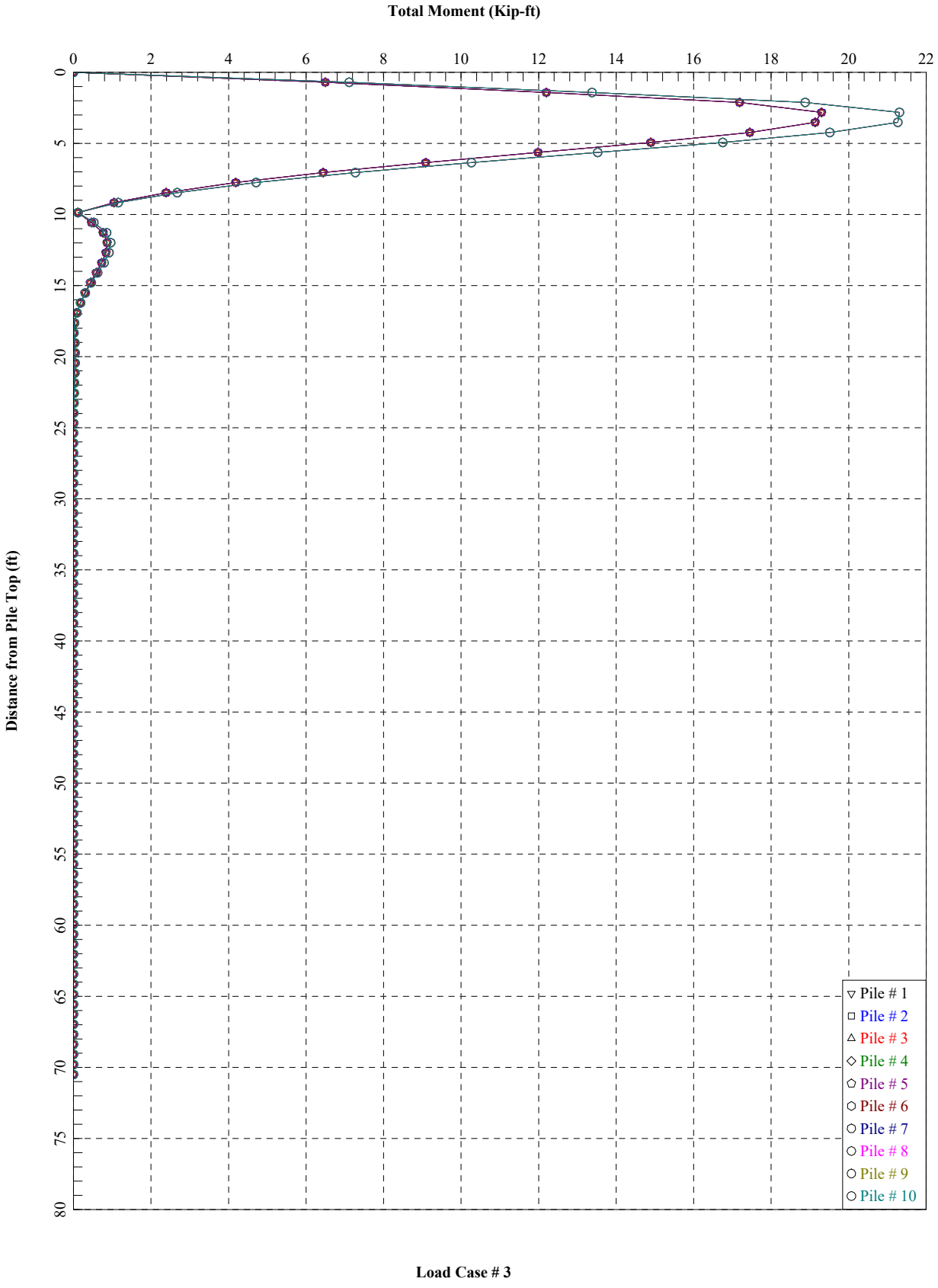

Load Case 2 = Strength I (Max)
Total Shear (Kip)
0
2
4
6
8
10
12
14
Distance from Pile Top (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Load Case # 2

Load Case 3 = Strength I (Min)

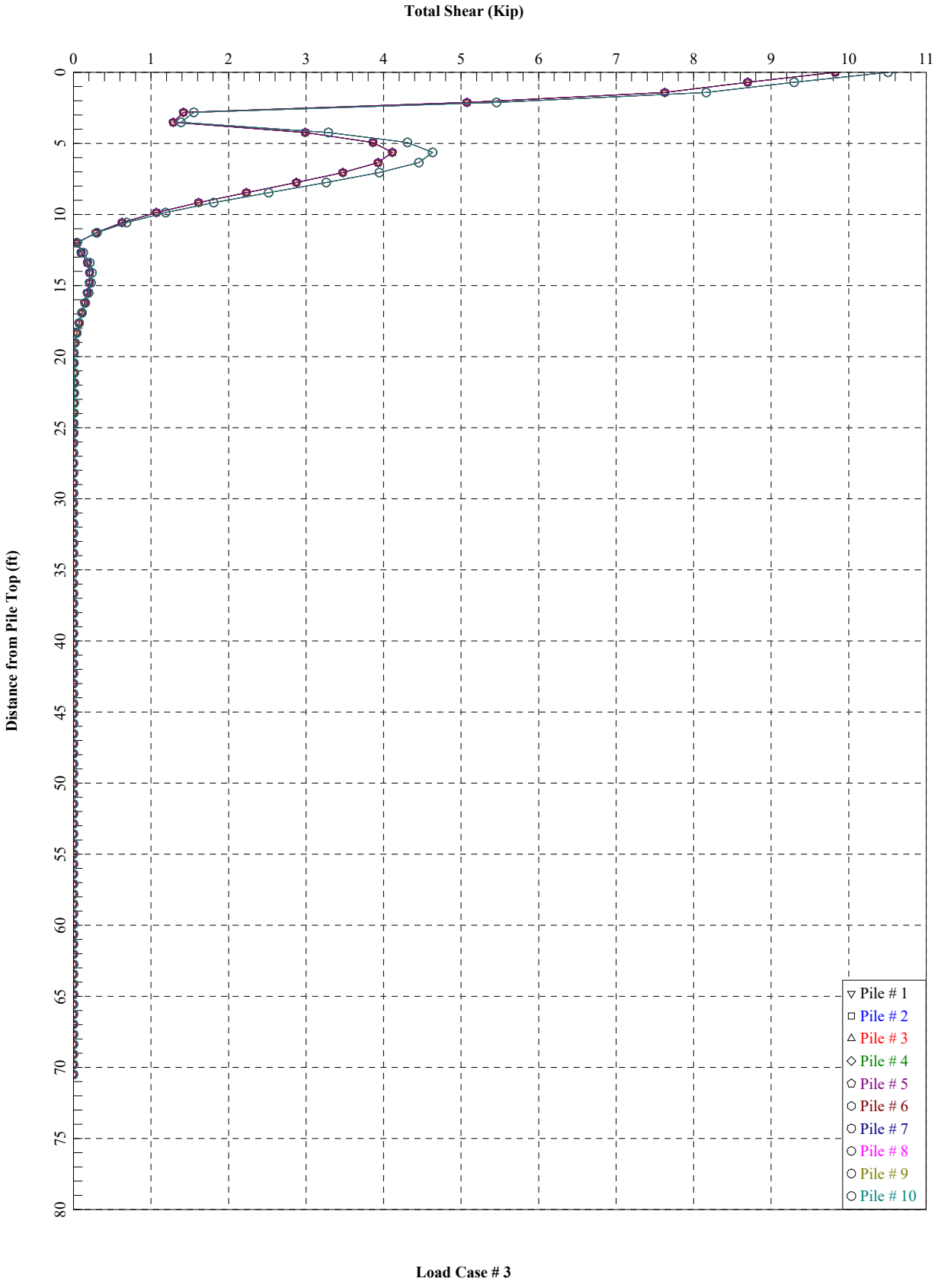



Load Case 3 = Strength I (Min)
Axial Force (Kip)
-20
-10
0
10
20
30
40
50
60
70
80
Distance from Pile Top (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Load Case # 3

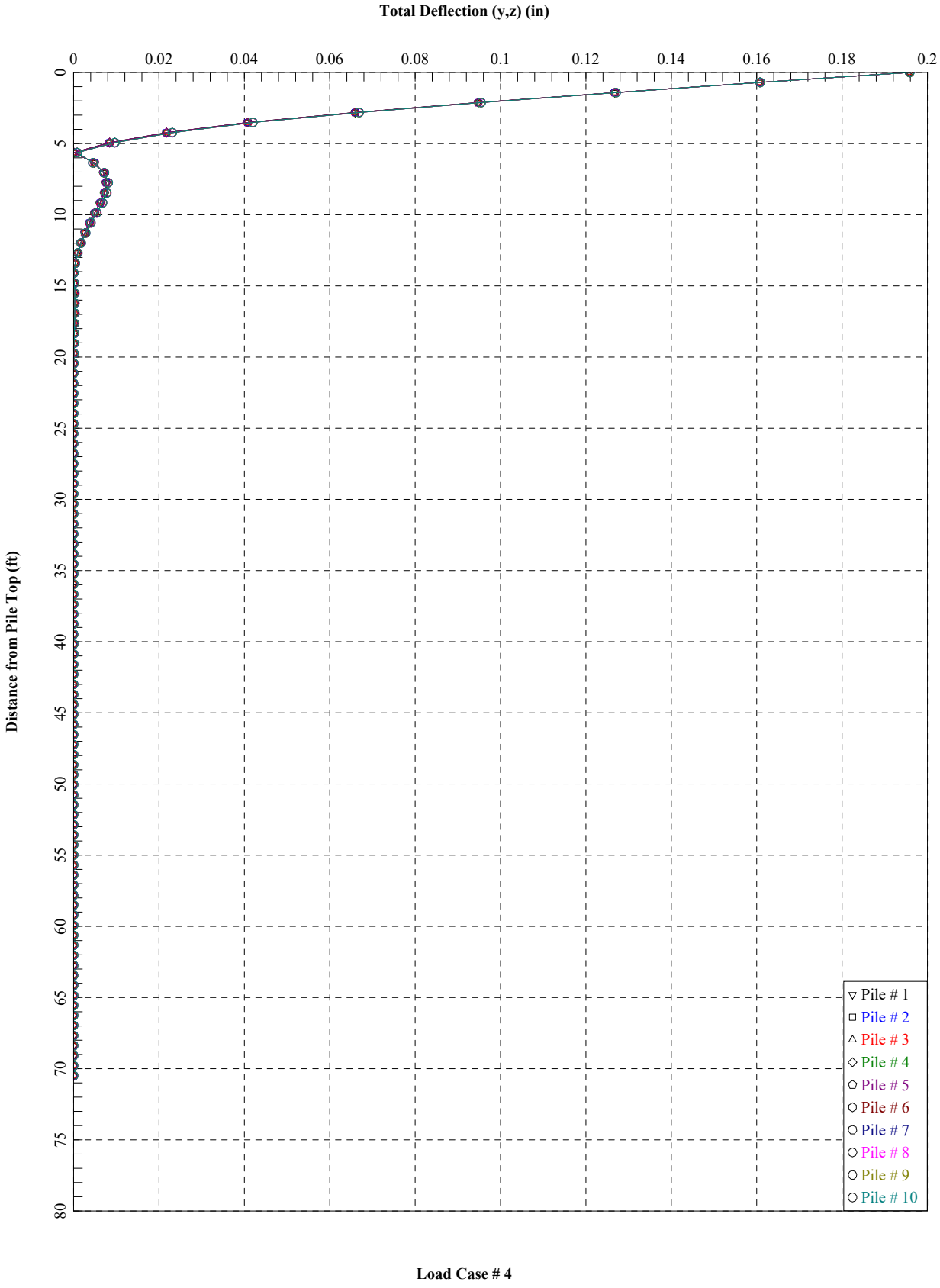
Load Case 3 = Strength I (Min)



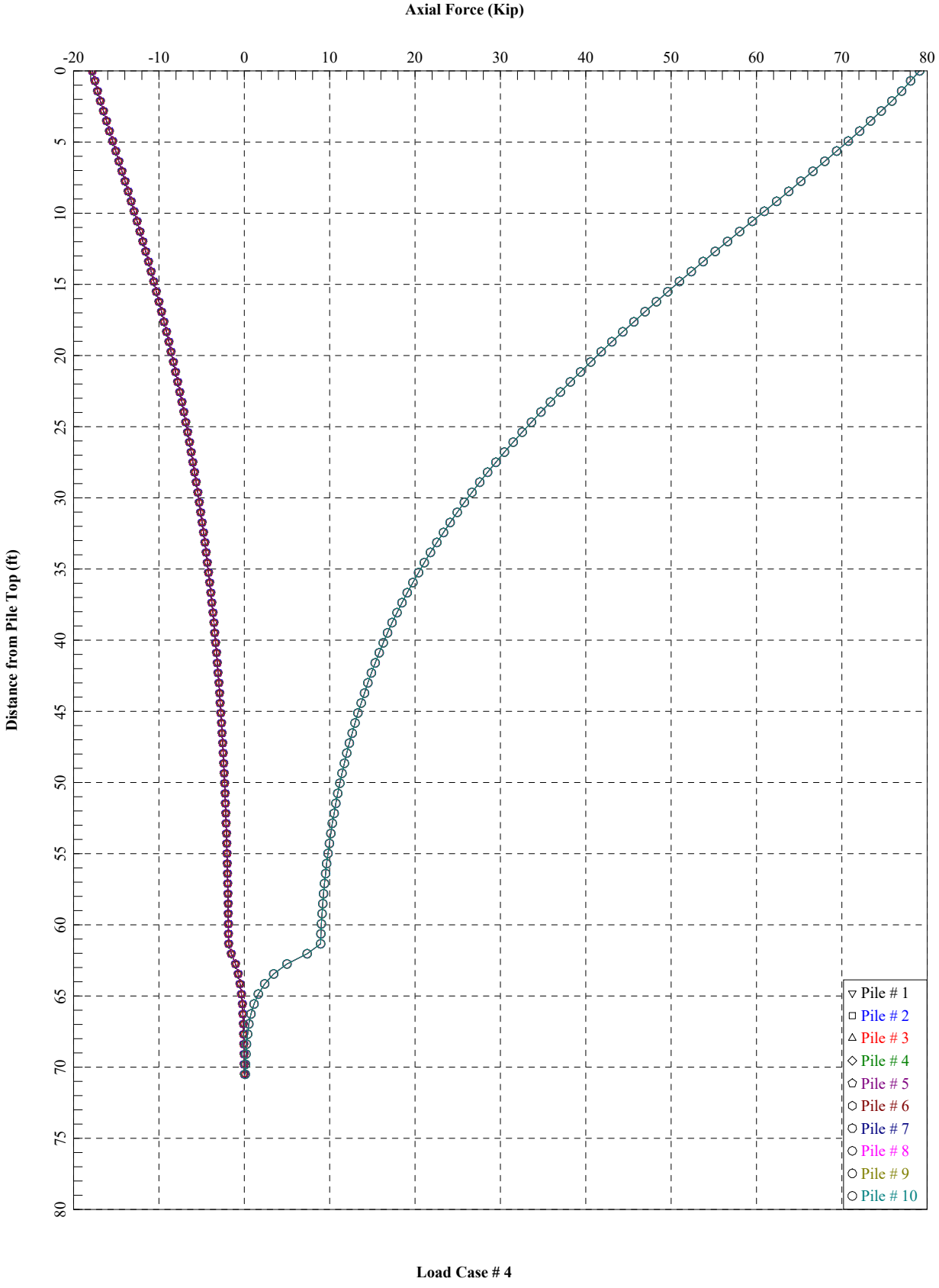
Load Case 3 = Strength I (Min)



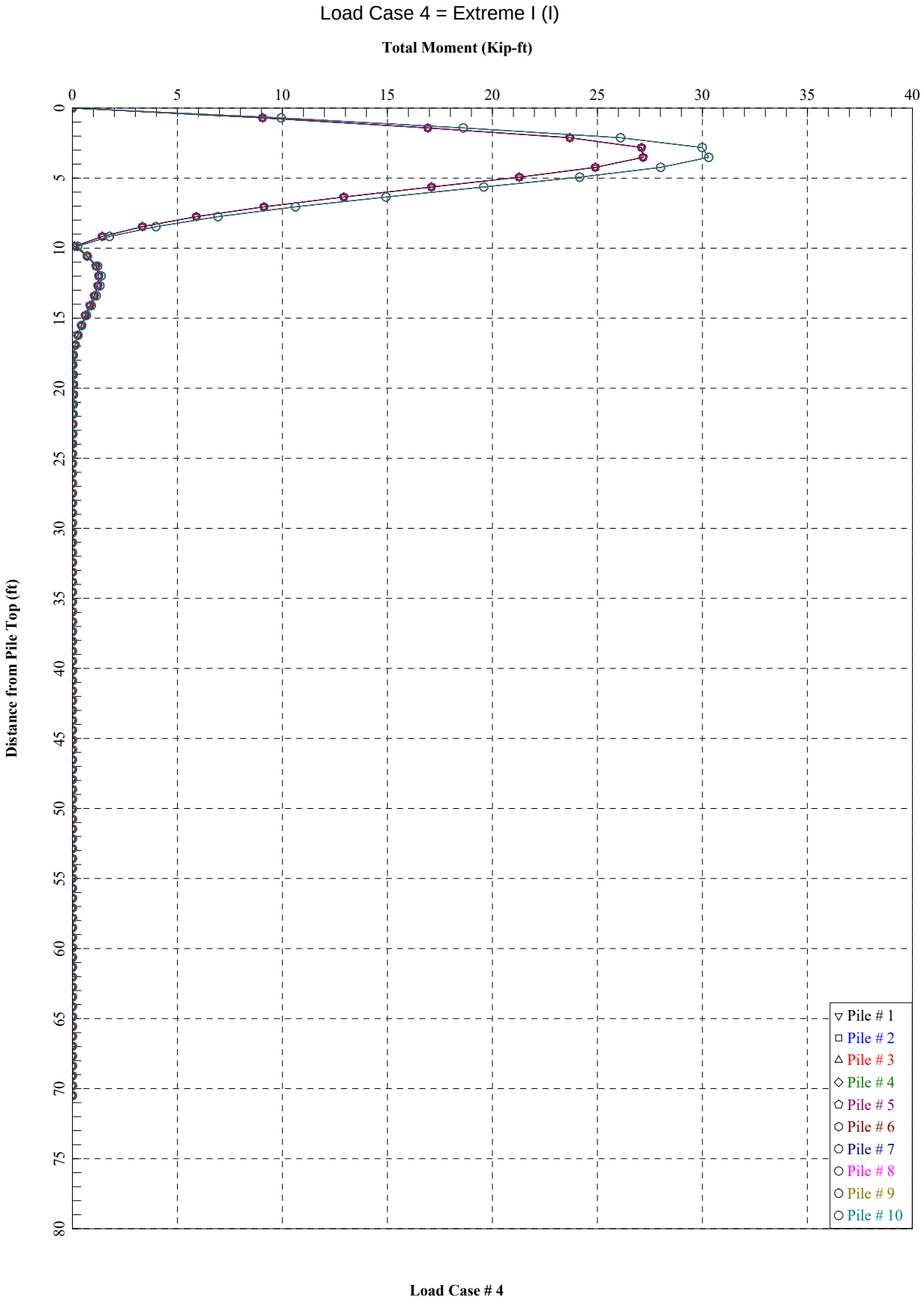
Load Case 4 = Extreme I (I)



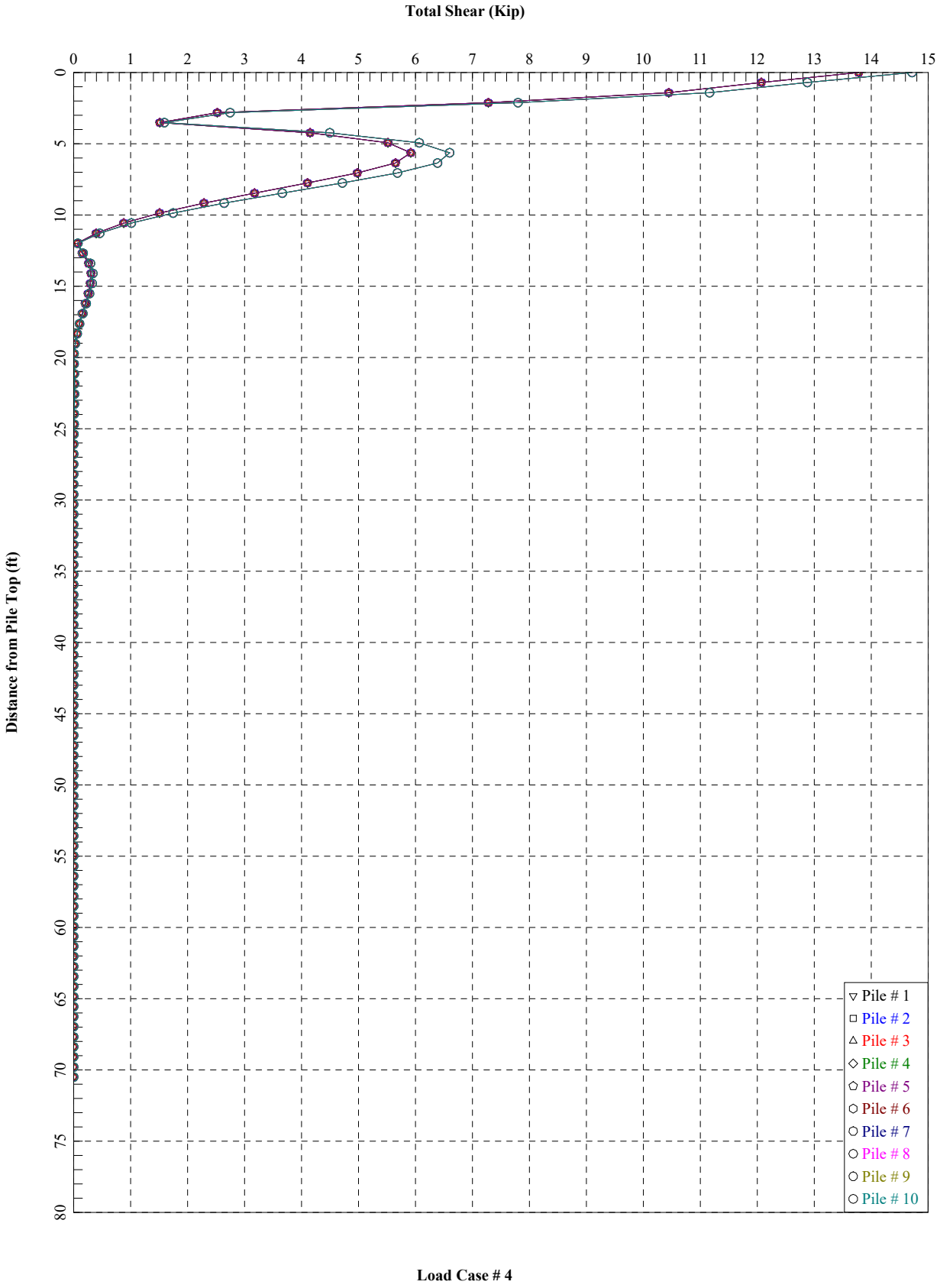
Load Case 4 = Extreme I (I)



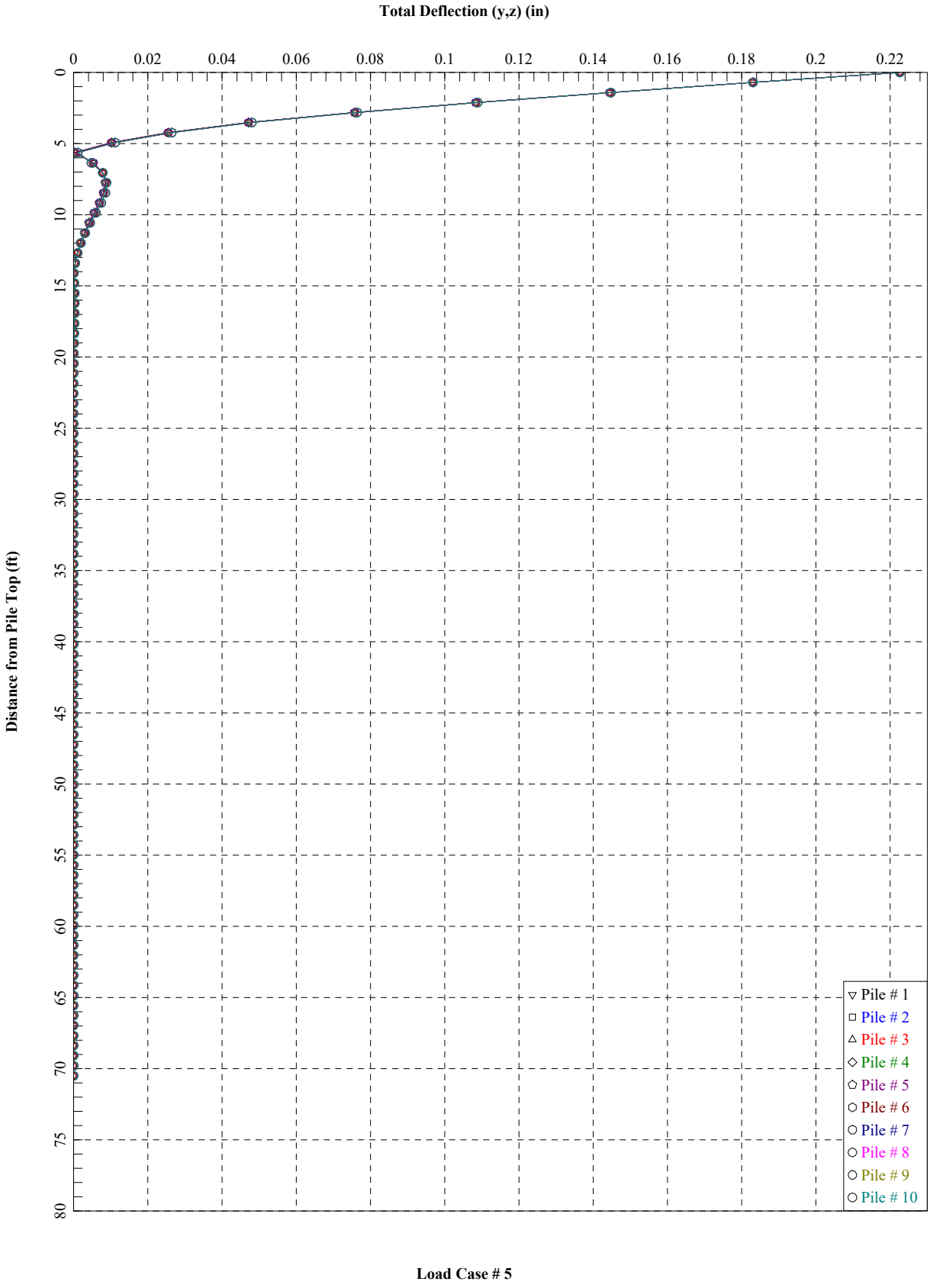
Load Case # 4

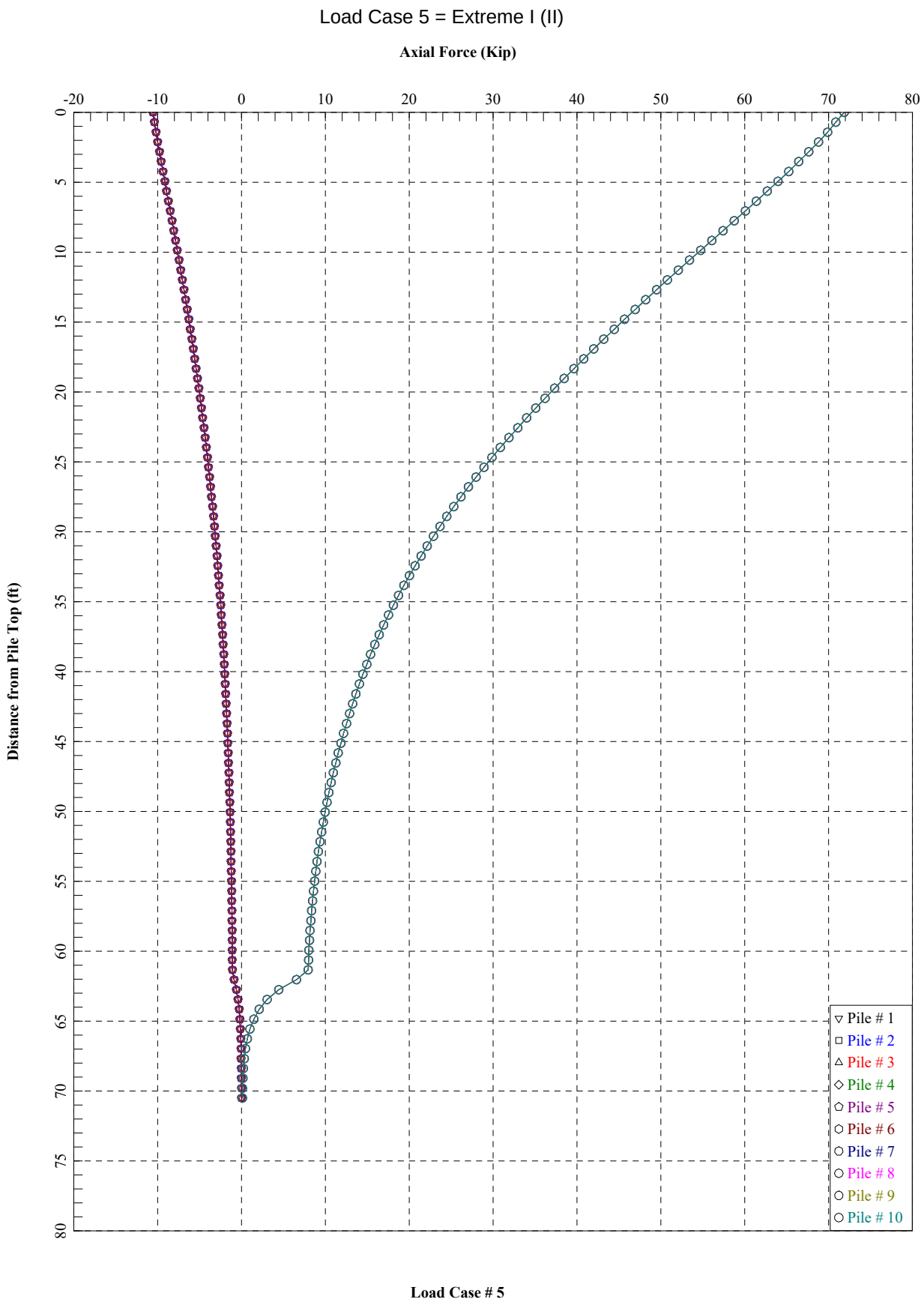

Load Case 4 = Extreme I (I)
Total Moment (Kip-ft)
0
5
10
15
20
25
30
35
40
Distance from Pile Top (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Load Case # 4

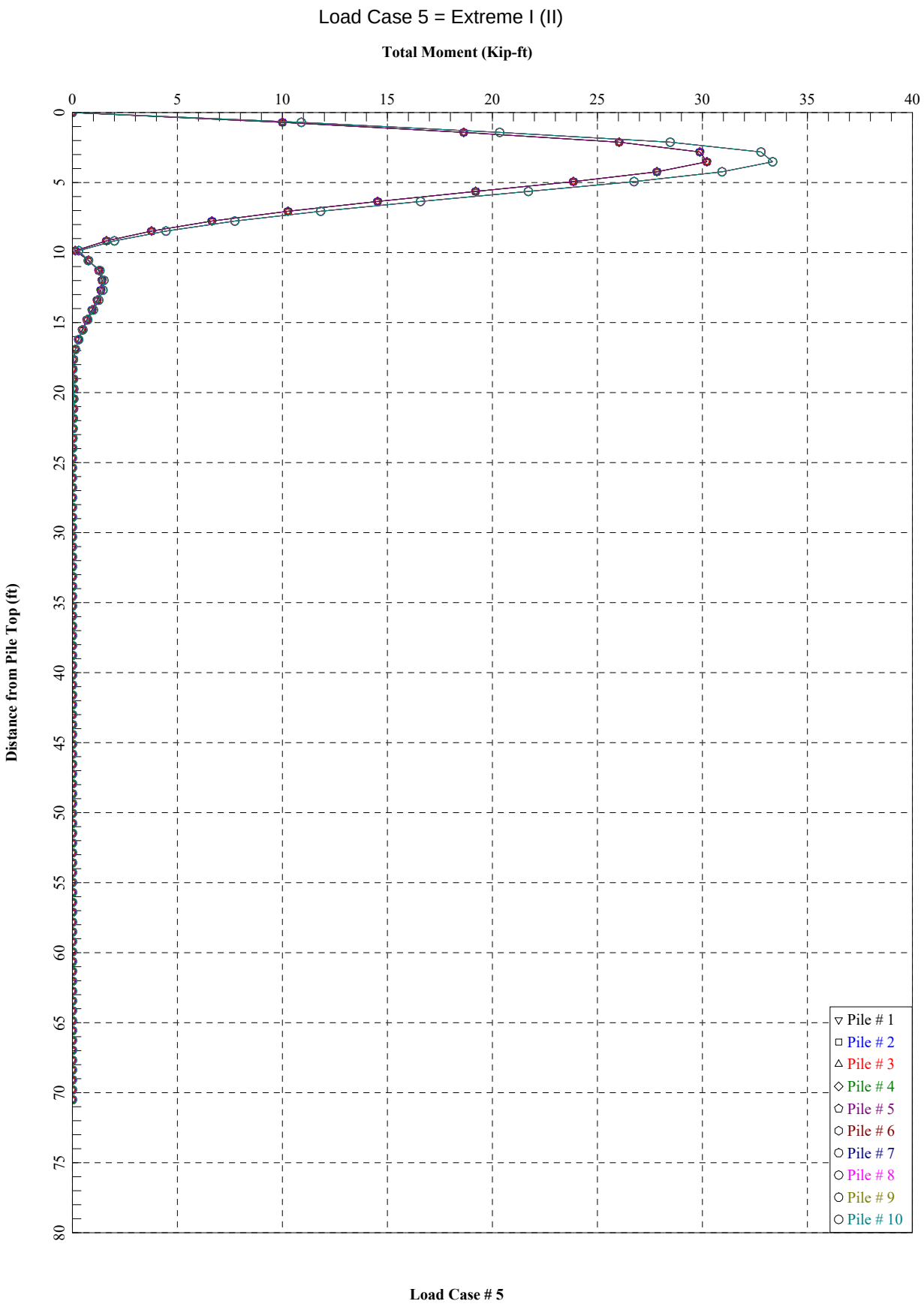
Load Case 4 = Extreme I (I)



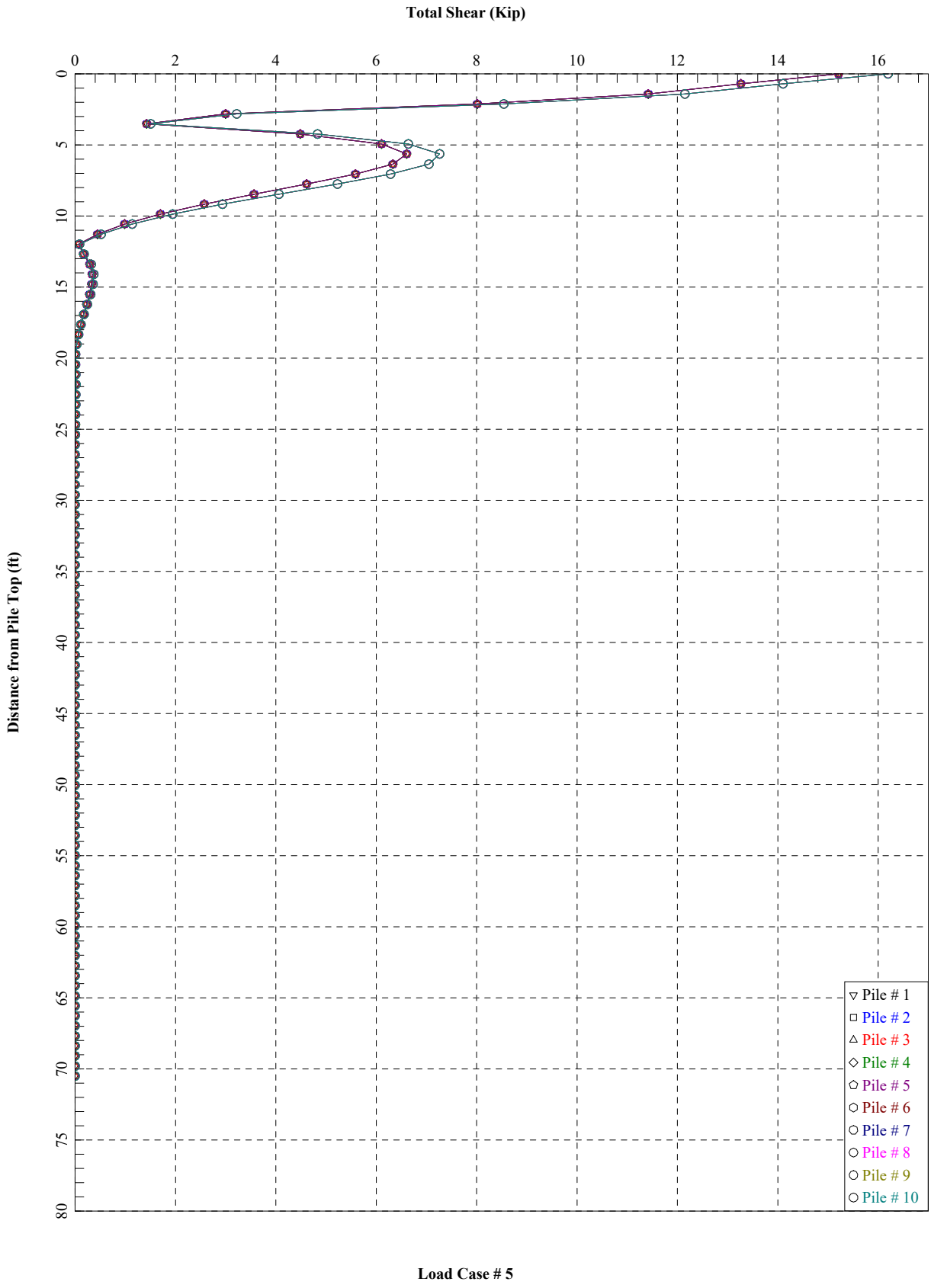
Load Case 5 = Extreme I (II)




Load Case 5 = Extreme I (II)
Axial Force (Kip)
-20
-10
0
10
20
30
40
50
60
70
80
Distance from Pile Top (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Load Case # 5


Load Case 5 = Extreme I (II)
Total Moment (Kip-ft)
0
5
10
15
20
25
30
35
40
Distance from Pile Top (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Pile # 8
Pile # 9
Pile # 10
Load Case # 5

Load Case 5 = Extreme I (II)



```
     ======================================================================

                    GROUP for Windows, Version 2022.12.4

                     Serial Number : 546958378

                     Analysis of A Group of Piles
                   Subjected to Axial and Lateral Loading

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     ======================================================================


     This program is licensed to :

     Nobis Engineering, Inc.
     Lowell, MA, USA

     Path to file locations      : J:\094184.100-MassDOT Armory Street Bridges, Springfield\Calculations\Axial-Lateral Pile Analysis\S-24-026\Updated North
and South Crash Walls\Group\
     Name of input data file     : North and South Crash Wall.gp12r
     Name of output echo file    : North and South Crash Wall.gp12e
     Name of output results file : North and South Crash Wall.gp12o
     Name of output summary file : North and South Crash Wall.gp12t
     Name of plot output file    : North and South Crash Wall.gp12p
     Name of runtime file        : North and South Crash Wall.gp12r


     ----------------------------------------------------------------------
                         Time and Date of Analysis
     ----------------------------------------------------------------------

               Date:  March 05, 2025     Time:  10:28:44




                *****     INPUT INFORMATION     *****


     Armory Street over Abandoned CSX Spur - S-24-026 - North and South Crash Wall

     ANALYSIS TYPE = 3D ANALYSIS

     ADJUST DEPTH FOR BATTER PILES

     GENERATE LOAD-DISP (AND T-R) CURVES BASED ON SOIL PROFILE

     EXTEND INTERPOLATION FOR L-DP (AND T-R) CURVES

     UNITS SYSTEM  = ENGL



     * TABLE B *  PILE CAP OPTIONS

     LENGTH,YY    ( FT ) =    8.500
     WIDTH, ZZ    ( FT ) =    20.50
     THICKNESS,XX ( FT ) =    2.500

     * PILE CAP DIMENSIONS ARE NOT CONSIDERED
       FOR THE PILE GROUP ANALYSIS




     * TABLE C *  LOAD AND CONTROL PARAMETERS


     ** LOAD CASES **


     NUMBER OF LOAD CASES :    5


     LOAD CASE    :     1
     CASE NAME    : Service I
     LOAD TYPE    : Dead, DL
     SCALE FACTOR :       1.0000

     * CONCENTRATED LOADS *

    NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
          LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
     1   3.06E+05  1.13E+05      0.00      0.00      0.00 -1.59E+07      0.00      0.00      0.00
```

```
 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           3.06480E+05       1.12960E+05           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
               0.00000           0.00000      -1.58572E+07


 * THE LOADING IS STATIC *


 * CONTROL PARAMETERS *
     TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
     TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-03 IN
     MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
     MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
     FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
     MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
     INCLUDE VARIATION OF AXIAL LOAD AT PILES
     * NOT FOR USER DEFINED LOAD SETTL. CURVE
     - PRINT RESULTS AT PILE CAP


 LOAD CASE    :     2
 CASE NAME    : Strength I Max
 LOAD TYPE    : Dead, DL
 SCALE FACTOR :       1.0000

 * CONCENTRATED LOADS *

NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
       LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
 1   3.87E+05  1.53E+05      0.00      0.00      0.00 -2.10E+07      0.00      0.00      0.00


 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           3.86630E+05       1.52520E+05           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
               0.00000           0.00000      -2.10182E+07


 * THE LOADING IS STATIC *


 * CONTROL PARAMETERS *
     TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
     TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-03 IN
     MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
     MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
     FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
     MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
     INCLUDE VARIATION OF AXIAL LOAD AT PILES
     * NOT FOR USER DEFINED LOAD SETTL. CURVE
     - PRINT RESULTS AT PILE CAP


 LOAD CASE    :     3
 CASE NAME    : Strength I Min
 LOAD TYPE    : Dead, DL
 SCALE FACTOR :       1.0000

 * CONCENTRATED LOADS *

NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
       LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
 1   2.79E+05  1.02E+05      0.00      0.00      0.00 -1.42E+07      0.00      0.00      0.00


 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           2.79420E+05       1.01680E+05           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
               0.00000           0.00000      -1.41745E+07


 * THE LOADING IS STATIC *


 * CONTROL PARAMETERS *
     TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
     TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-03 IN
     MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
     MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
     FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
     MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
```

```
    INCLUDE VARIATION OF AXIAL LOAD AT PILES
    * NOT FOR USER DEFINED LOAD SETTL. CURVE
    - PRINT RESULTS AT PILE CAP


 LOAD CASE    :     4
 CASE NAME    : Extreme Event I (I)
 LOAD TYPE    : Dead, DL
 SCALE FACTOR :       1.0000

 * CONCENTRATED LOADS *

NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
       LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
 1   3.06E+05  1.42E+05      0.00      0.00      0.00 -1.53E+07      0.00      0.00      0.00


 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           3.06480E+05       1.42480E+05           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
              0.00000           0.00000      -1.52644E+07


 * THE LOADING IS STATIC *


 * CONTROL PARAMETERS *
     TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
     TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-03 IN
     MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
     MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
     FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
     MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
     INCLUDE VARIATION OF AXIAL LOAD AT PILES
     * NOT FOR USER DEFINED LOAD SETTL. CURVE
     - PRINT RESULTS AT PILE CAP


 LOAD CASE    :     5
 CASE NAME    : Extreme Event I (II)
 LOAD TYPE    : Dead, DL
 SCALE FACTOR :       1.0000

 * CONCENTRATED LOADS *

NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
       LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
 1   3.06E+05  1.57E+05      0.00      0.00      0.00 -1.30E+07      0.00      0.00      0.00


 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           3.06480E+05       1.57030E+05           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
              0.00000           0.00000      -1.29815E+07


 * THE LOADING IS STATIC *


 * CONTROL PARAMETERS *
     TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
     TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-03 IN
     MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
     MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
     FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
     MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
     INCLUDE VARIATION OF AXIAL LOAD AT PILES
     * NOT FOR USER DEFINED LOAD SETTL. CURVE
     - PRINT RESULTS AT PILE CAP



 * TABLE D *   ARRANGEMENT OF PILE GROUPS

 GROUP  CONN.Z-Z   CONN.Y-Y   PILE PROP  P-Y CURVE  L-S CURVE  T-R CURVE  R-F-L SET
   1       PIN        PIN         1          0          1 G        1 G        0
   2       PIN        PIN         1          0          1 G        1 G        0
   3       PIN        PIN         1          0          1 G        1 G        0
   4       PIN        PIN         1          0          1 G        1 G        0
   5       PIN        PIN         1          0          1 G        1 G        0
   6       PIN        PIN         1          0          1 G        1 G        0
   7       PIN        PIN         1          0          1 G        1 G        0
   8       PIN        PIN         1          0          1 G        1 G        0
   9       PIN        PIN         1          0          1 G        1 G        0
  10       PIN        PIN         1          0          1 G        1 G        0
```

GROUP	CorX,FT	CorY,FT	CorZ,FT	ALPHA,DEG	BETA,DEG	THETA,DEG	GROUND,FT	SPz,LBS-IN	SPy,LBS-IN
1	0.000	-2.625	8.750	0.000	90.00	0.000	-4.000	0.000	0.000
2	0.000	-2.625	4.375	0.000	90.00	0.000	-4.000	0.000	0.000
3	0.000	-2.625	0.000	0.000	90.00	0.000	-4.000	0.000	0.000
4	0.000	-2.625	-4.375	0.000	90.00	0.000	-4.000	0.000	0.000
5	0.000	-2.625	-8.750	0.000	90.00	0.000	-4.000	0.000	0.000
6	0.000	2.625	8.750	0.000	90.00	0.000	-4.000	0.000	0.000
7	0.000	2.625	4.375	0.000	90.00	0.000	-4.000	0.000	0.000
8	0.000	2.625	0.000	0.000	90.00	0.000	-4.000	0.000	0.000
9	0.000	2.625	-4.375	0.000	90.00	0.000	-4.000	0.000	0.000
10	0.000	2.625	-8.750	0.000	90.00	0.000	-4.000	0.000	0.000

* TABLE E * PILE GEOMETRY AND PROPERTIES
PILE TYPE = 1 - DRIVEN PILE
= 2 - DRILLED SHAFT

PROP	SECTS	INC	PILE TYPE	LENGTH, FT
1	3	100	2	70.500

* PILE SECTIONS *

PROP	SECT	FROM,FT	TO,FT	CROSS SECT
1	1	0.00000	3.00000	1
1	2	3.00000	62.5000	2
1	3	62.5000	70.5000	3

* PILE CROSS SECTIONS *

CROSS SECTION : 1
SECTION NAME : 10.75"
TYPE : NONLINEAR
CROSS SECTION TYPE : ROUND CONC. SHAFT, CASING (AND STEEL SECTION)
CONCRETE DIAMETER : 9.75000 IN
CONCRETE FC : 5000.00 LBS/IN**2
DIAMETER CASING : 10.6250 IN
THICKNESS CASING : 0.43750 IN
ES CASING : 2.90000E+07 LBS/IN**2
FY CASING : 52000.0 LBS/IN**2
EMBEDDED STEEL SECT : NONE
NUMBER REBARS : 1
ES REINFORCEMENT : 2.90000E+07 LBS/IN**2
FY REINFORCEMENT : 60000.0 LBS/IN**2
REINF. LAYOUT : MANUAL
REINF. A , D, COORDS: IN^2 IN IN IN
- REBAR 1 : 0.79000 1.00000 0.00000 0.00000
EQ. YOUNG MODULUS : 9.96202E+06 LBS/IN**2

CROSS SECTION : 2
SECTION NAME : 10.75"
TYPE : NONLINEAR
CROSS SECTION TYPE : ROUND CONC. SHAFT, CASING (AND STEEL SECTION)
CONCRETE DIAMETER : 9.75000 IN
CONCRETE FC : 5000.00 LBS/IN**2
DIAMETER CASING : 10.2500 IN
THICKNESS CASING : 0.25000 IN
ES CASING : 2.90000E+07 LBS/IN**2
FY CASING : 52000.0 LBS/IN**2
EMBEDDED STEEL SECT : NONE
NUMBER REBARS : 1
ES REINFORCEMENT : 2.90000E+07 LBS/IN**2
FY REINFORCEMENT : 60000.0 LBS/IN**2
REINF. LAYOUT : MANUAL
REINF. A , D, COORDS: IN^2 IN IN IN
- REBAR 1 : 0.79000 1.00000 0.00000 0.00000
EQ. YOUNG MODULUS : 8.54351E+06 LBS/IN**2

CROSS SECTION : 3
SECTION NAME : 9.75"
TYPE : NONLINEAR
CROSS SECTION TYPE : ROUND CONCRETE SHAFT
EXTERNAL DIAMETER : 9.75000 IN
CONCRETE FC : 5000.00 LBS/IN**2
NUMBER REBARS : 1
ES REINFORCEMENT : 2.90000E+07 LBS/IN**2
FY REINFORCEMENT : 60000.0 LBS/IN**2
REINF. LAYOUT : MANUAL
REINF. A , D, COORDS: IN^2 IN IN IN
- REBAR 1 : 1.00000 1.12800 0.00000 0.00000
EQ. YOUNG MODULUS : 6.39161E+06 LBS/IN**2

* PILE CROSS SECTIONS PROPERTIES *

NONLINEAR SECTIONS

SECT	DIAM,IN	PERIM,IN	AREA,IN**2	Iz,IN**4	Iy,IN**4	GJ,LBS-IN**2	EIz IND	EIy IND	Mn,LBS-IN	Vn,LBS
1	10.625	33.379	88.664	0.0000	0.0000	5.4901E+09	0	0	0.0000	0.0000
2	10.250	32.201	82.516	0.0000	0.0000	3.6218E+09	0	0	0.0000	0.0000
3	9.7500	30.631	74.662	0.0000	0.0000	1.4303E+09	0	0	0.0000	0.0000

* TABLE F * SOIL DATA

SOILS INFORMATION

GROUND SURFACE = -4.00000 FT

7 LAYER(S) OF SOIL

LAYER 1
THE SOIL IS A SAND

		TOP OF LAYER	BOTTOM OF LAYER
X COORDINATE	(FT)	-4.00000	0.00000
EFFECTIVE UNIT WEIGHT	(LBS/FT**3)	115.000	115.000
FRICTION ANGLE	(DEGREES)	33.0000	33.0000
P-Y SUBGRADE MODULUS	(LBS/IN**3)	25.0000	25.0000
ULTIMATE UNIT SIDE FRICTION	(LBS/FT**2)	11.5000 (S)	552.000 (S)
ULTIMATE UNIT TIP RESISTANCE	(LBS/FT**2)	0.00000	0.00000

LAYER 2
THE SOIL IS A SAND

		TOP OF LAYER	BOTTOM OF LAYER
X COORDINATE	(FT)	0.00000	1.50000
EFFECTIVE UNIT WEIGHT	(LBS/FT**3)	115.000	115.000
FRICTION ANGLE	(DEGREES)	33.0000	33.0000
P-Y SUBGRADE MODULUS	(LBS/IN**3)	25.0000	25.0000
ULTIMATE UNIT SIDE FRICTION	(LBS/FT**2)	552.000 (S)	748.499 (S)
ULTIMATE UNIT TIP RESISTANCE	(LBS/FT**2)	0.00000	0.00000

LAYER 3
THE SOIL IS A SILT

		TOP OF LAYER	BOTTOM OF LAYER
X COORDINATE	(FT)	1.50000	38.5000
EFFECTIVE UNIT WEIGHT	(LBS/FT**3)	57.6000	57.6000
UNDRAINED COHESION, C	(LBS/FT**2)	130.000	130.000
FRICTION ANGLE	(DEGREES)	22.0000	22.0000
P-Y SUBGRADE MODULUS	(LBS/IN**3)	100.000	100.000
STRAIN AT 50% STRESS		1.00000E-02	1.00000E-02
ULTIMATE UNIT SIDE FRICTION	(LBS/FT**2)	819.999 (S)	1784.74 (S)
ULTIMATE UNIT TIP RESISTANCE	(LBS/FT**2)	0.00000	0.00000

LAYER 4
THE SOIL IS A SAND

		TOP OF LAYER	BOTTOM OF LAYER
X COORDINATE	(FT)	38.5000	50.0000
EFFECTIVE UNIT WEIGHT	(LBS/FT**3)	57.6000	57.6000
FRICTION ANGLE	(DEGREES)	26.0000	26.0000
P-Y SUBGRADE MODULUS	(LBS/IN**3)	50.0000	50.0000
ULTIMATE UNIT SIDE FRICTION	(LBS/FT**2)	1713.24 (S)	1740.31 (S)
ULTIMATE UNIT TIP RESISTANCE	(LBS/FT**2)	0.00000	0.00000

LAYER 5
THE SOIL IS A SAND

		TOP OF LAYER	BOTTOM OF LAYER
X COORDINATE	(FT)	50.0000	57.1000
EFFECTIVE UNIT WEIGHT	(LBS/FT**3)	72.6000	72.6000
FRICTION ANGLE	(DEGREES)	37.0000	37.0000
P-Y SUBGRADE MODULUS	(LBS/IN**3)	125.000	125.000
ULTIMATE UNIT SIDE FRICTION	(LBS/FT**2)	1740.31 (S)	1753.02 (S)
ULTIMATE UNIT TIP RESISTANCE	(LBS/FT**2)	0.00000	0.00000

LAYER 6
THE SOIL IS A SAND

		TOP OF LAYER	BOTTOM OF LAYER
X COORDINATE	(FT)	57.1000	61.5000
EFFECTIVE UNIT WEIGHT	(LBS/FT**3)	87.6000	87.6000
FRICTION ANGLE	(DEGREES)	38.0000	38.0000
P-Y SUBGRADE MODULUS	(LBS/IN**3)	150.000	150.000
ULTIMATE UNIT SIDE FRICTION	(LBS/FT**2)	1753.02 (S)	1762.89 (S)
ULTIMATE UNIT TIP RESISTANCE	(LBS/FT**2)	0.00000	0.00000

LAYER 7
THE LAYER IS A VUGGY LIMESTONE

		TOP OF LAYER	BOTTOM OF LAYER
X COORDINATE	(FT)	61.5000	100.000
EFFECTIVE UNIT WEIGHT	(LBS/FT**3)	101.600	101.600
UNIAXIAL COMPRESSIVE STRENGTH	(LBS/IN**2)	7500.00	7500.00
ULTIMATE UNIT SIDE FRICTION	(LBS/FT**2)	1.08000E+05 (S)	1.08000E+05 (S)
ULTIMATE UNIT TIP RESISTANCE	(LBS/FT**2)	9.72000E+06 (T)	9.72000E+06 (T)

Notes : Program estimated values for listed parameters
if zero input values were entered:
(S) ULTIMATE UNIT SIDE FRICTION for Drilled Shafts
(T) ULTIMATE UNIT TIP RESISTANCE for Drilled Shafts

* TABLE H * AXIAL LOAD VS DISPLACEMENT

AXIAL LOAD-DISPLACEMENT CURVES GENERATED INTERNALLY

NUM OF CURVES 1

CURVE 1 NUM OF POINTS 19

DISPLACEMENT, IN	AXIAL LOAD,LBS
-4.47781	-2.29852E+06
-3.48249	-2.30239E+06
-3.07712	-2.38481E+06
-2.79698	-2.48781E+06
-2.77134	-2.50968E+06
-2.40201	-2.24203E+06
-2.08922	-1.98734E+06
-1.25755	-1.27359E+06
-0.28826	-3.86639E+05
0.00000	0.00000
0.56698	6.47837E+05
1.76378	1.71387E+06
2.62722	2.42637E+06
3.05599	2.76697E+06
5.04669	4.31824E+06
6.11881	5.13074E+06
9.09726	7.18168E+06
9.71908	7.27817E+06
10.9169	7.43603E+06

DISPL. TIP , IN	AXIAL TIP ,LBS
-2.00000	-6.88103
-1.00000	-6.66926
-0.50000	-6.50779
-0.10000	-3.64897
-0.0500000	-2.50941
-1.00000E-02	-0.50188
-5.00000E-03	-0.25094
-1.00000E-03	-0.0501882
-1.00000E-04	-5.01882E-03
0.00000	0.00000
1.00000E-04	3747.15
1.00000E-03	37471.5
5.00000E-03	1.87357E+05
1.00000E-02	3.74715E+05
0.0500000	1.87357E+06
0.10000	2.72439E+06
0.50000	4.85884E+06
1.00000	4.97940E+06
2.00000	5.13751E+06

* TABLE I * TORS. MOM. VS ANGLE ROT.

TORQUE-ROTATION CURVES GENERATED INTERNALLY

NUM OF CURVES 1

CURVE 1 NUM OF POINTS 19

ROT. ANGLE,Rad.	TORS.MOMEN,LBS-IN
-3.05145	-1.22081E+07
-2.86503	-1.22150E+07
-2.81455	-1.23859E+07
-2.80693	-1.26545E+07
-2.81074	-1.27075E+07
-2.69947	-1.23252E+07
-2.56926	-1.18405E+07
-2.28499	-1.07643E+07
-1.78245	-8.77858E+06
0.00000	0.00000
1.78245	8.77858E+06
2.28499	1.07643E+07
2.56926	1.18405E+07
2.69947	1.23252E+07
2.81074	1.27075E+07
2.80693	1.26545E+07
2.81455	1.23859E+07
2.86503	1.22150E+07
3.05145	1.22081E+07

* TABLE K * REDUCTION FACTORS

AVERAGE DIAMETER IS USED TO GET RATIO S/B

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS ALONG Y-DIRECTION
ESTIMATED ASSUMING MOVEMENT IN THE DIRECTION OF Y-FORCE (+)

GROUP NO	P-FACTOR	Y-FACTOR
1	0.9440	1.0000

2	0.9440	1.0000
3	0.9440	1.0000
4	0.9440	1.0000
5	0.9440	1.0000
6	1.0000	1.0000
7	1.0000	1.0000
8	1.0000	1.0000
9	1.0000	1.0000
10	1.0000	1.0000

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS ALONG Z-DIRECTION
ESTIMATED ASSUMING MOVEMENT IN THE DIRECTION OF Z-FORCE (+)

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	0.8808	1.0000
3	0.8808	1.0000
4	0.8808	1.0000
5	0.8808	1.0000
6	1.0000	1.0000
7	0.8808	1.0000
8	0.8808	1.0000
9	0.8808	1.0000
10	0.8808	1.0000

```
     ======================================================================

                    GROUP for Windows, Version 2022.12.4

                     Serial Number : 546958378

                     Analysis of A Group of Piles
                   Subjected to Axial and Lateral Loading

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     ======================================================================


     This program is licensed to :

     Nobis Engineering, Inc.
     Lowell, MA, USA

     Path to file locations      : J:\094184.100-MassDOT Armory Street Bridges, Springfield\Calculations\Axial-Lateral Pile Analysis\S-24-026\Updated North
and South Crash Walls\Group\
     Name of input data file     : North and South Crash Wall.gp12d
     Name of output echo file    : North and South Crash Wall.gp12e
     Name of output results file : North and South Crash Wall.gp12o
     Name of output summary file : North and South Crash Wall.gp12t
     Name of plot output file    : North and South Crash Wall.gp12p
     Name of runtime file        : North and South Crash Wall.gp12r


     ----------------------------------------------------------------------
                         Time and Date of Analysis
     ----------------------------------------------------------------------

               Date:  March 05, 2025     Time:  10:28:44



                *****     COMPUTATION RESULTS     *****


     Armory Street over Abandoned CSX Spur - S-24-026 - North and South Crash Wall



                *****     LOAD CASES RESULTS      *****


     LOAD CASE :     1
     CASE NAME : Service I
     LOAD TYPE : Dead, DL

       REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
       ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

            GROUP NO     P-FACTOR     Y-FACTOR

                1           0.9440       1.0000
                2           0.9440       1.0000
                3           0.9440       1.0000
                4           0.9440       1.0000
                5           0.9440       1.0000
                6           1.0000       1.0000
                7           1.0000       1.0000
                8           1.0000       1.0000
                9           1.0000       1.0000
               10           1.0000       1.0000


     * TABLE L *   COMPUTATION ON PILE CAP


     * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *


          VERT. LOAD, LBS    HOR. LOAD Y, LBS   HOR. LOAD Z, LBS
            3.06480E+05        1.12960E+05           0.00000

         MOMENT X ,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
                0.00000            0.00000       -1.58572E+07


     * DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *


           VERTICAL ,IN      HORIZONTAL Y,IN     HORIZONTAL Z,IN
```

```
          0.0134075            0.14718        3.34730E-18

     ANGLE ROT. X,RAD    ANGLE ROT. Y,RAD    ANGLE ROT. Z,RAD
       -2.57837E-17        8.57022E-21       -6.74127E-04


     NUMBER OF GLOBAL ITERATIONS =    4


LOAD CASE :     2
CASE NAME : Strength I Max
LOAD TYPE : Dead, DL

  REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
  ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

       GROUP NO     P-FACTOR     Y-FACTOR

            1           0.9440       1.0000
            2           0.9440       1.0000
            3           0.9440       1.0000
            4           0.9440       1.0000
            5           0.9440       1.0000
            6           1.0000       1.0000
            7           1.0000       1.0000
            8           1.0000       1.0000
            9           1.0000       1.0000
           10           1.0000       1.0000


* TABLE L *   COMPUTATION ON PILE CAP


* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *


      VERT. LOAD, LBS    HOR. LOAD Y, LBS   HOR. LOAD Z, LBS
        3.86630E+05        1.52520E+05            0.00000

     MOMENT X ,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
            0.00000             0.00000       -2.10182E+07


* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *


       VERTICAL ,IN      HORIZONTAL Y,IN     HORIZONTAL Z,IN
          0.0182623            0.21297       -1.43276E-17

     ANGLE ROT. X,RAD    ANGLE ROT. Y,RAD    ANGLE ROT. Z,RAD
        4.50778E-17        6.33130E-20       -9.32655E-04


     NUMBER OF GLOBAL ITERATIONS =    4


LOAD CASE :     3
CASE NAME : Strength I Min
LOAD TYPE : Dead, DL

  REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
  ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

       GROUP NO     P-FACTOR     Y-FACTOR

            1           0.9440       1.0000
            2           0.9440       1.0000
            3           0.9440       1.0000
            4           0.9440       1.0000
            5           0.9440       1.0000
            6           1.0000       1.0000
            7           1.0000       1.0000
            8           1.0000       1.0000
            9           1.0000       1.0000
           10           1.0000       1.0000


* TABLE L *   COMPUTATION ON PILE CAP


* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *


      VERT. LOAD, LBS    HOR. LOAD Y, LBS   HOR. LOAD Z, LBS
        2.79420E+05        1.01680E+05            0.00000

     MOMENT X ,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
```

```
           0.00000            0.00000       -1.41745E+07


* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *


       VERTICAL ,IN      HORIZONTAL Y,IN     HORIZONTAL Z,IN
          0.0119598            0.12966       -8.37969E-18

     ANGLE ROT. X,RAD    ANGLE ROT. Y,RAD    ANGLE ROT. Z,RAD
        4.61435E-17        3.05386E-20       -5.95141E-04


     NUMBER OF GLOBAL ITERATIONS =    4



LOAD CASE :     4
CASE NAME : Extreme Event I (I)
LOAD TYPE : Dead, DL

  REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
  ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

       GROUP NO     P-FACTOR     Y-FACTOR

           1           0.9440       1.0000
           2           0.9440       1.0000
           3           0.9440       1.0000
           4           0.9440       1.0000
           5           0.9440       1.0000
           6           1.0000       1.0000
           7           1.0000       1.0000
           8           1.0000       1.0000
           9           1.0000       1.0000
          10           1.0000       1.0000


* TABLE L *   COMPUTATION ON PILE CAP


* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *


      VERT. LOAD, LBS    HOR. LOAD Y, LBS   HOR. LOAD Z, LBS
        3.06480E+05        1.42480E+05            0.00000

     MOMENT X ,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
            0.00000            0.00000       -1.52644E+07


* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *


       VERTICAL ,IN      HORIZONTAL Y,IN     HORIZONTAL Z,IN
          0.0133101            0.19581        6.63316E-21

     ANGLE ROT. X,RAD    ANGLE ROT. Y,RAD    ANGLE ROT. Z,RAD
       -5.53551E-20        5.47183E-22       -6.47532E-04


     NUMBER OF GLOBAL ITERATIONS =    4



LOAD CASE :     5
CASE NAME : Extreme Event I (II)
LOAD TYPE : Dead, DL

  REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
  ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

       GROUP NO     P-FACTOR     Y-FACTOR

           1           0.9440       1.0000
           2           0.9440       1.0000
           3           0.9440       1.0000
           4           0.9440       1.0000
           5           0.9440       1.0000
           6           1.0000       1.0000
           7           1.0000       1.0000
           8           1.0000       1.0000
           9           1.0000       1.0000
          10           1.0000       1.0000


* TABLE L *   COMPUTATION ON PILE CAP
```

```
* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

      VERT. LOAD, LBS    HOR. LOAD Y, LBS   HOR. LOAD Z, LBS
        3.06480E+05        1.57030E+05            0.00000

     MOMENT X ,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
            0.00000            0.00000       -1.29815E+07


* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

       VERTICAL ,IN      HORIZONTAL Y,IN     HORIZONTAL Z,IN
          0.0129938            0.22256        3.85134E-17

     ANGLE ROT. X,RAD    ANGLE ROT. Y,RAD    ANGLE ROT. Z,RAD
       -2.12712E-16        1.08873E-19       -5.45939E-04


     NUMBER OF GLOBAL ITERATIONS =    4
```

Armory Street over CSX Mainline
Bridge No. S-24-026
Micropiles for Return Wall #3 and #4
Springfield, Massachusetts

Calculated by: RAC Date: 2/4/2025
Checked by: BTW Date: 3/5/2025

Purpose: Perform axial and lateral analyses for the proposed micropiles for the above-referenced project. See table and summary provided in Step 3 and 4 for results of the lateral and axial analyses, respectively. The Structural Engineer should evaluate the structural adequacy of the micropiles.

References:
1) FHWA-NHI-05-039 Micropile Manual, 2005.
2) MassDOT Bridge Design Manual, 2024.
3) Computer program GROUP, Version 2022, and associated user's manual, by Ensoft, Inc.
4) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
5) Loads assuming lightweight fill, provided by Tetra Tech via email on December 10, 2024.
6) Sketch of return wall and micropile geometry provided by Tetra Tech via email on December 13, 2024.
7) Test borings observed by Nobis at the site in 2019 and 2022.
8) Email and phone communications with design team.

Given:
1) Factored loads provided by Tetra Tech per Reference No. 5.
2) Pile cap geometry per References No. 5 and 6.
3) A pinned pile head conditions at Return Wall #3 and #4 micropiles. (See graphic for #3).

Assumptions:
1) F'c of grout is 5 ksi, Fy of casing and rebar are 52 ksi and 60 ksi, respectively.
2) Micropiles will consist of casing with an outer diameter of 10.75-inch and 0.5-inch thick walls with a #8 sized center bar.
3) Structural engineer will verify the loads and the pile head condition used in analysis, and evaluate the structural resistance of the micropiles in accordance with AASHTO.
4) Subsurface information from Reference 7 is representative of subsurface conditions.
5) Pile cap geometry with 6 micropiles was considered (3 rows of 2). See Step 2.
6) A casing thickness loss of 1/16-inch in the top 3 feet due to corrosion and 50% loss below the top 3 feet of the pile are used. No casing joints are located in the top 3 feet of the micropiles.
7) The effects of nearby piles from the abutments and crash walls were ignored for the purposes of this analysis. P-multipliers (Pm) were calculated directly by Group for the micropiles of the abutment return walls
8) P-reduction factors of 0.5 were used for both Return Wall #3 and #4.

Solution:

Step 1: Soil Properties and Profile

Nobis used subsurface information from Borings BB-5 through BB-8 and BB-8A of Reference No. 7 to develop soil parameters in the table below. The datum was taken at the bottom of the Pile Cap (El. 129.25) at the north substructure. Soil unit weight (γ_{moist}) soil angle of internal friction (ϕ) and cohesions were estimated based on field and laboratory testing and a study performed on Connecticut Valley Varved Clay entitled “Geology and Engineering Properties of Connecticut Valley Varved Clay” (DeGroot, D.J. and Lutenegger, A.J.). The groundwater table was taken at approximately El. 129.25. Soil modulus parameters (k) and strain factor for the varved silt/clay were determined using Table 3.7 and Table 3.5 from Reference No. 3, respectively. Uniaxial Compressive Strength (U.C.S.) of rock was based on lab test data.

Armory Street over CSX Mainline
Bridge No. S-24-026
Micropiles for Return Wall #3 and #4
Springfield, Massachusetts

Calculated by: RAC Date: 2/4/2025
Checked by: BTW Date: 3/5/2025

Soil Layer	Elevation (ft)	Depth (ft)	γ_{moist} (pcf)	ϕ (^{o})	k (pci)	U.C.S. (psi)	Cohesion (psf)	Strain Fact. (dims)
Fill	133.25 to 128	-4 to 1.5	115	33	25/20	-	-	-
Varved Silt & Clay	128 to 91	1.5 to 38.5	120	22	100	-	130	0.01
Silt	91 to 79.5	38.5 to 50	120	26	50	-	-	-
Glacial Till	79.5 to 72.4	50 to 57.1	135	37	125	-	-	-
W. Bedrock	72.4 to 68	57.1 to 61.5	150	38	150	-	-	-
Bedrock	<68	>61.5	164	-	-	7,500	-	-

1) Assumed 25 pci for fill above water table and 20 pci for fill below water table.

Step 2: Micropile and Pile Cap Properties

Micropile Cased (50%): micropile strength with 50% casing reduction due to threaded sections

Section Length:	62.5	ft*	Outer Diameter w/loss:	10.25 **in**
Outside Diameter:	10.75	in	Casing Thickness w/loss:	0.25 **in**
Casing Thickness:	0.5	in		
Percent of Casing loss to Thread:	50	%		
Yield Stress of Casing:	52	ksi		
Elastic modulus of Casing:	29000	ksi		
Center Bar:	# 8	bar	Area of Casing (A_{ct}):	**7.9 in^2**
Yield Stress of Center Bar:	60	ksi	Area of Bar (A_b):	**0.8 in^2**
Grout Compressive Strength:	5	ksi	Area of Grout (A_g):	**73.9 in^2**

*Section length includes the 1-foot of embedment into bedrock required by the MassDOT Bridge Manual.

Micropile Uncased: micropile strength with no casing (inside rock socket)

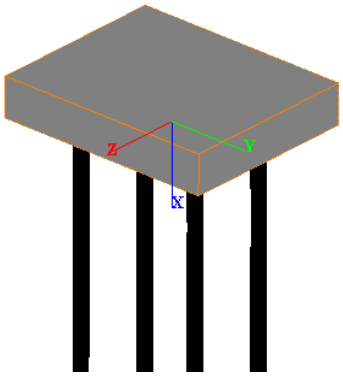
Section Length:	10	ft		
Outside Diameter (before corrosion):	9.75	in		
Center Bar:	# 8	bar		
Yield Stress of Center Bar:	60	ksi	Area of Bar (A_b):	**0.8 in^2**
Grout Compressive Strength:	5	ksi	Area of Grout (A_g):	**73.9 in^2**

Armory Street over CSX Mainline
Bridge No. S-24-026
Micropiles for Return Wall #3 and #4
Springfield, Massachusetts

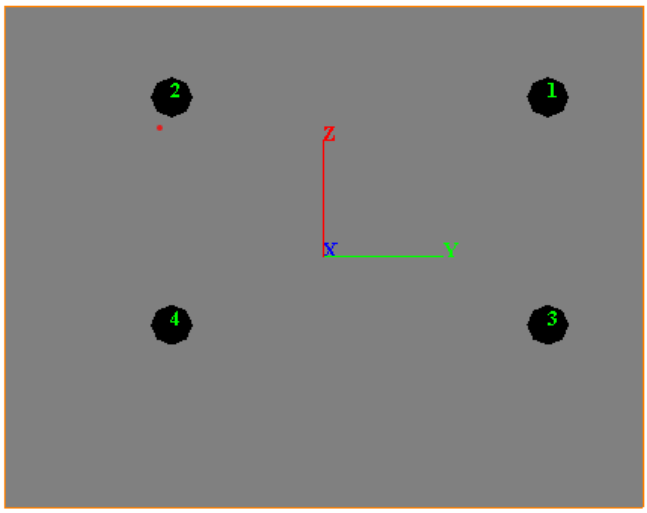
Calculated by: RAC Date: 2/4/2025
Checked by: BTW Date: 3/5/2025

Pile Cap: See graphic for Return Wall #3.

Cap Length in Z-axis (Transverse):	11 ft
Cap Width in Y-axis (Longitudinal):	13.5 ft
Cap Thickness in X-axis (Vertical):	2.5 ft
Center-to-center spacing in Z-axis :	5 ft
Center-to-center spacing in Y-axis :	8 ft



(not to scale)



(not to scale)

Step 3: Lateral Analysis

The Computer Program GROUP, version 2022 by Ensoft, Inc. was used for the lateral analyses. Pinned head conditions were assumed between the micropiles and the proposed return walls. The analyses (GROUP) used the provided loads including the effects of regular fill from Tetra Tech. Non-linear EI was assumed in all analyses. Structural engineer shall evaluate the structural adequacy of the micropiles.

Results of Micropile Lateral Analyses for Proposed Return Walls (per micropile)

Structure	Load Case	Max Shear (kip)	Max Deflection (in)	Max Moment Below 3 Feet (kip*ft)[2]	Max Axial Load (kip)	Min Axial Load (kip)
Return Walls	Ser. I	17.2	0.25	37.0	110.0	-15.0
	Str. I (Max)	23.0	0.37	50.1	140.0	-20.0
	Str. I (Min)	15.5	0.22	33.3	100.0	-10.0
	Ext. I (I)[3]	22.7	0.37	48.8	110.0	-10.0
	Ext. I (II)[4]	25.7	0.45	55.7	100.0	-5.0

1) Depth of fixity is approximately 14 feet below the bottom of pile cap, and taken at the 2nd point of zero deflection
2) Maximum moment below the top 3 feet with loss of 50% casing due to threaded connections.
3) Extreme I (I) is 50% Inertial + 100% P_{ea}
4) Extreme I (II) is 100% Inertial + 50% P_{ea}

Armory Street over CSX Mainline
Bridge No. S-24-026
Micropiles for Return Wall #3 and #4
Springfield, Massachusetts

Calculated by: RAC Date: 2/4/2025
Checked by: BTW Date: 3/5/2025

Step 4: Axial Analysis

Structural Resistance Factors			
Load Case	**Compression**	**Tension**	
Strength	**0.75**	**0.8**	Ref. No. 4 Tb. 10.5.5.2.5-2
Service	**1**	**1**	Ref. No. 4 Section 10.5.5.1
Extreme	**1**	**0.8**	Ref. No. 4 Section 10.5.5.3

Load Demand (from Group)		
Load Case	**Compression (kips)**	**Tension (kips)**
Strength	**140.0**	**-20.0**
Service	**110.0**	**-15.0**
Extreme	**110.0**	**-10.0**

Geotechnical Resistance Factors			
Load Case	**Compression**	**Tension**	
Strength	**0.55**	**0.55**	Ref. No. 4 Tb. 10.5.5.2.5-1
Service	**1**	**1**	Ref. No. 4 Section 10.5.5.1
Extreme	**1**	**0.8**	Ref. No. 4 Section 10.5.5.3

Evaluate the structural resistance of the micropile for axial load only (negating lateral loads).

For micropile cased section (assuming 50% section):

Nominal axial compressive structural resistance (R_n):	**648.7 kips**	Ref. No. 4 Eq. 10.9.3.10.2a-2
Nominal axial tension structural resistance (R_n):	**449.2 kips**	Ref. No. 4 Eq. 10.9.3.10.3a-2

For micropile uncased section:

Nominal axial compressive structural resistance (R_n):	**306.9 kips**	Ref. No. 4 Eq. 10.9.3.10.2b-2
Nominal axial tension structural resistance (R_n):	**47.1 kips**	Ref. No. 4 Eq. 10.9.3.10.3b-2

Evaluate the geotechnical resistance of the micropile for axial loads.

Grout-to-ground bond strength in Bedrock:	**11 ksf**	Ref. No. 4 Table C10.9.3.5.2-1
Minimum Rock Socket Length:	**10 feet**	assumption
Total Nominal grout-to-ground bond resistance:	**281 Kips**	Ref. No. 4 Eq. 10.9.3.5.2-1

nobis

Armory Street over CSX Mainline
Bridge No. S-24-026
Micropiles for Return Wall #3 and #4
Springfield, Massachusetts

Calculated by: RAC Date: 2/4/2025
Checked by: BTW Date: 3/5/2025

Summary

Check to verify that a 10 foot rock socket is adequate based on the maximum factored axial load.

Geotechnical					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**154.4**	**140.0**	**154.4**	**20.0**	OK
Service	**280.8**	**110.0**	**280.8**	**15.0**	
Extreme	**280.8**	**110.0**	**224.6**	**10.0**	

Check to verify that the cased micropile is *adequate based on the maximum factored axial load (negating lateral loads).

Structural (cased): Check the strucural resistance of the micropile					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**486.6**	**140.0**	**359.4**	**20.0**	OK
Service	**648.7**	**110.0**	**449.2**	**15.0**	
Extreme	**648.7**	**110.0**	**359.4**	**10.0**	

*Structural engineer shall evaluate the structural adequacy of the micropiles.

Check to verify that the uncased micropile is *adequate based on the maximum factored axial load (negating lateral loads) and to verify that a plunge length is not needed.

Structural (uncased)					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**230.2**	**140.0**	**37.7**	**20.0**	OK
Service	**306.9**	**110.0**	**47.1**	**15.0**	
Extreme	**306.9**	**110.0**	**37.7**	**10.0**	

*Structural engineer shall evaluate the structural adequacy of the micropiles.

JOB:	Armory Street Bridge No S-24-026			SHEET NO.	
SUBJECT:	North Abutment Return Wall #3			FILE NO.	
COMP. BY:	AJF	DATE: 12/10/2024	CHK. BY:	DATE:	

CONSTANTS

Type of Wall: Wing / Retaining Wall

Type of Backwall: Independent

Type of Foundation: Pile Supported

Footing Constructed on Tremie? N

Type of Backfill: Lightweight fill

Type of Lateral Soil Pressure: Temporary Condition: Active Permanent Condition: At-Rest

Method for Calculating Active Earth Pressure: Rankine

Include Lateral Load on Backwall in Case IB? Y

Pile Information: Pile Type: Metal Shell 12" OD Testing: Gates Dynamic Formula

Include: Lateral load from EPS conc cap? N/A Pile Shading for Lateral Resistance? N

Pile Reaction for Top Fnd Reinf.? Y Earth Load for Bottom Fnd Reinf.? Y

Pile Properties:	Default		Overwrite		Final	
Nom. Pile Resistance:	250	K/Pile		K/Pile	250	K/Pile
Resistance Factor:	0.50				0.50	
Factored Pile Resist.:	125	K/Pile		K/Pile	125	K/Pile
Pile Width/Diameter:	12	in		in	12	in
Lateral Pile Resistance:			10	K/Pile	10	K/Pile

Soil Properties:	Default		Overwrite		Final	
Backfill weight, w:	0.120	Kcf	0.125	Kcf	0.125	Kcf
Angle (beta):	0	degrees		degrees	0	degrees
Angle (phi):	30	degrees	33	degrees	33	degrees
Angle (delta):	17	degrees		degrees	17	degrees
Angle (theta):					90	degrees
Active Coeff, K_a:	0.295		0.350		0.350	
At-Rest Coeff, K_o:	0.455		0.460		0.460	
Seismic Coeff, K_{AE}:			0.333			
Seismic Coeff, K_{h0}:			0.225			

Lightweight Fill Properties:	Default		Overwrite		Final	
Lightweight Concrete Weight, w:		Kcf	0.023	Kcf	0.023	Kcf
Lateral Lightweight Concrete Load:		Ksf	0.008	Ksf	0.008	Ksf
Seismic Lateral Lightweight Concrete Load:		Ksf	0.008	Ksf	0.008	Ksf

Structural Material Properties:	Default		Overwrite		Final	
Concrete Strength, f'c:	3	Ksi	4	Ksi	4	Ksi
Concrete Weight, w:	0.150	Kcf		Kcf	0.150	Kcf
	0.145	Kcf		Kcf	0.145	Kcf
Concrete Modulus of Elasticity, Ec:					3987	Ksi
Concrete Modulus of Rupture, fr:					0.48	Ksi
Max Aggregate Size	1.5	in		in	1.500	in
Rebar Strength, Fy:	60	Ksi		Ksi	60	Ksi
Rebar Modulus of Elasticity, Es:					29000	Ksi
Modular Ratio, n:					7	

Miscellaneous Properties: Unit Weight of Water: 0.0624 Kcf

Reinforcement Centerline:	Default		Overwrite		Final	
Wall Back Face:	3	in		in	3	in
Footing Top:	4	in		in	4	in
Footing Bottom:	9	in	14	in	14	in
Wall Increment:	0.50	Ft	1.00	Ft	1.00	Ft

Reinforcement Epoxy Coated? Footing: Y Wall: Y

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Return Wall #3 FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

INPUT AND SUMMARY OF RESULTS

Superstructure Bearing Loads:		Vertical Loads: maximum	Vertical Loads: minimum	Horizontal Loads: maximum	Horizontal Loads: minimum	
Self-Weight (Temporary)	DC1:	0.00		0.00		K/Ft
Self-Weight (Permanent)	DC1:	0.00		0.00		K/Ft
Superimposed Dead Loads	DC2:	0.00		0.00		K/Ft
Wearing Surface / Utilities	DW:	0.00		0.00		K/Ft
Post-Tensioning, Creep, Shrinkage	PS+CR+SH:	0.00	0.00	0.00	0.00	K/Ft
Thermal Contraction	TU:	0.00		0.00		K/Ft
Thermal Expansion	TU:	0.00		0.00		K/Ft
Live Loads	LL:	0.00		0.00		K/Ft
Braking	BR:			0.00		K/Ft
Wind on Structure (Service I)	WS:	0.00		0.00		K/Ft
Wind on Structure (Strength III)	WS:	0.00		0.00		K/Ft
Wind on Structure (Strength V)	WS:	0.00		0.00		K/Ft
Wind on Live Load (Service I)	WL:	0.00		0.00		K/Ft
Wind on Live Load (Strength V)	WL:	0.00		0.00		K/Ft

Approach Equivalent Live Loads:

Depth of equiv fill - temporary	HE =	0.000	Ft
Depth of equiv fill - permanent		0.000	Ft

Wind Load on Wall (wing/retaining walls):

Service I wind load:	0.000	Ksf
Strength III wind load:	0.000	Ksf
Strength V wind load:	0.000	Ksf

Backfill Dimensions:

Temp height of soil (from bott of ftg)	HT =		Ft
Height of EPS concrete cap	HC =	0.000	Ft
Height of lightweight fill	HFF =	21.938	Ft
Add Height of lightweight fill		7.625	Ft
Height of soil below lightweight fill		0.000	Ft
Soil depth at toe	HP =		Ft
Height of water table	HWT =	0.000	Ft

Abutment Stem Wall Dimensions:

Bearing distance	BD =	0.000	Ft
Bearing height	BH =	0.000	Ft
Height of backwall/upper wall	HB =	5.625	Ft
Height of upper wall above grade	HG =	0.000	Ft
Thickness of backwall/upper wall	TB =	0.000	Ft
Location of backwall/upper wall	DB =	0.000	Ft
Height of stem wall	HW =	19.438	Ft
Thickness of stem wall	TW =	3.500	Ft
Railing height on wingwall	HR =	0.000	Ft

Abutment Footing Dimensions:

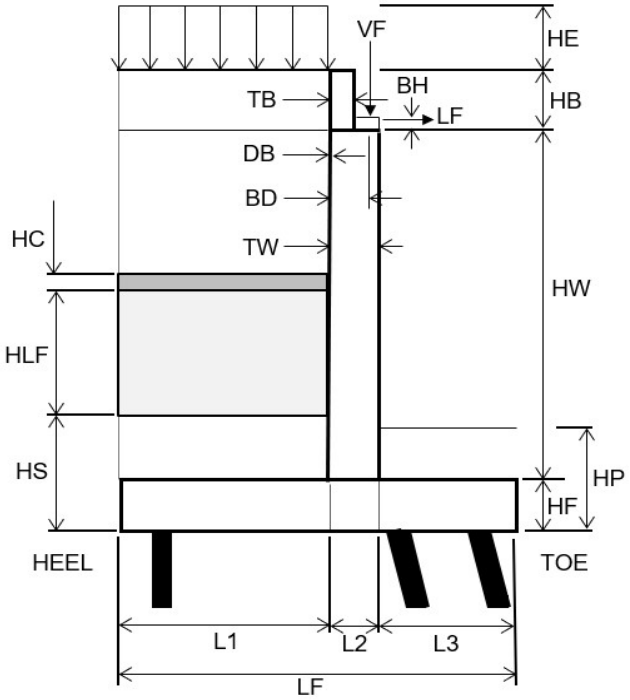
Height of footing	HF =	2.500	Ft
Total length of footing	LF =	13.500	Ft
Length of footing at toe	L3 =	2.500	Ft
Pile location - First pile from heel:		3.500	Ft

Pile Spacing Dimensions:

Pile Row:	Toe	1	2	3	4	5	Heel	
Piles Present in this Row?		Y	Y	N	N	Y		
Pile Distance from Toe:		2.00	6.00			10.00		Ft
Longitudinal Pile Spacing:		5.000	5.000			5.000		Ft
Battered Piles in this Row?		N	N	N	N	N		
Pile Batter:								to 1
Percent of Piles Battered:								

JOB:	Armory Street Bridge No S-24-026					SHEET NO.	
SUBJECT:	North Abutment Return Wall #3					FILE NO.	
COMP. BY:	AJF	DATE:	12/10/2024	CHK. BY:		DATE:	

INPUT AND SUMMARY OF RESULTS - CONTINUED



L1= 7.500 L2= 3.500 L3= 2.500 Ft

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Return Wall #3 FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

VERTICAL LOAD CALCULATIONS:

Load No.		Load Description	Unfactored Loads Width Ft	Height Ft	Unit Wt. Kcf	Maximum K/Ft	Minimum K/Ft	Centroid Y from Heel Ft	Moment Arm from CL Ftg Ft
1A	DC	Footing Heel Dead Load	7.50 x	2.50 x	0.150 =	2.81	2.81	3.750	-3.000
1A	DC	Footing Mid Dead Load	3.50 x	2.50 x	0.150 =	1.31	1.31	9.250	2.500
1A	DC	Footing Toe Dead Load	2.50 x	2.50 x	0.150 =	0.94	0.94	12.250	5.500
1B	DC	Stem Wall Dead Load	3.50 x	19.44 x	0.150 =	10.20	10.20	9.250	2.500
1C	DC	Backwall Dead Load	0.00 x	5.63 x	0.150 =	0.00	0.00	0.000	0.000
1C	DC	Backwall Dead Load (Case IB)	0.00 x	5.63 x	0.150 =	0.00	0.00	0.000	0.000
2A	EV	Soil Vertical Load Temp							
2A	EV	Soil Vertical Load 1	7.50 x	0.00 x	0.150 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 2	7.50 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 2 (Case IB)	0.00 x	5.63 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 3	0.00 x	5.63 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 4	2.50 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Load (below lightwt fill)	7.50 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00	0.000	0.000
4A	DC1	Super Dead Load Permanent	0.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
4B	DC2	Superimposed Dead Load			=	0.00	0.00	0.000	0.000
4C	DW	Wearing Surface / Utilities			=	0.00	0.00	0.000	0.000
5	LS	Temp LL Surcharge	7.50 x	0.00 x	0.125 =	0.00	0.00	3.750	0.000
5	LS	Equiv LL Surcharge	7.50 x	0.00 x	0.125 =	0.00	0.00	3.750	0.000
6	LL	Superstructure Live Load			=	0.00	0.00	0.000	0.000
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00	0.000	0.000
7B	TU	Thermal Contraction			=	0.00	0.00	0.000	0.000
7C	TU	Thermal Expansion			=	0.00	0.00	0.000	0.000
8A	EV	Lightweight Fill below Bearing	7.50 x	19.44 x	0.023 =	3.35	3.35	3.750	-3.000
8B	EV	Lightweight Fill above Bearing	7.50 x	0.00 x	0.023 =	0.00	0.00	0.000	0.000
9A	EV	EPS Concrete Cap below Brg	7.50 x	0.00 x	0.150 =	0.00	0.00	0.000	0.000
9B	EV	EPS Concrete Cap above Brg	7.50 x	0.00 x	0.150 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Heel	7.50 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Mid	3.50 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Toe	2.50 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00	0.000	0.000
	WS	Wind on Structure (Str III)			=	0.00	0.00	0.000	0.000
	WS	Wind on Structure (Str V)			=	0.00	0.00	0.000	0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00	0.000	0.000
	WL	Wind on Live Load (Str V)			=	0.00	0.00	0.000	0.000

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Return Wall #3 FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

VERTICAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Extreme Event I Load Factors Max	Extreme Event I Load Factors Min
1A	DC	Footing Heel Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1A	DC	Footing Mid Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1A	DC	Footing Toe Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1B	DC	Stem Wall Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1C	DC	Backwall Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1C	DC	Backwall Dead Load (Case IB)	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
2A	EV	Soil Vertical Load Temp	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2A	EV	Soil Vertical Load 1	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 2	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 2 (Case IB)	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 3	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 4	1.00	1.00	1.35	0.00	1.35	0.00	1.00	1.00
2B	EV	Soil Load (below lightwt fill)	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface / Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5	LS	Temp LL Surcharge	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5	LS	Equiv LL Surcharge	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	1.00	1.00
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	0.50	0.50	0.50	0.50	1.00	1.00
8A	EV	Lightweight Fill below Bearing	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
8B	EV	Lightweight Fill above Bearing	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
9A	EV	EPS Concrete Cap below Brg	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
9B	EV	EPS Concrete Cap above Brg	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
10	WA	Buoyancy Heel	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	WA	Buoyancy Mid	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	WA	Buoyancy Toe	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Return Wall #3 FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

HORIZONTAL LOAD CALCULATIONS:

3	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Soil above bearing elevation
3	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Soil below bearing elevation
3	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Soil under lightweight fill
5	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Temporary live load surcharge
5	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Equivalent live load surcharge
8		0.008	Ksf	Lightweight Fill
9A	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap below Bearing
9B	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap above Bearing
9C	19.44 ft x 0.023 kcf x 0.350 =	0.156	Ksf	Lightweight Fill below Bearing Surcharge
9D	0.00 ft x 0.023 kcf x 0.350 =	0.000	Ksf	Lightweight Fill above Bearing Surcharge
9E	0.00 ft x 0.150 kcf x 0.350 =	0.000	Ksf	EPS Concrete Cap below Bearing Surcharge
9F	0.00 ft x 0.150 kcf x 0.350 =	0.000	Ksf	EPS Concrete Cap above Bearing Surcharge

Load No.		Load Description	Unfactored Loads Height Ft	Load Ksf		Maximum K/Ft	Minimum K/Ft		Moment Arm Ft
3	EH	Soil Lateral Load 1	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
3A	EH	Soil Lateral Load 2	0.00 x	0.000	=	0.00	0.00		0.000
3A	EH	Soil Lateral Load 2 (Case IB)	0.00 x	0.000	=	0.00	0.00		0.000
3B	EH	Soil Lateral Load 3	21.94 x	0.000		0.00	0.00		12.938
3B	EH	Soil Lateral Load 3 (Case IB)	0.00 x	0.000	/ 2 =	0.00	0.00		27.563
3C	EH	Soil Lateral Load 4	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
3D	EH	Soil Lateral Load 5	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6 (Case IB)	0.00 x	0.000	=	0.00	0.00		0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00		21.938
4A	DC1	Super Dead Load Permanent			=	0.00	0.00		21.938
4B	DC2	Superimposed Dead Loads			=	0.00	0.00		21.938
4C	DW	Wearing Surface + Utilities			=	0.00	0.00		21.938
5A	LS	Temp LL Surcharge 1	0.00 x	0.000	=	0.00	0.00		21.938
5B	LS	Temp LL Surcharge 2	5.63 x	0.000	=	0.00	0.00		24.751
5B	LS	Temp LL Surcharge 2 (Case IB)	5.63 x	0.000	=	0.00	0.00		24.751
5C	LS	Temp LL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
5A	LS	Equiv LL Surcharge 1	0.00 x	0.000	=	0.00	0.00		21.938
5B	LS	Equiv LL Surcharge 2	21.94 x	0.000	=	0.00	0.00		16.594
5C	LS	Equiv LL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
6A	LL	Superstructure Live Load			=	0.00	0.00		21.938
6B	BR	Braking (Contraction)			=	0.00	0.00		21.938
6C	BR	Braking (Expansion)			=	0.00	0.00		21.938
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00		21.938
7B	TU	Thermal Contraction			=	0.00	0.00		21.938
7C	TU	Thermal Expansion			=	0.00	0.00		21.938
8A	EH	Lightweight Fill below Bearing	21.94^2 x	0.008	/ 2 =	1.93	1.93		7.313
8B	EH	Lightweight Fill above Bearing	21.94 x	0.166	=	3.65	3.65		10.969
9A	EH	EPS Cap below Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9B	EH	EPS Cap above Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9C	EH	Lwt Fill below Brg Surcharge	0.00 x	0.156	=	0.00	0.00		0.000
9D	EH	Lwt Fill above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9E	EH	EPS Cap below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9F	EH	EPS Cap above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00		21.938
	WS	Wind on Structure (Str III)			=	0.00	0.00		21.938
	WS	Wind on Structure (Str V)			=	0.00	0.00		21.938
12B	WS	Wind on Stem Wall (Serv I)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str III)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str V)	0.00 x	0.000	=	0.00	0.00		0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00		21.938
	WL	Wind on Live Load (Str V)			=	0.00	0.00		21.938
13	EQ	Earthquake Load		0.23 x	18.62 =	4.19	4.19	-----	-----

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Return Wall #3 FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

HORIZONTAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Strength V Load Factors Max	Strength V Load Factors Min
3	EH	Soil Lateral Load 1	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3C	EH	Soil Lateral Load 4	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3D	EH	Soil Lateral Load 5	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Loads	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface + Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5A	LS	Temp LL Surcharge 1	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5B	LS	Temp LL Surcharge 2	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5B	LS	Temp LL Surcharge 2 (Case IB)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5C	LS	Temp LL Surcharge 3	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5A	LS	Equiv LL Surcharge 1	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5B	LS	Equiv LL Surcharge 2	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5C	LS	Equiv LL Surcharge 3	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6A	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6B	BR	Braking (Contraction)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6C	BR	Braking (Expansion)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
8A	EH	Lightweight Fill below Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
8B	EH	Lightweight Fill above Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9A	EH	EPS Cap below Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9B	EH	EPS Cap above Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9C	EH	Lwt Fill below Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9D	EH	Lwt Fill above Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9E	EH	EPS Cap below Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9F	EH	EPS Cap above Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12B	WS	Wind on Stem Wall (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Stem Wall (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Stem Wall (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
13	EQ	Earthquake Load	-----	-----	-----	-----	-----	-----	1.00	1.00

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Return Wall #3 FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

EARTHQUAKE HORIZONTAL LOAD CALCULATIONS:

3	0.00 ft x 0.125 kcf x 0.333 =	0.000	Ksf	Soil above bearing elevation
3	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Soil below bearing elevation
3	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Soil under lightweight fill
5	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Temporary live load surcharge
5	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Equivalent live load surcharge
8		0.008	Ksf	Lightweight Fill
9A	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap below Bearing
9B	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap above Bearing
9C	19.44 ft x 0.0077 ksf =	0.150	Ksf	Lightweight Fill below Bearing Surcharge
9D	0.00 ft x 0.0077 ksf =	0.000	Ksf	Lightweight Fill above Bearing Surcharge
9E	0.00 ft x 0.0077 ksf =	0.000	Ksf	EPS Concrete Cap below Bearing Surcharge
9F	0.00 ft x 0.0077 ksf =	0.000	Ksf	EPS Concrete Cap above Bearing Surcharge

Load No.		Load Description	Unfactored Loads Height Ft	Load Ksf		Maximum K/Ft	Minimum K/Ft		Moment Arm Ft
3	EH	Soil Lateral Load 1	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
3A	EH	Soil Lateral Load 2	0.00 x	0.000	=	0.00	0.00		0.000
3A	EH	Soil Lateral Load 2 (Case IB)	0.00 x	0.000	=	0.00	0.00		0.000
3B	EH	Soil Lateral Load 3	21.94 x	0.000		0.00	0.00		12.938
3B	EH	Soil Lateral Load 3 (Case IB)	0.00 x	0.000	/ 2 =	0.00	0.00		27.563
3C	EH	Soil Lateral Load 4	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
3D	EH	Soil Lateral Load 5	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6 (Case IB)	0.00 x	0.000	=	0.00	0.00		0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00		21.938
4A	DC1	Super Dead Load Permanent			=	0.00	0.00		21.938
4B	DC2	Superimposed Dead Loads			=	0.00	0.00		21.938
4C	DW	Wearing Surface + Utilities			=	0.00	0.00		21.938
5A	LS	Temp LL Surcharge 1	0.00 x	0.000	=	0.00	0.00		21.938
5B	LS	Temp LL Surcharge 2	5.63 x	0.000	=	0.00	0.00		24.751
5B	LS	Temp LL Surcharge 2 (Case IB)	5.63 x	0.000	=	0.00	0.00		24.751
5C	LS	Temp LL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
5A	LS	Equiv LL Surcharge 1	0.00 x	0.000	=	0.00	0.00		21.938
5B	LS	Equiv LL Surcharge 2	21.94 x	0.000	=	0.00	0.00		16.594
5C	LS	Equiv LL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
6A	LL	Superstructure Live Load			=	0.00	0.00		21.938
6B	BR	Braking (Contraction)			=	0.00	0.00		21.938
6C	BR	Braking (Expansion)			=	0.00	0.00		21.938
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00		21.938
7B	TU	Thermal Contraction			=	0.00	0.00		21.938
7C	TU	Thermal Expansion			=	0.00	0.00		21.938
8A	EH	Lightweight Fill below Bearing	21.94^2 x	0.0077	/ 2 =	1.85	1.85		7.313
8B	EH	Lightweight Fill above Bearing	21.94 x	0.158	=	3.47	3.47		10.969
9A	EH	EPS Cap below Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9B	EH	EPS Cap above Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9C	EH	Lwt Fill below Brg Surcharge	0.00 x	0.156	=	0.00	0.00		0.000
9D	EH	Lwt Fill above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9E	EH	EPS Cap below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9F	EH	EPS Cap above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00		21.938
	WS	Wind on Structure (Str III)			=	0.00	0.00		21.938
	WS	Wind on Structure (Str V)			=	0.00	0.00		21.938
12B	WS	Wind on Stem Wall (Serv I)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str III)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str V)	0.00 x	0.000	=	0.00	0.00		0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00		21.938
	WL	Wind on Live Load (Str V)			=	0.00	0.00		21.938
13	EQ	Earthquake Load		0.23 x	18.62 =	4.19	4.19	-----	-----

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Return Wall #3 FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

HORIZONTAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Strength V Load Factors Max	Strength V Load Factors Min
3	EH	Soil Lateral Load 1	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3C	EH	Soil Lateral Load 4	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3D	EH	Soil Lateral Load 5	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Loads	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface + Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5A	LS	Temp LL Surcharge 1	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5B	LS	Temp LL Surcharge 2	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5B	LS	Temp LL Surcharge 2 (Case IB)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5C	LS	Temp LL Surcharge 3	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5A	LS	Equiv LL Surcharge 1	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5B	LS	Equiv LL Surcharge 2	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
5C	LS	Equiv LL Surcharge 3	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6A	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6B	BR	Braking (Contraction)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6C	BR	Braking (Expansion)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
8A	EH	Lightweight Fill below Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
8B	EH	Lightweight Fill above Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9A	EH	EPS Cap below Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9B	EH	EPS Cap above Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9C	EH	Lwt Fill below Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9D	EH	Lwt Fill above Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9E	EH	EPS Cap below Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9F	EH	EPS Cap above Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12B	WS	Wind on Stem Wall (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Stem Wall (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Stem Wall (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
13	EQ	Earthquake Load	-----	-----	-----	-----	-----	-----	1.00	1.00

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Return Wall #3 FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

CASE II **Strength I** **Live Load on Approach** 11 feet

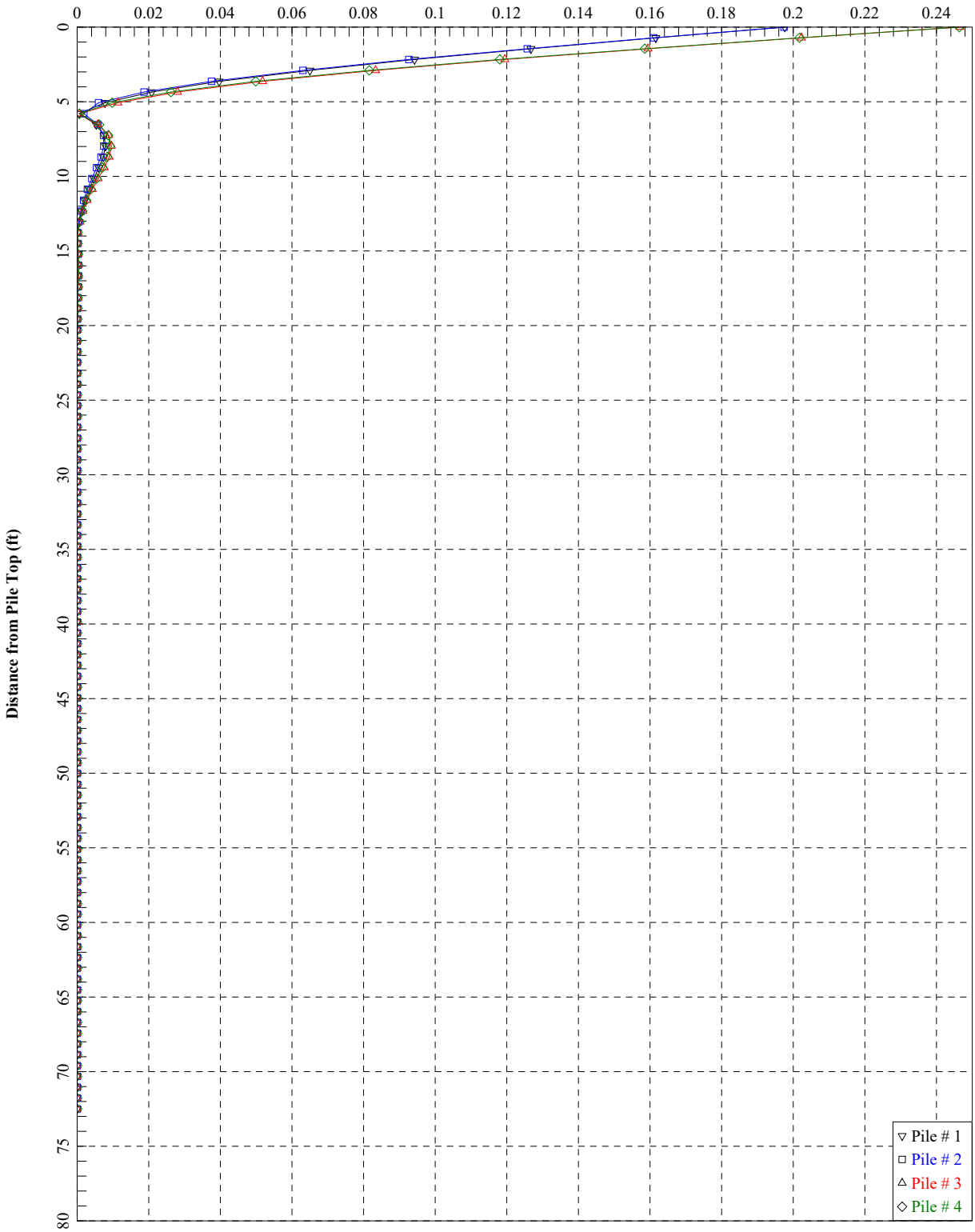
			SERVICE I		STRENGTH I MAX			STRENGTH I MIN		
Load No.		Load Description	Load	Moment	Factors	Load	Moment	Factors	Load	Moment
			K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft
VERTICAL LOADS:										
1A	DC	Footing Heel Dead Load	2.81	-8.44	1.25	3.52	-10.55	0.90	2.53	-7.59
1A	DC	Footing Mid Dead Load	1.31	3.28	1.25	1.64	4.10	0.90	1.18	2.95
1A	DC	Footing Toe Dead Load	0.94	5.16	1.25	1.17	6.45	0.90	0.84	4.64
1B	DC	Stem Wall Dead Load	10.20	25.51	1.25	12.76	31.89	0.90	9.18	22.96
1C	DC	Backwall Dead Load	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
2A	EV	Soil Vertical Load 1	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 2	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 3	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 4	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2C	EV	Soil Load (below lightwt fill)	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4B	DC2	Superimposed Dead Load	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4C	DW	Wearing Surface / Utilities	0.00	0.00	1.50	0.00	0.00	0.65	0.00	0.00
5	LS	Equiv LL Surcharge	0.00	0.00	1.75	0.00	0.00	1.75	0.00	0.00
8A	EV	Lightweight Fill below Bearing	3.35	-10.06	1.35	4.53	-13.58	1.00	3.35	-10.06
8B	EV	Lightweight Fill above Bearing	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
9A	EV	EPS Concrete Cap below Brg	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9B	EV	EPS Concrete Cap above Brg	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Heel	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Mid	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Toe	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
Total Vertical:		204.82	18.62	15.45	259.71	23.61	18.31	187.99	17.09	12.90
HORIZONTAL LOADS:										
3	EH	Soil Lateral Load 1	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3A	EH	Soil Lateral Load 2	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3B	EH	Soil Lateral Load 3	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3C	EH	Soil Lateral Load 4	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3D	EH	Soil Lateral Load 5	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3E	EH	Soil Lateral Load 6	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4B	DC2	Superimposed Dead Loads	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4C	DW	Wearing Surface + Utilities	0.00	0.00	1.50	0.00	0.00	0.65	0.00	0.00
5A	LS	Equiv LL Surcharge 1	0.00	0.00	1.75	0.00	0.00	1.75	0.00	0.00
5B	LS	Equiv LL Surcharge 2	0.00	0.00	1.75	0.00	0.00	1.75	0.00	0.00
5C	LS	Equiv LL Surcharge 3	0.00	0.00	1.75	0.00	0.00	1.75	0.00	0.00
8A	EH	Lightweight Fill below Bearing	1.93	14.08	1.35	2.60	19.00	0.90	1.73	12.67
8B	EH	Lightweight Fill above Bearing	3.65	40.04	1.35	4.93	54.05	0.90	3.29	36.03
9A	EH	EPS Cap below Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9B	EH	EPS Cap above Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9C	EH	Lwt Fill below Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9D	EH	Lwt Fill above Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9C	EH	EPS Cap below Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9D	EH	EPS Cap above Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
Total Horizontal:		61.38	5.58	54.12	82.83	7.53	73.06	55.22	5.02	48.70
Moment Grand Total:				69.57			91.37			61.61
				765.27			1005.07			677.71

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: North Abutment Return Wall #3 FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

CASE II **Extreme I** **Live Load on Approach**

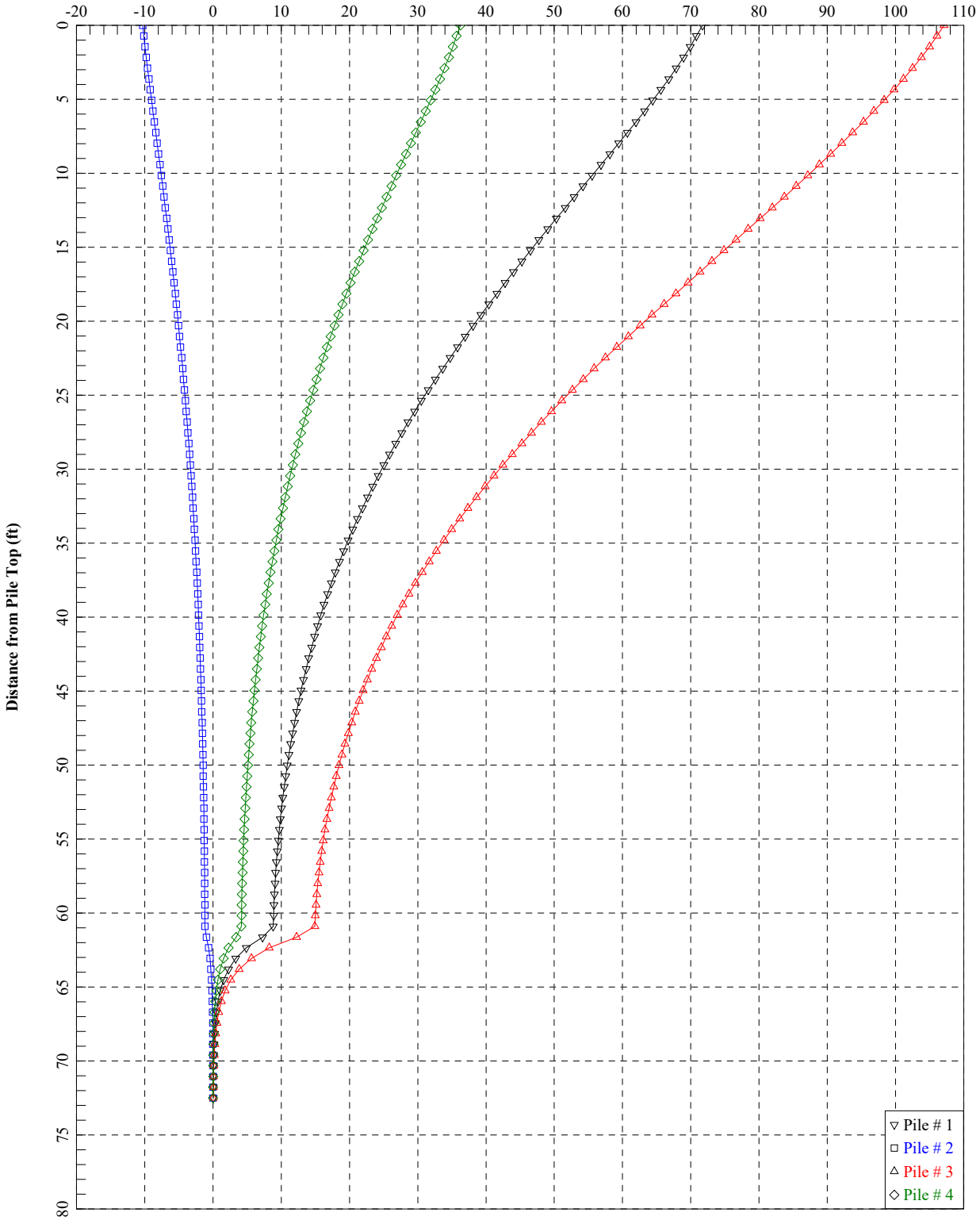
			SERVICE I		EXTREME I 50% Inertial + 100% PAE			EXTREME I 100% Inertial + 50% PAE		
Load No.		Load Description	Load	Moment	Factors	Load	Moment	Factors	Load	Moment
			K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft
VERTICAL LOADS:										
1A	DC	Footing Heel Dead Load	2.81	-8.44	1.00	2.81	-8.44	1.00	2.81	-8.44
	DC	Footing Mid Dead Load	1.31	3.28	1.00	1.31	3.28	1.00	1.31	3.28
	DC	Footing Toe Dead Load	0.94	5.16	1.00	0.94	5.16	1.00	0.94	5.16
1B	DC	Stem Wall Dead Load	10.20	25.51	1.00	10.20	25.51	1.00	10.20	25.51
	DC	Backwall Dead Load	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2A	EV	Soil Vertical Load 1	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	EV	Soil Vertical Load 2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	EV	Soil Vertical Load 4	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2C	EV	Soil Load (below lightwt fill)	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4B	DC2	Superimposed Dead Load	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4C	DW	Wearing Surface / Utilities	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5	LS	Equiv LL Surcharge	0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00
8A	EV	Lightweight Fill below Bearing	3.35	-10.06	1.00	3.35	-10.06	1.00	3.35	-10.06
8B	EV	Lightweight Fill above Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9A	EV	EPS Concrete Cap below Brg	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9B	EV	EPS Concrete Cap above Brg	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
10	WA	Buoyancy Heel	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	WA	Buoyancy Mid	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	WA	Buoyancy Toe	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
12A	WS	Wind on Structure (Serv I)	0.00	0.00						
	WS	Wind on Structure (Str V)								
Total Vertical:			18.62	15.45	204.82	18.62	15.45	204.82	18.62	15.45
HORIZONTAL LOADS:										
3	EH	Soil Lateral Load 1	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3A	EH	Soil Lateral Load 2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3B	EH	Soil Lateral Load 3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3C	EH	Soil Lateral Load 4	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3D	EH	Soil Lateral Load 5	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3E	EH	Soil Lateral Load 6	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4B	DC2	Superimposed Dead Loads	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4C	DW	Wearing Surface + Utilities	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5A	LS	Equiv LL Surcharge 1	0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00
5B	LS	Equiv LL Surcharge 2	0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00
5C	LS	Equiv LL Surcharge 3	0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00
8A	EH	Lightweight Fill below Bearing	1.85	13.55	1.00	1.85	13.55	1.00	1.51	11.05
8B	EH	Lightweight Fill above Bearing	3.47	38.09	1.00	3.47	38.09	1.00	2.83	31.06
9A	EH	EPS Cap below Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9B	EH	EPS Cap above Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9C	EH	Lwt Fill below Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9D	EH	Lwt Fill above Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9C	EH	EPS Cap below Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9D	EH	EPS Cap above Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
12A	WS	Wind on Structure (Serv I)	0.00	0.00						
	WS	Wind on Structure (Str V)								
12B	WS	Wind on Stem Wall (Serv I)	0.00	0.00						
	WS	Wind on Stem Wall (Str V)								
13	EQ	Earthquake Load	4.19	0.00	1.00	2.09	0.00	1.00	4.19	0.00
Total Horizontal:			9.52	51.64	81.62	7.42	51.64	93.83	8.53	42.11
Moment Grand Total:				67.10			67.10			57.56
							738.10			633.16

Load Case 1 = Service I



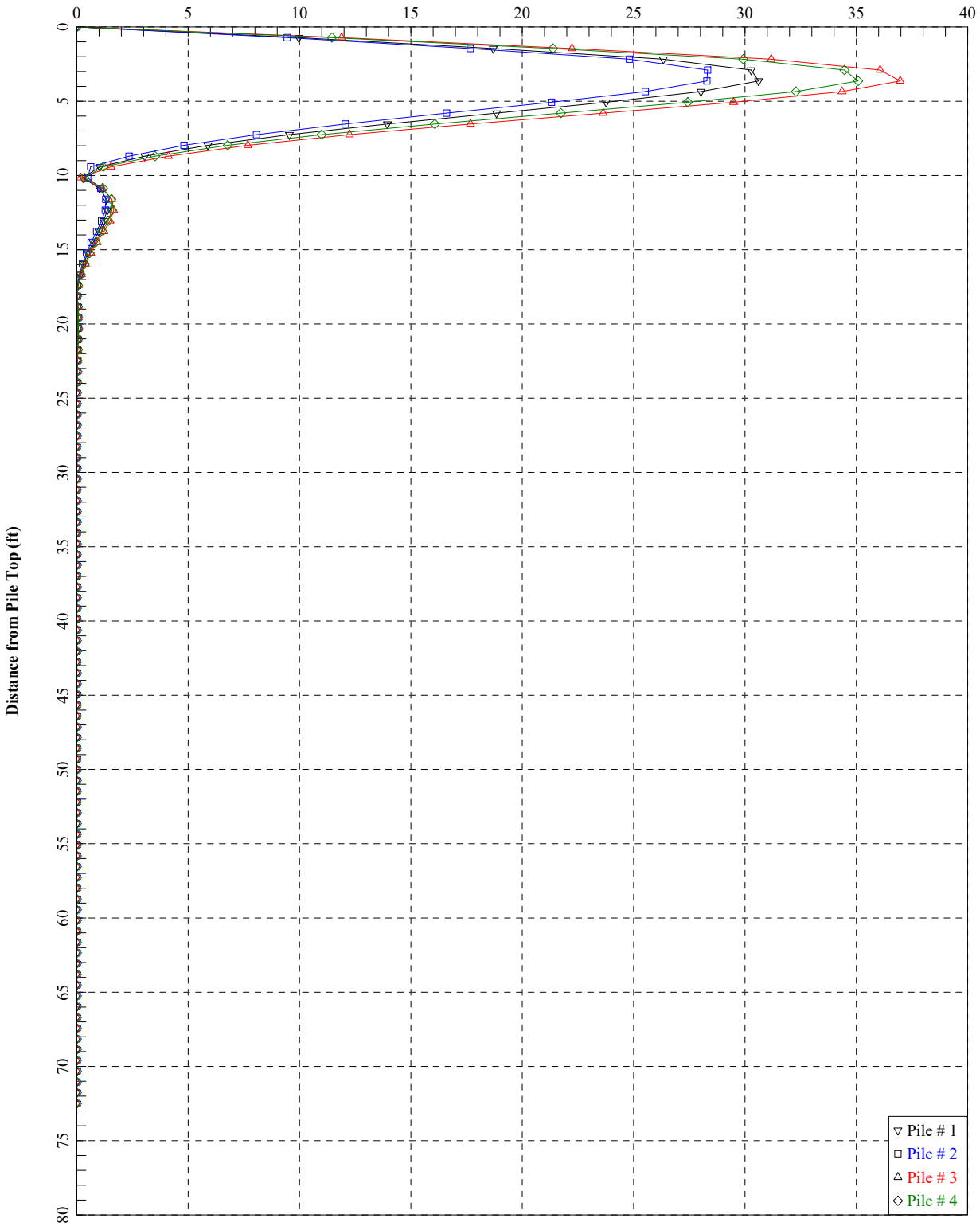
Load Case # 1

Load Case 1 = Service I

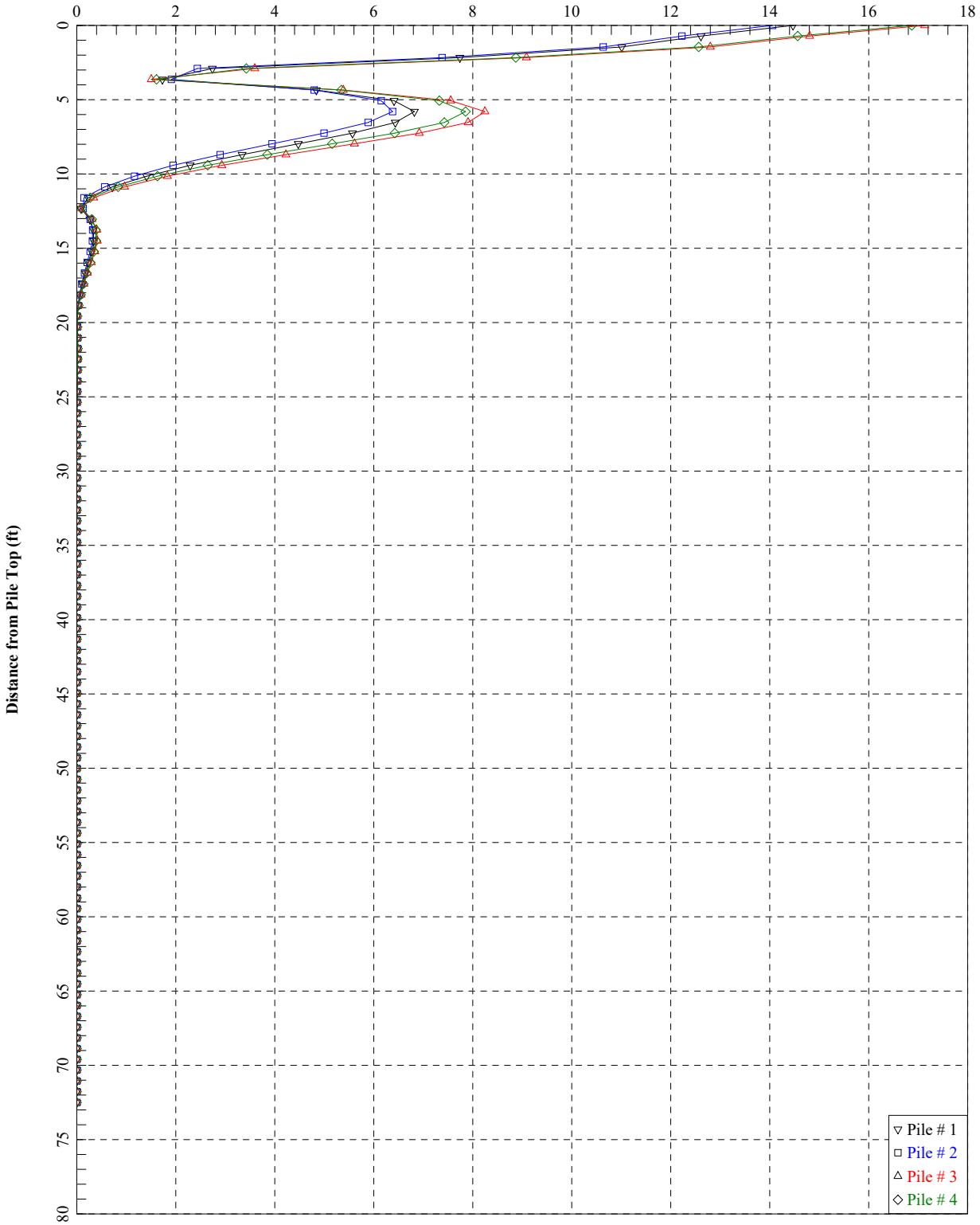


Load Case # 1

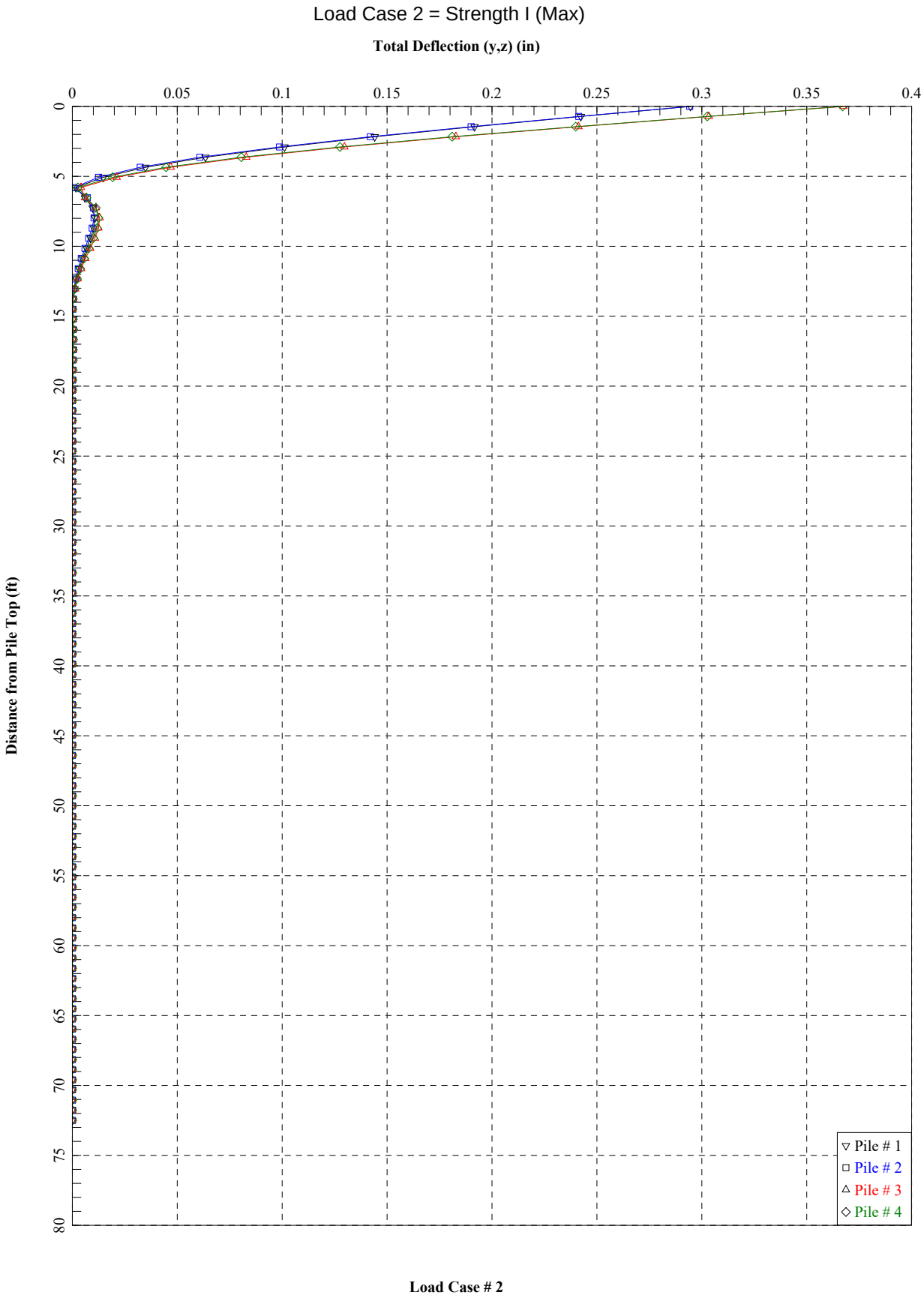
Load Case 1 = Service I



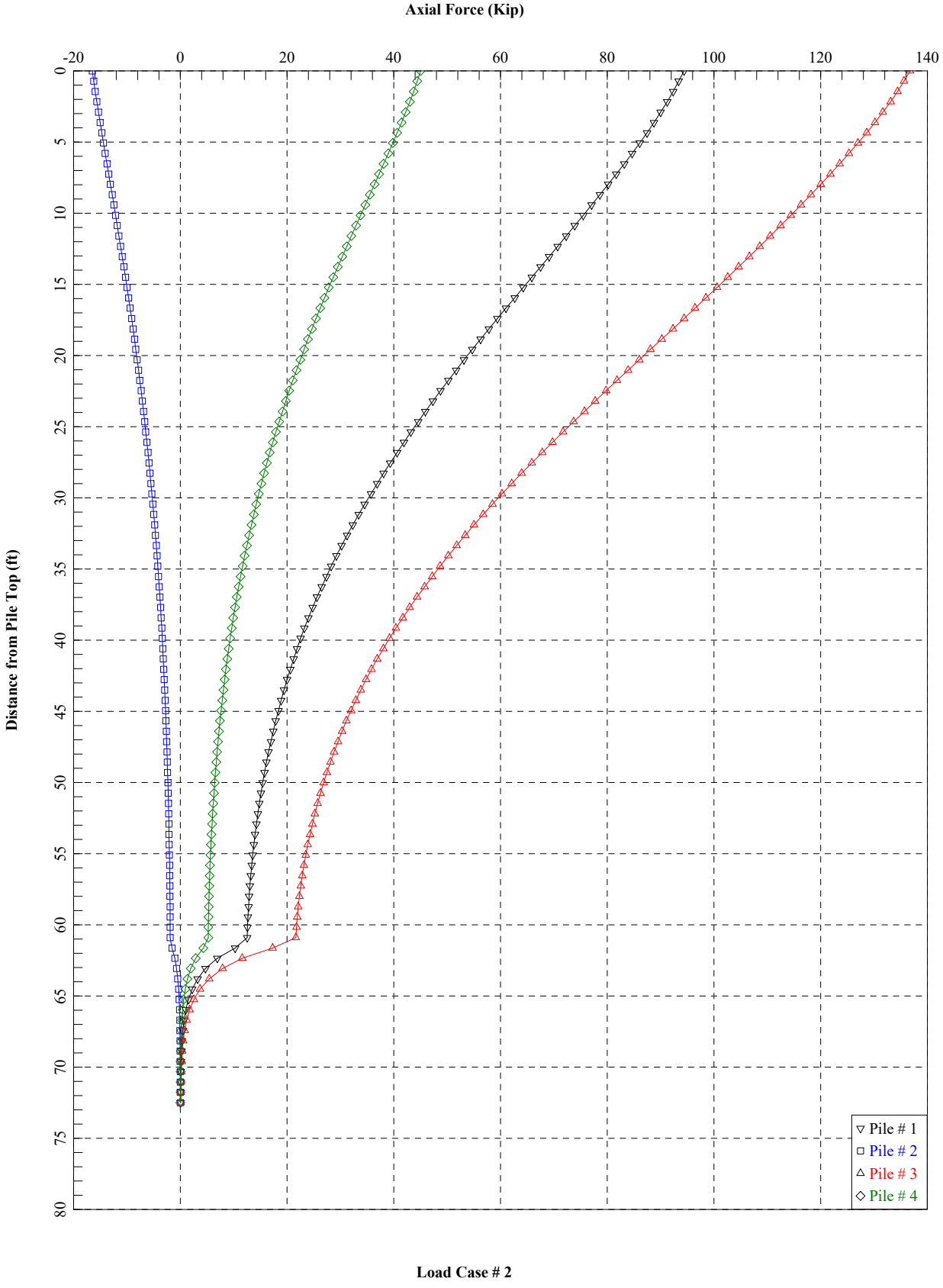
Load Case 1 = Service I



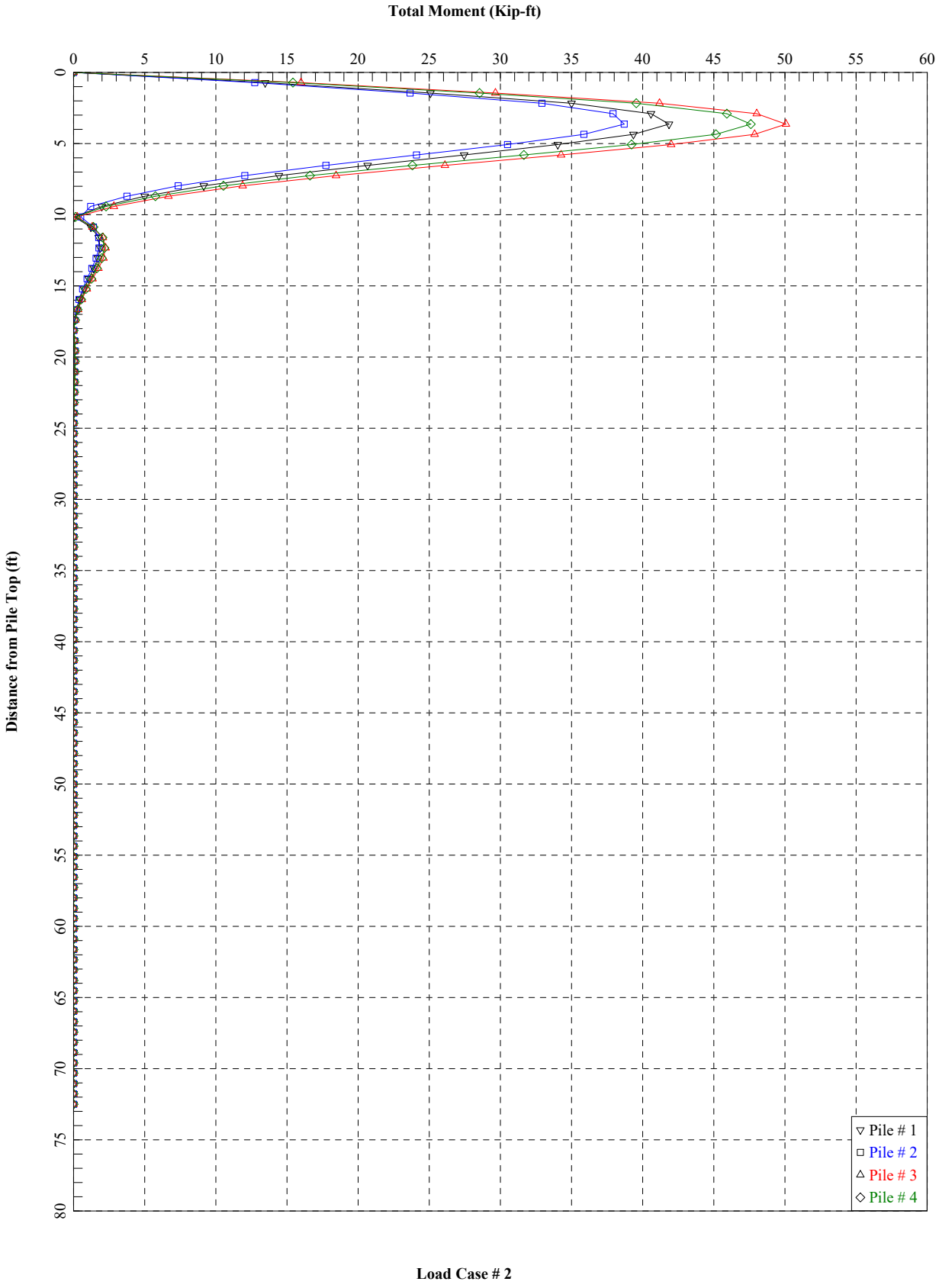
Load Case # 1


Load Case 2 = Strength I (Max)
Total Deflection (y,z) (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Distance from Pile Top (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Load Case # 2

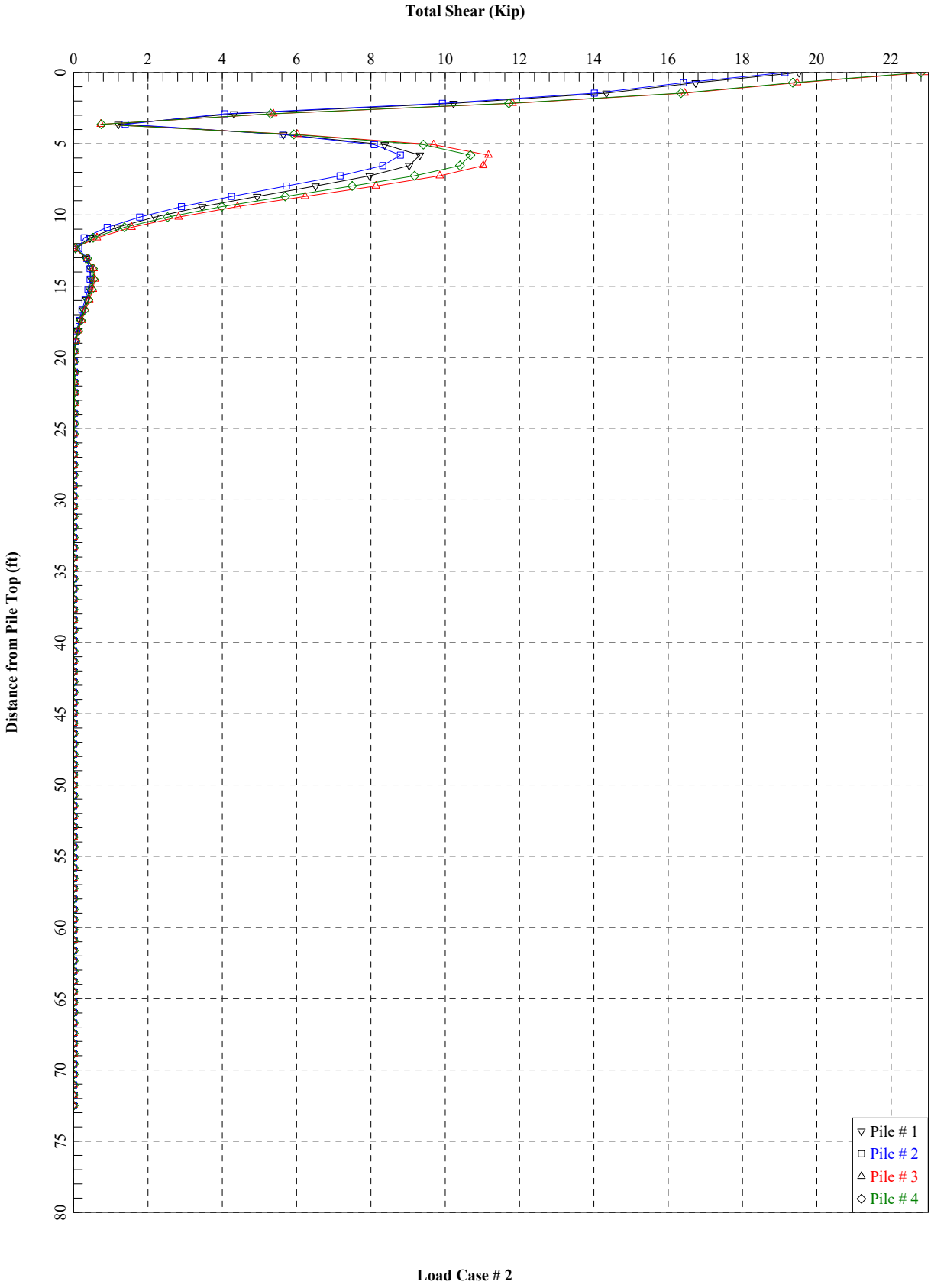
Load Case 2 = Strength I (Max)



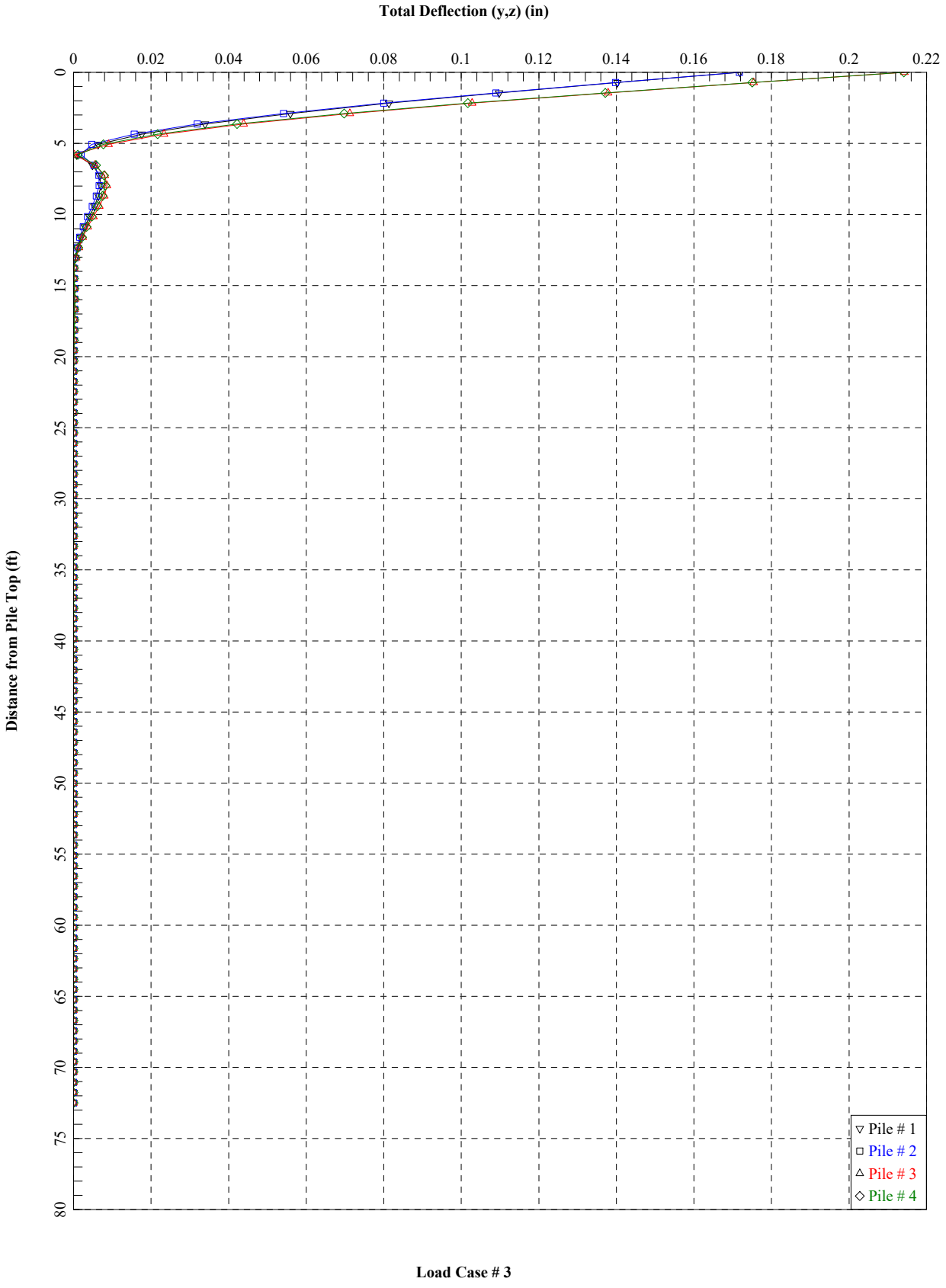
Load Case 2 = Strength I (Max)



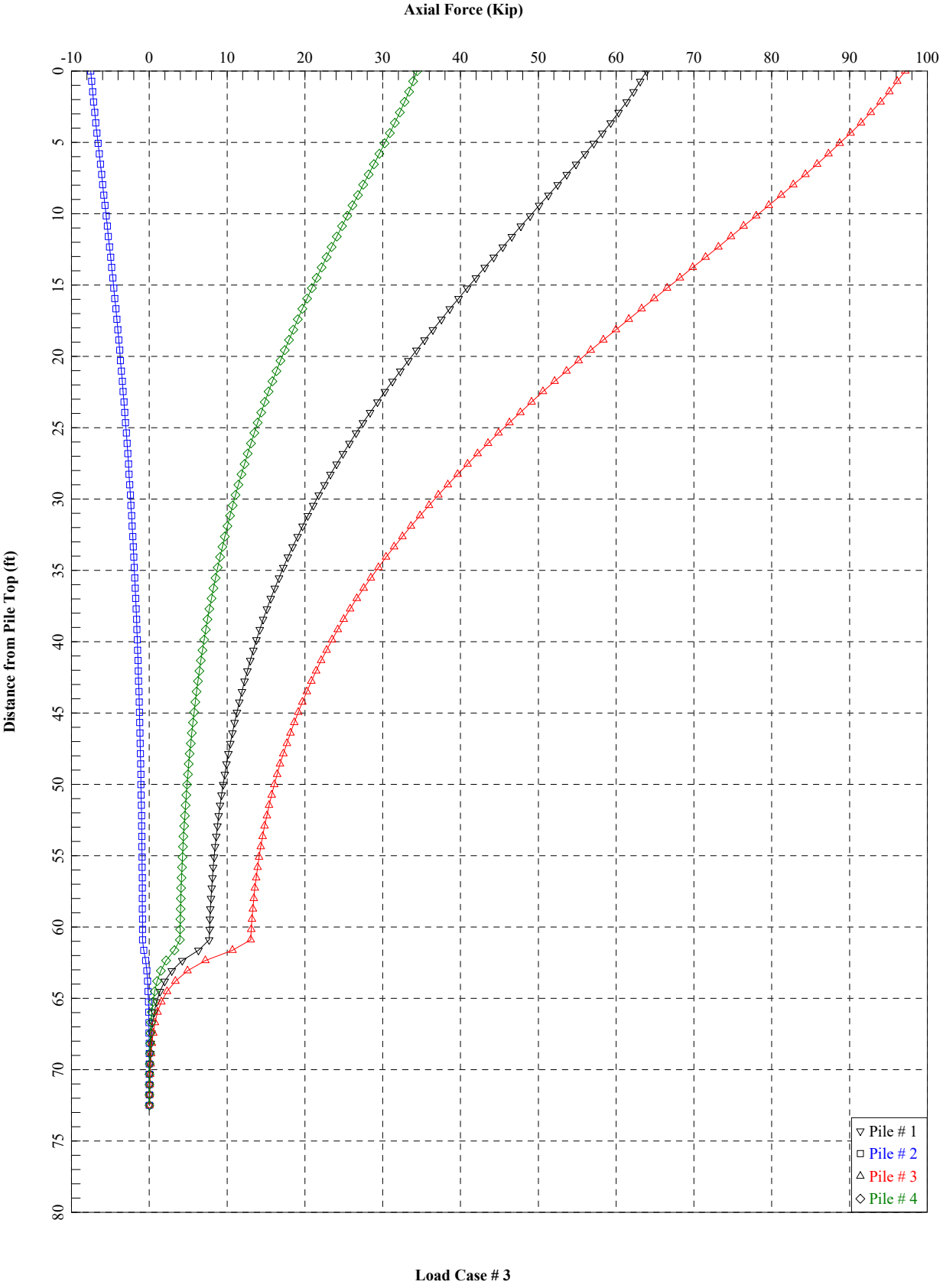
Load Case 2 = Strength I (Max)



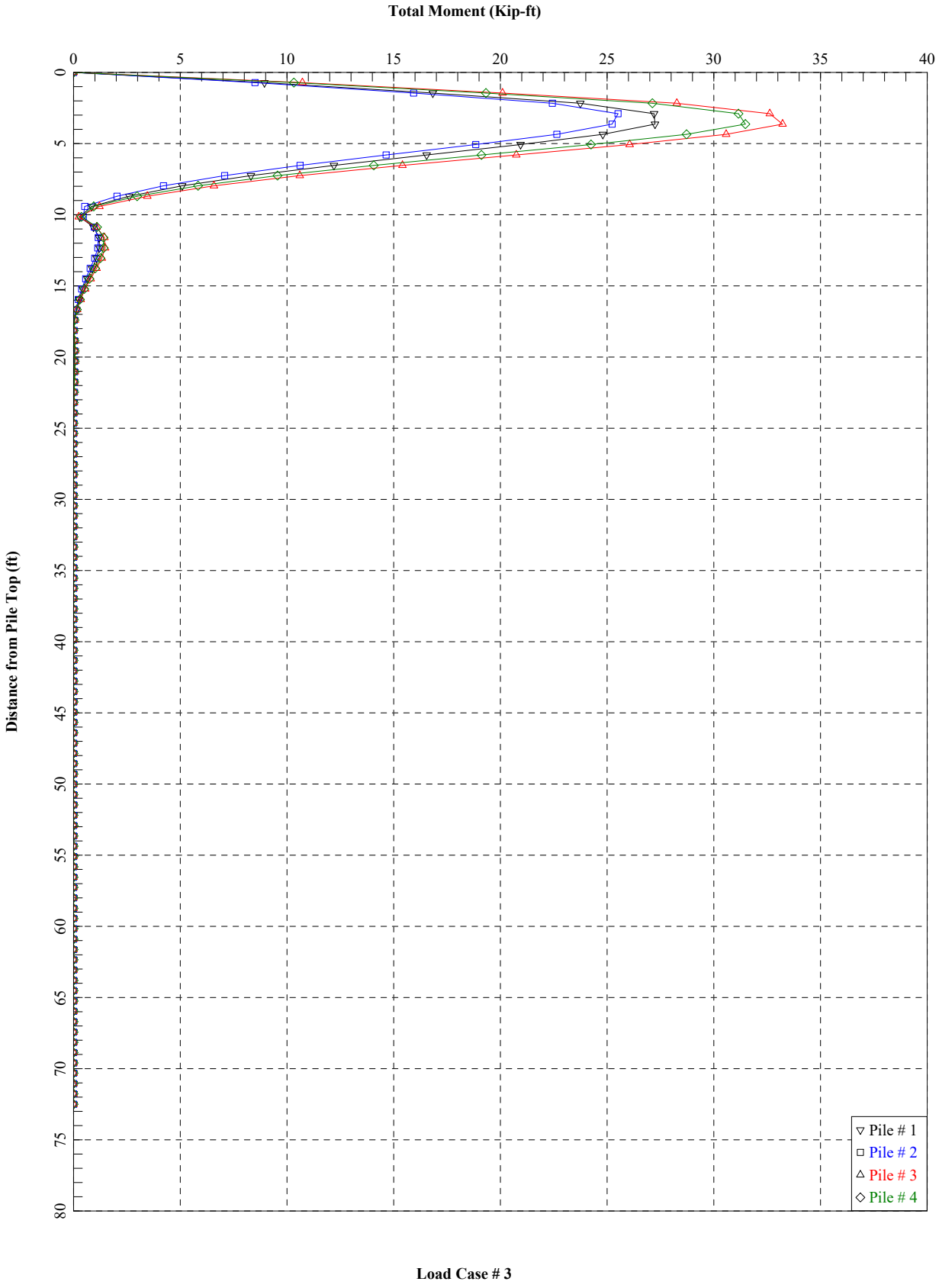
Load Case 3 = Strength I (Min)



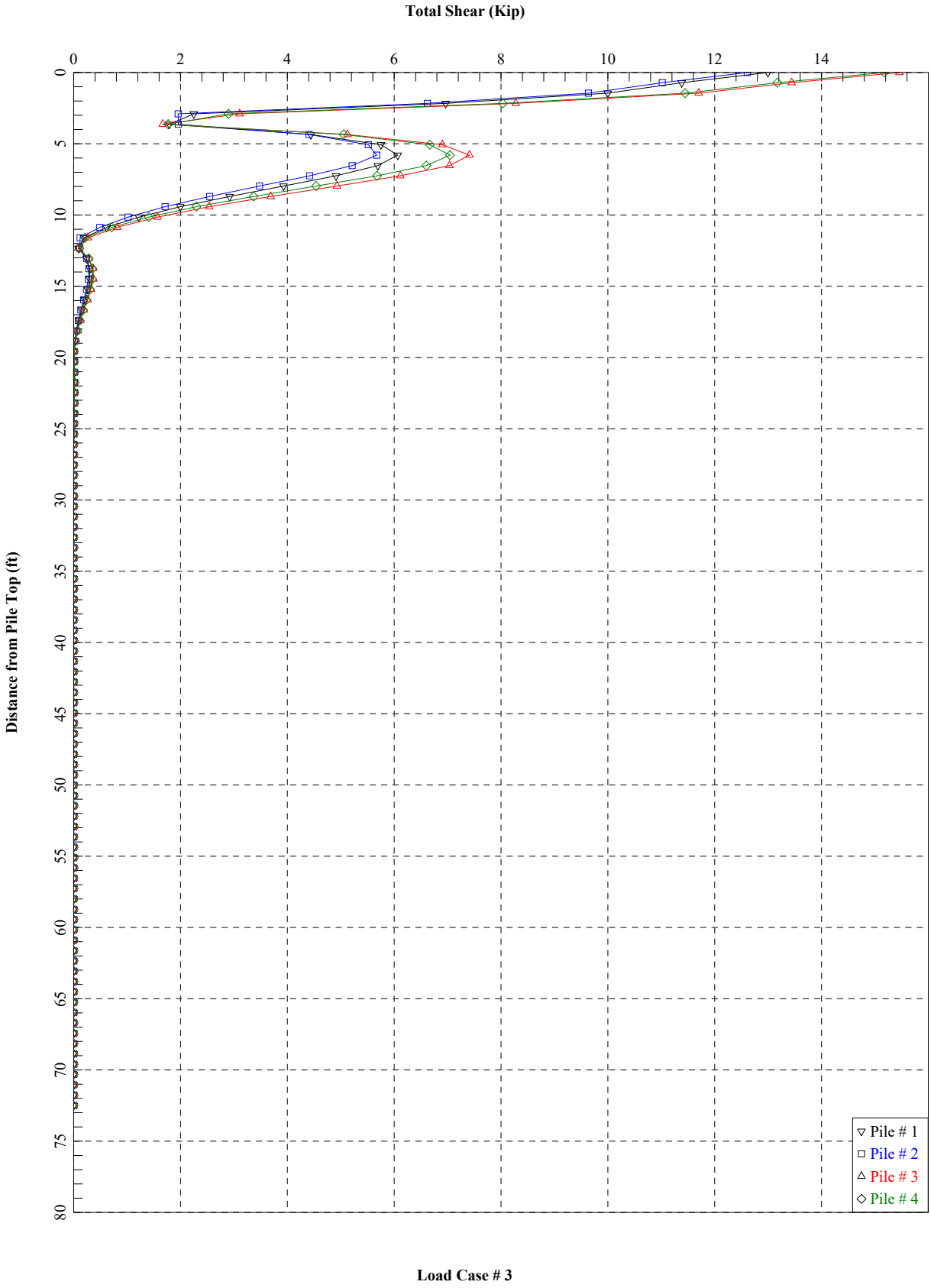
Load Case 3 = Strength I (Min)

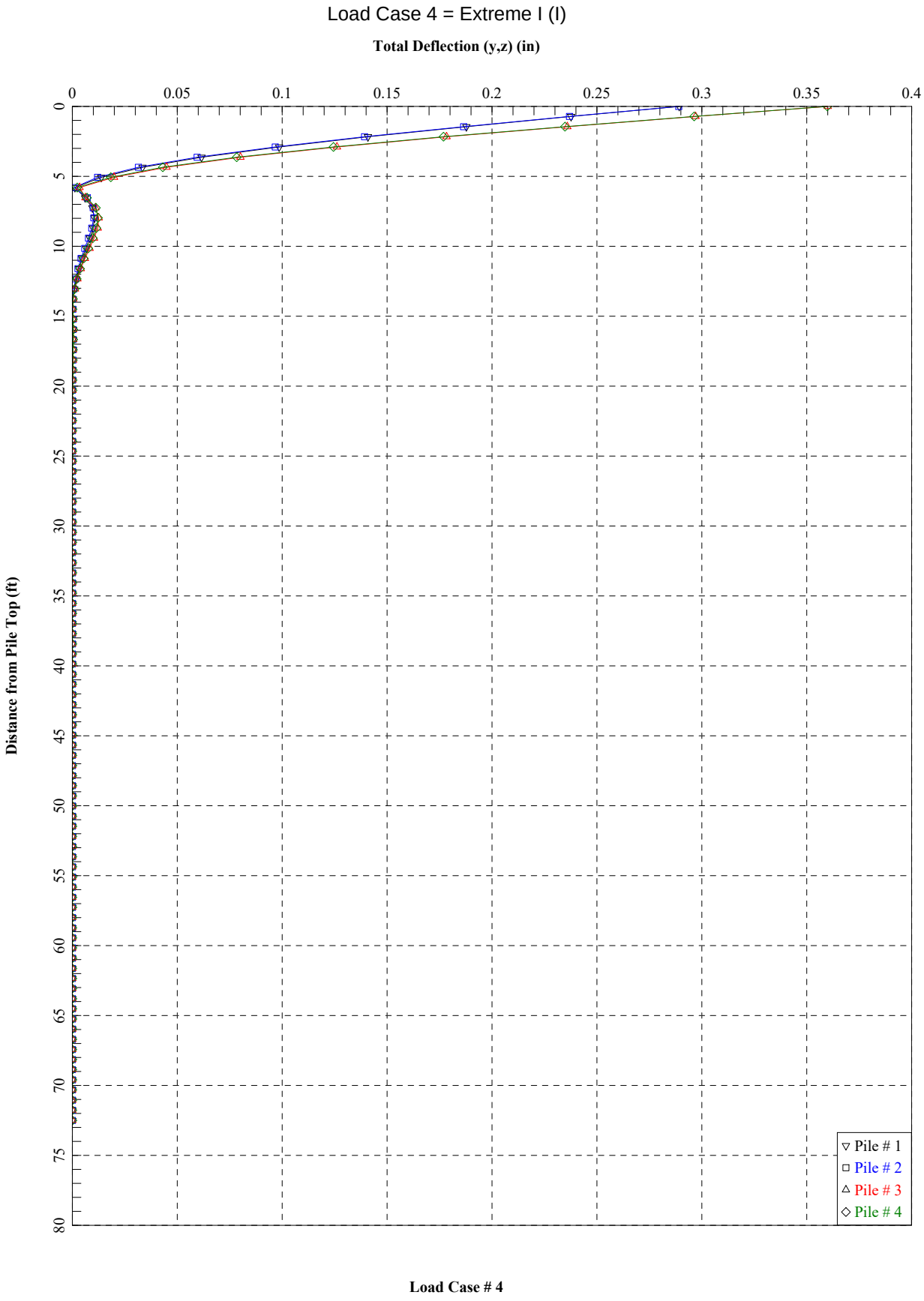


Load Case 3 = Strength I (Min)

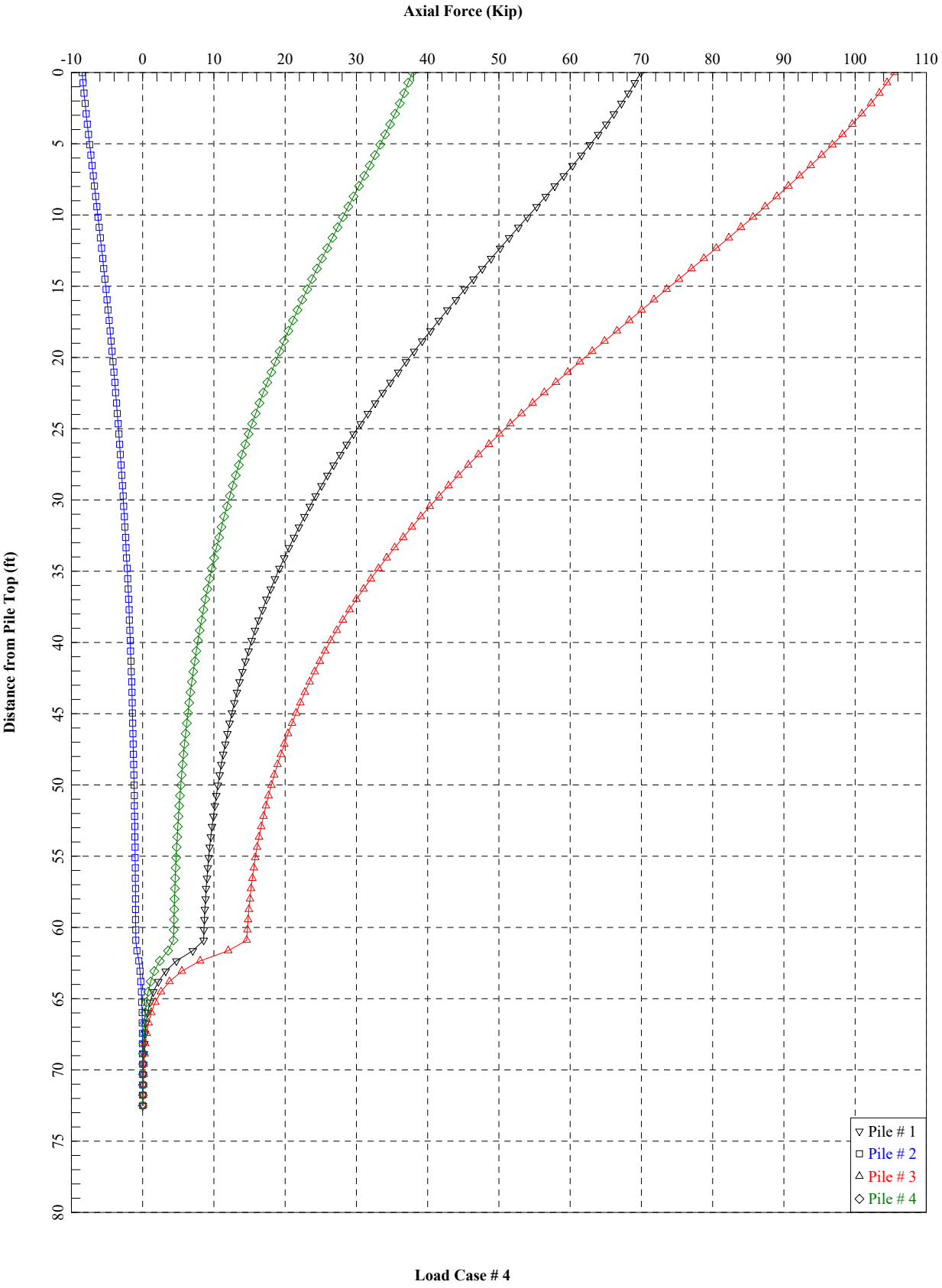


Load Case 3 = Strength I (Min)

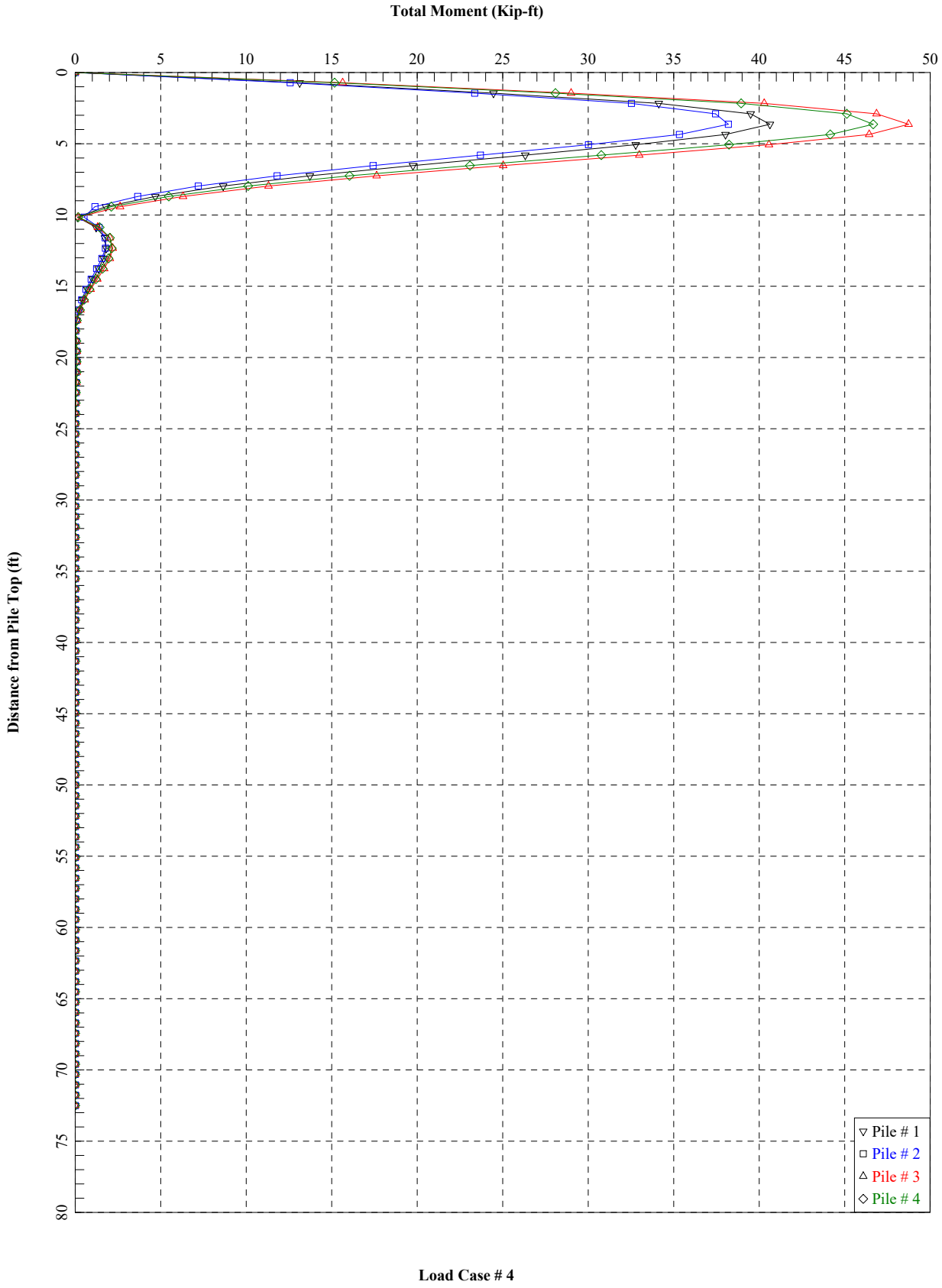



Load Case 4 = Extreme I (I)
Total Deflection (y,z) (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Distance from Pile Top (ft)
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Load Case # 4

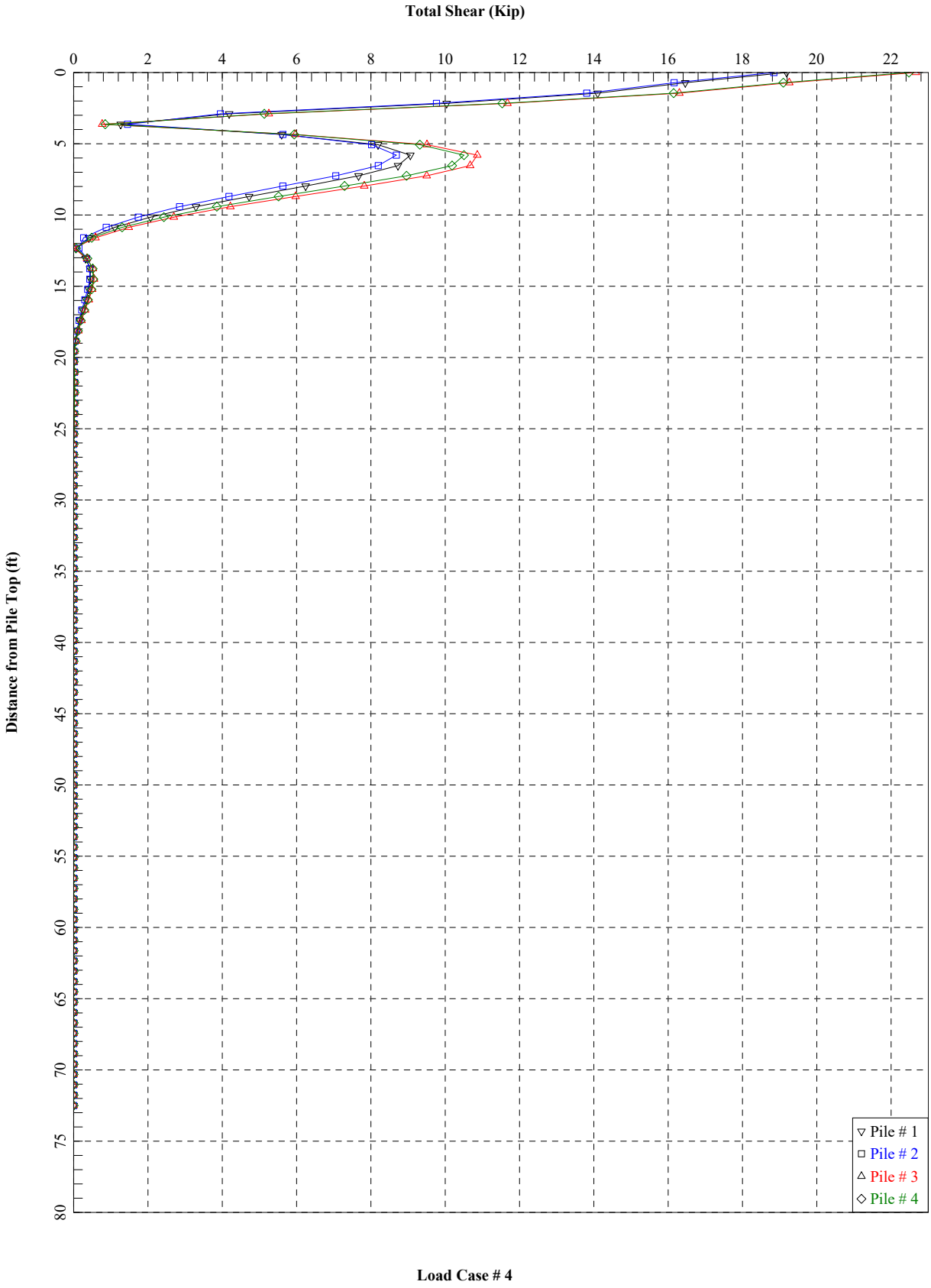
Load Case 4 = Extreme I (I)



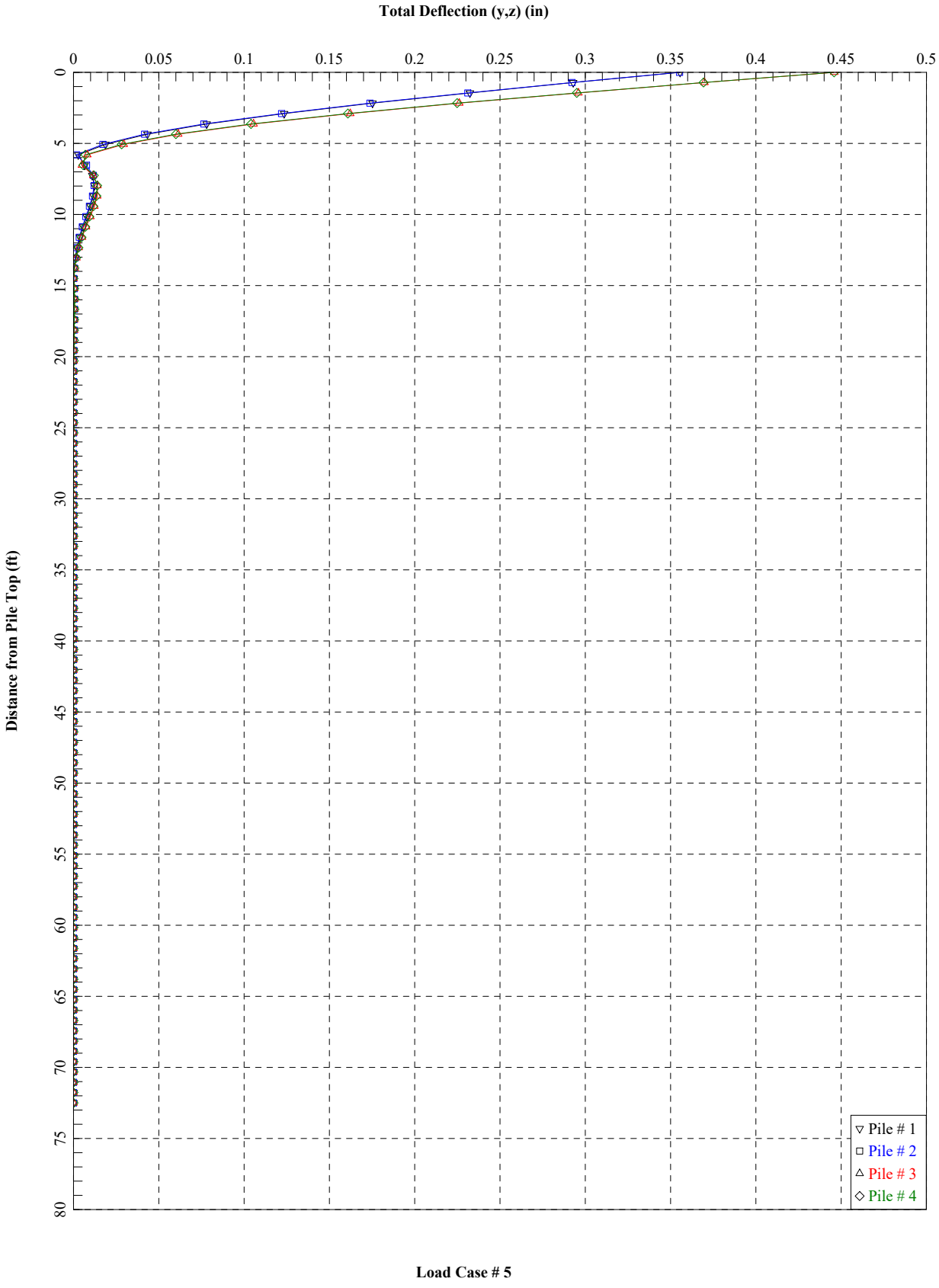
Load Case 4 = Extreme I (I)



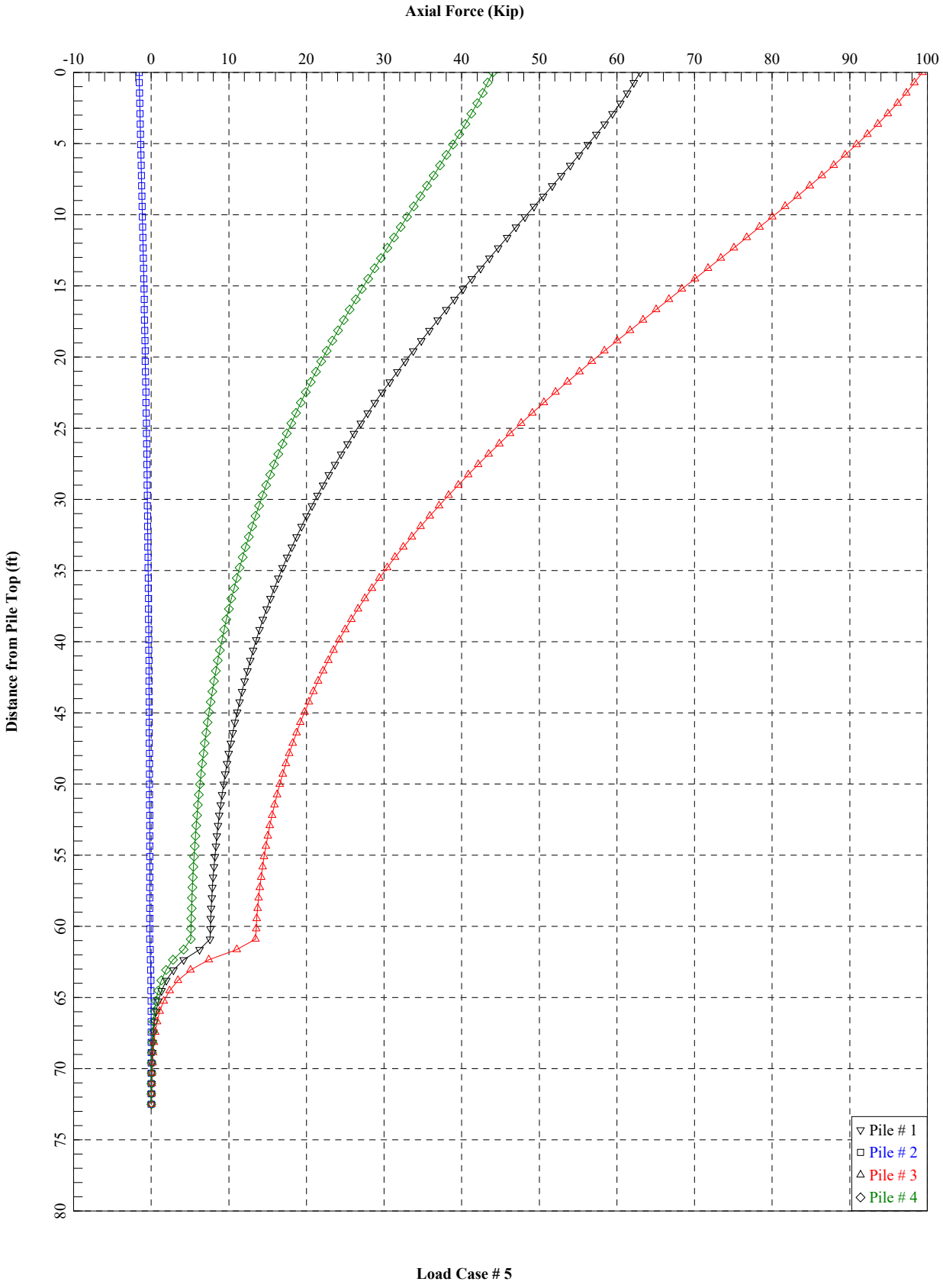
Load Case 4 = Extreme I (I)



Load Case 5 = Extreme I (II)

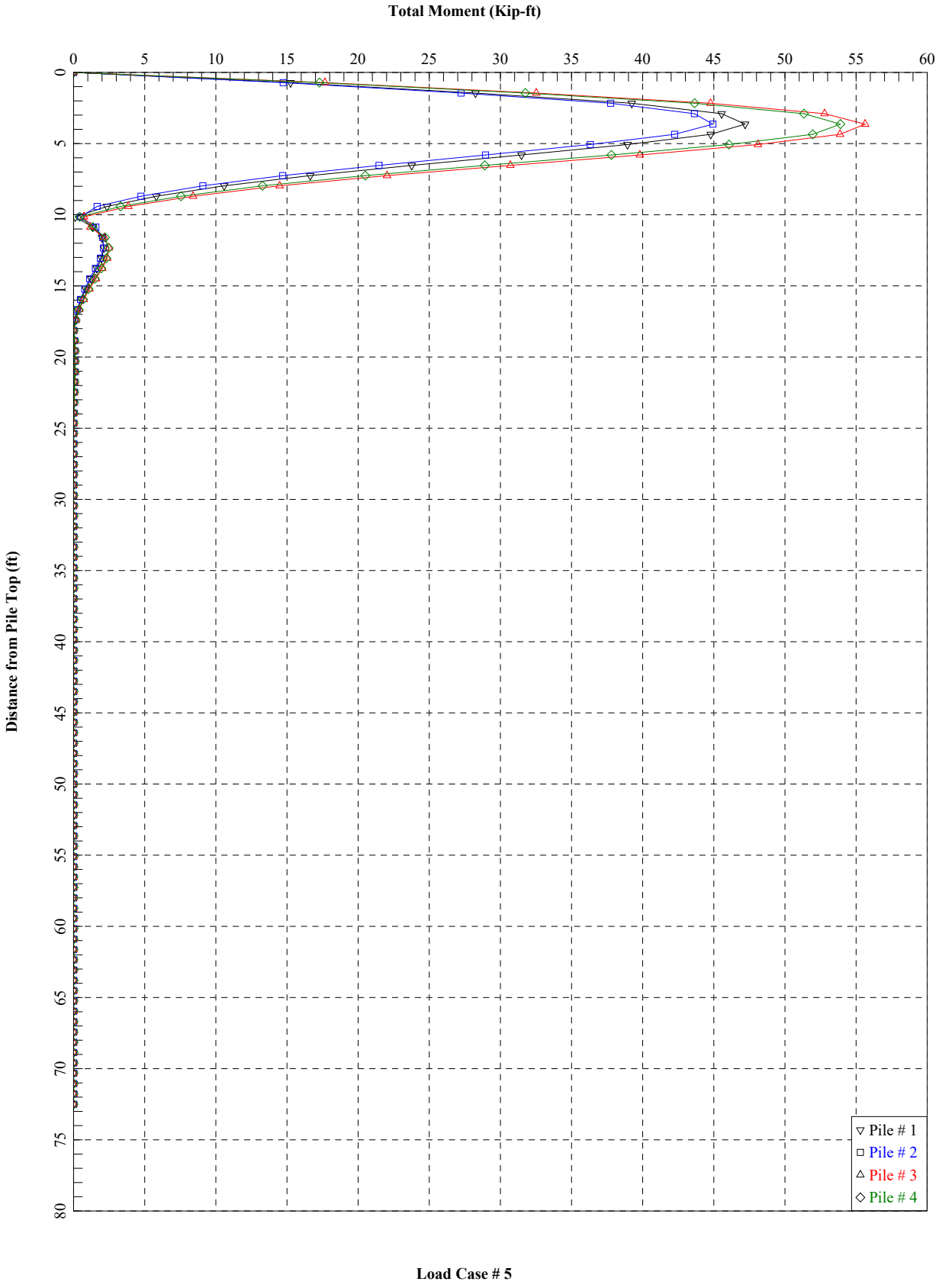


Load Case 5 = Extreme I (II)

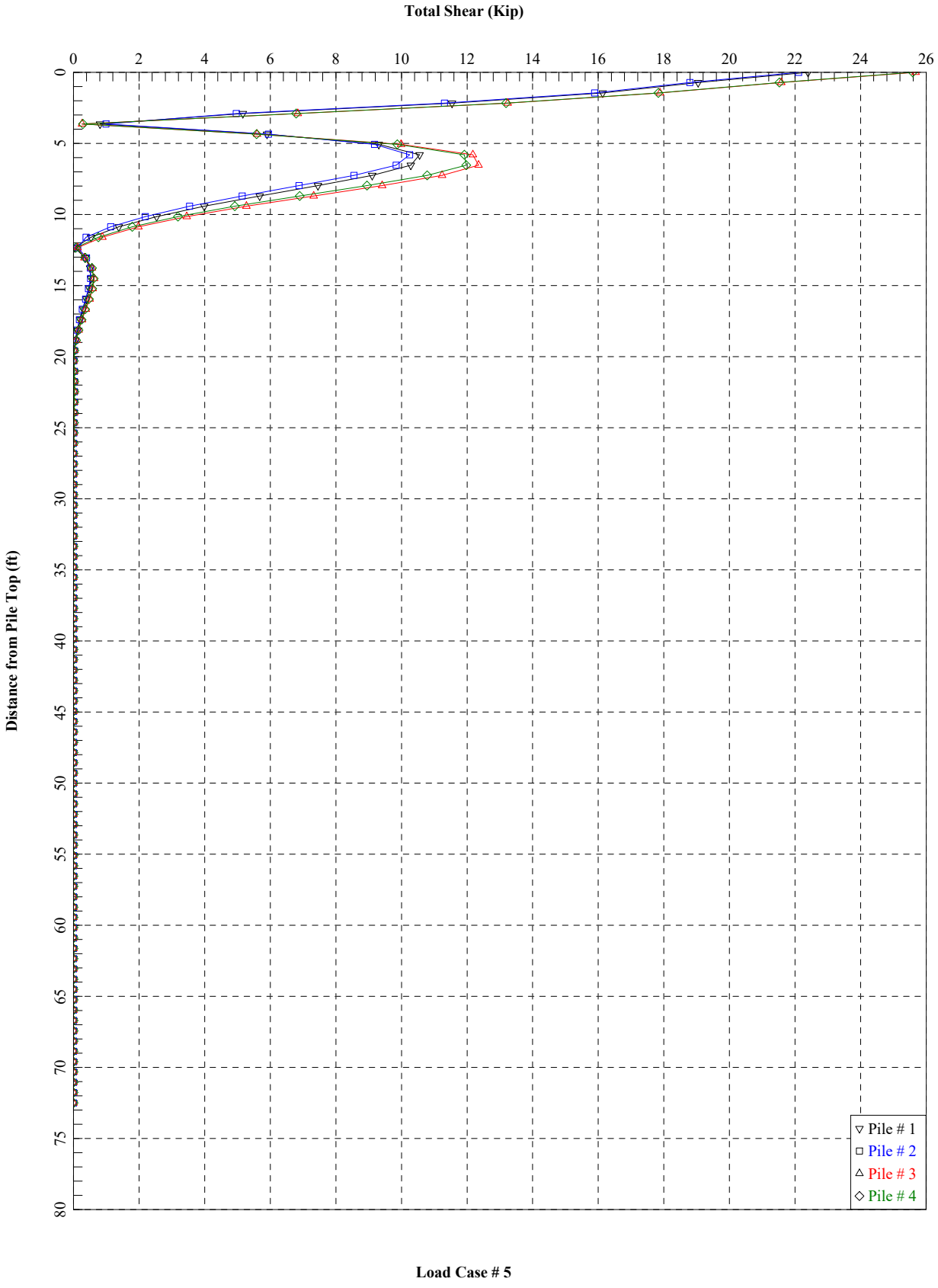


Load Case # 5

Load Case 5 = Extreme I (II)



Load Case 5 = Extreme I (II)



```
     ======================================================================

                    GROUP for Windows, Version 2022.12.4

                     Serial Number : 546958378

                     Analysis of A Group of Piles
                   Subjected to Axial and Lateral Loading

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     ======================================================================


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     Nobis Engineering, Inc.
     Lowell, MA, USA

     Path to file locations      : J:\094184.100-MassDOT Armory Street Bridges, Springfield\Calculations\Axial-Lateral Pile Analysis\S-24-026\Updated
Return Wall 3 and 4\Group\
     Name of input data file     : North Return Wall #3.gp12r
     Name of output echo file    : North Return Wall #3.gp12e
     Name of output results file : North Return Wall #3.gp12o
     Name of output summary file : North Return Wall #3.gp12t
     Name of plot output file    : North Return Wall #3.gp12p
     Name of runtime file        : North Return Wall #3.gp12r


     ----------------------------------------------------------------------
                         Time and Date of Analysis
     ----------------------------------------------------------------------

               Date:  March 07, 2025     Time:  06:57:18




                *****     INPUT INFORMATION     *****


     Armory Street over Abandoned CSX Spur - S-24-026 - South Abutment Return Wall #4

     ANALYSIS TYPE = 3D ANALYSIS

     ADJUST DEPTH FOR BATTER PILES

     GENERATE LOAD-DISP (AND T-R) CURVES BASED ON SOIL PROFILE

     EXTEND INTERPOLATION FOR L-DP (AND T-R) CURVES

     UNITS SYSTEM  = ENGL



     * TABLE B *  PILE CAP OPTIONS

     LENGTH,YY    ( FT ) =    13.50
     WIDTH, ZZ    ( FT ) =    11.00
     THICKNESS,XX ( FT ) =   -2.500

     * PILE CAP DIMENSIONS ARE NOT CONSIDERED
       FOR THE PILE GROUP ANALYSIS




     * TABLE C *  LOAD AND CONTROL PARAMETERS


     ** LOAD CASES **


     NUMBER OF LOAD CASES :    5


     LOAD CASE    :     1
     CASE NAME    : Service I
     LOAD TYPE    : Dead, DL
     SCALE FACTOR :       1.0000

     * CONCENTRATED LOADS *

    NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
          LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
     1   2.05E+05  6.14E+04      0.00      0.00      0.00 -9.18E+06      0.00      0.00      0.00
```

```
 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           2.04820E+05           61380.0           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
               0.00000           0.00000      -9.18324E+06


 * THE LOADING IS STATIC *


 * CONTROL PARAMETERS *
     TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
     TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-03 IN
     MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
     MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
     FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
     MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
     INCLUDE VARIATION OF AXIAL LOAD AT PILES
     * NOT FOR USER DEFINED LOAD SETTL. CURVE
     - PRINT RESULTS AT PILE CAP


 LOAD CASE    :     2
 CASE NAME    : Strength I Max
 LOAD TYPE    : Dead, DL
 SCALE FACTOR :       1.0000

 * CONCENTRATED LOADS *

NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
       LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
 1   2.60E+05  8.28E+04      0.00      0.00      0.00 -1.21E+07      0.00      0.00      0.00


 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           2.59710E+05           82830.0           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
               0.00000           0.00000      -1.20608E+07


 * THE LOADING IS STATIC *


 * CONTROL PARAMETERS *
     TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
     TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-03 IN
     MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
     MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
     FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
     MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
     INCLUDE VARIATION OF AXIAL LOAD AT PILES
     * NOT FOR USER DEFINED LOAD SETTL. CURVE
     - PRINT RESULTS AT PILE CAP


 LOAD CASE    :     3
 CASE NAME    : Strength I Min
 LOAD TYPE    : Dead, DL
 SCALE FACTOR :       1.0000

 * CONCENTRATED LOADS *

NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
       LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
 1   1.88E+05  5.52E+04      0.00      0.00      0.00 -8.13E+06      0.00      0.00      0.00


 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           1.87990E+05           55220.0           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
               0.00000           0.00000      -8.13252E+06


 * THE LOADING IS STATIC *


 * CONTROL PARAMETERS *
     TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
     TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-03 IN
     MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
     MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
     FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
     MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
```

```
    INCLUDE VARIATION OF AXIAL LOAD AT PILES
    * NOT FOR USER DEFINED LOAD SETTL. CURVE
    - PRINT RESULTS AT PILE CAP


 LOAD CASE    :     4
 CASE NAME    : Extreme Event I (I)
 LOAD TYPE    : Dead, DL
 SCALE FACTOR :       1.0000

 * CONCENTRATED LOADS *

NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
       LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
 1   2.05E+05  8.16E+04      0.00      0.00      0.00 -8.86E+06      0.00      0.00      0.00


 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           2.04820E+05           81620.0           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
               0.00000           0.00000      -8.85720E+06


 * THE LOADING IS STATIC *


 * CONTROL PARAMETERS *
     TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
     TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-03 IN
     MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
     MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
     FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
     MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
     INCLUDE VARIATION OF AXIAL LOAD AT PILES
     * NOT FOR USER DEFINED LOAD SETTL. CURVE
     - PRINT RESULTS AT PILE CAP


 LOAD CASE    :     5
 CASE NAME    : Extreme Event I (II)
 LOAD TYPE    : Dead, DL
 SCALE FACTOR :       1.0000

 * CONCENTRATED LOADS *

NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
       LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
 1   2.05E+05  9.38E+04      0.00      0.00      0.00 -7.60E+06      0.00      0.00      0.00


 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           2.04820E+05           93830.0           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
               0.00000           0.00000      -7.59792E+06


 * THE LOADING IS STATIC *


 * CONTROL PARAMETERS *
     TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
     TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-03 IN
     MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
     MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
     FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
     MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
     INCLUDE VARIATION OF AXIAL LOAD AT PILES
     * NOT FOR USER DEFINED LOAD SETTL. CURVE
     - PRINT RESULTS AT PILE CAP



 * TABLE D *   ARRANGEMENT OF PILE GROUPS

 GROUP  CONN.Z-Z   CONN.Y-Y   PILE PROP  P-Y CURVE  L-S CURVE  T-R CURVE  R-F-L SET
   1       PIN        PIN         1          0          1 G        1 G        0
   2       PIN        PIN         1          0          1 G        1 G        0
   3       PIN        PIN         1          0          1 G        1 G        0
   4       PIN        PIN         1          0          1 G        1 G        0

 GROUP   CorX,FT    CorY,FT    CorZ,FT  ALPHA,DEG   BETA,DEG  THETA,DEG  GROUND,FT SPz,LBS-IN SPy,LBS-IN
   1       0.000      4.750      3.500      0.000      90.00      0.000     -4.000      0.000      0.000
   2       0.000     -3.250      3.500      0.000      90.00      0.000     -4.000      0.000      0.000
   3       0.000      4.750     -1.500      0.000      90.00      0.000     -4.000      0.000      0.000
   4       0.000     -3.250     -1.500      0.000      90.00      0.000     -4.000      0.000      0.000
```

```
 * TABLE E *   PILE GEOMETRY AND PROPERTIES
               PILE TYPE = 1 - DRIVEN PILE
                         = 2 - DRILLED SHAFT

   PROP   SECTS   INC     PILE TYPE      LENGTH, FT
     1      3     100          2             72.500

 * PILE SECTIONS *

   PROP    SECT      FROM,FT         TO,FT    CROSS SECT
     1       1        0.00000        3.00000       1
     1       2        3.00000        62.5000       2
     1       3        62.5000        72.5000       3

 * PILE CROSS SECTIONS *

  CROSS SECTION       :     1
  SECTION NAME        : 10.75"
  TYPE                :  NONLINEAR
  CROSS SECTION TYPE  : ROUND CONC. SHAFT, CASING (AND STEEL SECTION)
  CONCRETE DIAMETER   :       9.75000 IN
  CONCRETE FC         :       5000.00 LBS/IN**2
  DIAMETER CASING     :       10.6250 IN
  THICKNESS CASING    :       0.43750 IN
  ES CASING           :   2.90000E+07 LBS/IN**2
  FY CASING           :       52000.0 LBS/IN**2
  EMBEDDED STEEL SECT : NONE
  NUMBER REBARS       :             1
  ES REINFORCEMENT    :   2.90000E+07 LBS/IN**2
  FY REINFORCEMENT    :       60000.0 LBS/IN**2
  REINF. LAYOUT       :       MANUAL
  REINF. A , D, COORDS:        IN^2             IN              IN              IN
  - REBAR    1        :       0.79000         1.00000         0.00000         0.00000
  EQ. YOUNG MODULUS   :   9.96202E+06 LBS/IN**2

  CROSS SECTION       :     2
  SECTION NAME        : 10.75"
  TYPE                :  NONLINEAR
  CROSS SECTION TYPE  : ROUND CONC. SHAFT, CASING (AND STEEL SECTION)
  CONCRETE DIAMETER   :       9.75000 IN
  CONCRETE FC         :       5000.00 LBS/IN**2
  DIAMETER CASING     :       10.2500 IN
  THICKNESS CASING    :       0.25000 IN
  ES CASING           :   2.90000E+07 LBS/IN**2
  FY CASING           :       52000.0 LBS/IN**2
  EMBEDDED STEEL SECT : NONE
  NUMBER REBARS       :             1
  ES REINFORCEMENT    :   2.90000E+07 LBS/IN**2
  FY REINFORCEMENT    :       60000.0 LBS/IN**2
  REINF. LAYOUT       :       MANUAL
  REINF. A , D, COORDS:        IN^2             IN              IN              IN
  - REBAR    1        :       0.79000         1.00000         0.00000         0.00000
  EQ. YOUNG MODULUS   :   8.54351E+06 LBS/IN**2

  CROSS SECTION       :     3
  SECTION NAME        : 10.75"
  TYPE                :  NONLINEAR
  CROSS SECTION TYPE  : ROUND CONCRETE SHAFT
  EXTERNAL DIAMETER   :       9.75000 IN
  CONCRETE FC         :       5000.00 LBS/IN**2
  NUMBER REBARS       :             1
  ES REINFORCEMENT    :   2.90000E+07 LBS/IN**2
  FY REINFORCEMENT    :       60000.0 LBS/IN**2
  REINF. LAYOUT       :       MANUAL
  REINF. A , D, COORDS:        IN^2             IN              IN              IN
  - REBAR    1        :       1.00000         1.12800         0.00000         0.00000
  EQ. YOUNG MODULUS   :   6.39161E+06 LBS/IN**2

 * PILE CROSS SECTIONS PROPERTIES *

          NONLINEAR SECTIONS

SECT    DIAM,IN   PERIM,IN AREA,IN**2   Iz,IN**4   Iy,IN**4  GJ,LBS-IN**2   EIz IND  EIy IND   Mn,LBS-IN    Vn,LBS
  1      10.625     33.379     88.664     0.0000     0.0000   5.4901E+09      0        0         0.0000     0.0000
  2      10.250     32.201     82.516     0.0000     0.0000   3.6218E+09      0        0         0.0000     0.0000
  3      9.7500     30.631     74.662     0.0000     0.0000   1.4303E+09      0        0         0.0000     0.0000


 * TABLE F *   SOIL DATA


 SOILS INFORMATION

     GROUND SURFACE          =     -4.00000  FT

     7 LAYER(S) OF SOIL
```

```
    LAYER  1
    THE SOIL IS A SAND
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       -4.00000          0.00000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       115.000          115.000
    FRICTION ANGLE                  (DEGREES)       33.0000          33.0000
    P-Y SUBGRADE MODULUS          (LBS/IN**3)       25.0000          25.0000
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)       11.5000 (S)      552.000 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)       0.00000          0.00000

    LAYER  2
    THE SOIL IS A SAND
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       0.00000          1.50000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       52.6000          52.6000
    FRICTION ANGLE                  (DEGREES)       33.0000          33.0000
    P-Y SUBGRADE MODULUS          (LBS/IN**3)       20.0000          20.0000
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)       552.000 (S)      637.733 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)       0.00000          0.00000

    LAYER  3
    THE SOIL IS A SILT
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       1.50000          38.5000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       57.6000          57.6000
    UNDRAINED COHESION, C         (LBS/FT**2)       130.000          130.000
    FRICTION ANGLE                  (DEGREES)       22.0000          22.0000
    P-Y SUBGRADE MODULUS          (LBS/IN**3)       100.000          100.000
    STRAIN AT 50% STRESS                         1.00000E-02       1.00000E-02
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)       709.233 (S)      1726.72 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)       0.00000          0.00000

    LAYER  4
    THE SOIL IS A SAND
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       38.5000          50.0000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       57.6000          57.6000
    FRICTION ANGLE                  (DEGREES)       26.0000          26.0000
    P-Y SUBGRADE MODULUS          (LBS/IN**3)       50.0000          50.0000
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)       1655.22 (S)      1692.77 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)       0.00000          0.00000

    LAYER  5
    THE SOIL IS A SAND
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       50.0000          57.1000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       72.6000          72.6000
    FRICTION ANGLE                  (DEGREES)       37.0000          37.0000
    P-Y SUBGRADE MODULUS          (LBS/IN**3)       125.000          125.000
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)       1692.77 (S)      1711.39 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)       0.00000          0.00000

    LAYER  6
    THE SOIL IS A SAND
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       57.1000          61.5000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       87.6000          87.6000
    FRICTION ANGLE                  (DEGREES)       38.0000          38.0000
    P-Y SUBGRADE MODULUS          (LBS/IN**3)       150.000          150.000
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)       1711.39 (S)      1724.76 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)       0.00000          0.00000

    LAYER  7
    THE LAYER IS A VUGGY LIMESTONE
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       61.5000          100.000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       101.600          101.600
    UNIAXIAL COMPRESSIVE STRENGTH (LBS/IN**2)       7500.00          7500.00
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)    1.08000E+05 (S)   1.08000E+05 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)    9.72000E+06 (T)   9.72000E+06 (T)

  Notes :  Program estimated values for listed parameters
           if zero input values were entered:
           (S) ULTIMATE UNIT SIDE FRICTION for Drilled Shafts
           (T) ULTIMATE UNIT TIP RESISTANCE for Drilled Shafts


* TABLE H *   AXIAL LOAD VS DISPLACEMENT

AXIAL LOAD-DISPLACEMENT CURVES GENERATED INTERNALLY

  NUM OF CURVES  1

   CURVE  1          NUM OF POINTS 19

  DISPLACEMENT, IN       AXIAL LOAD,LBS
         -5.16769         -2.84376E+06
         -4.17257         -2.84763E+06
         -3.78463         -2.94242E+06
         -3.52949         -3.06395E+06
```

-3.50763	-3.08826E+06
-3.13066	-2.82669E+06
-2.80131	-2.56983E+06
-1.96436	-1.88674E+06
-0.71651	-7.82087E+05
0.00000	0.00000
1.19533	1.21791E+06
2.47344	2.30727E+06
3.36143	3.00731E+06
3.80280	3.34282E+06
5.85532	4.87414E+06
6.95994	5.67647E+06
10.0470	7.72688E+06
10.6740	7.82340E+06
11.8803	7.98127E+06

DISPL. TIP , IN	AXIAL TIP ,LBS
-2.00000	-6.88103
-1.00000	-6.66926
-0.50000	-6.50779
-0.10000	-3.64897
-0.0500000	-2.50941
-1.00000E-02	-0.50188
-5.00000E-03	-0.25094
-1.00000E-03	-0.0501882
-1.00000E-04	-5.01882E-03
0.00000	0.00000
1.00000E-04	3747.15
1.00000E-03	37471.5
5.00000E-03	1.87357E+05
1.00000E-02	3.74715E+05
0.0500000	1.87357E+06
0.10000	2.72439E+06
0.50000	4.85884E+06
1.00000	4.97940E+06
2.00000	5.13751E+06

* TABLE I * TORS. MOM. VS ANGLE ROT.

TORQUE-ROTATION CURVES GENERATED INTERNALLY

NUM OF CURVES 1

CURVE 1 NUM OF POINTS 19

ROT. ANGLE,Rad.	TORS.MOMEN,LBS-IN
-3.85217	-1.51047E+07
-3.66589	-1.51115E+07
-3.61873	-1.52829E+07
-3.61609	-1.55514E+07
-3.62092	-1.56045E+07
-3.50401	-1.52273E+07
-3.36209	-1.47335E+07
-3.05043	-1.36305E+07
-2.52078	-1.16810E+07
0.00000	0.00000
2.52078	1.16810E+07
3.05043	1.36305E+07
3.36209	1.47335E+07
3.50401	1.52273E+07
3.62092	1.56045E+07
3.61609	1.55514E+07
3.61873	1.52829E+07
3.66589	1.51115E+07
3.85217	1.51047E+07

* TABLE K * REDUCTION FACTORS

AVERAGE DIAMETER IS USED TO GET RATIO S/B

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS ALONG Y-DIRECTION
ESTIMATED ASSUMING MOVEMENT IN THE DIRECTION OF Y-FORCE (+)

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	1.0000	1.0000
3	1.0000	1.0000
4	1.0000	1.0000

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS ALONG Z-DIRECTION
ESTIMATED ASSUMING MOVEMENT IN THE DIRECTION OF Z-FORCE (+)

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	1.0000	1.0000
3	0.9267	1.0000

4	0.9267	1.0000

```
     ======================================================================

                    GROUP for Windows, Version 2022.12.4

                     Serial Number : 546958378

                     Analysis of A Group of Piles
                   Subjected to Axial and Lateral Loading

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     ======================================================================


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     Lowell, MA, USA

     Path to file locations      : J:\094184.100-MassDOT Armory Street Bridges, Springfield\Calculations\Axial-Lateral Pile Analysis\S-24-026\Updated
Return Wall 3 and 4\Group\
     Name of input data file     : North Return Wall #3.gp12d
     Name of output echo file    : North Return Wall #3.gp12e
     Name of output results file : North Return Wall #3.gp12o
     Name of output summary file : North Return Wall #3.gp12t
     Name of plot output file    : North Return Wall #3.gp12p
     Name of runtime file        : North Return Wall #3.gp12r


     ----------------------------------------------------------------------
                         Time and Date of Analysis
     ----------------------------------------------------------------------

               Date:  March 07, 2025     Time:  06:57:18



                *****     COMPUTATION RESULTS     *****


     Armory Street over Abandoned CSX Spur - S-24-026 - South Abutment Return Wall #4



                *****     LOAD CASES RESULTS      *****


     LOAD CASE :     1
     CASE NAME : Service I
     LOAD TYPE : Dead, DL

       REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
       ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

            GROUP NO     P-FACTOR     Y-FACTOR

                1           0.9999       1.0000
                2           0.9999       1.0000
                3           1.0000       1.0000
                4           1.0000       1.0000


     * TABLE L *   COMPUTATION ON PILE CAP


     * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *


          VERT. LOAD, LBS    HOR. LOAD Y, LBS   HOR. LOAD Z, LBS
            2.04820E+05            61380.0            0.00000

         MOMENT X ,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
                0.00000            0.00000       -9.18324E+06


     * DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *


            VERTICAL ,IN      HORIZONTAL Y,IN     HORIZONTAL Z,IN
               0.0236957            0.22830       -6.96290E-03

           ANGLE ROT. X,RAD    ANGLE ROT. Y,RAD    ANGLE ROT. Z,RAD
              8.28181E-04       -3.21028E-04       -3.70870E-04
```

```
     NUMBER OF GLOBAL ITERATIONS =    4


LOAD CASE :     2
CASE NAME : Strength I Max
LOAD TYPE : Dead, DL

  REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
  ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

       GROUP NO     P-FACTOR     Y-FACTOR

           1           0.9999       1.0000
           2           0.9999       1.0000
           3           1.0000       1.0000
           4           1.0000       1.0000


* TABLE L *   COMPUTATION ON PILE CAP


* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *


      VERT. LOAD, LBS    HOR. LOAD Y, LBS   HOR. LOAD Z, LBS
        2.59710E+05            82830.0            0.00000

     MOMENT X ,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
            0.00000            0.00000       -1.20608E+07


* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *


       VERTICAL ,IN      HORIZONTAL Y,IN     HORIZONTAL Z,IN
          0.0315195            0.34022         -0.0101349

     ANGLE ROT. X,RAD    ANGLE ROT. Y,RAD    ANGLE ROT. Z,RAD
        1.23551E-03       -4.27673E-04       -5.22080E-04


     NUMBER OF GLOBAL ITERATIONS =    5


LOAD CASE :     3
CASE NAME : Strength I Min
LOAD TYPE : Dead, DL

  REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
  ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

       GROUP NO     P-FACTOR     Y-FACTOR

           1           0.9999       1.0000
           2           0.9999       1.0000
           3           1.0000       1.0000
           4           1.0000       1.0000


* TABLE L *   COMPUTATION ON PILE CAP


* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *


      VERT. LOAD, LBS    HOR. LOAD Y, LBS   HOR. LOAD Z, LBS
        1.87990E+05            55220.0            0.00000

     MOMENT X ,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
            0.00000            0.00000       -8.13252E+06


* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *


       VERTICAL ,IN      HORIZONTAL Y,IN     HORIZONTAL Z,IN
          0.0214772            0.19847       -6.10373E-03

     ANGLE ROT. X,RAD    ANGLE ROT. Y,RAD    ANGLE ROT. Z,RAD
        7.19241E-04       -2.89030E-04       -3.19174E-04


     NUMBER OF GLOBAL ITERATIONS =    4


LOAD CASE :     4
```

CASE NAME : Extreme Event I (I)
LOAD TYPE : Dead, DL

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

GROUP NO	P-FACTOR	Y-FACTOR
1	0.9999	1.0000
2	0.9999	1.0000
3	1.0000	1.0000
4	1.0000	1.0000

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD, LBS	HOR. LOAD Y, LBS	HOR. LOAD Z, LBS
2.04820E+05	81620.0	0.00000

MOMENT X ,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
0.00000	0.00000	-8.85720E+06

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0237422	0.33369	-0.0101209

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
1.19968E-03	-3.20238E-04	-3.53913E-04

NUMBER OF GLOBAL ITERATIONS = 5

LOAD CASE : 5
CASE NAME : Extreme Event I (II)
LOAD TYPE : Dead, DL

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

GROUP NO	P-FACTOR	Y-FACTOR
1	0.9999	1.0000
2	0.9999	1.0000
3	1.0000	1.0000
4	1.0000	1.0000

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD, LBS	HOR. LOAD Y, LBS	HOR. LOAD Z, LBS
2.04820E+05	93830.0	0.00000

MOMENT X ,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
0.00000	0.00000	-7.59792E+06

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0239511	0.41214	-0.0131786

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
1.53450E-03	-3.17337E-04	-2.88756E-04

NUMBER OF GLOBAL ITERATIONS = 5

Armory Street over CSX Mainline
Bridge No. S-24-016
Micropiles for Gravity Block Wall 3
Springfield, Massachusetts

Calculated by: RAC Date: 1/27/2025
Checked by: BTW Date: 2/26/2025

Purpose: Perform axial and lateral analyses for the proposed micropiles for the above-referenced project. See table and summary provided in Step 3 and 4 for results of the lateral and axial analyses, respectively. The Structural Engineer should evaluate the structural adequacy of the micropiles.

References:
1) FHWA-NHI-05-039 Micropile Manual, 2005.
2) MassDOT Bridge Design Manual, 2024.
3) Computer program GROUP, Version 2022, and associated user's manual, by Ensoft, Inc.
4) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
5) Loads provided by Tetra Tech via email on December 10, 2024.
6) Gravity Thrust Block diagrams with elevations provided by Tetra Tech on November 14, 2024.
7) Test borings observed by Nobis at the site in 2019 and 2022.
8) Email and phone communications with design team.

Given:
1) Thrust block loads, factored dead loads (concrete, soil, pipe), and water pressure loads calculated by Nobis based on Reference No. 5.
2) Pile cap geometry per discussions with Tetra Tech via phone on November 14, 2024.
3) A pinned head condition between micropiles and pile cap at the proposed gravity wall/thrust blocks.

Assumptions:
1) Compressive strength of grout (f'_c) is 5 ksi, and yield strength (F_y) of casing and rebar are 52 ksi and 60 ksi, respectively.
2) Micropiles will consist of casing with an outer diameter of 10.75-inch and 0.5-inch thick walls with a #8 sized center bar.
3) Structural engineer will verify the loads and the pile head condition used in analysis, and evaluate the structural resistance of the micropiles in accordance with AASHTO and the MassDOT Bridge Design Manual.
4) Subsurface information from Reference 7 is representative of subsurface conditions at the proposed gravity wall/thrust block.
5) A casing thickness loss of 1/16-inch in the top 3 feet due to corrosion and 50% loss below the top 3 feet of the pile are used. This assumes that no casing joints are located in the top 3 feet of the micropiles.

Solution:

Step 1: Soil Properties and Profile

Nobis used subsurface information from WB-4 of Reference No. 7 to develop soil parameters in the table below. The depth datum was taken at the bottom proposed pile cap (El. 140.2). Soil unit weight (γ_{moist}), angle of internal friction (ϕ), and cohesion were estimated based on field and laboratory testing and a study performed on Connecticut Valley Varved Clay entitled “Geology and Engineering Properties of Connecticut Valley Varved Clay” (DeGroot, D.J. and Lutenegger, A.J.). The groundwater table was taken at the fill/clay interface at the existing south abutment, or approximately El. 135.0. Soil modulus parameters (k) and strain factors for the varved silt/clay were determined using Tables 3.7 and 3.5 from Reference No. 3, respectively. Uniaxial Compressive Strength (U.C.S.) of rock was based on lab test data.

nobis

Armory Street over CSX Mainline
Bridge No. S-24-016
Micropiles for Gravity Block Wall 3
Springfield, Massachusetts

Calculated by: RAC Date: 1/27/2025
Checked by: BTW Date: 2/26/2025

Soil Layer	Elevation (ft)	Depth (ft)	γ_{moist} (pcf)	ϕ (^{o})	k (pci)	U.C.S. (psi)	Cohesion (psf)	Strain Fact. (dims)
Fill	144.2 to 135.2	-4.0 to 5	115	33	25/20	-	-	-
Reworked Silt and Clay	135.2 to 125	5 to 16.5	120	22	100	-	130	0.01
Varved Silt & Clay	125 to 82	16.5 to 59.5	120	22	100	-	130	0.01
Glacial Till	82 to 73	59.5 to 68.5	135	37	125	-	-	-
W. Bedrock	73 to 70.5	68.5 to 71	135	37	125	-	-	-
Bedrock	<70.5	>71	164	-	-	7,500	-	-

1) Assumed 25 pci for fill above water table and 20 pci for fill below water table.

Step 2: Micropile and Pile Cap Properties

Micropile Cased (50%): micropile strength with 50% casing reduction due to threaded sections

Section Length:	72	ft*	Outer Diameter w/loss:	10.25 **in**
Outside Diameter:	10.75	in	Casing Thickness w/loss:	0.25 **in**
Casing Thickness:	0.5	in		
Percent of Casing loss to Thread:	50	%		
Yield Stress of Casing:	52	ksi		
Elastic modulus of Casing:	29000	ksi		
Center Bar:	# 8	bar	Area of Casing (A_{ct}):	**7.9** **in^2**
Yield Stress of Center Bar:	60	ksi	Area of Bar (A_b):	**0.8** **in^2**
Grout Compressive Strength:	5	ksi	Area of Grout (A_g):	**73.9** **in^2**

*Section length includes the 1-foot of embedment into bedrock required by the MassDOT Bridge Manual.

Micropile Uncased: micropile strength with no casing (inside rock socket)

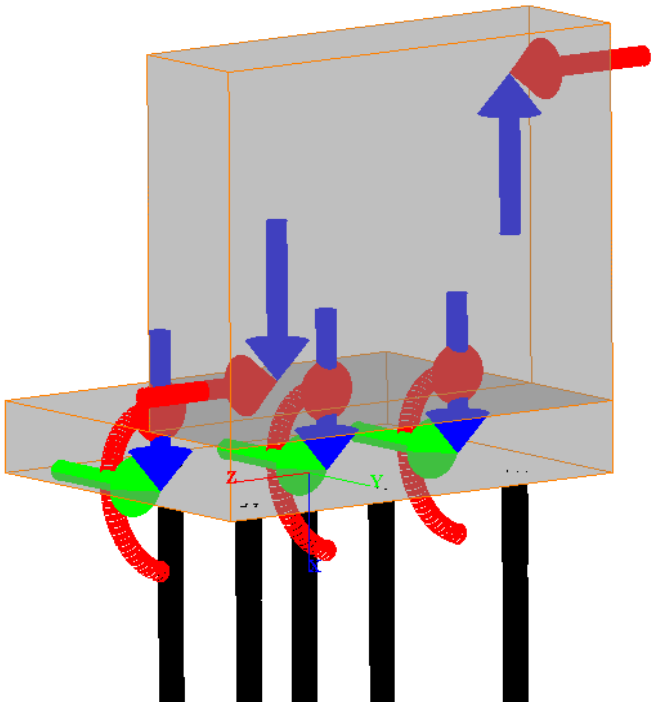
Section Length:	10	ft		
Outside Diameter (before corrosion):	9.75	in		
Center Bar:	# 8	bar		
Yield Stress of Center Bar:	60	ksi	Area of Bar (A_b):	**0.8** **in^2**
Grout Compressive Strength:	5	ksi	Area of Grout (A_g):	**73.9** **in^2**

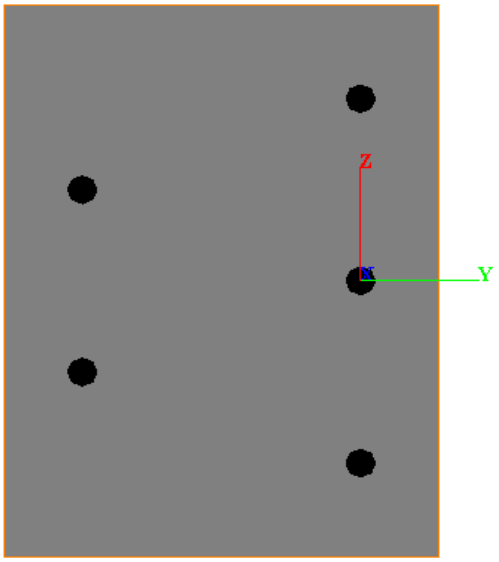
Armory Street over CSX Mainline
Bridge No. S-24-016
Micropiles for Gravity Block Wall 3
Springfield, Massachusetts

Calculated by: RAC Date: 1/27/2025
Checked by: BTW Date: 2/26/2025

Pile Cap: See graphic.

Cap Length in Z-axis (Transverse):	16.82 ft
Cap Width in Y-axis (Longitudinal):	12.5 ft
Cap Thickness in X-axis (Vertical):	2.5 ft
Center-to-center spacing in Y-axis :	8 ft
Center-to-center spacing in Z-axis :	5.5 ft





Armory Street over CSX Mainline
Bridge No. S-24-016
Micropiles for Gravity Block Wall 3
Springfield, Massachusetts

Calculated by: RAC Date: 1/27/2025
Checked by: BTW Date: 2/26/2025

Step 3: Lateral Analysis

The Computer Program GROUP version 2019 by Ensoft, Inc. was used for the lateral analyses. Pinned head conditions were assumed between the micropiles and proposed pile cap (gravity wall/thrust block location 1). Non-linear EI was assumed in all analyses. Structural engineer shall evaluate the structural adequacy of the micropiles.

Results of Micropile Lateral Analyses for Proposed Gravity Wall/Thrust Block Location 1 (per micropile)

Proposed Structure	Load Case	Max Shear (kip)	Max Lateral Deflection (in)	Max Moment Below 3 Feet (kip*ft)[2]	Max Axial Load (kip)	Min Axial Load (kip)
Gravity Thrust Block Location 1	Ser. I	28.2	0.67	58.4	95.0	50
	Str. I (Max)	37.6	1.09	90.3	135.0	60
	Str. I (Min)	25.4	0.58	51.5	110.0	40
	Ext I (50+100)	32.8	0.86	72.3	90.0	55
	Ext I (100+50)	37.9	1.10	88.9	90.0	65

1) Depth of fixity is approximately 15 feet below the bottom of pile cap, and taken at the 2nd point of zero deflection
2) Maximum moment below the top 3 feet with loss of 50% casing due to threaded connections.

Step 4: Axial Analysis

Structural Resistance Factors			
Load Case	**Compression**	**Tension**	
Strength	**0.75**	**0.8**	Ref. No. 4 Tb. 10.5.5.2.5-2
Service	**1**	**1**	Ref. No. 4 Section 10.5.5.1
Extreme	**1**	**0.8**	Ref. No. 4 Section 10.5.5.3

Load Demand (from Group)		
Load Case	**Compression (kips)**	**Tension (kips)**
Strength	**135.0**	**0.0**
Service	**95.0**	**0.0**
Extreme	**90.0**	**0.0**

Geotechnical Resistance Factors			
Load Case	**Compression**	**Tension**	
Strength	**0.55**	**0.55**	Ref. No. 4 Tb. 10.5.5.2.5-1
Service	**1**	**1**	Ref. No. 4 Section 10.5.5.1
Extreme	**1**	**0.8**	Ref. No. 4 Section 10.5.5.3

Evaluate the structural resistance of the micropile for axial load only (negating lateral loads).

For micropile cased section (assuming 50% section):

Nominal axial compressive structural resistance (R_n): **648.7 kips** Ref. No. 4 Eq. 10.9.3.10.2a-2

Nominal axial tension structural resistance (R_n): **449.2 kips** Ref. No. 4 Eq. 10.9.3.10.3a-2

nobis

Armory Street over CSX Mainline
Bridge No. S-24-016
Micropiles for Gravity Block Wall 3
Springfield, Massachusetts

Calculated by: RAC Date: 1/27/2025
Checked by: BTW Date: 2/26/2025

For micropile uncased section:

Nominal axial compressive structural resistance (R_n):	**306.9 kips**	Ref. No. 4 Eq. 10.9.3.10.2b-2
Nominal axial tension structural resistance (R_n):	**47.1 kips**	Ref. No. 4 Eq. 10.9.3.10.3b-2

Evaluate the geotechnical resistance of the micropile for axial loads.

Grout-to-ground bond strength in Bedrock:	**11 ksf**	Ref. No. 4 Table C10.9.3.5.2-1
Minimum Rock Socket Length:	**10 feet**	assumption
Total Nominal grout-to-ground bond resistance:	**281 Kips**	Ref. No. 4 Eq. 10.9.3.5.2-1

Summary

Check to verify that a 10 foot rock socket is adequate based on the maximum factored axial load.

Geotechnical					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**154.4**	**135.0**	**154.4**	**0.0**	OK
Service	**280.8**	**95.0**	**280.8**	**0.0**	
Extreme	**280.8**	**90.0**	**224.6**	**0.0**	

Check to verify that the cased micropile is *adequate based on the maximum factored axial load (negating lateral loads).

Structural (cased): Check the structural resistance of the micropile					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**486.6**	**135.0**	**359.4**	**0.0**	OK
Service	**648.7**	**95.0**	**449.2**	**0.0**	
Extreme	**648.7**	**90.0**	**359.4**	**0.0**	

*Structural engineer shall evaluate the structural adequacy of the micropiles.

Armory Street over CSX Mainline
Bridge No. S-24-016
Micropiles for Gravity Block Wall 3
Springfield, Massachusetts

Calculated by: RAC Date: 1/27/2025
Checked by: BTW Date: 2/26/2025

Check to verify that the uncased micropile is *adequate based on the maximum factored axial load (negating lateral loads) and to verify that a plunge length is not needed.

Structural (uncased)					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**230.2**	**135.0**	**37.7**	**0.0**	OK
Service	**306.9**	**95.0**	**47.1**	**0.0**	
Extreme	**306.9**	**90.0**	**37.7**	**0.0**	

*Structural engineer shall evaluate the structural adequacy of the micropiles.

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 Start FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

CONSTANTS

Type of Wall: Wing / Retaining Wall
Type of Backwall: Independent
Type of Foundation: Pile Supported
Footing Constructed on Tremie? N
Type of Backfill: Granular soil backfill only
Type of Lateral Soil Pressure: Temporary Condition: Active Permanent Condition: At-Rest
Method for Calculating Active Earth Pressure: Rankine
Include Lateral Load on Backwall in Case IB? Y
Pile Information: Pile Type: Metal Shell 12" OD Testing: Gates Dynamic Formula
Include: Lateral load from EPS conc cap? N/A Pile Shading for Lateral Resistance? N
Pile Reaction for Top Fnd Reinf.? Y Earth Load for Bottom Fnd Reinf.? Y

Pile Properties:	Default		Overwrite		Final	
Nom. Pile Resistance:	250	K/Pile		K/Pile	250	K/Pile
Resistance Factor:	0.50				0.50	
Factored Pile Resist.:	125	K/Pile		K/Pile	125	K/Pile
Pile Width/Diameter:	12	in		in	12	in
Lateral Pile Resistance:			10	K/Pile	10	K/Pile

Soil Properties:	Default		Overwrite		Final	
Backfill weight, w:	0.120	Kcf	0.125	Kcf	0.125	Kcf
Angle (beta):	0	degrees		degrees	0	degrees
Angle (phi):	30	degrees	33	degrees	33	degrees
Angle (delta):	17	degrees		degrees	17	degrees
Angle (theta):					90	degrees
Active Coeff, K_a:	0.295		0.350		0.350	
At-Rest Coeff, K_o:	0.455		0.460		0.460	
Seismic Coeff, K_{AE}:			0.333			
Seismic Coeff, K_{h0}:			0.225			

Lightweight Fill Properties:	Default		Overwrite		Final	
Lightweight Concrete Weight, w:		Kcf	0.023	Kcf	0.023	Kcf
Lateral Lightweight Concrete Load:		Ksf	0.008	Ksf	0.008	Ksf
Seismic Lateral Lightweight Concrete Load:		Ksf	0.008	Ksf	0.008	Ksf

Structural Material Properties:	Default		Overwrite		Final	
Concrete Strength, f'c:	3	Ksi	4	Ksi	4	Ksi
Concrete Weight, w:	0.150	Kcf		Kcf	0.150	Kcf
	0.145	Kcf		Kcf	0.145	Kcf
Concrete Modulus of Elasticity, Ec:					3987	Ksi
Concrete Modulus of Rupture, fr:					0.48	Ksi
Max Aggregate Size	1.5	in		in	1.500	in
Rebar Strength, Fy:	60	Ksi		Ksi	60	Ksi
Rebar Modulus of Elasticity, Es:					29000	Ksi
Modular Ratio, n:					7	

Miscellaneous Properties: Unit Weight of Water: 0.0624 Kcf

Reinforcement Centerline:	Default		Overwrite		Final	
Wall Back Face:	3	in		in	3	in
Footing Top:	4	in		in	4	in
Footing Bottom:	9	in	14	in	14	in
Wall Increment:	0.50	Ft	1.00	Ft	1.00	Ft

Reinforcement Epoxy Coated? Footing: Y Wall: Y

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 Start FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

INPUT AND SUMMARY OF RESULTS

Superstructure Bearing Loads:		Vertical Loads: maximum	Vertical Loads: minimum	Horizontal Loads: maximum	Horizontal Loads: minimum	
Self-Weight (Temporary)	DC1:	0.00		0.00		K/Ft
Self-Weight (Permanent)	DC1:	0.00		0.00		K/Ft
Superimposed Dead Loads	DC2:	0.00		0.00		K/Ft
Wearing Surface / Utilities	DW:	0.00		0.00		K/Ft
Post-Tensioning, Creep, Shrinkage	PS+CR+SH:	0.00	0.00	0.00	0.00	K/Ft
Thermal Contraction	TU:	0.00		0.00		K/Ft
Thermal Expansion	TU:	0.00		0.00		K/Ft
Live Loads	LL:	0.00		0.00		K/Ft
Braking	BR:			0.00		K/Ft
Wind on Structure (Service I)	WS:	0.00		0.00		K/Ft
Wind on Structure (Strength III)	WS:	0.00		0.00		K/Ft
Wind on Structure (Strength V)	WS:	0.00		0.00		K/Ft
Wind on Live Load (Service I)	WL:	0.00		0.00		K/Ft
Wind on Live Load (Strength V)	WL:	0.00		0.00		K/Ft

Approach Equivalent Dead Loads:

Depth of equiv fill - temporary	HE =	0.000	Ft
Depth of equiv fill - permanent		1.848	Ft

Wind Load on Wall (wing/retaining walls):

Service I wind load:	0.000	Ksf
Strength III wind load:	0.000	Ksf
Strength V wind load:	0.000	Ksf

Backfill Dimensions:

Temp height of soil (from bott of ftg)	HT =		Ft
Height of EPS concrete cap	HC =	0.000	Ft
Height of lightweight fill		0.000	Ft
Add Height of lightweight fill (vert only)		0.000	Ft
Height of soil below lightweight fill		0.000	Ft
Soil depth at toe	HP =		Ft
Height of water table	HWT =	0.000	Ft

Abutment Stem Wall Dimensions:

Bearing distance	BD =	0.000	Ft
Bearing height	BH =	0.000	Ft
Height of backwall/upper wall	HB =	9.820	Ft
Height of upper wall above grade	HG =	0.000	Ft
Thickness of backwall/upper wall	TB =	1.500	Ft
Location of backwall/upper wall	DB =	0.000	Ft
Height of stem wall	HW =	1.500	Ft
Thickness of stem wall	TW =	4.500	Ft
Railing height on wingwall	HR =	0.000	Ft

Abutment Footing Dimensions:

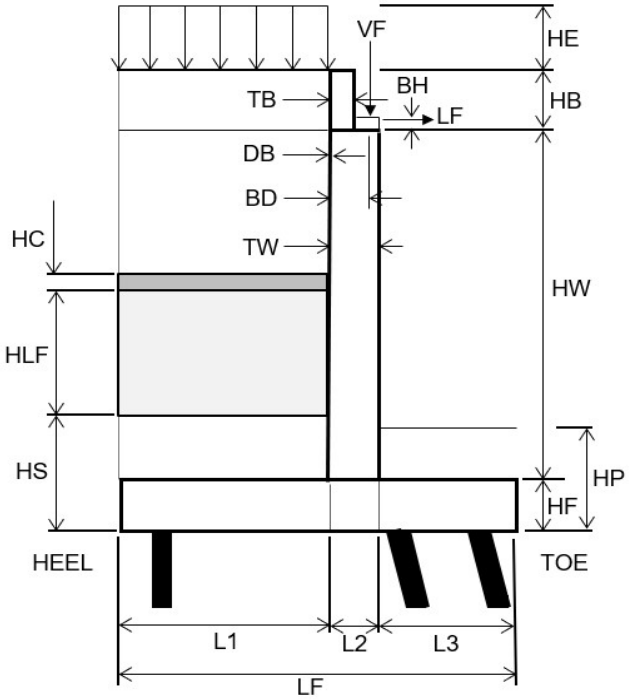
Height of footing	HF =	2.500	Ft
Total length of footing	LF =	12.500	Ft
Length of footing at toe	L3 =	0.000	Ft
Pile location - First pile from heel:		2.250	Ft

Pile Spacing Dimensions:

Pile Row:	Toe	1	2	3	4	5	Heel
Piles Present in this Row?		Y	N	N	N	Y	
Pile Distance from Toe:		2.25				11.00	Ft
Longitudinal Pile Spacing:		5.500				11.000	Ft
Battered Piles in this Row?		N	N	N	N	N	
Pile Batter:							to 1
Percent of Piles Battered:							

JOB:	Armory Street Bridge No S-24-026					SHEET NO.	
SUBJECT:	Gravity Wall 3 Start					FILE NO.	
COMP. BY:	AJF	DATE:	12/10/2024	CHK. BY:		DATE:	

INPUT AND SUMMARY OF RESULTS - CONTINUED



L1= 8.000 L2= 4.500 L3= 0.000 Ft

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 Start FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

VERTICAL LOAD CALCULATIONS:

Load No.		Load Description	Unfactored Loads Width Ft	Height Ft	Unit Wt. Kcf	Maximum K/Ft	Minimum K/Ft	Centroid Y from Heel Ft	Moment Arm from CL Ftg Ft
1A	DC	Footing Heel Dead Load	8.00 x	2.50 x	0.150 =	3.00	3.00	4.000	-2.250
1A	DC	Footing Mid Dead Load	4.50 x	2.50 x	0.150 =	1.69	1.69	10.250	4.000
1A	DC	Footing Toe Dead Load	0.00 x	2.50 x	0.150 =	0.00	0.00	0.000	0.000
1B	DC	Stem Wall Dead Load	4.50 x	1.50 x	0.150 =	1.01	1.01	10.250	4.000
1C	DC	Backwall Dead Load	1.50 x	9.82 x	0.150 =	2.21	2.21	8.750	2.500
1C	DC	Backwall Dead Load (Case IB)	1.50 x	9.82 x	0.150 =	2.21	2.21	8.750	2.500
2A	EV	Soil Vertical Load Temp							
2A	EV	Soil Vertical Load 1	8.00 x	9.82 x	0.125 =	9.82	9.82	4.000	-2.250
2B	EV	Soil Vertical Load 2	8.00 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 2 (Case IB)	8.00 x	9.82 x	0.125 =	9.82	9.82	4.000	-2.250
2B	EV	Soil Vertical Load 3	0.00 x	9.82 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 4	0.00 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Load (below lightwt fill)	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00	0.000	0.000
4A	DC1	Super Dead Load Permanent	0.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
4B	DC2	Superimposed Dead Load			=	0.00	0.00	0.000	0.000
4C	DW	Wearing Surface / Utilities			=	0.00	0.00	0.000	0.000
5	LS	Temp DL Surcharge	8.00 x	0.00 x	0.125 =	0.00	0.00	4.000	0.000
5	LS	Equiv DL Surcharge	8.00 x	1.85 x	0.125 =	1.85	1.85	4.000	-2.250
6	LL	Superstructure Live Load			=	0.00	0.00	0.000	0.000
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00	0.000	0.000
7B	TU	Thermal Contraction			=	0.00	0.00	0.000	0.000
7C	TU	Thermal Expansion			=	0.00	0.00	0.000	0.000
8A	EV	Lightweight Fill below Bearing	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
8B	EV	Lightweight Fill above Bearing	8.00 x	9.82 x	0.000 =	0.00	0.00	0.000	0.000
9A	EV	EPS Concrete Cap below Brg	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
9B	EV	EPS Concrete Cap above Brg	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Heel	8.00 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Mid	4.50 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Toe	0.00 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00	0.000	0.000
	WS	Wind on Structure (Str III)			=	0.00	0.00	0.000	0.000
	WS	Wind on Structure (Str V)			=	0.00	0.00	0.000	0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00	0.000	0.000
	WL	Wind on Live Load (Str V)			=	0.00	0.00	0.000	0.000

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 Start FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

VERTICAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Extreme Event I Load Factors Max	Extreme Event I Load Factors Min
1A	DC	Footing Heel Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1A	DC	Footing Mid Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1A	DC	Footing Toe Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1B	DC	Stem Wall Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1C	DC	Backwall Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1C	DC	Backwall Dead Load (Case IB)	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
2A	EV	Soil Vertical Load Temp	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2A	EV	Soil Vertical Load 1	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 2	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 2 (Case IB)	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 3	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 4	1.00	1.00	1.35	0.00	1.35	0.00	1.00	1.00
2B	EV	Soil Load (below lightwt fill)	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface / Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5	LS	Temp DL Surcharge	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5	LS	Equiv DL Surcharge	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
6	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	1.00	1.00
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	0.50	0.50	0.50	0.50	1.00	1.00
8A	EV	Lightweight Fill below Bearing	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
8B	EV	Lightweight Fill above Bearing	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
9A	EV	EPS Concrete Cap below Brg	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
9B	EV	EPS Concrete Cap above Brg	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
10	WA	Buoyancy Heel	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	WA	Buoyancy Mid	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	WA	Buoyancy Toe	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 Start FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

HORIZONTAL LOAD CALCULATIONS:

3	9.82 ft x 0.125 kcf x 0.460 =	0.565	Ksf	Soil above bearing elevation
3	4.00 ft x 0.125 kcf x 0.460 =	0.230	Ksf	Soil below bearing elevation
3		0.000	Ksf	Soil under lightweight fill
5	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Temporary live load surcharge
5	1.85 ft x 0.125 kcf x 0.460 =	0.106	Ksf	Equivalent live load surcharge
8		0.000	Ksf	Lightweight Fill
9A	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap below Bearing
9B	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap above Bearing
9C	0.00 ft x 0.023 kcf x 0.350 =	0.000	Ksf	Lightweight Fill below Bearing Surcharge
9D	9.82 ft x 0.023 kcf x 0.350 =	0.079	Ksf	Lightweight Fill above Bearing Surcharge
9E	0.00 ft x 0.150 kcf x 0.350 =	0.000	Ksf	EPS Concrete Cap below Bearing Surcharge
9F	0.00 ft x 0.150 kcf x 0.350 =	0.000	Ksf	EPS Concrete Cap above Bearing Surcharge

Load No.		Load Description	Unfactored Loads Height Ft	Load Ksf		Maximum K/Ft	Minimum K/Ft		Moment Arm Ft
3	EH	Soil Lateral Load 1	4.00 x	0.230	/ 2 =	0.46	0.46		1.333
3A	EH	Soil Lateral Load 2	4.00 x	0.565	=	2.26	2.26		2.000
3A	EH	Soil Lateral Load 2 (Case IB)	4.00 x	0.565	=	2.26	2.26		2.000
3B	EH	Soil Lateral Load 3	9.82 x	0.565		5.54	5.54		7.273
3B	EH	Soil Lateral Load 3 (Case IB)	0.00 x	0.565	/ 2 =	0.00	0.00		13.820
3C	EH	Soil Lateral Load 4	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
3D	EH	Soil Lateral Load 5	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6 (Case IB)	0.00 x	0.000	=	0.00	0.00		0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00		4.000
4A	DC1	Super Dead Load Permanent			=	0.00	0.00		4.000
4B	DC2	Superimposed Dead Loads			=	0.00	0.00		4.000
4C	DW	Wearing Surface + Utilities			=	0.00	0.00		4.000
5A	LS	Temp DL Surcharge 1	4.00 x	0.000	=	0.00	0.00		2.000
5B	LS	Temp DL Surcharge 2	9.82 x	0.000	=	0.00	0.00		8.910
5B	LS	Temp DL Surcharge 2 (Case IB	9.82 x	0.000	=	0.00	0.00		8.910
5C	LS	Temp DL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
5A	LS	Equiv DL Surcharge 1	4.00 x	0.106	=	0.43	0.43		2.000
5B	LS	Equiv DL Surcharge 2	9.82 x	0.106	=	1.04	1.04		8.910
5C	LS	Equiv DL Surcharge 3	0.00 x	0.106	=	0.00	0.00		0.000
6A	LL	Superstructure Live Load			=	0.00	0.00		4.000
6B	BR	Braking (Contraction)			=	0.00	0.00		4.000
6C	BR	Braking (Expansion)			=	0.00	0.00		4.000
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00		4.000
7B	TU	Thermal Contraction			=	0.00	0.00		4.000
7C	TU	Thermal Expansion			=	0.00	0.00		4.000
8A	EH	Lightweight Fill below Bearing	9.82^2 x	0.000	/ 2 =	0.00	0.00		0.000
8B	EH	Lightweight Fill above Bearing	0.00 x	0.105	=	0.00	0.00		0.000
9A	EH	EPS Cap below Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9B	EH	EPS Cap above Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9C	EH	Lwt Fill below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9D	EH	Lwt Fill above Brg Surcharge	0.00 x	0.079	=	0.00	0.00		0.000
9E	EH	EPS Cap below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9F	EH	EPS Cap above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00		4.000
	WS	Wind on Structure (Str III)			=	0.00	0.00		4.000
	WS	Wind on Structure (Str V)			=	0.00	0.00		4.000
12B	WS	Wind on Stem Wall (Serv I)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str III)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str V)	0.00 x	0.000	=	0.00	0.00		0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00		4.000
	WL	Wind on Live Load (Str V)			=	0.00	0.00		4.000
13	EQ	Earthquake Load		0.23 x	31.61 =	7.11	7.11	-----	-----

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 Start FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

HORIZONTAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Strength V Load Factors Max	Strength V Load Factors Min
3	EH	Soil Lateral Load 1	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3C	EH	Soil Lateral Load 4	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3D	EH	Soil Lateral Load 5	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Loads	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface + Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5A	LS	Temp DL Surcharge 1	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Temp DL Surcharge 2	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Temp DL Surcharge 2 (Case IB	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5C	LS	Temp DL Surcharge 3	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5A	LS	Equiv DL Surcharge 1	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Equiv DL Surcharge 2	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5C	LS	Equiv DL Surcharge 3	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
6A	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6B	BR	Braking (Contraction)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6C	BR	Braking (Expansion)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
8A	EH	Lightweight Fill below Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
8B	EH	Lightweight Fill above Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9A	EH	EPS Cap below Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9B	EH	EPS Cap above Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9C	EH	Lwt Fill below Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9D	EH	Lwt Fill above Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9E	EH	EPS Cap below Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9F	EH	EPS Cap above Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12B	WS	Wind on Stem Wall (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Stem Wall (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Stem Wall (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
13	EQ	Earthquake Load	-----	-----	-----	-----	-----	-----	1.00	1.00

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 Start FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

EARTHQUAKE HORIZONTAL LOAD CALCULATIONS:

3	9.82 ft x 0.125 kcf x 0.333 =	0.409	Ksf	Soil above bearing elevation
3	4.00 ft x 0.125 kcf x 0.460 =	0.167	Ksf	Soil below bearing elevation
3		0.000	Ksf	Soil under lightweight fill
5	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Temporary live load surcharge
5	1.85 ft x 0.125 kcf x 0.333 =	0.077	Ksf	Equivalent live load surcharge
8		0.000	Ksf	Lightweight Fill
9A	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap below Bearing
9B	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap above Bearing
9C	0.00 ft x 0.0077 ksf =	0.000	Ksf	Lightweight Fill below Bearing Surcharge
9D	9.82 ft x 0.0077 ksf =	0.079	Ksf	Lightweight Fill above Bearing Surcharge
9E	0.00 ft x 0.0077 ksf =	0.000	Ksf	EPS Concrete Cap below Bearing Surcharge
9F	0.00 ft x 0.0077 ksf =	0.000	Ksf	EPS Concrete Cap above Bearing Surcharge

Load No.		Load Description	Unfactored Loads Height Ft	Load Ksf		Maximum K/Ft	Minimum K/Ft		Moment Arm Ft
3	EH	Soil Lateral Load 1	4.00 x	0.230	/ 2 =	0.46	0.46		1.333
3A	EH	Soil Lateral Load 2	4.00 x	0.565	=	2.26	2.26		2.000
3A	EH	Soil Lateral Load 2 (Case IB)	4.00 x	0.565	=	2.26	2.26		2.000
3B	EH	Soil Lateral Load 3	9.82 x	0.565		5.54	5.54		7.273
3B	EH	Soil Lateral Load 3 (Case IB)	0.00 x	0.565	/ 2 =	0.00	0.00		13.820
3C	EH	Soil Lateral Load 4	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
3D	EH	Soil Lateral Load 5	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6 (Case IB)	0.00 x	0.000	=	0.00	0.00		0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00		4.000
4A	DC1	Super Dead Load Permanent			=	0.00	0.00		4.000
4B	DC2	Superimposed Dead Loads			=	0.00	0.00		4.000
4C	DW	Wearing Surface + Utilities			=	0.00	0.00		4.000
5A	LS	Temp DL Surcharge 1	4.00 x	0.000	=	0.00	0.00		2.000
5B	LS	Temp DL Surcharge 2	9.82 x	0.000	=	0.00	0.00		8.910
5B	LS	Temp DL Surcharge 2 (Case IB	9.82 x	0.000	=	0.00	0.00		8.910
5C	LS	Temp DL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
5A	LS	Equiv DL Surcharge 1	4.00 x	0.000	=	0.00	0.00		2.000
5B	LS	Equiv DL Surcharge 2	9.82 x	0.077	=	0.76	0.76		8.910
5C	LS	Equiv DL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
6A	LL	Superstructure Live Load			=	0.00	0.00		4.000
6B	BR	Braking (Contraction)			=	0.00	0.00		4.000
6C	BR	Braking (Expansion)			=	0.00	0.00		4.000
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00		4.000
7B	TU	Thermal Contraction			=	0.00	0.00		4.000
7C	TU	Thermal Expansion			=	0.00	0.00		4.000
8A	EH	Lightweight Fill below Bearing	9.82^2 x	0.0077	/ 2 =	0.00	0.00		0.000
8B	EH	Lightweight Fill above Bearing	0.00 x	0.100	=	0.00	0.00		0.000
9A	EH	EPS Cap below Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9B	EH	EPS Cap above Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9C	EH	Lwt Fill below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9D	EH	Lwt Fill above Brg Surcharge	0.00 x	0.079	=	0.00	0.00		0.000
9E	EH	EPS Cap below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9F	EH	EPS Cap above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00		4.000
	WS	Wind on Structure (Str III)			=	0.00	0.00		4.000
	WS	Wind on Structure (Str V)			=	0.00	0.00		4.000
12B	WS	Wind on Stem Wall (Serv I)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str III)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str V)	0.00 x	0.000	=	0.00	0.00		0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00		4.000
	WL	Wind on Live Load (Str V)			=	0.00	0.00		4.000
13	EQ	Earthquake Load		0.23 x	19.94 =	4.49	4.49	-----	-----

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 Start FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

HORIZONTAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Strength V Load Factors Max	Strength V Load Factors Min
3	EH	Soil Lateral Load 1	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3C	EH	Soil Lateral Load 4	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3D	EH	Soil Lateral Load 5	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Loads	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface + Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5A	LS	Temp DL Surcharge 1	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Temp DL Surcharge 2	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Temp DL Surcharge 2 (Case IB	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5C	LS	Temp DL Surcharge 3	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5A	LS	Equiv DL Surcharge 1	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Equiv DL Surcharge 2	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5C	LS	Equiv DL Surcharge 3	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
6A	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6B	BR	Braking (Contraction)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6C	BR	Braking (Expansion)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
8A	EH	Lightweight Fill below Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
8B	EH	Lightweight Fill above Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9A	EH	EPS Cap below Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9B	EH	EPS Cap above Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9C	EH	Lwt Fill below Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9D	EH	Lwt Fill above Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9E	EH	EPS Cap below Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9F	EH	EPS Cap above Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12B	WS	Wind on Stem Wall (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Stem Wall (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Stem Wall (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
13	EQ	Earthquake Load	-----	-----	-----	-----	-----	-----	1.00	1.00

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 Start FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

CASE II **Strength I** **Live Load on Approach** 3.5 feet wide

			SERVICE I		STRENGTH I MAX			STRENGTH I MIN		
Load No.		Load Description	Load	Moment	Factors	Load	Moment	Factors	Load	Moment
			K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft
VERTICAL LOADS:										
1A	DC	Footing Heel Dead Load	3.00	-6.75	1.25	3.75	-8.44	0.90	2.70	-6.08
1A	DC	Footing Mid Dead Load	1.69	6.75	1.25	2.11	8.44	0.90	1.52	6.08
1A	DC	Footing Toe Dead Load	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
1B	DC	Stem Wall Dead Load	1.01	4.05	1.25	1.27	5.06	0.90	0.91	3.65
1C	DC	Backwall Dead Load	2.21	5.52	1.25	2.76	6.90	0.90	1.99	4.97
2A	EV	Soil Vertical Load 1	9.82	-22.10	1.35	13.26	-29.83	1.00	9.82	-22.10
2B	EV	Soil Vertical Load 2	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 3	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 4	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2C	EV	Soil Load (below lightwt fill)	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4B	DC2	Superimposed Dead Load	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4C	DW	Wearing Surface / Utilities	0.00	0.00	1.50	0.00	0.00	0.65	0.00	0.00
5	LS	Equiv DL Surcharge	1.85	-4.16	1.25	2.31	-5.20	0.90	1.66	-3.74
8A	EV	Lightweight Fill below Bearing	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
8B	EV	Lightweight Fill above Bearing	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
9A	EV	EPS Concrete Cap below Brg	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9B	EV	EPS Concrete Cap above Brg	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Heel	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Mid	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Toe	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
Total Vertical:		68.53	19.58	-16.68	89.08	25.45	-23.06	65.10	18.60	-17.22
HORIZONTAL LOADS:										
3	EH	Soil Lateral Load 1	0.46	0.61	1.35	0.62	0.83	0.90	0.41	0.55
3A	EH	Soil Lateral Load 2	2.26	4.52	1.35	3.05	6.10	0.90	2.03	4.07
3B	EH	Soil Lateral Load 3	5.54	40.33	1.35	7.49	54.45	0.90	4.99	36.30
3C	EH	Soil Lateral Load 4	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3D	EH	Soil Lateral Load 5	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3E	EH	Soil Lateral Load 6	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4B	DC2	Superimposed Dead Loads	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4C	DW	Wearing Surface + Utilities	0.00	0.00	1.50	0.00	0.00	0.65	0.00	0.00
5A	LS	Equiv DL Surcharge 1	0.43	0.85	1.25	0.53	1.06	0.90	0.38	0.77
5B	LS	Equiv DL Surcharge 2	1.04	9.30	1.25	1.30	11.62	0.90	0.94	8.37
5C	LS	Equiv DL Surcharge 3	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
8A	EH	Lightweight Fill below Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
8B	EH	Lightweight Fill above Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9A	EH	EPS Cap below Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9B	EH	EPS Cap above Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9C	EH	Lwt Fill below Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9D	EH	Lwt Fill above Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9C	EH	EPS Cap below Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9D	EH	EPS Cap above Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
Total Horizontal:		34.06	9.73	55.61	45.47	12.99	74.06	30.66	8.76	50.05
Moment Grand Total:				38.93			51.00			32.83
				136.26			178.5			114.91

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 Start FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

CASE II **Extreme I** **Live Load on Approach**

			SERVICE I		EXTREME I 50% Inertial + 100% PAE			EXTREME I 100% Inertial + 50% PAE		
Load No.		Load Description	Load	Moment	Factors	Load	Moment	Factors	Load	Moment
			K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft
VERTICAL LOADS:										
1A	DC	Footing Heel Dead Load	3.00	-6.75	1.00	3.00	-6.75	1.00	3.00	-6.75
	DC	Footing Mid Dead Load	1.69	6.75	1.00	1.69	6.75	1.00	1.69	6.75
	DC	Footing Toe Dead Load	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
1B	DC	Stem Wall Dead Load	1.01	4.05	1.00	1.01	4.05	1.00	1.01	4.05
	DC	Backwall Dead Load	2.21	5.52	1.00	2.21	5.52	1.00	2.21	5.52
2A	EV	Soil Vertical Load 1	9.82	-22.10	1.00	9.82	-22.10	1.00	9.82	-22.10
	EV	Soil Vertical Load 2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	EV	Soil Vertical Load 4	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2C	EV	Soil Load (below lightwt fill)	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4B	DC2	Superimposed Dead Load	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4C	DW	Wearing Surface / Utilities	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5	LS	Equiv DL Surcharge	1.85	-4.16	1.00	1.85	-4.16	1.00	1.85	-4.16
8A	EV	Lightweight Fill below Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
8B	EV	Lightweight Fill above Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9A	EV	EPS Concrete Cap below Brg	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9B	EV	EPS Concrete Cap above Brg	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
10	WA	Buoyancy Heel	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	WA	Buoyancy Mid	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	WA	Buoyancy Toe	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
12A	WS	Wind on Structure (Serv I)	0.00	0.00						
	WS	Wind on Structure (Str V)								
Total Vertical:			19.58	-16.68	68.53	19.58	-16.68	68.53	19.58	-16.68
HORIZONTAL LOADS:										
3	EH	Soil Lateral Load 1	0.46	0.61	1.00	0.46	0.61	1.00	0.39	0.51
3A	EH	Soil Lateral Load 2	2.26	4.52	1.00	2.26	4.52	1.00	1.89	3.78
3B	EH	Soil Lateral Load 3	5.54	40.33	1.00	5.54	40.33	1.00	4.65	33.79
3C	EH	Soil Lateral Load 4	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3D	EH	Soil Lateral Load 5	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3E	EH	Soil Lateral Load 6	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4B	DC2	Superimposed Dead Loads	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4C	DW	Wearing Surface + Utilities	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5A	LS	Equiv DL Surcharge 1	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5B	LS	Equiv DL Surcharge 2	0.76	6.73	1.00	0.76	6.73	1.00	0.63	5.64
5C	LS	Equiv DL Surcharge 3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
8A	EH	Lightweight Fill below Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
8B	EH	Lightweight Fill above Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9A	EH	EPS Cap below Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9B	EH	EPS Cap above Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9C	EH	Lwt Fill below Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9D	EH	Lwt Fill above Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9C	EH	EPS Cap below Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9D	EH	EPS Cap above Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
12A	WS	Wind on Structure (Serv I)	0.00	0.00						
	WS	Wind on Structure (Str V)								
12B	WS	Wind on Stem Wall (Serv I)	0.00	0.00						
	WS	Wind on Stem Wall (Str V)								
13	EQ	Earthquake Load	4.49	0.00	1.00	2.24	0.00	1.00	4.49	0.00
Total Horizontal:			13.51	52.19	39.41	11.26	52.19	42.14	12.04	43.73
Moment Grand Total:				35.51			35.51			27.05
							124.29			94.68

JOB:	Armory Street Bridge No S-24-026			SHEET NO.	
SUBJECT:	Gravity Wall 3 End			FILE NO.	
COMP. BY:	AJF	DATE: 12/10/2024	CHK. BY:	DATE:	

CONSTANTS

Type of Wall: Wing / Retaining Wall
Type of Backwall: Independent
Type of Foundation: Pile Supported
Footing Constructed on Tremie? N
Type of Backfill: Granular soil backfill only
Type of Lateral Soil Pressure: Temporary Condition: Active Permanent Condition: At-Rest
Method for Calculating Active Earth Pressure: Rankine
Include Lateral Load on Backwall in Case IB? Y
Pile Information: Pile Type: Metal Shell 12" OD Testing: Gates Dynamic Formula
Include: Lateral load from EPS conc cap? N/A Pile Shading for Lateral Resistance? N
Pile Reaction for Top Fnd Reinf.? Y Earth Load for Bottom Fnd Reinf.? Y

Pile Properties:	Default		Overwrite		Final	
Nom. Pile Resistance:	250	K/Pile		K/Pile	250	K/Pile
Resistance Factor:	0.50				0.50	
Factored Pile Resist.:	125	K/Pile		K/Pile	125	K/Pile
Pile Width/Diameter:	12	in		in	12	in
Lateral Pile Resistance:			10	K/Pile	10	K/Pile

Soil Properties:	Default		Overwrite		Final	
Backfill weight, w:	0.120	Kcf	0.125	Kcf	0.125	Kcf
Angle (beta):	0	degrees		degrees	0	degrees
Angle (phi):	30	degrees	33	degrees	33	degrees
Angle (delta):	17	degrees		degrees	17	degrees
Angle (theta):					90	degrees
Active Coeff, K_a:	0.295		0.350		0.350	
At-Rest Coeff, K_o:	0.455		0.460		0.460	
Seismic Coeff, K_{AE}:			0.333			
Seismic Coeff, K_{h0}:			0.225			

Lightweight Fill Properties:	Default		Overwrite		Final	
Lightweight Concrete Weight, w:		Kcf	0.023	Kcf	0.023	Kcf
Lateral Lightweight Concrete Load:		Ksf	0.008	Ksf	0.008	Ksf
Seismic Lateral Lightweight Concrete Load:		Ksf	0.008	Ksf	0.008	Ksf

Structural Material Properties:	Default		Overwrite		Final	
Concrete Strength, f'c:	3	Ksi	4	Ksi	4	Ksi
Concrete Weight, w:	0.150	Kcf		Kcf	0.150	Kcf
	0.145	Kcf		Kcf	0.145	Kcf
Concrete Modulus of Elasticity, Ec:					3987	Ksi
Concrete Modulus of Rupture, fr:					0.48	Ksi
Max Aggregate Size	1.5	in		in	1.500	in
Rebar Strength, Fy:	60	Ksi		Ksi	60	Ksi
Rebar Modulus of Elasticity, Es:					29000	Ksi
Modular Ratio, n:					7	

Miscellaneous Properties: Unit Weight of Water: 0.0624 Kcf

Reinforcement Centerline:	Default		Overwrite		Final	
Wall Back Face:	3	in		in	3	in
Footing Top:	4	in		in	4	in
Footing Bottom:	9	in	14	in	14	in
Wall Increment:	0.50	Ft	1.00	Ft	1.00	Ft

Reinforcement Epoxy Coated? Footing: Y Wall: Y

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 End FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

INPUT AND SUMMARY OF RESULTS

Superstructure Bearing Loads:		Vertical Loads: maximum	Vertical Loads: minimum	Horizontal Loads: maximum	Horizontal Loads: minimum	
Self-Weight (Temporary)	DC1:	0.00		0.00		K/Ft
Self-Weight (Permanent)	DC1:	0.00		0.00		K/Ft
Superimposed Dead Loads	DC2:	0.00		0.00		K/Ft
Wearing Surface / Utilities	DW:	0.00		0.00		K/Ft
Post-Tensioning, Creep, Shrinkage	PS+CR+SH:	0.00	0.00	0.00	0.00	K/Ft
Thermal Contraction	TU:	0.00		0.00		K/Ft
Thermal Expansion	TU:	0.00		0.00		K/Ft
Live Loads	LL:	0.00		0.00		K/Ft
Braking	BR:			0.00		K/Ft
Wind on Structure (Service I)	WS:	0.00		0.00		K/Ft
Wind on Structure (Strength III)	WS:	0.00		0.00		K/Ft
Wind on Structure (Strength V)	WS:	0.00		0.00		K/Ft
Wind on Live Load (Service I)	WL:	0.00		0.00		K/Ft
Wind on Live Load (Strength V)	WL:	0.00		0.00		K/Ft

Approach Equivalent Dead Loads:

Depth of equiv fill - temporary	HE =	0.000	Ft
Depth of equiv fill - permanent		1.848	Ft

Wind Load on Wall (wing/retaining walls):

Service I wind load:	0.000	Ksf
Strength III wind load:	0.000	Ksf
Strength V wind load:	0.000	Ksf

Backfill Dimensions:

Temp height of soil (from bott of ftg)	HT =		Ft
Height of EPS concrete cap	HC =	0.000	Ft
Height of lightweight fill		0.000	Ft
Add Height of lightweight fill (vert only)		0.000	Ft
Height of soil below lightweight fill		0.000	Ft
Soil depth at toe	HP =		Ft
Height of water table	HWT =	0.000	Ft

Abutment Stem Wall Dimensions:

Bearing distance	BD =	0.000	Ft
Bearing height	BH =	0.000	Ft
Height of backwall/upper wall	HB =	0.000	Ft
Height of upper wall above grade	HG =	0.000	Ft
Thickness of backwall/upper wall	TB =	0.000	Ft
Location of backwall/upper wall	DB =	0.000	Ft
Height of stem wall	HW =	11.320	Ft
Thickness of stem wall	TW =	4.500	Ft
Railing height on wingwall	HR =	0.000	Ft

Abutment Footing Dimensions:

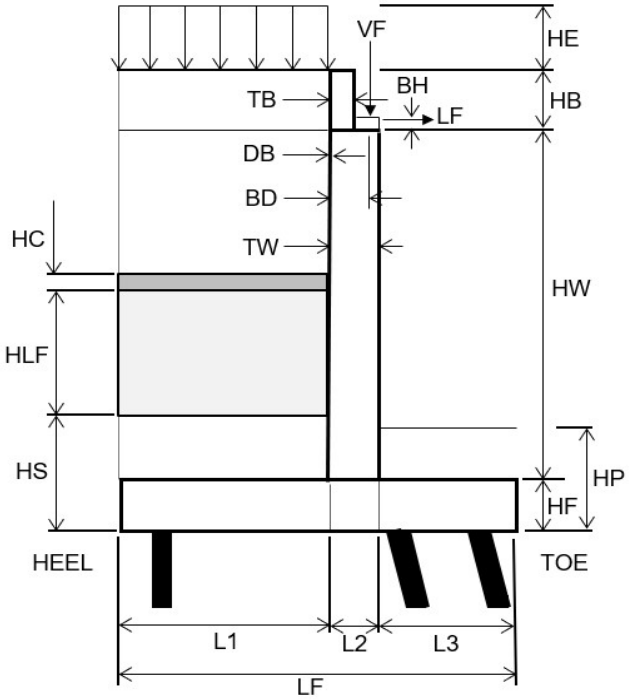
Height of footing	HF =	2.500	Ft
Total length of footing	LF =	12.500	Ft
Length of footing at toe	L3 =	0.000	Ft
Pile location - First pile from heel:		2.250	Ft

Pile Spacing Dimensions:

Pile Row:	Toe	1	2	3	4	5	Heel
Piles Present in this Row?		Y	N	N	N	Y	
Pile Distance from Toe:		2.25				11.00	Ft
Longitudinal Pile Spacing:		5.500				11.000	Ft
Battered Piles in this Row?		N	N	N	N	N	
Pile Batter:							to 1
Percent of Piles Battered:							

JOB:	Armory Street Bridge No S-24-026					SHEET NO.	
SUBJECT:	Gravity Wall 3 End					FILE NO.	
COMP. BY:	AJF	DATE:	12/10/2024	CHK. BY:		DATE:	

INPUT AND SUMMARY OF RESULTS - CONTINUED



L1= 8.000 L2= 4.500 L3= 0.000 Ft

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 End FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

VERTICAL LOAD CALCULATIONS:

Load No.		Load Description	Unfactored Loads Width Ft	Height Ft	Unit Wt. Kcf	Maximum K/Ft	Minimum K/Ft	Centroid Y from Heel Ft	Moment Arm from CL Ftg Ft
1A	DC	Footing Heel Dead Load	8.00 x	2.50 x	0.150 =	3.00	3.00	4.000	-2.250
1A	DC	Footing Mid Dead Load	4.50 x	2.50 x	0.150 =	1.69	1.69	10.250	4.000
1A	DC	Footing Toe Dead Load	0.00 x	2.50 x	0.150 =	0.00	0.00	0.000	0.000
1B	DC	Stem Wall Dead Load	4.50 x	11.32 x	0.150 =	7.64	7.64	10.250	4.000
1C	DC	Backwall Dead Load	0.00 x	0.00 x	0.150 =	0.00	0.00	0.000	0.000
1C	DC	Backwall Dead Load (Case IB)	0.00 x	0.00 x	0.150 =	0.00	0.00	0.000	0.000
2A	EV	Soil Vertical Load Temp							
2A	EV	Soil Vertical Load 1	8.00 x	11.32 x	0.125 =	11.32	11.32	4.000	-2.250
2B	EV	Soil Vertical Load 2	8.00 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 2 (Case IB)	8.00 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 3	0.00 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 4	0.00 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Load (below lightwt fill)	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00	0.000	0.000
4A	DC1	Super Dead Load Permanent	0.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
4B	DC2	Superimposed Dead Load			=	0.00	0.00	0.000	0.000
4C	DW	Wearing Surface / Utilities			=	0.00	0.00	0.000	0.000
5	LS	Temp DL Surcharge	8.00 x	0.00 x	0.125 =	0.00	0.00	4.000	0.000
5	LS	Equiv DL Surcharge	8.00 x	1.85 x	0.125 =	1.85	1.85	4.000	-2.250
6	LL	Superstructure Live Load			=	0.00	0.00	0.000	0.000
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00	0.000	0.000
7B	TU	Thermal Contraction			=	0.00	0.00	0.000	0.000
7C	TU	Thermal Expansion			=	0.00	0.00	0.000	0.000
8A	EV	Lightweight Fill below Bearing	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
8B	EV	Lightweight Fill above Bearing	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
9A	EV	EPS Concrete Cap below Brg	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
9B	EV	EPS Concrete Cap above Brg	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Heel	8.00 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Mid	4.50 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Toe	0.00 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00	0.000	0.000
	WS	Wind on Structure (Str III)			=	0.00	0.00	0.000	0.000
	WS	Wind on Structure (Str V)			=	0.00	0.00	0.000	0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00	0.000	0.000
	WL	Wind on Live Load (Str V)			=	0.00	0.00	0.000	0.000

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 End FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

VERTICAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Extreme Event I Load Factors Max	Extreme Event I Load Factors Min
1A	DC	Footing Heel Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1A	DC	Footing Mid Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1A	DC	Footing Toe Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1B	DC	Stem Wall Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1C	DC	Backwall Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1C	DC	Backwall Dead Load (Case IB)	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
2A	EV	Soil Vertical Load Temp	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2A	EV	Soil Vertical Load 1	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 2	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 2 (Case IB)	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 3	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 4	1.00	1.00	1.35	0.00	1.35	0.00	1.00	1.00
2B	EV	Soil Load (below lightwt fill)	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface / Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5	LS	Temp DL Surcharge	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5	LS	Equiv DL Surcharge	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
6	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	1.00	1.00
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	0.50	0.50	0.50	0.50	1.00	1.00
8A	EV	Lightweight Fill below Bearing	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
8B	EV	Lightweight Fill above Bearing	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
9A	EV	EPS Concrete Cap below Brg	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
9B	EV	EPS Concrete Cap above Brg	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
10	WA	Buoyancy Heel	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	WA	Buoyancy Mid	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	WA	Buoyancy Toe	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 End FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

HORIZONTAL LOAD CALCULATIONS:

3	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Soil above bearing elevation
3	13.82 ft x 0.125 kcf x 0.460 =	0.795	Ksf	Soil below bearing elevation
3		0.000	Ksf	Soil under lightweight fill
5	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Temporary live load surcharge
5	1.85 ft x 0.125 kcf x 0.460 =	0.106	Ksf	Equivalent live load surcharge
8		0.000	Ksf	Lightweight Fill
9A	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap below Bearing
9B	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap above Bearing
9C	0.00 ft x 0.023 kcf x 0.350 =	0.000	Ksf	Lightweight Fill below Bearing Surcharge
9D	0.00 ft x 0.023 kcf x 0.350 =	0.000	Ksf	Lightweight Fill above Bearing Surcharge
9E	0.00 ft x 0.150 kcf x 0.350 =	0.000	Ksf	EPS Concrete Cap below Bearing Surcharge
9F	0.00 ft x 0.150 kcf x 0.350 =	0.000	Ksf	EPS Concrete Cap above Bearing Surcharge

Load No.		Load Description	Unfactored Loads Height Ft	Load Ksf		Maximum K/Ft	Minimum K/Ft		Moment Arm Ft
3	EH	Soil Lateral Load 1	13.82 x	0.795	/ 2 =	5.49	5.49		4.607
3A	EH	Soil Lateral Load 2	13.82 x	0.000	=	0.00	0.00		6.910
3A	EH	Soil Lateral Load 2 (Case IB)	13.82 x	0.000	=	0.00	0.00		6.910
3B	EH	Soil Lateral Load 3	0.00 x	0.000		0.00	0.00		13.820
3B	EH	Soil Lateral Load 3 (Case IB)	0.00 x	0.000	/ 2 =	0.00	0.00		13.820
3C	EH	Soil Lateral Load 4	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
3D	EH	Soil Lateral Load 5	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6 (Case IB)	0.00 x	0.000	=	0.00	0.00		0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00		13.820
4A	DC1	Super Dead Load Permanent			=	0.00	0.00		13.820
4B	DC2	Superimposed Dead Loads			=	0.00	0.00		13.820
4C	DW	Wearing Surface + Utilities			=	0.00	0.00		13.820
5A	LS	Temp DL Surcharge 1	13.82 x	0.000	=	0.00	0.00		6.910
5B	LS	Temp DL Surcharge 2	0.00 x	0.000	=	0.00	0.00		13.820
5B	LS	Temp DL Surcharge 2 (Case IB	0.00 x	0.000	=	0.00	0.00		13.820
5C	LS	Temp DL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
5A	LS	Equiv DL Surcharge 1	13.82 x	0.106	=	1.47	1.47		6.910
5B	LS	Equiv DL Surcharge 2	0.00 x	0.000	=	0.00	0.00		13.820
5C	LS	Equiv DL Surcharge 3	0.00 x	0.106	=	0.00	0.00		0.000
6A	LL	Superstructure Live Load			=	0.00	0.00		13.820
6B	BR	Braking (Contraction)			=	0.00	0.00		13.820
6C	BR	Braking (Expansion)			=	0.00	0.00		13.820
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00		13.820
7B	TU	Thermal Contraction			=	0.00	0.00		13.820
7C	TU	Thermal Expansion			=	0.00	0.00		13.820
8A	EH	Lightweight Fill below Bearing	0.00^2 x	0.000	/ 2 =	0.00	0.00		0.000
8B	EH	Lightweight Fill above Bearing	0.00 x	0.105	=	0.00	0.00		0.000
9A	EH	EPS Cap below Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9B	EH	EPS Cap above Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9C	EH	Lwt Fill below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9D	EH	Lwt Fill above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9E	EH	EPS Cap below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9F	EH	EPS Cap above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00		13.820
	WS	Wind on Structure (Str III)			=	0.00	0.00		13.820
	WS	Wind on Structure (Str V)			=	0.00	0.00		13.820
12B	WS	Wind on Stem Wall (Serv I)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str III)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str V)	0.00 x	0.000	=	0.00	0.00		0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00		13.820
	WL	Wind on Live Load (Str V)			=	0.00	0.00		13.820
13	EQ	Earthquake Load		0.23 x	25.50 =	5.74	5.74	-----	-----

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 End FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

HORIZONTAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Strength V Load Factors Max	Strength V Load Factors Min
3	EH	Soil Lateral Load 1	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3C	EH	Soil Lateral Load 4	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3D	EH	Soil Lateral Load 5	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Loads	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface + Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5A	LS	Temp DL Surcharge 1	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Temp DL Surcharge 2	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Temp DL Surcharge 2 (Case IB	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5C	LS	Temp DL Surcharge 3	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5A	LS	Equiv DL Surcharge 1	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Equiv DL Surcharge 2	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5C	LS	Equiv DL Surcharge 3	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
6A	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6B	BR	Braking (Contraction)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6C	BR	Braking (Expansion)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
8A	EH	Lightweight Fill below Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
8B	EH	Lightweight Fill above Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9A	EH	EPS Cap below Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9B	EH	EPS Cap above Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9C	EH	Lwt Fill below Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9D	EH	Lwt Fill above Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9E	EH	EPS Cap below Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9F	EH	EPS Cap above Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12B	WS	Wind on Stem Wall (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Stem Wall (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Stem Wall (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
13	EQ	Earthquake Load	-----	-----	-----	-----	-----	-----	1.00	1.00

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 End FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

EARTHQUAKE HORIZONTAL LOAD CALCULATIONS:

3	0.00 ft x 0.125 kcf x 0.333 =	0.000	Ksf	Soil above bearing elevation
3	13.82 ft x 0.125 kcf x 0.460 =	0.575	Ksf	Soil below bearing elevation
3		0.000	Ksf	Soil under lightweight fill
5	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Temporary live load surcharge
5	1.85 ft x 0.125 kcf x 0.333 =	0.077	Ksf	Equivalent live load surcharge
8		0.000	Ksf	Lightweight Fill
9A	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap below Bearing
9B	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap above Bearing
9C	0.00 ft x 0.0077 ksf =	0.000	Ksf	Lightweight Fill below Bearing Surcharge
9D	0.00 ft x 0.0077 ksf =	0.000	Ksf	Lightweight Fill above Bearing Surcharge
9E	0.00 ft x 0.0077 ksf =	0.000	Ksf	EPS Concrete Cap below Bearing Surcharge
9F	0.00 ft x 0.0077 ksf =	0.000	Ksf	EPS Concrete Cap above Bearing Surcharge

Load No.		Load Description	Unfactored Loads Height Ft	Load Ksf		Maximum K/Ft	Minimum K/Ft		Moment Arm Ft
3	EH	Soil Lateral Load 1	13.82 x	0.795	/ 2 =	5.49	5.49		4.607
3A	EH	Soil Lateral Load 2	13.82 x	0.000	=	0.00	0.00		6.910
3A	EH	Soil Lateral Load 2 (Case IB)	13.82 x	0.000	=	0.00	0.00		6.910
3B	EH	Soil Lateral Load 3	0.00 x	0.000		0.00	0.00		13.820
3B	EH	Soil Lateral Load 3 (Case IB)	0.00 x	0.000	/ 2 =	0.00	0.00		13.820
3C	EH	Soil Lateral Load 4	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
3D	EH	Soil Lateral Load 5	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6 (Case IB)	0.00 x	0.000	=	0.00	0.00		0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00		13.820
4A	DC1	Super Dead Load Permanent			=	0.00	0.00		13.820
4B	DC2	Superimposed Dead Loads			=	0.00	0.00		13.820
4C	DW	Wearing Surface + Utilities			=	0.00	0.00		13.820
5A	LS	Temp DL Surcharge 1	13.82 x	0.000	=	0.00	0.00		6.910
5B	LS	Temp DL Surcharge 2	0.00 x	0.000	=	0.00	0.00		13.820
5B	LS	Temp DL Surcharge 2 (Case IB	0.00 x	0.000	=	0.00	0.00		13.820
5C	LS	Temp DL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
5A	LS	Equiv DL Surcharge 1	13.82 x	0.000	=	0.00	0.00		6.910
5B	LS	Equiv DL Surcharge 2	0.00 x	0.077	=	0.00	0.00		13.820
5C	LS	Equiv DL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
6A	LL	Superstructure Live Load			=	0.00	0.00		13.820
6B	BR	Braking (Contraction)			=	0.00	0.00		13.820
6C	BR	Braking (Expansion)			=	0.00	0.00		13.820
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00		13.820
7B	TU	Thermal Contraction			=	0.00	0.00		13.820
7C	TU	Thermal Expansion			=	0.00	0.00		13.820
8A	EH	Lightweight Fill below Bearing	0.00^2 x	0.0077	/ 2 =	0.00	0.00		0.000
8B	EH	Lightweight Fill above Bearing	0.00 x	0.100	=	0.00	0.00		0.000
9A	EH	EPS Cap below Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9B	EH	EPS Cap above Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9C	EH	Lwt Fill below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9D	EH	Lwt Fill above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9E	EH	EPS Cap below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9F	EH	EPS Cap above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00		13.820
	WS	Wind on Structure (Str III)			=	0.00	0.00		13.820
	WS	Wind on Structure (Str V)			=	0.00	0.00		13.820
12B	WS	Wind on Stem Wall (Serv I)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str III)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str V)	0.00 x	0.000	=	0.00	0.00		0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00		13.820
	WL	Wind on Live Load (Str V)			=	0.00	0.00		13.820
13	EQ	Earthquake Load		0.23 x	23.65 =	5.32	5.32	-----	-----

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 End FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

HORIZONTAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Strength V Load Factors Max	Strength V Load Factors Min
3	EH	Soil Lateral Load 1	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3C	EH	Soil Lateral Load 4	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3D	EH	Soil Lateral Load 5	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Loads	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface + Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5A	LS	Temp DL Surcharge 1	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Temp DL Surcharge 2	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Temp DL Surcharge 2 (Case IB	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5C	LS	Temp DL Surcharge 3	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5A	LS	Equiv DL Surcharge 1	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Equiv DL Surcharge 2	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5C	LS	Equiv DL Surcharge 3	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
6A	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6B	BR	Braking (Contraction)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6C	BR	Braking (Expansion)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
8A	EH	Lightweight Fill below Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
8B	EH	Lightweight Fill above Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9A	EH	EPS Cap below Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9B	EH	EPS Cap above Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9C	EH	Lwt Fill below Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9D	EH	Lwt Fill above Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9E	EH	EPS Cap below Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9F	EH	EPS Cap above Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12B	WS	Wind on Stem Wall (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Stem Wall (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Stem Wall (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
13	EQ	Earthquake Load	-----	-----	-----	-----	-----	-----	1.00	1.00

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 End FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

CASE II **Strength I** **Live Load on Approach** 3.5 feet wide 9.82 feet wide

			SERVICE I		STRENGTH I MAX			STRENGTH I MIN		
Load No.		Load Description	Load	Moment	Factors	Load	Moment	Factors	Load	Moment
			K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft
VERTICAL LOADS:										
1A	DC	Footing Heel Dead Load	3.00	-6.75	1.25	3.75	-8.44	0.90	2.70	-6.08
1A	DC	Footing Mid Dead Load	1.69	6.75	1.25	2.11	8.44	0.90	1.52	6.08
1A	DC	Footing Toe Dead Load	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
1B	DC	Stem Wall Dead Load	7.64	30.56	1.25	9.55	38.21	0.90	6.88	27.51
1C	DC	Backwall Dead Load	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
2A	EV	Soil Vertical Load 1	11.32	-25.47	1.35	15.28	-34.38	1.00	11.32	-25.47
2B	EV	Soil Vertical Load 2	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 3	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 4	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2C	EV	Soil Load (below lightwt fill)	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4B	DC2	Superimposed Dead Load	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4C	DW	Wearing Surface / Utilities	0.00	0.00	1.50	0.00	0.00	0.65	0.00	0.00
5	LS	Equiv DL Surcharge	1.85	-4.16	1.25	2.31	-5.20	0.90	1.66	-3.74
8A	EV	Lightweight Fill below Bearing	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
8B	EV	Lightweight Fill above Bearing	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
9A	EV	EPS Concrete Cap below Brg	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9B	EV	EPS Concrete Cap above Brg	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Heel	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Mid	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Toe	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
		(25.5+19.58)/2=22.54=> 221.34					(24.08+18.60)/2=21.34=> 209.56			
Total Vertical:			89.25	25.50	0.94	115.5	33.00	-1.38	84.28	24.08	-1.70
				(33.00+25.45)/2=29.23=> 286.99						
HORIZONTAL LOADS:										
3	EH	Soil Lateral Load 1	5.49	25.30	1.35	7.41	34.15	0.90	4.94	22.77
3A	EH	Soil Lateral Load 2	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3B	EH	Soil Lateral Load 3	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3C	EH	Soil Lateral Load 4	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3D	EH	Soil Lateral Load 5	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3E	EH	Soil Lateral Load 6	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4B	DC2	Superimposed Dead Loads	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4C	DW	Wearing Surface + Utilities	0.00	0.00	1.50	0.00	0.00	0.65	0.00	0.00
5A	LS	Equiv DL Surcharge 1	1.47	10.15	1.25	1.84	12.68	0.90	1.32	9.13
5B	LS	Equiv DL Surcharge 2	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
5C	LS	Equiv DL Surcharge 3	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
8A	EH	Lightweight Fill below Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
8B	EH	Lightweight Fill above Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9A	EH	EPS Cap below Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9B	EH	EPS Cap above Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9C	EH	Lwt Fill below Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9D	EH	Lwt Fill above Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9C	EH	EPS Cap below Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9D	EH	EPS Cap above Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
				(9.25+12.99)/2=11.12=> 109.20					(6.26+8.76)/2=7.51=> 73.75	
(6.96+9.73)/2=8.345=> 81.95										
Total Horizontal:			24.36	6.96	35.44	32.38	9.25	46.83	21.91	6.26	31.90
Moment Grand Total:					36.38			45.46			30.19
					127.33			159.11			105.67
(36.38+38.93)/2=37.66=> 369.77					(45.46+51.00)/2=48.23=> 473.62				(30.19+32.83)/2=31.51=> 309.43		

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 3 End FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

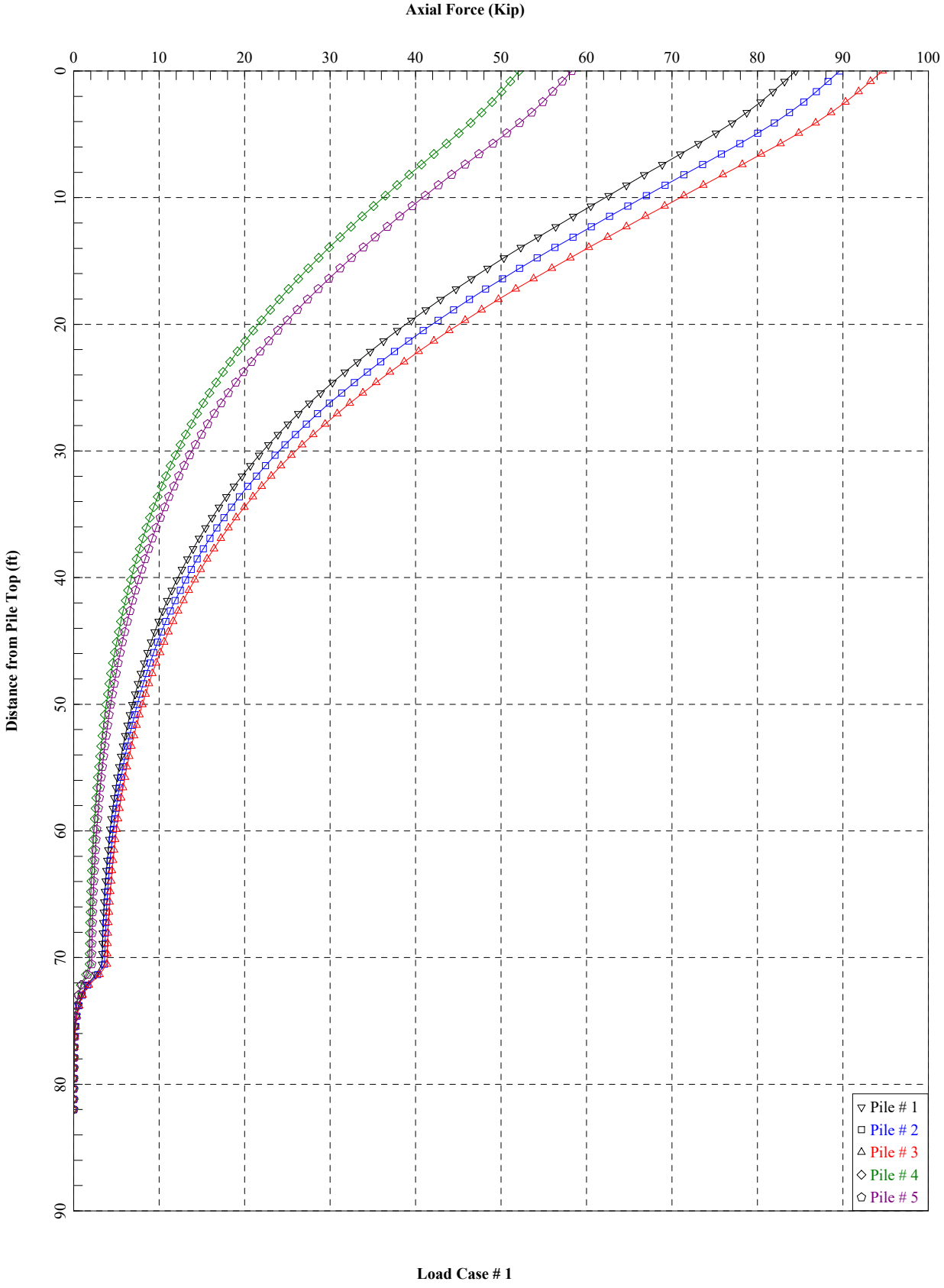
CASE II Extreme I Live Load on Approach

			SERVICE I		EXTREME I 50% Inertial + 100% PAE			EXTREME I 100% Inertial + 50% PAE		
Load No.		Load Description	Load	Moment	Factors	Load	Moment	Factors	Load	Moment
			K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft
VERTICAL LOADS:										
1A	DC	Footing Heel Dead Load	3.00	-6.75	1.00	3.00	-6.75	1.00	3.00	-6.75
	DC	Footing Mid Dead Load	1.69	6.75	1.00	1.69	6.75	1.00	1.69	6.75
	DC	Footing Toe Dead Load	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
1B	DC	Stem Wall Dead Load	7.64	30.56	1.00	7.64	30.56	1.00	7.64	30.56
	DC	Backwall Dead Load	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2A	EV	Soil Vertical Load 1	11.32	-25.47	1.00	11.32	-25.47	1.00	11.32	-25.47
	EV	Soil Vertical Load 2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	EV	Soil Vertical Load 4	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2C	EV	Soil Load (below lightwt fill)	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4B	DC2	Superimposed Dead Load	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4C	DW	Wearing Surface / Utilities	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5	LS	Equiv DL Surcharge	1.85	-4.16	1.00	1.85	-4.16	1.00	1.85	-4.16
8A	EV	Lightweight Fill below Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
8B	EV	Lightweight Fill above Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9A	EV	EPS Concrete Cap below Brg	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9B	EV	EPS Concrete Cap above Brg	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
10	WA	Buoyancy Heel	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	WA	Buoyancy Mid	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	WA	Buoyancy Toe	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
12A	WS	Wind on Structure (Serv I)	0.00	0.00						
	WS	Wind on Structure (Str V)								
		(25.50+19.58)/2=22.54=> 221.34								
Total Vertical:			25.50	0.94	89.25	25.50	0.94	89.25	25.50	0.94
HORIZONTAL LOADS:										
3	EH	Soil Lateral Load 1	5.49	25.30	1.00	5.49	25.30	1.00	4.60	21.19
3A	EH	Soil Lateral Load 2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3B	EH	Soil Lateral Load 3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3C	EH	Soil Lateral Load 4	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3D	EH	Soil Lateral Load 5	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3E	EH	Soil Lateral Load 6	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4B	DC2	Superimposed Dead Loads	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4C	DW	Wearing Surface + Utilities	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5A	LS	Equiv DL Surcharge 1	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5B	LS	Equiv DL Surcharge 2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5C	LS	Equiv DL Surcharge 3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
8A	EH	Lightweight Fill below Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
8B	EH	Lightweight Fill above Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9A	EH	EPS Cap below Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9B	EH	EPS Cap above Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9C	EH	Lwt Fill below Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9D	EH	Lwt Fill above Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9C	EH	EPS Cap below Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9D	EH	EPS Cap above Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
12A	WS	Wind on Structure (Serv I)	0.00	0.00						
	WS	Wind on Structure (Str V)								
12B	WS	Wind on Stem Wall (Serv I)	0.00	0.00						
	WS	Wind on Stem Wall (Str V)								
13	EQ	Earthquake Load	5.32	0.00	1.00	2.66	0.00	1.00	5.32	0.00
		(8.15+11.26)/2=9.71=> 95.30								
		(9.92+12.04)/2=10.98=> 107.82								
Total Horizontal:			10.81	25.30	28.53	8.15	25.30	34.72	9.92	21.19
Moment Grand Total:				26.23			26.23			22.13
							91.81			77.46

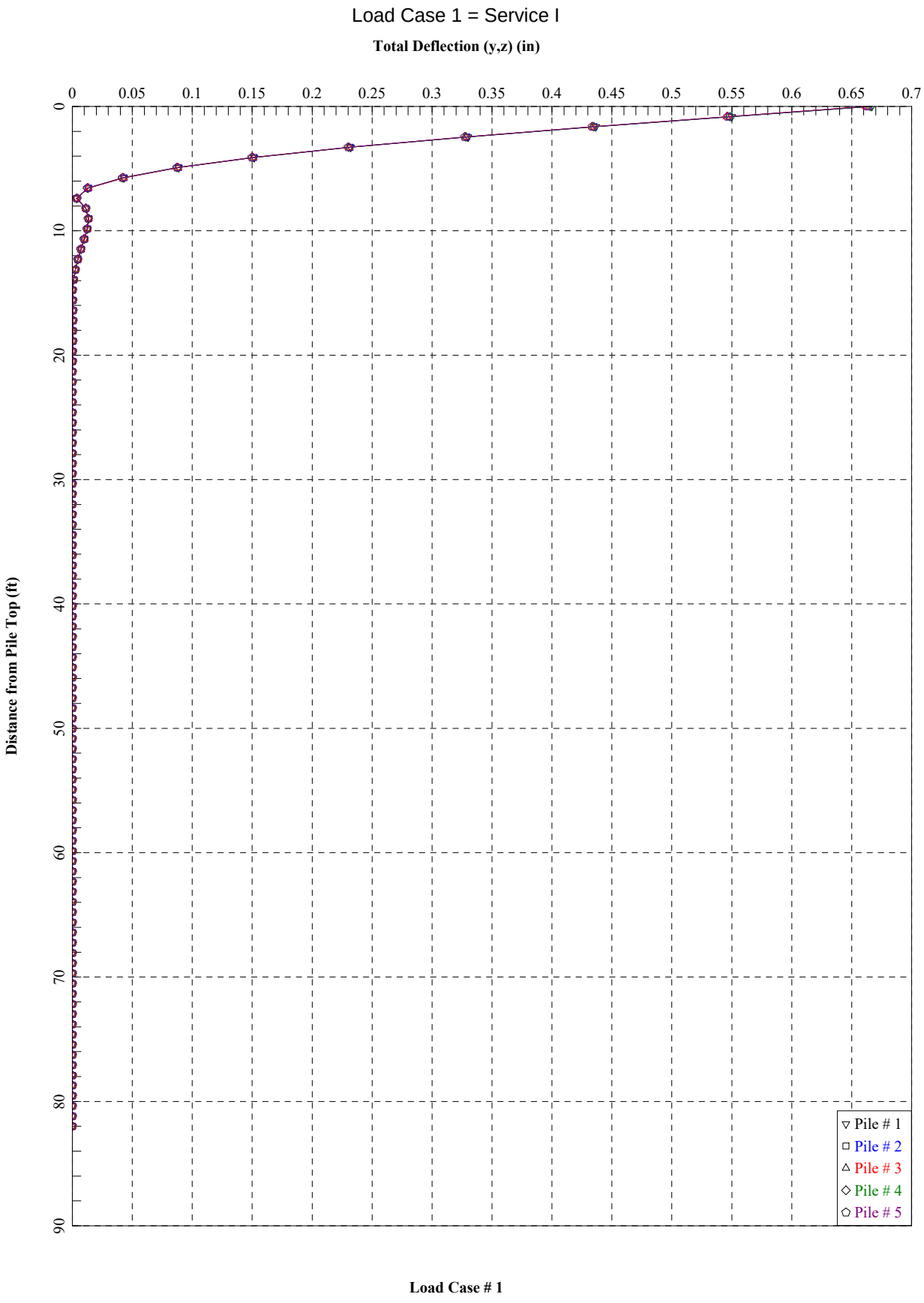
(26.23+35.51)/2=30.87=> 303.14

(22.13+27.05)/2=24.59=> 241.47

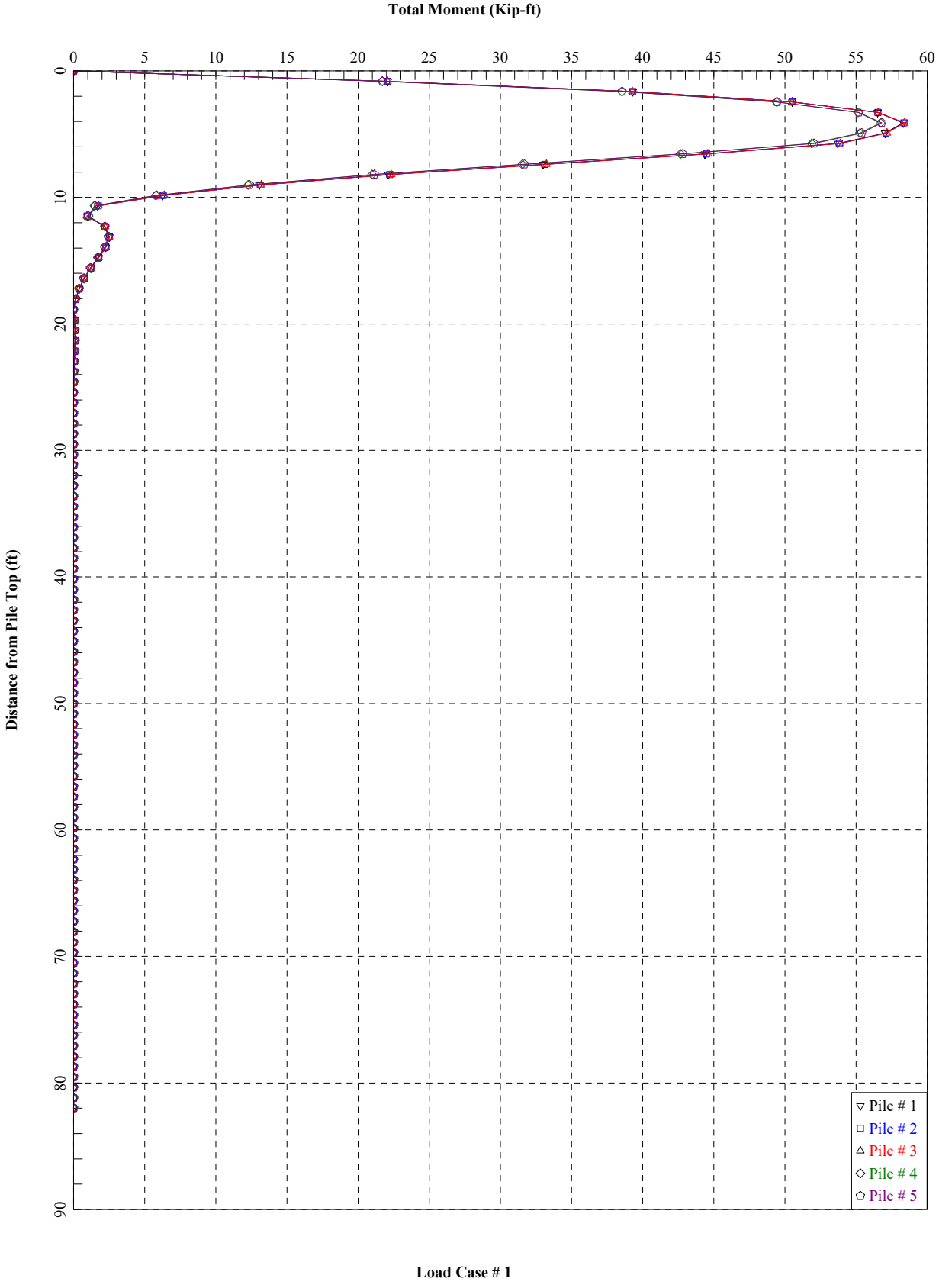
Load Case 1 = Service I



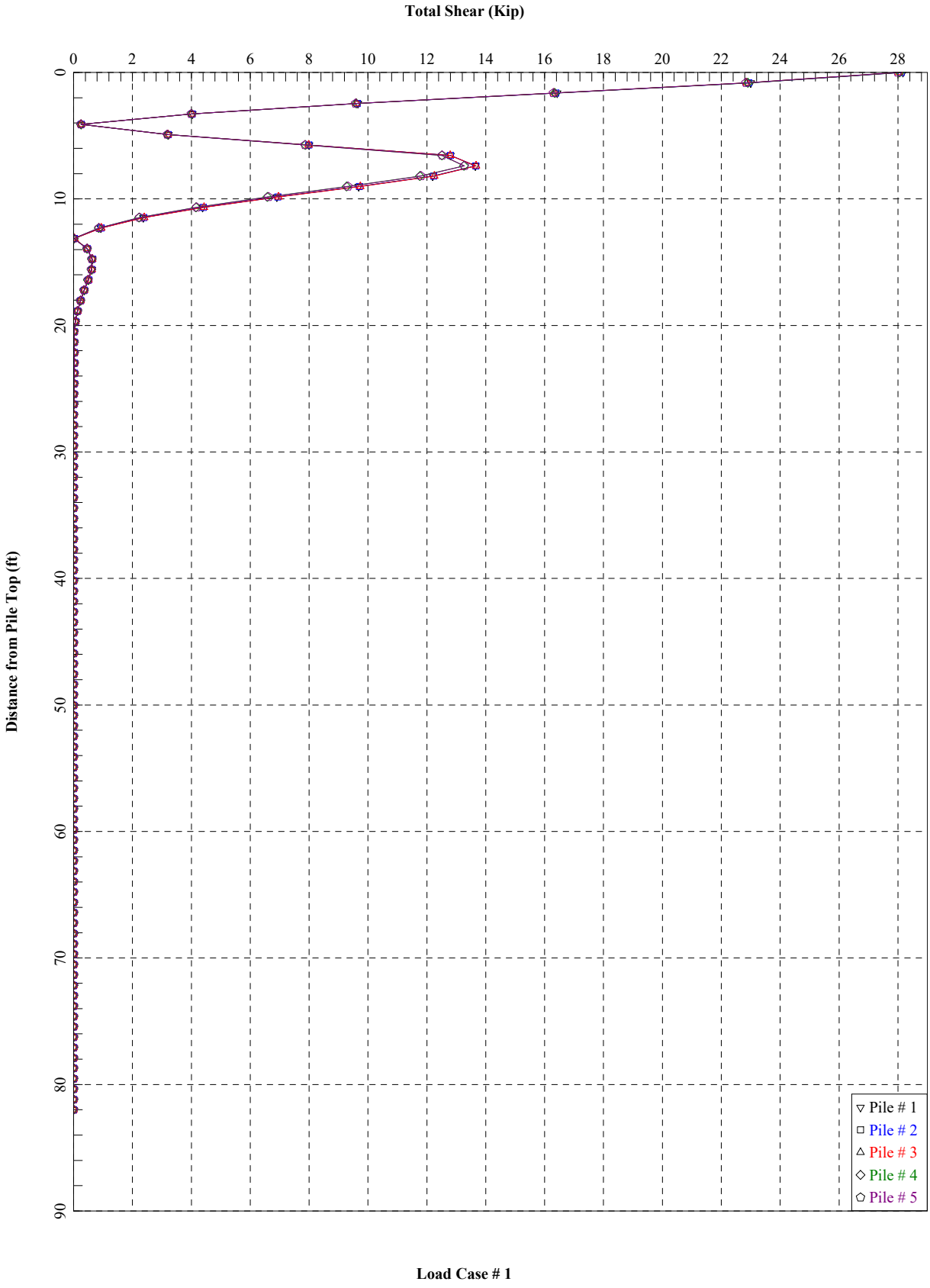
Load Case # 1


Load Case 1 = Service I
Total Deflection (y,z) (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
Distance from Pile Top (ft)
0
10
20
30
40
50
60
70
80
90
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Load Case # 1

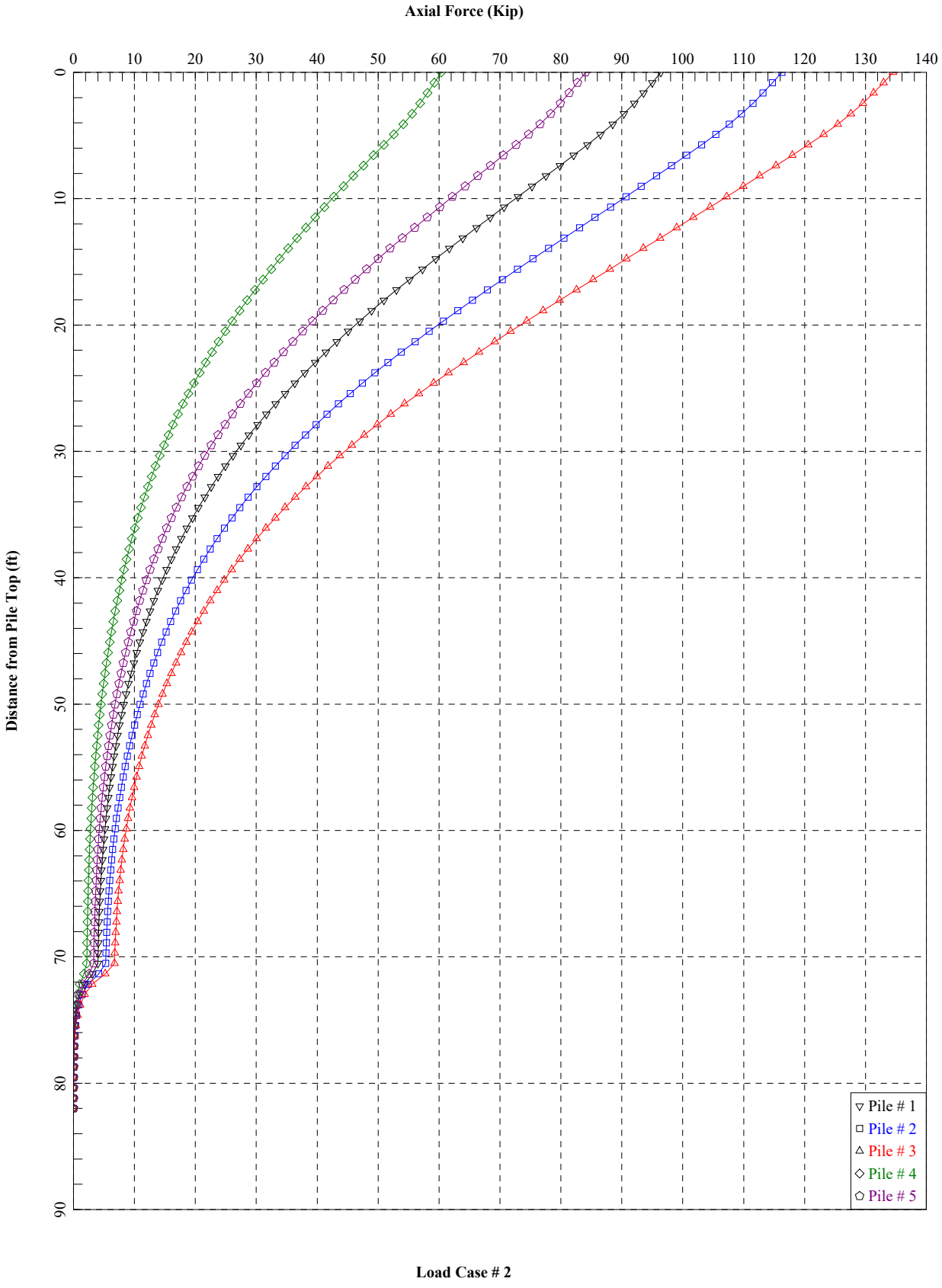
Load Case 1 = Service I



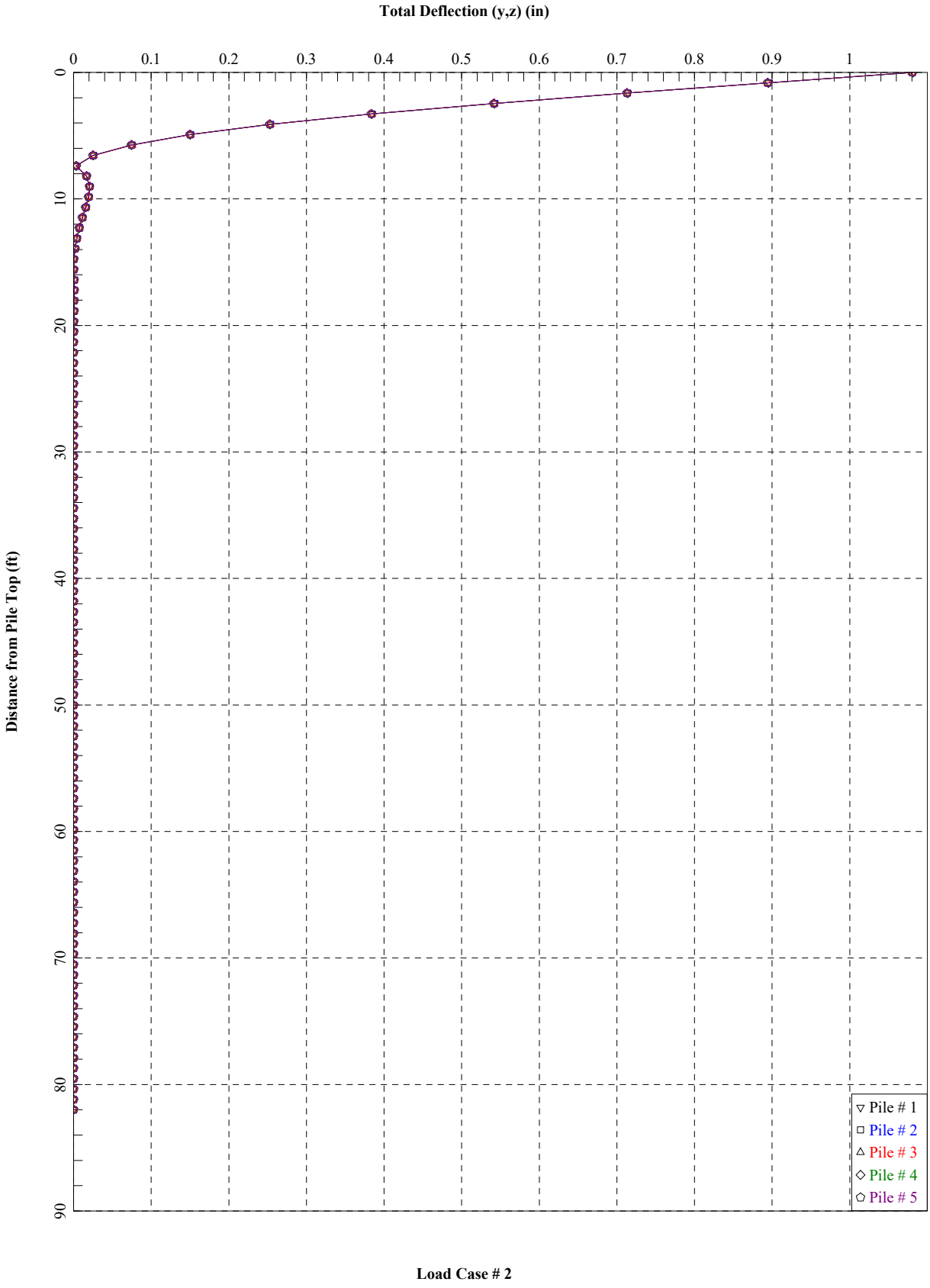
Load Case 1 = Service I

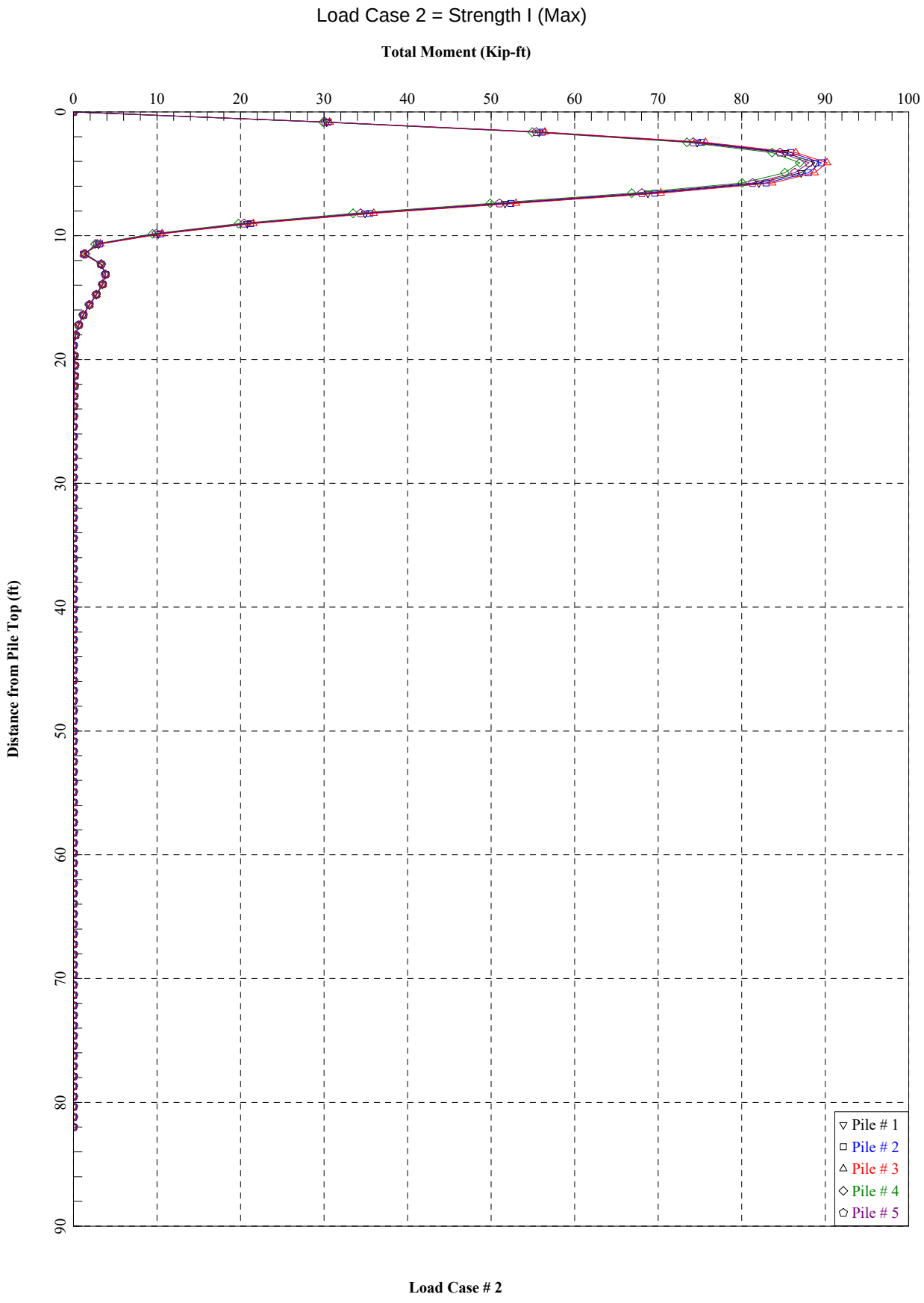


Load Case 2 = Strength I (Max)

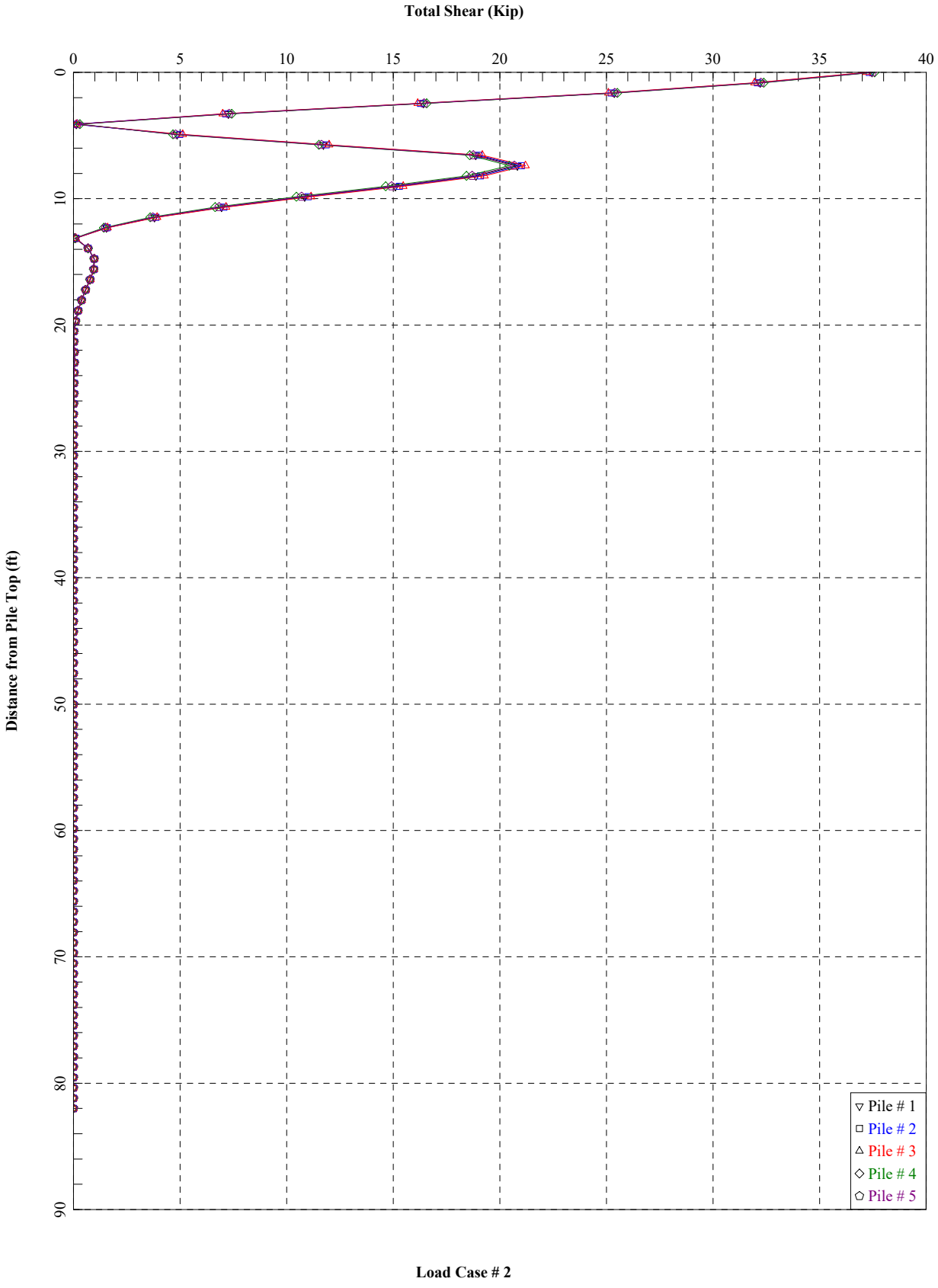


Load Case 2 = Strength I (Max)

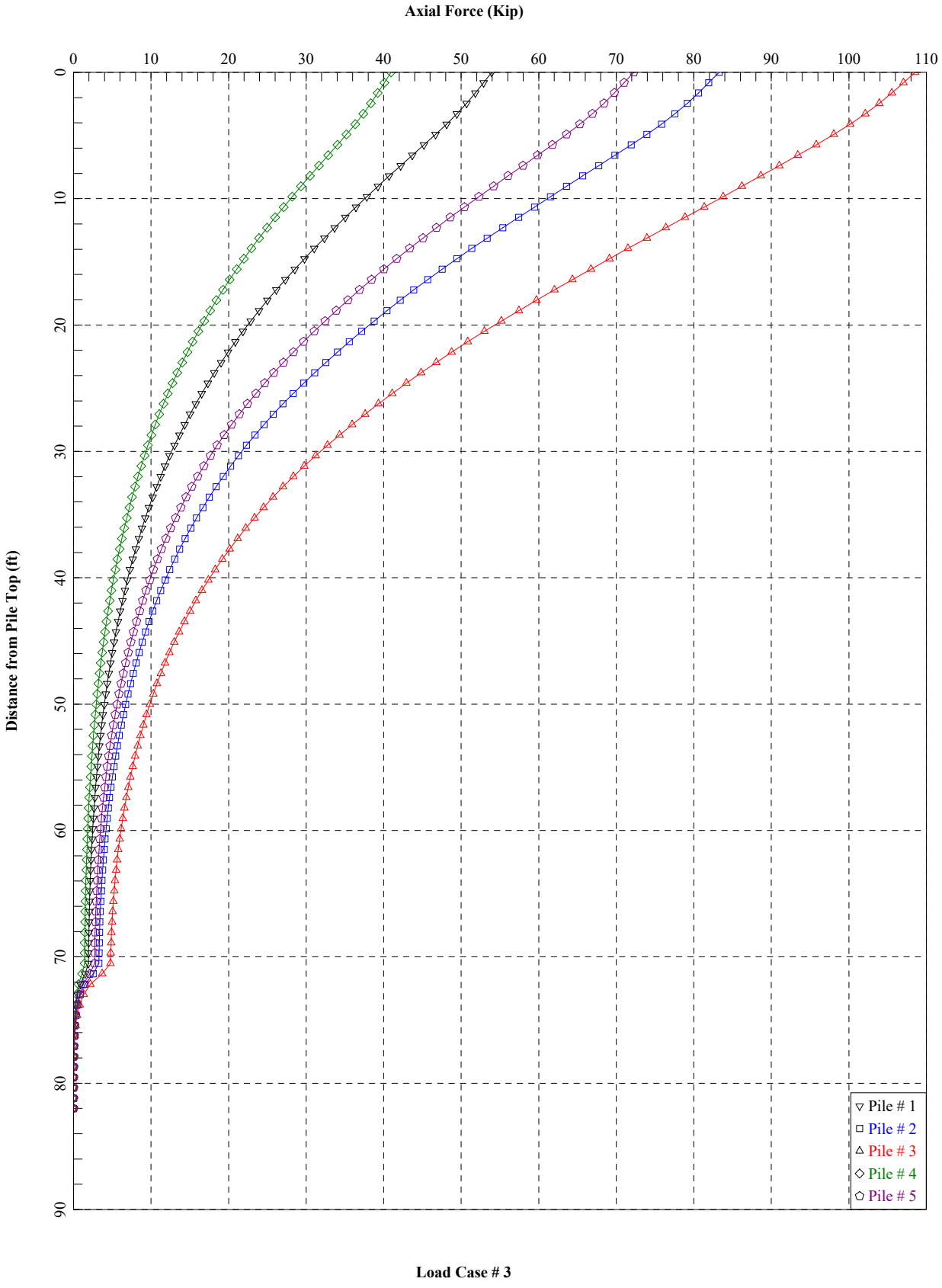



Load Case 2 = Strength I (Max)
Total Moment (Kip-ft)
0
10
20
30
40
50
60
70
80
90
100
Distance from Pile Top (ft)
0
10
20
30
40
50
60
70
80
90
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Load Case # 2

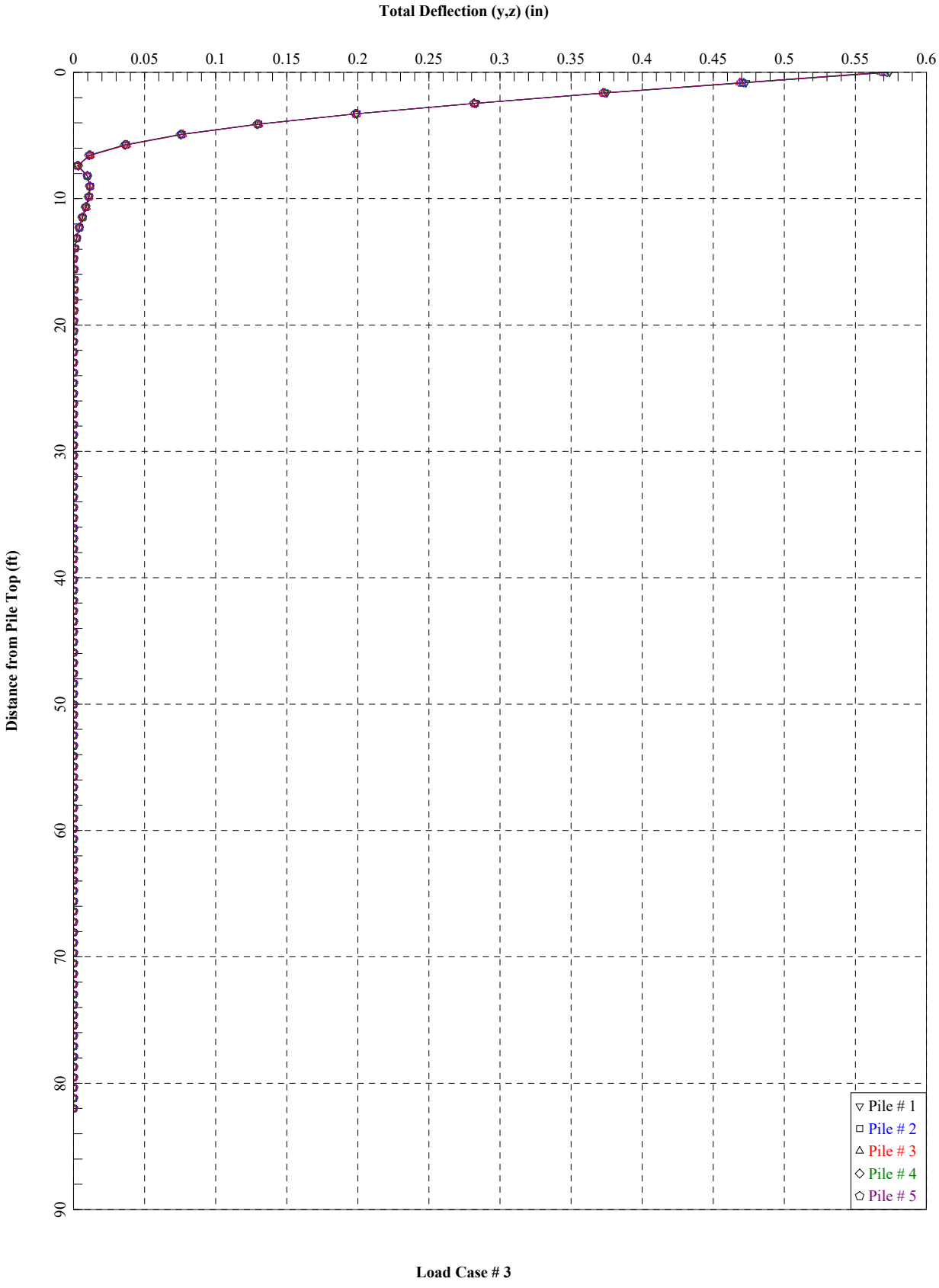
Load Case 2 = Strength I (Max)



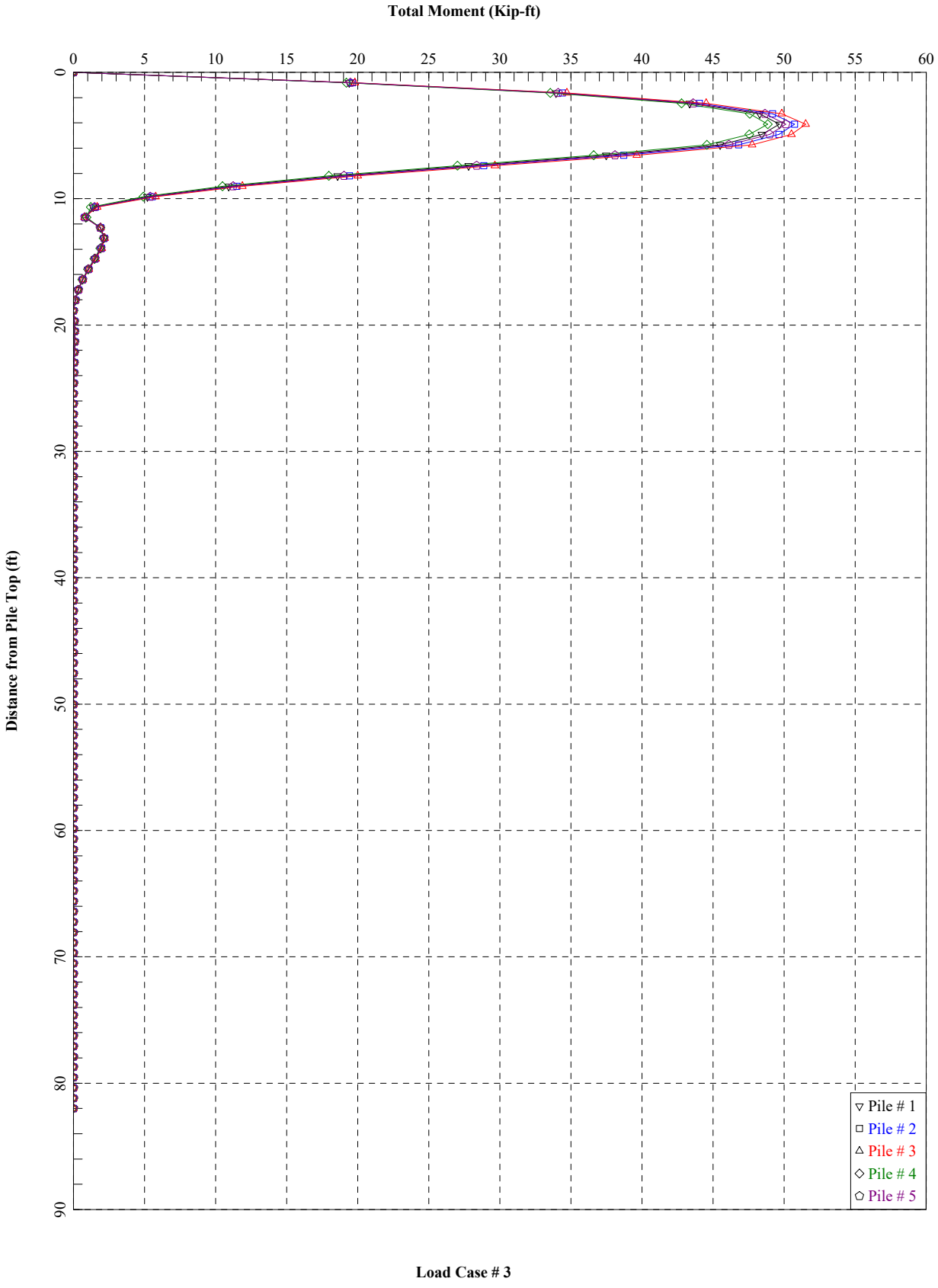
Load Case 3 = Strength I (Min)



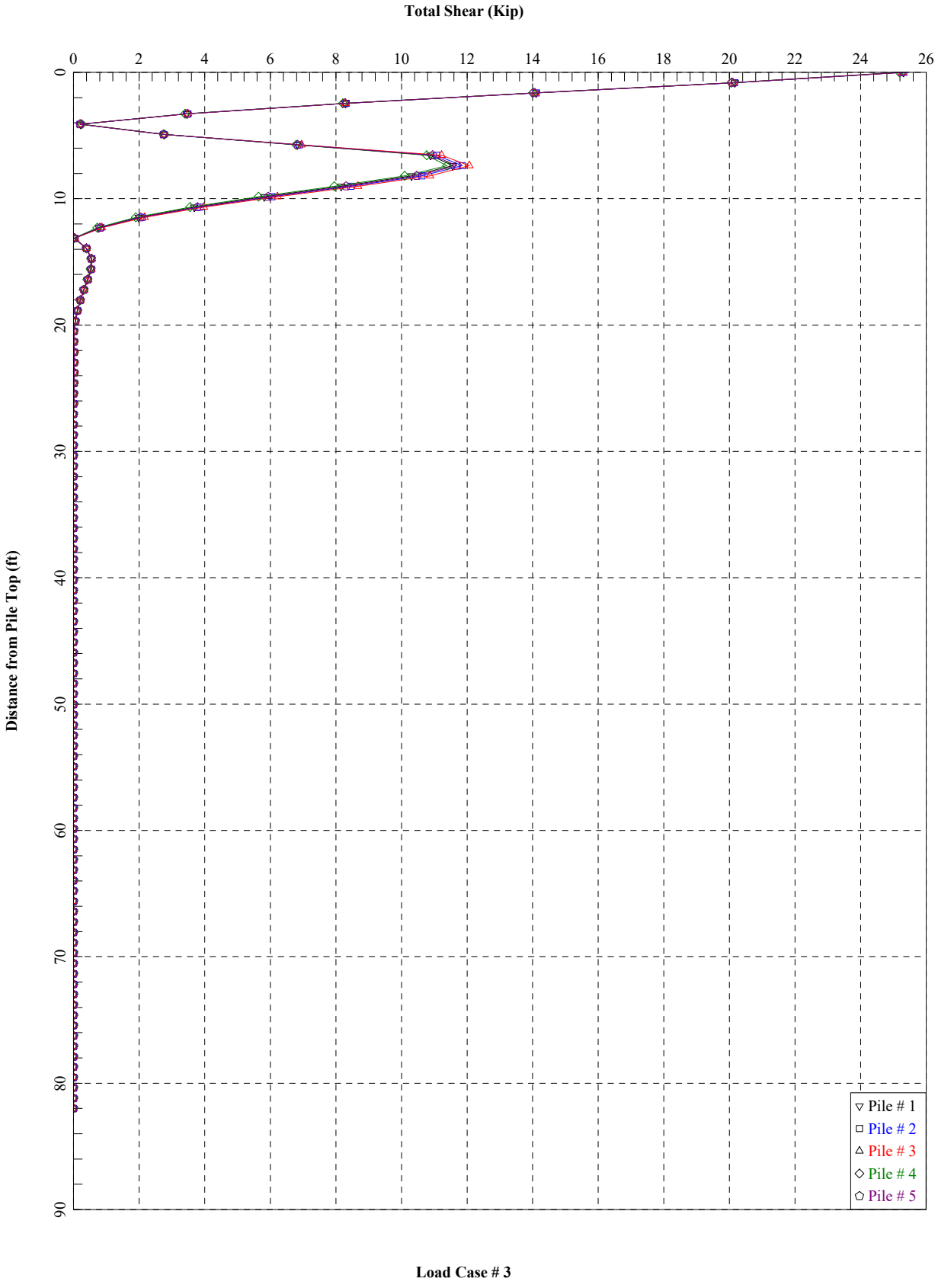
Load Case 3 = Strength I (Min)



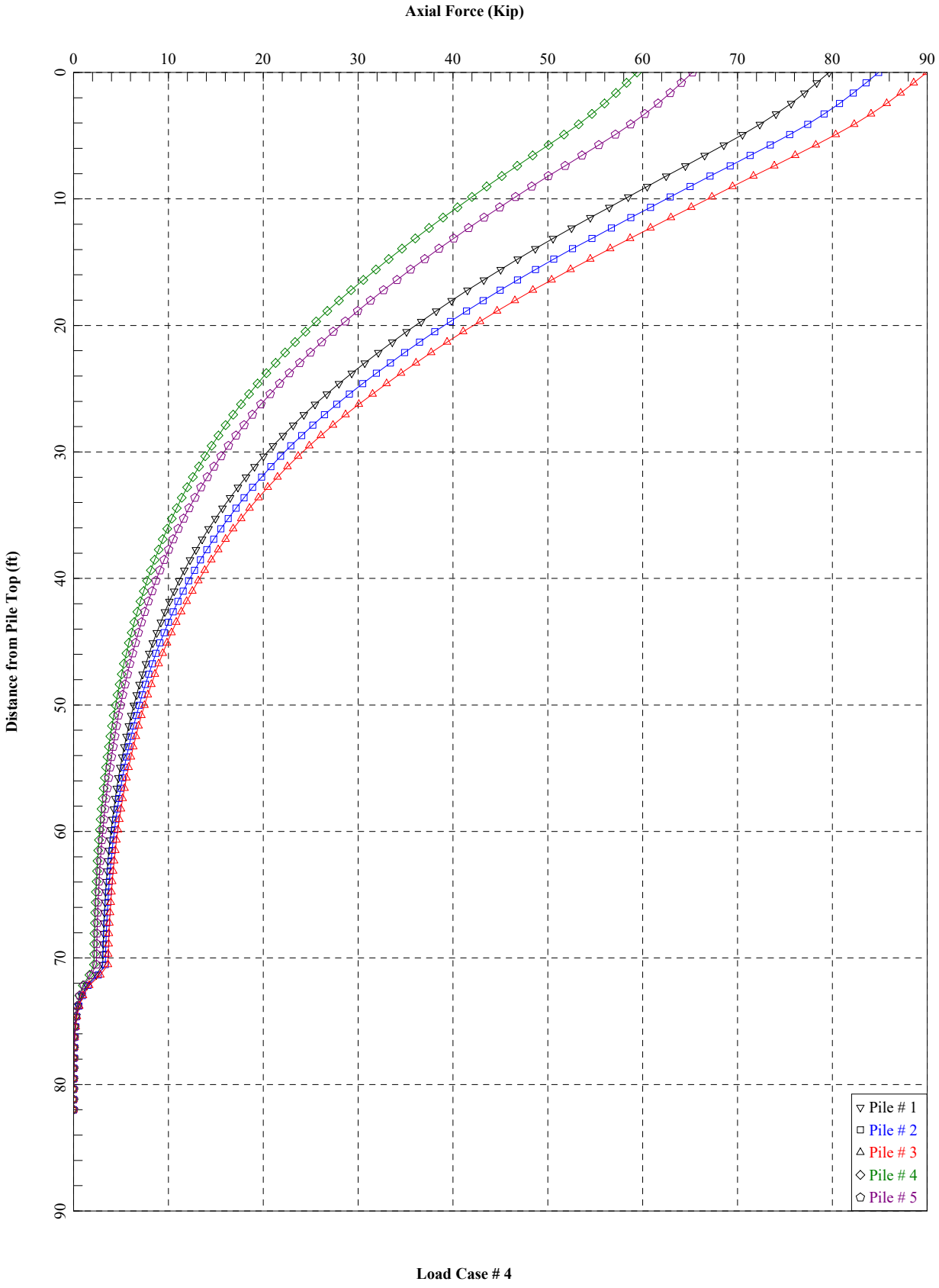
Load Case 3 = Strength I (Min)



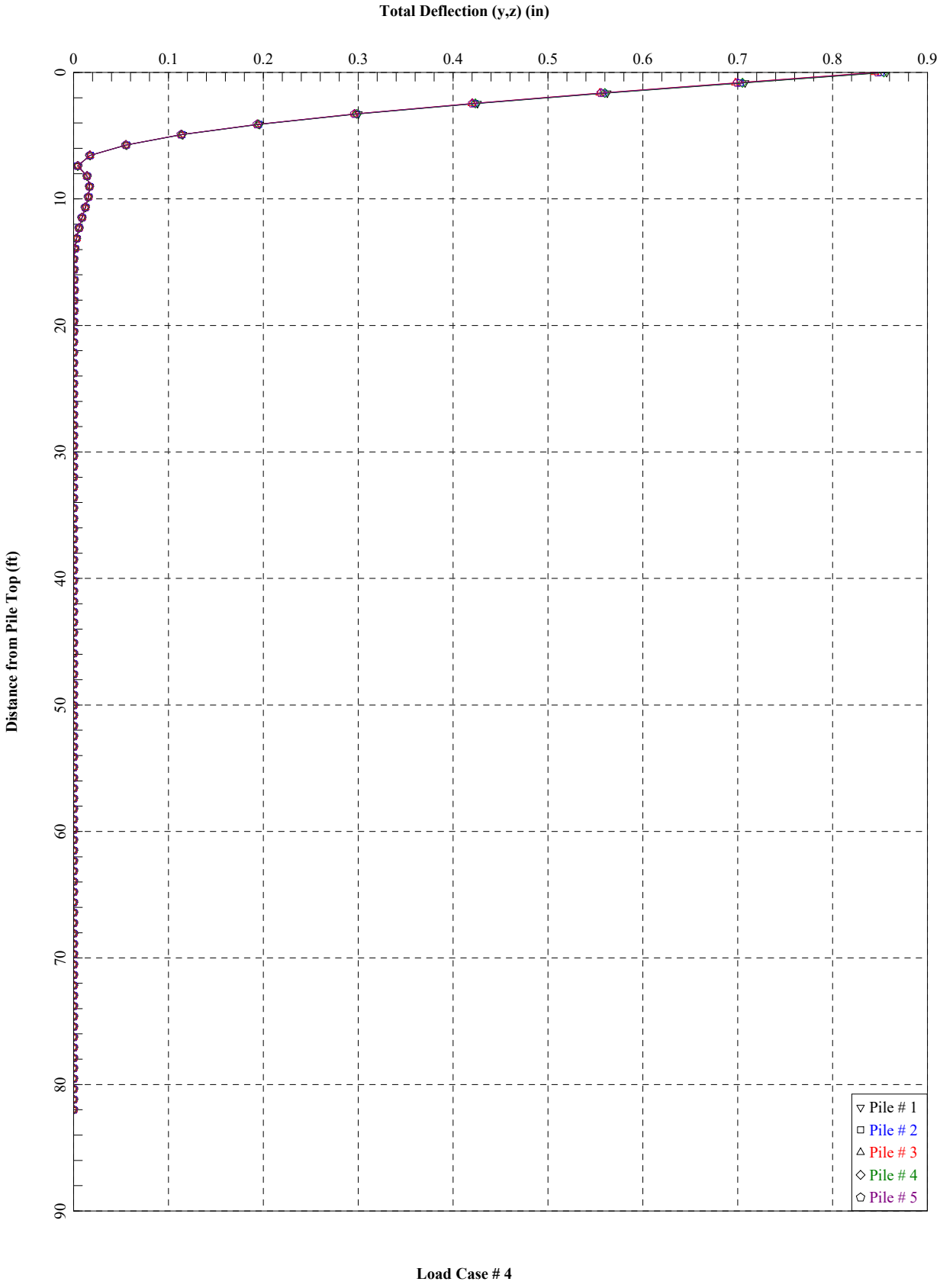
Load Case 3 = Strength I (Min)

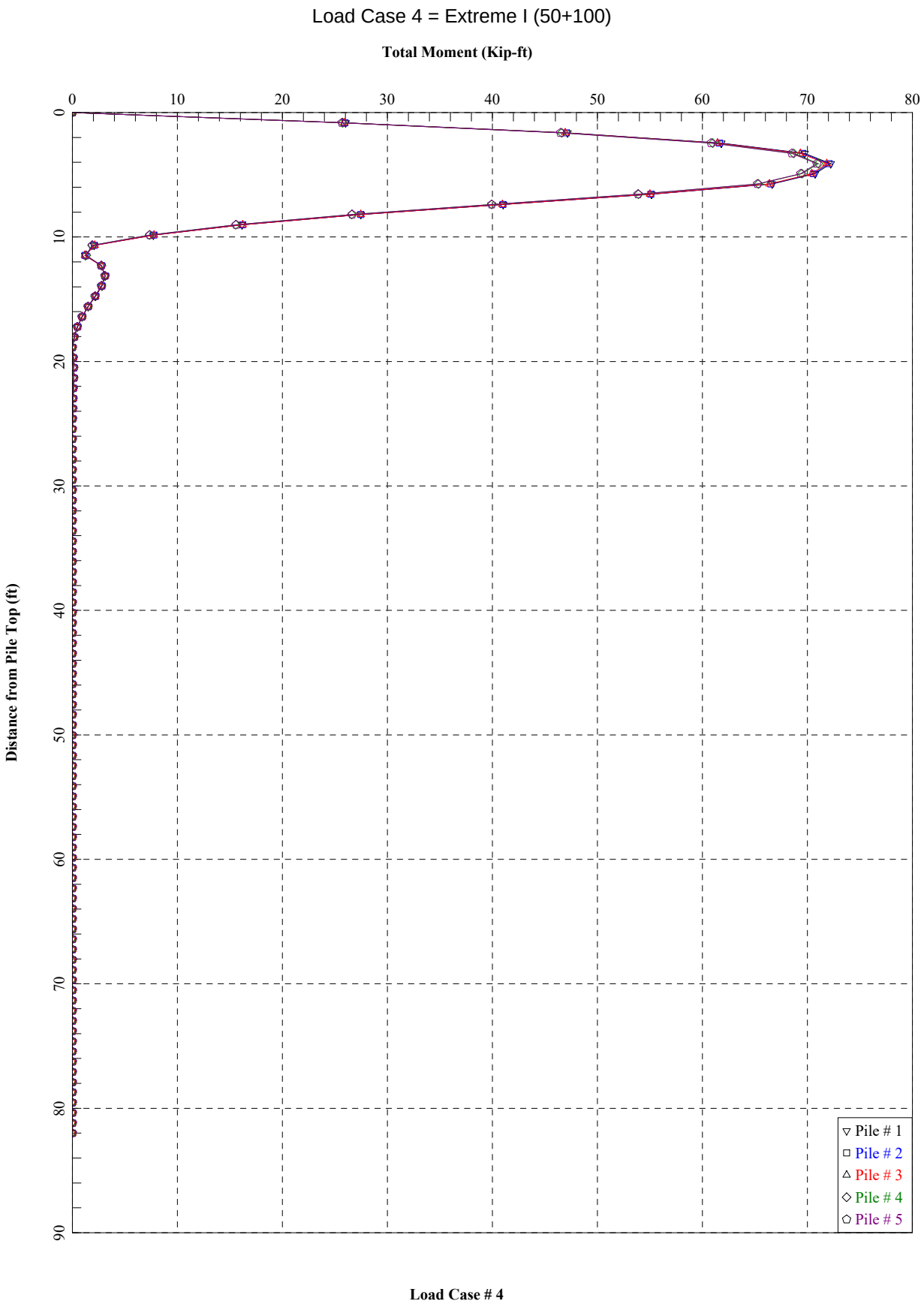


Load Case 4 = Extreme I (50+100)

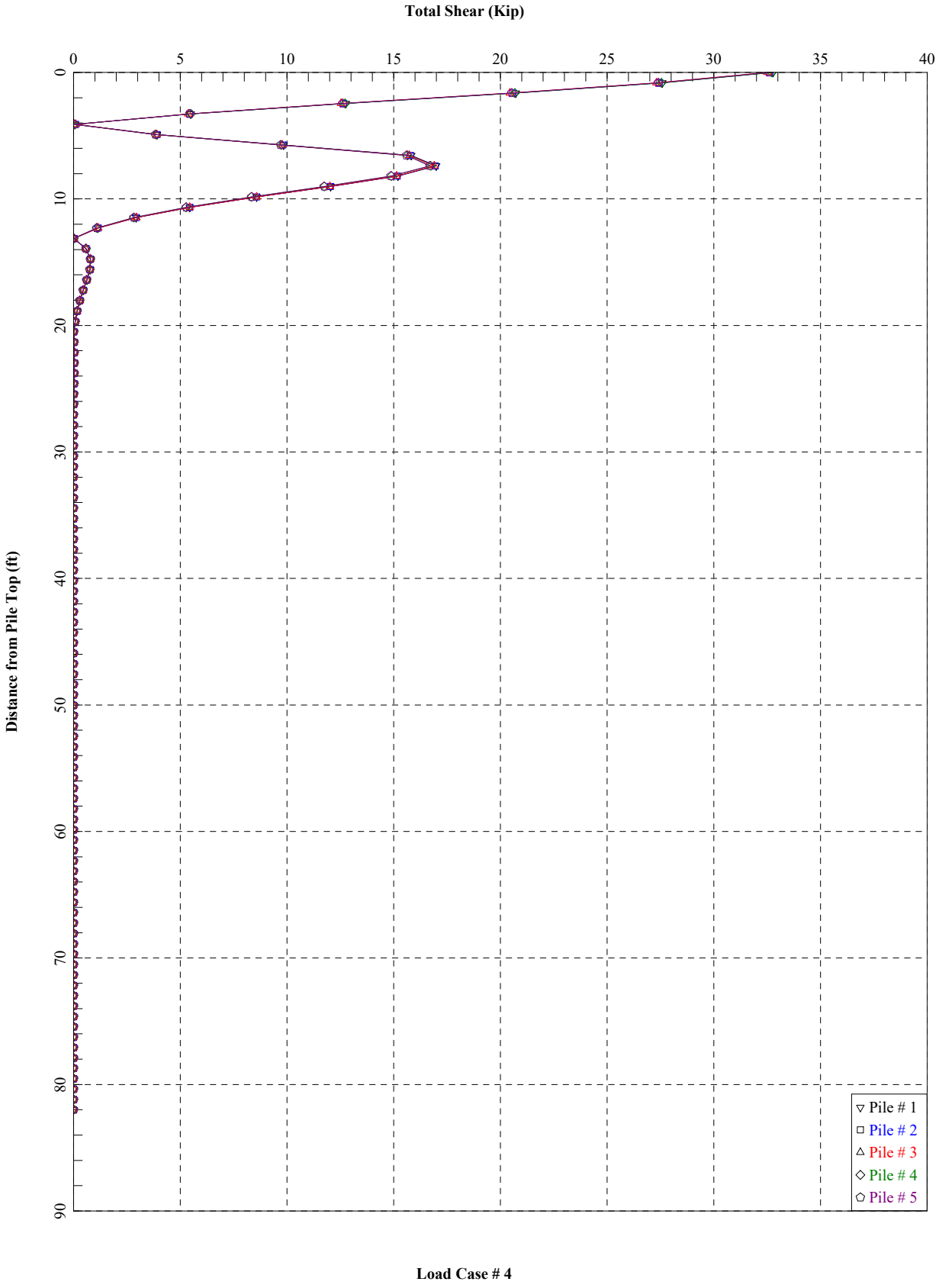


Load Case 4 = Extreme I (50+100)

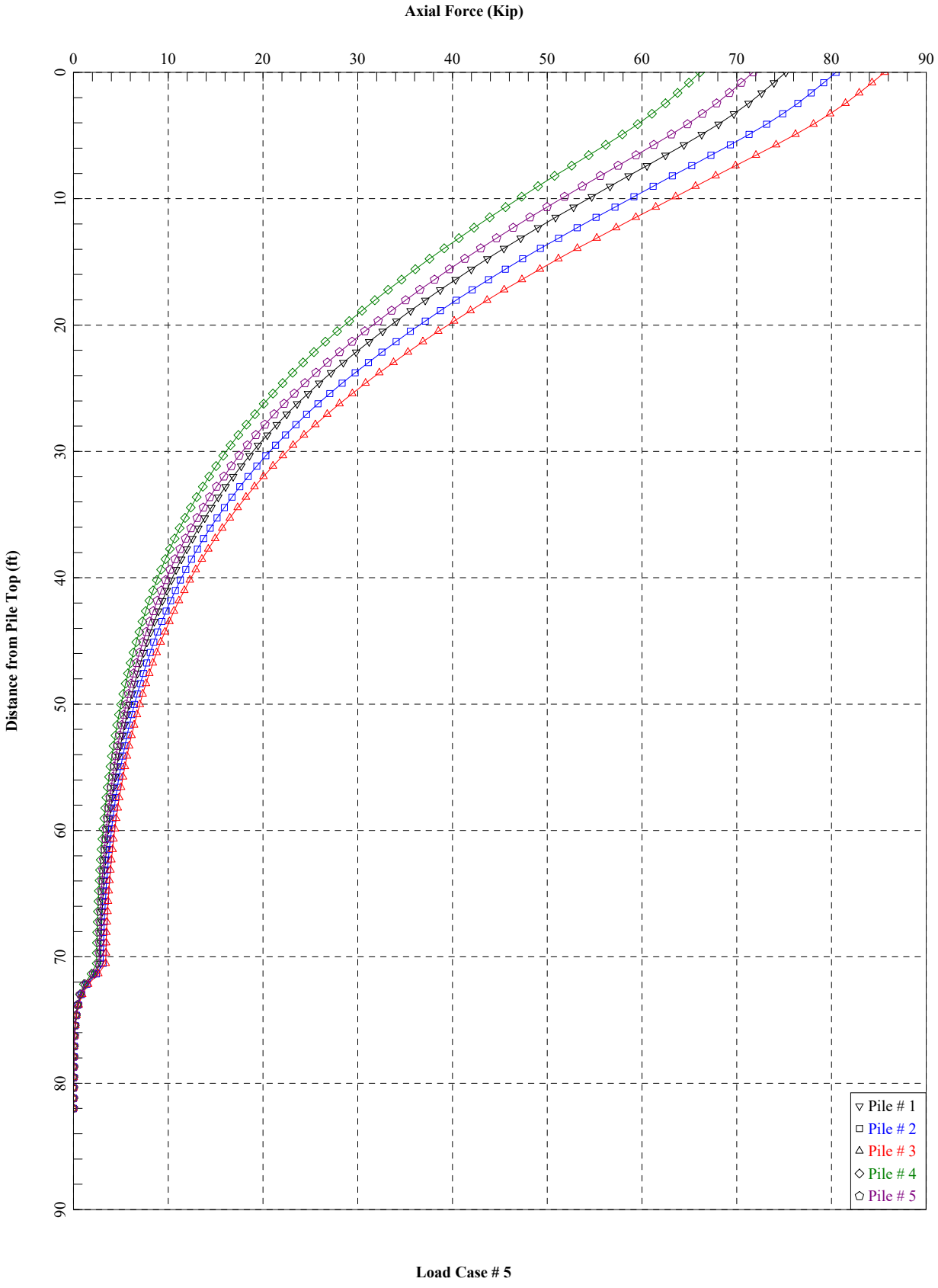



Load Case 4 = Extreme I (50+100)
Total Moment (Kip-ft)
0
10
20
30
40
50
60
70
80
Distance from Pile Top (ft)
0
10
20
30
40
50
60
70
80
90
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Load Case # 4

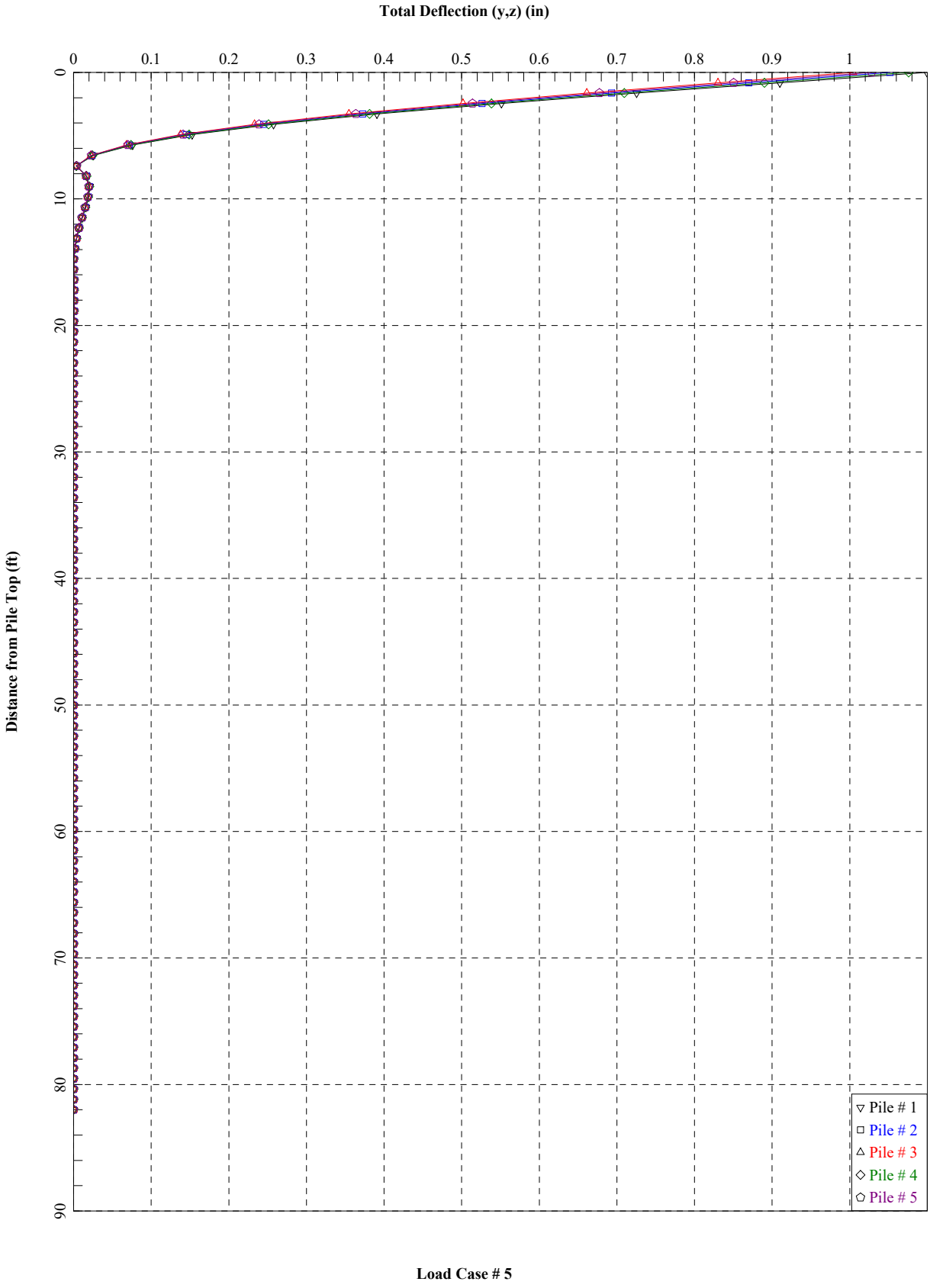
Load Case 4 = Extreme I (50+100)



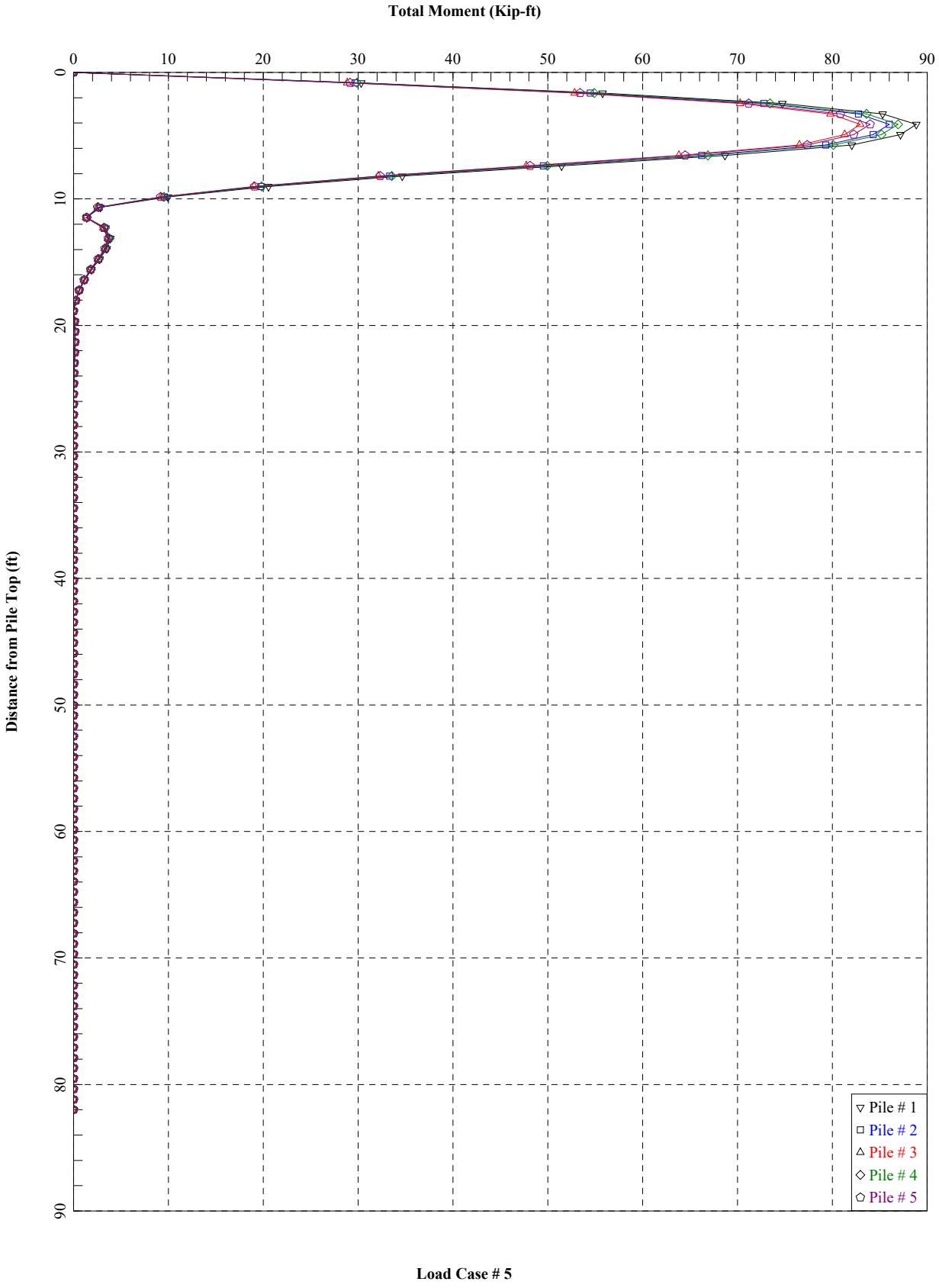
Load Case 5 = Extreme I (100+50)



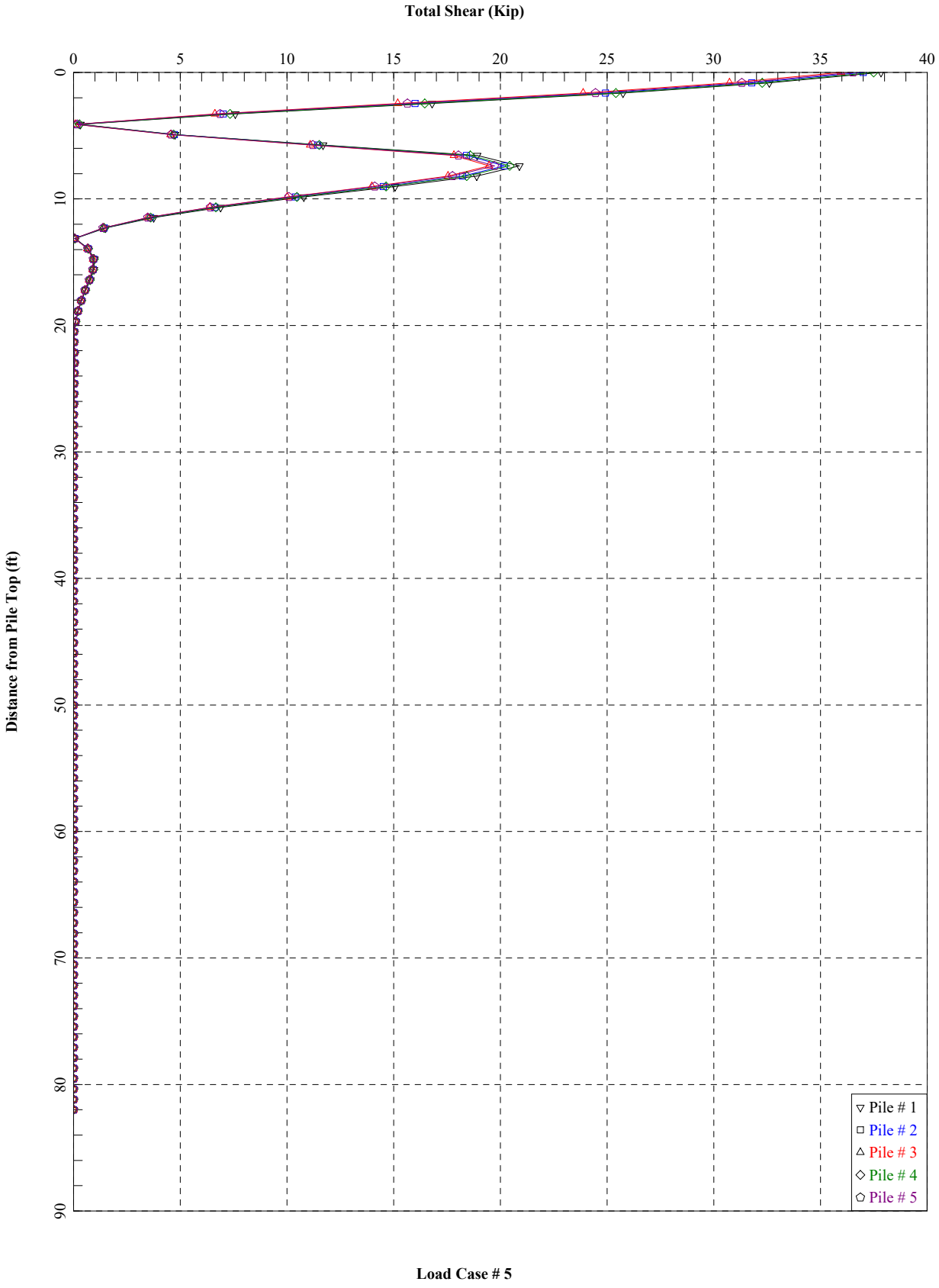
Load Case 5 = Extreme I (100+50)



Load Case 5 = Extreme I (100+50)



Load Case 5 = Extreme I (100+50)



```
     ======================================================================

                    GROUP for Windows, Version 2022.12.4

                     Serial Number : 546958378

                     Analysis of A Group of Piles
                   Subjected to Axial and Lateral Loading

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     ======================================================================


     This program is licensed to :

     Nobis Engineering, Inc.
     Lowell, MA, USA

     Path to file locations      : J:\094184.100-MassDOT Armory Street Bridges, Springfield\Calculations\Axial-Lateral Pile Analysis\S-24-026\Updated
Gravity Block 3 and 4\Group\
     Name of input data file     : Thrust Block Location 3.gp12r
     Name of output echo file    : Thrust Block Location 3.gp12e
     Name of output results file : Thrust Block Location 3.gp12o
     Name of output summary file : Thrust Block Location 3.gp12t
     Name of plot output file    : Thrust Block Location 3.gp12p
     Name of runtime file        : Thrust Block Location 3.gp12r


     ----------------------------------------------------------------------
                         Time and Date of Analysis
     ----------------------------------------------------------------------

               Date:  March 04, 2025     Time:  08:34:36




                *****     INPUT INFORMATION     *****


     094184.100 - Armory Street - Thrust Block Location 3

     ANALYSIS TYPE = 3D ANALYSIS

     ADJUST DEPTH FOR BATTER PILES

     GENERATE LOAD-DISP (AND T-R) CURVES BASED ON SOIL PROFILE

     EXTEND INTERPOLATION FOR L-DP (AND T-R) CURVES

     UNITS SYSTEM  = ENGL



     * TABLE B *  PILE CAP OPTIONS

     LENGTH,YY    ( FT ) =    12.50
     WIDTH, ZZ    ( FT ) =    16.82
     THICKNESS,XX ( FT ) =    11.50

     * PILE CAP DIMENSIONS ARE NOT CONSIDERED
       FOR THE PILE GROUP ANALYSIS




     * TABLE C *  LOAD AND CONTROL PARAMETERS


     ** LOAD CASES **


     NUMBER OF LOAD CASES :    5


     LOAD CASE    :     1
     CASE NAME    : Service I
     LOAD TYPE    : Dead, DL
     SCALE FACTOR :       1.0000

     * CONCENTRATED LOADS *

    NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
          LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
     1   6.85E+04  3.41E+04      0.00      0.00      0.00 -1.64E+06      0.00      0.00      6.66
     2   8.92E+04  2.44E+04      0.00      0.00      0.00 -1.53E+06      0.00      0.00     -6.66
     3   2.21E+05  8.20E+04      0.00      0.00      0.00 -4.44E+06      0.00      0.00     -0.82
```

```
4   3.00E+04      0.00      0.00      0.00      0.00      0.00     -4.00      4.75      4.50
5  -3.00E+04      0.00      0.00      0.00      0.00      0.00     -13.8      4.75     -4.50
6       0.00      0.00 -1.24E+04      0.00      0.00      0.00     -4.00      4.75      4.50
7       0.00      0.00  1.24E+04      0.00      0.00      0.00     -13.8      4.75     -4.50


 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           3.79120E+05       1.40370E+05           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
               29197.2       8.72600E+05      -7.60032E+06


 * THE LOADING IS STATIC *


 * CONTROL PARAMETERS *
     TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
     TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-03 IN
     MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
     MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
     FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
     MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
     INCLUDE VARIATION OF AXIAL LOAD AT PILES
     * NOT FOR USER DEFINED LOAD SETTL. CURVE
     - PRINT RESULTS AT PILE CAP


 LOAD CASE    :     2
 CASE NAME    : Strength I (Max)
 LOAD TYPE    : Dead, DL
 SCALE FACTOR :       1.0000

 * CONCENTRATED LOADS *

NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
       LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
 1   8.91E+04  4.55E+04      0.00      0.00      0.00 -2.14E+06      0.00      0.00      6.66
 2   1.16E+05  3.24E+04      0.00      0.00      0.00 -1.91E+06      0.00      0.00     -6.66
 3   2.87E+05  1.09E+05      0.00      0.00      0.00 -5.68E+06      0.00      0.00     -0.82
 4   5.25E+04      0.00      0.00      0.00      0.00      0.00     -4.00      4.75      4.50
 5  -5.25E+04      0.00      0.00      0.00      0.00      0.00     -13.8      4.75     -4.50
 6       0.00      0.00 -2.17E+04      0.00      0.00      0.00     -4.00      4.75      4.50
 7       0.00      0.00  2.17E+04      0.00      0.00      0.00     -13.8      4.75     -4.50


 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           4.91570E+05       1.87050E+05           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
               25754.4       3.29855E+06      -9.73476E+06


 * THE LOADING IS STATIC *


 * CONTROL PARAMETERS *
     TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
     TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-03 IN
     MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
     MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
     FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
     MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
     INCLUDE VARIATION OF AXIAL LOAD AT PILES
     * NOT FOR USER DEFINED LOAD SETTL. CURVE
     - PRINT RESULTS AT PILE CAP


 LOAD CASE    :     3
 CASE NAME    : Strength I (Min)
 LOAD TYPE    : Dead, DL
 SCALE FACTOR :       1.0000

 * CONCENTRATED LOADS *

NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
       LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
 1   6.51E+04  3.07E+04      0.00      0.00      0.00 -1.38E+06      0.00      0.00      6.66
 2   8.43E+04  2.19E+04      0.00      0.00      0.00 -1.27E+06      0.00      0.00     -6.66
 3   2.10E+05  7.38E+04      0.00      0.00      0.00 -3.71E+06      0.00      0.00     -0.82
 4   5.25E+04      0.00      0.00      0.00      0.00      0.00     -4.00      4.75      4.50
 5  -5.25E+04      0.00      0.00      0.00      0.00      0.00     -13.8      4.75     -4.50
 6       0.00      0.00 -2.17E+04      0.00      0.00      0.00     -4.00      4.75      4.50
 7       0.00      0.00  2.17E+04      0.00      0.00      0.00     -13.8      4.75     -4.50


 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *
```

```
        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           3.58940E+05       1.26320E+05           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
               24630.0       4.63722E+06      -6.36012E+06


 * THE LOADING IS STATIC *


 * CONTROL PARAMETERS *
     TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
     TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-03 IN
     MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
     MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
     FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
     MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
     INCLUDE VARIATION OF AXIAL LOAD AT PILES
     * NOT FOR USER DEFINED LOAD SETTL. CURVE
     - PRINT RESULTS AT PILE CAP


 LOAD CASE    :     4
 CASE NAME    : Extreme I (50%+100%PAE)
 LOAD TYPE    : Dead, DL
 SCALE FACTOR :       1.0000

 * CONCENTRATED LOADS *

NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
       LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
 1   6.85E+04  3.94E+04      0.00      0.00      0.00 -1.49E+06      0.00      0.00      6.66
 2   8.92E+04  2.85E+04      0.00      0.00      0.00 -1.10E+06      0.00      0.00     -6.66
 3   2.21E+05  9.53E+04      0.00      0.00      0.00 -3.64E+06      0.00      0.00     -0.82
 4   3.00E+04      0.00      0.00      0.00      0.00      0.00     -4.00      4.75      4.50
 5  -3.00E+04      0.00      0.00      0.00      0.00      0.00     -13.8      4.75     -4.50
 6       0.00      0.00 -1.24E+04      0.00      0.00      0.00     -4.00      4.75      4.50
 7       0.00      0.00  1.24E+04      0.00      0.00      0.00     -13.8      4.75     -4.50


 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           3.79120E+05       1.63240E+05           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
               65935.2       8.72600E+05      -6.23088E+06


 * THE LOADING IS STATIC *


 * CONTROL PARAMETERS *
     TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
     TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-04 IN
     MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
     MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
     FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
     MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
     INCLUDE VARIATION OF AXIAL LOAD AT PILES
     * NOT FOR USER DEFINED LOAD SETTL. CURVE
     - PRINT RESULTS AT PILE CAP


 LOAD CASE    :     5
 CASE NAME    : Extreme I (1000%+50%PAE)
 LOAD TYPE    : Dead, DL
 SCALE FACTOR :       1.0000

 * CONCENTRATED LOADS *

NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
       LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
 1   6.85E+04  4.21E+04      0.00      0.00      0.00 -1.14E+06      0.00      0.00      6.66
 2   8.92E+04  3.47E+04      0.00      0.00      0.00 -9.30E+05      0.00      0.00     -6.66
 3   2.21E+05  1.08E+05      0.00      0.00      0.00 -2.90E+06      0.00      0.00     -0.82
 4   3.00E+04      0.00      0.00      0.00      0.00      0.00     -4.00      4.75      4.50
 5  -3.00E+04      0.00      0.00      0.00      0.00      0.00     -13.8      4.75     -4.50
 6       0.00      0.00 -1.24E+04      0.00      0.00      0.00     -4.00      4.75      4.50
 7       0.00      0.00  1.24E+04      0.00      0.00      0.00     -13.8      4.75     -4.50


 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           3.79120E+05       1.84680E+05           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
           4.65355E+05       8.72600E+05      -4.96332E+06
```

```
* THE LOADING IS STATIC *


* CONTROL PARAMETERS *
    TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
    TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-04 IN
    MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
    MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
    FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
    MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
    INCLUDE VARIATION OF AXIAL LOAD AT PILES
    * NOT FOR USER DEFINED LOAD SETTL. CURVE
    - PRINT RESULTS AT PILE CAP



* TABLE D *   ARRANGEMENT OF PILE GROUPS

GROUP  CONN.Z-Z   CONN.Y-Y   PILE PROP  P-Y CURVE  L-S CURVE  T-R CURVE  R-F-L SET
  1       PIN        PIN         1          0          1 G        1 G        0
  2       PIN        PIN         1          0          1 G        1 G        0
  3       PIN        PIN         1          0          1 G        1 G        0
  4       PIN        PIN         1          0          1 G        1 G        0
  5       PIN        PIN         1          0          1 G        1 G        0

GROUP   CorX,FT    CorY,FT    CorZ,FT  ALPHA,DEG   BETA,DEG  THETA,DEG  GROUND,FT SPz,LBS-IN SPy,LBS-IN
  1       0.000      4.000     -5.500      0.000      90.00      0.000     -4.000      0.000      0.000
  2       0.000      4.000      0.000      0.000      90.00      0.000     -4.000      0.000      0.000
  3       0.000      4.000      5.500      0.000      90.00      0.000     -4.000      0.000      0.000
  4       0.000     -4.000     -2.750      0.000      90.00      0.000     -4.000      0.000      0.000
  5       0.000     -4.000      2.750      0.000      90.00      0.000     -4.000      0.000      0.000



* TABLE E *   PILE GEOMETRY AND PROPERTIES
              PILE TYPE = 1 - DRIVEN PILE
                        = 2 - DRILLED SHAFT

  PROP   SECTS   INC     PILE TYPE      LENGTH, FT
    1      3     100          2            82.000

* PILE SECTIONS *

  PROP    SECT      FROM,FT         TO,FT    CROSS SECT
    1       1        0.00000        3.00000       1
    1       2        3.00000        72.0000       2
    1       3        72.0000        82.0000       3

* PILE CROSS SECTIONS *

 CROSS SECTION       :     1
 SECTION NAME        : 10.75-inch
 TYPE                :  NONLINEAR
 CROSS SECTION TYPE  : ROUND CONC. SHAFT, CASING (AND STEEL SECTION)
 CONCRETE DIAMETER   :       9.75000 IN
 CONCRETE FC         :       5000.00 LBS/IN**2
 DIAMETER CASING     :       10.6250 IN
 THICKNESS CASING    :       0.43750 IN
 ES CASING           :   2.90000E+07 LBS/IN**2
 FY CASING           :       52000.0 LBS/IN**2
 EMBEDDED STEEL SECT : NONE
 NUMBER REBARS       :             1
 ES REINFORCEMENT    :   2.90000E+07 LBS/IN**2
 FY REINFORCEMENT    :       60000.0 LBS/IN**2
 REINF. LAYOUT       :       MANUAL
 REINF. A , D, COORDS:        IN^2             IN              IN              IN
 - REBAR    1        :       0.79000         1.00000         0.00000         0.00000
 EQ. YOUNG MODULUS   :   8.19627E+06 LBS/IN**2

 CROSS SECTION       :     2
 SECTION NAME        : 10.75-inch
 TYPE                :  NONLINEAR
 CROSS SECTION TYPE  : ROUND CONC. SHAFT, CASING (AND STEEL SECTION)
 CONCRETE DIAMETER   :       9.75000 IN
 CONCRETE FC         :       5000.00 LBS/IN**2
 DIAMETER CASING     :       10.2500 IN
 THICKNESS CASING    :       0.25000 IN
 ES CASING           :   2.90000E+07 LBS/IN**2
 FY CASING           :       52000.0 LBS/IN**2
 EMBEDDED STEEL SECT : NONE
 NUMBER REBARS       :             1
 ES REINFORCEMENT    :   2.90000E+07 LBS/IN**2
 FY REINFORCEMENT    :       60000.0 LBS/IN**2
 REINF. LAYOUT       :       MANUAL
 REINF. A , D, COORDS:        IN^2             IN              IN              IN
 - REBAR    1        :       0.79000         1.00000         0.00000         0.00000
 EQ. YOUNG MODULUS   :   6.64620E+06 LBS/IN**2

 CROSS SECTION       :     3
 SECTION NAME        : 9.75-inch
```

```
 TYPE                :  NONLINEAR
 CROSS SECTION TYPE  : ROUND CONCRETE SHAFT
 EXTERNAL DIAMETER   :       9.75000 IN
 CONCRETE FC         :       5000.00 LBS/IN**2
 NUMBER REBARS       :             1
 ES REINFORCEMENT    :   2.90000E+07 LBS/IN**2
 FY REINFORCEMENT    :       60000.0 LBS/IN**2
 REINF. LAYOUT       :       MANUAL
 REINF. A , D, COORDS:        IN^2            IN             IN             IN
 - REBAR    1        :       0.79000         1.00000        0.00000        0.00000
 EQ. YOUNG MODULUS   :   4.29471E+06 LBS/IN**2

* PILE CROSS SECTIONS PROPERTIES *

         NONLINEAR SECTIONS

SECT    DIAM,IN   PERIM,IN AREA,IN**2   Iz,IN**4   Iy,IN**4  GJ,LBS-IN**2   EIz IND  EIy IND   Mn,LBS-IN    Vn,LBS
  1      10.625     33.379     88.664     0.0000     0.0000   5.4901E+09      0        0         0.0000     0.0000
  2      10.250     32.201     82.516     0.0000     0.0000   3.6218E+09      0        0         0.0000     0.0000
  3      9.7500     30.631     74.662     0.0000     0.0000   1.4303E+09      0        0         0.0000     0.0000


* TABLE F *   SOIL DATA


SOILS INFORMATION

    GROUND SURFACE          =     -4.00000  FT

    6 LAYER(S) OF SOIL

    LAYER  1
    THE SOIL IS A SAND
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       -4.00000          5.00000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       115.000          115.000
    FRICTION ANGLE                  (DEGREES)       33.0000          33.0000
    P-Y SUBGRADE MODULUS          (LBS/IN**3)       25.0000          25.0000
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)       11.5000 (S)      1133.32 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)       0.00000          0.00000

    LAYER  2
    THE SOIL IS A SILT
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       5.00000          16.5000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       57.6000          57.6000
    UNDRAINED COHESION, C         (LBS/FT**2)       130.000          130.000
    FRICTION ANGLE                  (DEGREES)       22.0000          22.0000
    P-Y SUBGRADE MODULUS          (LBS/IN**3)       100.000          100.000
    STRAIN AT 50% STRESS                          1.00000E-02      1.00000E-02
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)       1204.82 (S)      1580.08 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)       0.00000          0.00000

    LAYER  3
    THE SOIL IS A SILT
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       16.5000          59.5000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       57.6000          57.6000
    UNDRAINED COHESION, C         (LBS/FT**2)       130.000          130.000
    FRICTION ANGLE                  (DEGREES)       22.0000          22.0000
    P-Y SUBGRADE MODULUS          (LBS/IN**3)       100.000          100.000
    STRAIN AT 50% STRESS                          1.00000E-02      1.00000E-02
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)       1580.08 (S)      1842.31 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)       0.00000          0.00000

    LAYER  4
    THE SOIL IS A SAND
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       59.5000          68.5000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       72.6000          72.6000
    FRICTION ANGLE                  (DEGREES)       37.0000          37.0000
    P-Y SUBGRADE MODULUS          (LBS/IN**3)       125.000          125.000
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)       1770.81 (S)      1692.15 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)       0.00000          0.00000

    LAYER  5
    THE SOIL IS A SAND
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       68.5000          71.0000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       72.6000          72.6000
    FRICTION ANGLE                  (DEGREES)       37.0000          37.0000
    P-Y SUBGRADE MODULUS          (LBS/IN**3)       125.000          125.000
    ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)       1692.15 (S)      1657.34 (S)
    ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)       0.00000          0.00000

    LAYER  6
    THE LAYER IS A VUGGY LIMESTONE
                                                TOP OF LAYER    BOTTOM OF LAYER
    X COORDINATE                        (FT)       71.0000          100.000
    EFFECTIVE UNIT WEIGHT         (LBS/FT**3)       101.600          101.600
```

UNIAXIAL COMPRESSIVE STRENGTH (LBS/IN**2)	7500.00	7500.00
ULTIMATE UNIT SIDE FRICTION (LBS/FT**2)	1.08000E+05 (S)	1.08000E+05 (S)
ULTIMATE UNIT TIP RESISTANCE (LBS/FT**2)	9.72000E+06 (T)	9.72000E+06 (T)

Notes : Program estimated values for listed parameters
if zero input values were entered:
(S) ULTIMATE UNIT SIDE FRICTION for Drilled Shafts
(T) ULTIMATE UNIT TIP RESISTANCE for Drilled Shafts

* TABLE H * AXIAL LOAD VS DISPLACEMENT

AXIAL LOAD-DISPLACEMENT CURVES GENERATED INTERNALLY

NUM OF CURVES 1

CURVE 1 NUM OF POINTS 19

DISPLACEMENT, IN	AXIAL LOAD,LBS
-6.67921	-2.88886E+06
-5.68516	-2.89203E+06
-5.32944	-2.97369E+06
-5.12966	-3.08745E+06
-5.11731	-3.10919E+06
-4.67763	-2.90042E+06
-4.28851	-2.69627E+06
-3.26155	-2.13616E+06
-1.73080	-1.24374E+06
0.00000	0.00000
2.43715	1.66534E+06
3.97771	2.52992E+06
5.06245	3.10235E+06
5.63565	3.39647E+06
8.55673	4.87899E+06
10.1791	5.69094E+06
14.5857	7.76407E+06
15.2874	7.86826E+06
16.5925	8.02636E+06

DISPL. TIP , IN	AXIAL TIP ,LBS
-2.00000	-6.88103
-1.00000	-6.66926
-0.50000	-6.50779
-0.10000	-3.64897
-0.0500000	-2.50941
-1.00000E-02	-0.50188
-5.00000E-03	-0.25094
-1.00000E-03	-0.0501882
-1.00000E-04	-5.01882E-03
0.00000	0.00000
1.00000E-04	3747.15
1.00000E-03	37471.5
5.00000E-03	1.87357E+05
1.00000E-02	3.74715E+05
0.0500000	1.87357E+06
0.10000	2.72439E+06
0.50000	4.85884E+06
1.00000	4.97940E+06
2.00000	5.13751E+06

* TABLE I * TORS. MOM. VS ANGLE ROT.

TORQUE-ROTATION CURVES GENERATED INTERNALLY

NUM OF CURVES 1

CURVE 1 NUM OF POINTS 19

ROT. ANGLE,Rad.	TORS.MOMEN,LBS-IN
-4.28595	-1.53439E+07
-4.09988	-1.53508E+07
-4.05738	-1.55208E+07
-4.06325	-1.57914E+07
-4.06751	-1.58375E+07
-3.93037	-1.54313E+07
-3.78795	-1.49823E+07
-3.40492	-1.37516E+07
-2.79271	-1.17111E+07
0.00000	0.00000
2.79271	1.17111E+07
3.40492	1.37516E+07
3.78795	1.49823E+07
3.93037	1.54313E+07
4.06751	1.58375E+07
4.06325	1.57914E+07
4.05738	1.55208E+07
4.09988	1.53508E+07
4.28595	1.53439E+07

* TABLE K * REDUCTION FACTORS

AVERAGE DIAMETER IS USED TO GET RATIO S/B

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS ALONG Y-DIRECTION
ESTIMATED ASSUMING MOVEMENT IN THE DIRECTION OF Y-FORCE (+)

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	1.0000	1.0000
3	1.0000	1.0000
4	1.0000	1.0000
5	1.0000	1.0000

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS ALONG Z-DIRECTION
ESTIMATED ASSUMING MOVEMENT IN THE DIRECTION OF Z-FORCE (+)

GROUP NO	P-FACTOR	Y-FACTOR
1	0.9609	1.0000
2	0.9609	1.0000
3	1.0000	1.0000
4	0.9609	1.0000
5	1.0000	1.0000

```
     ======================================================================

                    GROUP for Windows, Version 2022.12.4

                     Serial Number : 546958378

                     Analysis of A Group of Piles
                   Subjected to Axial and Lateral Loading

                   (c) Copyright ENSOFT, Inc., 1987-2022
                         All Rights Reserved

     ======================================================================


     This program is licensed to :

     Nobis Engineering, Inc.
     Lowell, MA, USA

     Path to file locations      : J:\094184.100-MassDOT Armory Street Bridges, Springfield\Calculations\Axial-Lateral Pile Analysis\S-24-026\Updated
Gravity Block 3 and 4\Group\
     Name of input data file     : Thrust Block Location 3.gp12d
     Name of output echo file    : Thrust Block Location 3.gp12e
     Name of output results file : Thrust Block Location 3.gp12o
     Name of output summary file : Thrust Block Location 3.gp12t
     Name of plot output file    : Thrust Block Location 3.gp12p
     Name of runtime file        : Thrust Block Location 3.gp12r


     ----------------------------------------------------------------------
                         Time and Date of Analysis
     ----------------------------------------------------------------------

               Date:  March 04, 2025     Time:  08:34:36



                *****     COMPUTATION RESULTS     *****


     094184.100 - Armory Street - Thrust Block Location 3



                *****     LOAD CASES RESULTS      *****


     LOAD CASE :     1
     CASE NAME : Service I
     LOAD TYPE : Dead, DL

       REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
       ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

            GROUP NO     P-FACTOR     Y-FACTOR

                1           1.0000       1.0000
                2           1.0000       1.0000
                3           1.0000       1.0000
                4           1.0000       1.0000
                5           1.0000       1.0000


     * TABLE L *   COMPUTATION ON PILE CAP


     * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *


           VERT. LOAD, LBS    HOR. LOAD Y, LBS   HOR. LOAD Z, LBS
             3.79120E+05        1.40370E+05           0.00000

          MOMENT X ,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
                 29197.2        8.72600E+05       -7.60032E+06


     * DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *


            VERTICAL ,IN      HORIZONTAL Y,IN     HORIZONTAL Z,IN
               0.0339119             0.66431       -3.49734E-04

          ANGLE ROT. X,RAD    ANGLE ROT. Y,RAD    ANGLE ROT. Z,RAD
             3.76872E-05        4.57949E-05       -1.93993E-04
```

NUMBER OF GLOBAL ITERATIONS = 4

LOAD CASE : 2
CASE NAME : Strength I (Max)
LOAD TYPE : Dead, DL

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	1.0000	1.0000
3	1.0000	1.0000
4	1.0000	1.0000
5	1.0000	1.0000

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD, LBS	HOR. LOAD Y, LBS	HOR. LOAD Z, LBS
4.91570E+05	1.87050E+05	0.00000

MOMENT X ,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
25754.4	3.29855E+06	-9.73476E+06

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0468282	1.08087	-1.32799E-04

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
1.45733E-05	1.93577E-04	-2.76661E-04

NUMBER OF GLOBAL ITERATIONS = 5

LOAD CASE : 3
CASE NAME : Strength I (Min)
LOAD TYPE : Dead, DL

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	1.0000	1.0000
3	1.0000	1.0000
4	1.0000	1.0000
5	1.0000	1.0000

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD, LBS	HOR. LOAD Y, LBS	HOR. LOAD Z, LBS
3.58940E+05	1.26320E+05	0.00000

MOMENT X ,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
24630.0	4.63722E+06	-6.36012E+06

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0325470	0.57088	-4.33999E-04

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
4.63016E-05	2.35127E-04	-1.44602E-04

NUMBER OF GLOBAL ITERATIONS = 4

LOAD CASE : 4
CASE NAME : Extreme I (50%+100%PAE)
LOAD TYPE : Dead, DL

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	1.0000	1.0000
3	1.0000	1.0000
4	1.0000	1.0000
5	1.0000	1.0000

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD, LBS	HOR. LOAD Y, LBS	HOR. LOAD Z, LBS
3.79120E+05	1.63240E+05	0.00000

MOMENT X ,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
65935.2	8.72600E+05	-6.23088E+06

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0343001	0.85081	-8.76464E-04

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
9.35409E-05	4.53256E-05	-1.27629E-04

NUMBER OF GLOBAL ITERATIONS = 5

LOAD CASE : 5
CASE NAME : Extreme I (1000%+50%PAE)
LOAD TYPE : Dead, DL

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	1.0000	1.0000
3	1.0000	1.0000
4	1.0000	1.0000
5	1.0000	1.0000

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD, LBS	HOR. LOAD Y, LBS	HOR. LOAD Z, LBS
3.79120E+05	1.84680E+05	0.00000

MOMENT X ,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
4.65355E+05	8.72600E+05	-4.96332E+06

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0347495	1.05131	-6.83325E-03

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
7.21514E-04	4.47251E-05	-6.56434E-05

NUMBER OF GLOBAL ITERATIONS = 5

Armory Street over CSX Mainline
Bridge No. S-24-016
Micropiles for Gravity Block Wall 4
Springfield, Massachusetts

Calculated by: RAC Date: 1/27/2025
Checked by: BTW Date: 2/27/2025

Purpose: Perform axial and lateral analyses for the proposed micropiles for the above-referenced project. See table and summary provided in Step 3 and 4 for results of the lateral and axial analyses, respectively. The Structural Engineer should evaluate the structural adequacy of the micropiles.

References:
1) FHWA-NHI-05-039 Micropile Manual, 2005.
2) MassDOT Bridge Design Manual, 2024.
3) Computer program GROUP, Version 2022, and associated user's manual, by Ensoft, Inc.
4) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
5) Loads provided by Tetra Tech via email on December 10, 2024.
6) Gravity Thrust Block diagrams with elevations provided by Tetra Tech on November 14, 2024.
7) Test borings observed by Nobis at the site in 2019 and 2022.
8) Email and phone communications with design team.

Given:
1) Thrust block loads, factored dead loads (concrete, soil, pipe), and water pressure loads calculated by Nobis based on Reference No. 5.
2) Pile cap geometry per discussions with Tetra Tech via phone on November 14, 2024.
3) A pinned head condition between micropiles and pile cap at the proposed gravity wall/thrust blocks.

Assumptions:
1) Compressive strength of grout (f'_c) is 5 ksi, and yield strength (F_y) of casing and rebar are 52 ksi and 60 ksi, respectively.
2) Micropiles will consist of casing with an outer diameter of 10.75-inch and 0.5-inch thick walls with a #8 sized center bar.
3) Structural engineer will verify the loads and the pile head condition used in analysis, and evaluate the structural resistance of the micropiles in accordance with AASHTO and the MassDOT Bridge Design Manual.
4) Subsurface information from Reference 7 is representative of subsurface conditions at the proposed gravity wall/thrust block.
5) A casing thickness loss of 1/16-inch in the top 3 feet due to corrosion and 50% loss below the top 3 feet of the pile are used. This assumes that no casing joints are located in the top 3 feet of the micropiles.

Solution:

Step 1: Soil Properties and Profile

Nobis used subsurface information from WB-4 of Reference No. 7 to develop soil parameters in the table below. The depth datum was taken at the bottom proposed pile cap (El. 145.04). Soil unit weight (γ_{moist}), angle of internal friction (ϕ), and cohesion were estimated based on field and laboratory testing and a study performed on Connecticut Valley Varved Clay entitled “Geology and Engineering Properties of Connecticut Valley Varved Clay” (DeGroot, D.J. and Lutenegger, A.J.). The groundwater table was taken at the fill/clay interface at the existing south abutment, or approximately El. 140.0. Soil modulus parameters (k) and strain factors for the varved silt/clay were determined using Tables 3.7 and 3.5 from Reference No. 3, respectively. Uniaxial Compressive Strength (U.C.S.) of rock was based on lab test data.

nobis

Armory Street over CSX Mainline
Bridge No. S-24-016
Micropiles for Gravity Block Wall 4
Springfield, Massachusetts

Calculated by: RAC Date: 1/27/2025
Checked by: BTW Date: 2/27/2025

Soil Layer	Elevation (ft)	Depth (ft)	γ_{moist} (pcf)	ϕ (^{o})	k (pci)	U.C.S. (psi)	Cohesion (psf)	Strain Fact. (dims)
Existing Fill	149 to 130.0	-4 to 15.0	115	33	25/20	-	-	-
Varved Silt and Clay	130.0 to 99.5	15.0 to 45.5	120	22	100	-	130	0.01
Silt	99.5 to 83.5	45.5 to 62.5	120	26	50	-	-	-
Glacial Till	83.5 to 78.5	62.5 to 67.5	135	37	125	-	-	-
W. Bedrock	78.5 to 78.0	67.5 to 68	135	37	125	-	-	-
Bedrock	<78.0	>68	164	-	-	7,500	-	-

1) Assumed 25 pci for fill above water table and 20 pci for fill below water table.

Step 2: Micropile and Pile Cap Properties

Micropile Cased (50%): micropile strength with 50% casing reduction due to threaded sections

Section Length:	69	ft*	Outer Diameter w/loss:	10.25 **in**
Outside Diameter:	10.75	in	Casing Thickness w/loss:	0.25 **in**
Casing Thickness:	0.5	in		
Percent of Casing loss to Thread:	50	%		
Yield Stress of Casing:	52	ksi		
Elastic modulus of Casing:	29000	ksi		
Center Bar:	# 8	bar	Area of Casing (A_{ct}):	**7.9 in^2**
Yield Stress of Center Bar:	60	ksi	Area of Bar (A_b):	**0.8 in^2**
Grout Compressive Strength:	5	ksi	Area of Grout (A_g):	**73.9 in^2**

*Section length includes the 1-foot of embedment into bedrock required by the MassDOT Bridge Manual.

Micropile Uncased: micropile strength with no casing (inside rock socket)

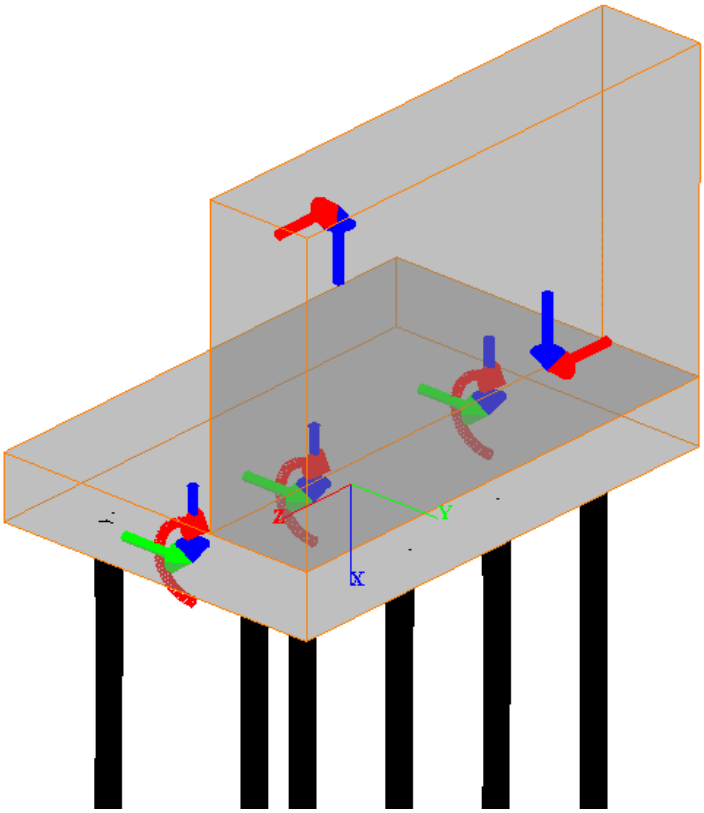
Section Length:	7	ft		
Outside Diameter (before corrosion):	9.75	in		
Center Bar:	# 8	bar		
Yield Stress of Center Bar:	60	ksi	Area of Bar (A_b):	**0.8 in^2**
Grout Compressive Strength:	5	ksi	Area of Grout (A_g):	**73.9 in^2**

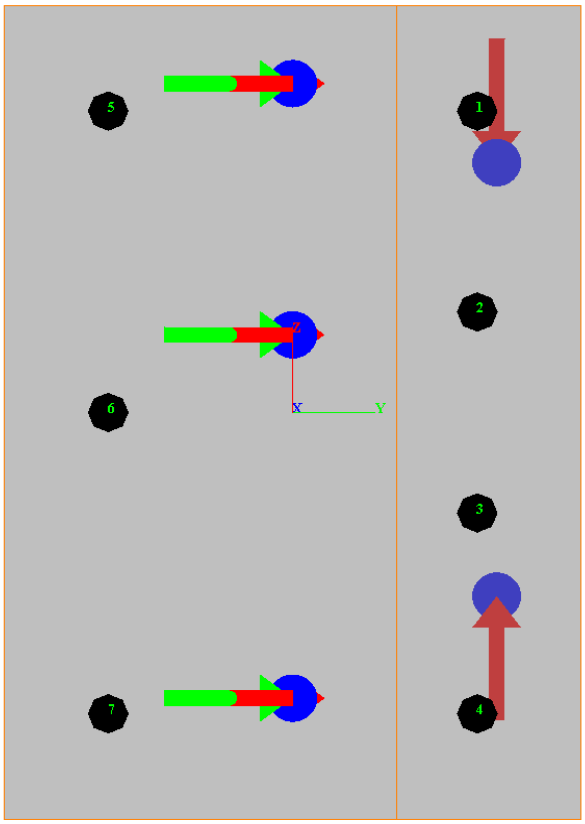
Armory Street over CSX Mainline
Bridge No. S-24-016
Micropiles for Gravity Block Wall 4
Springfield, Massachusetts

Calculated by: RAC Date: 1/27/2025
Checked by: BTW Date: 2/27/2025

Pile Cap: See graphic.

Cap Length in Z-axis (Transverse):	18.23 ft
Cap Width in Y-axis (Longitudinal):	12.5 ft
Cap Thickness in X-axis (Vertical):	2.5 ft
Center-to-center spacing in Y-axis :	8 ft
Center-to-center spacing in Z-axis :	4.5-6.75 ft





Armory Street over CSX Mainline
Bridge No. S-24-016
Micropiles for Gravity Block Wall 4
Springfield, Massachusetts

Calculated by: RAC Date: 1/27/2025
Checked by: BTW Date: 2/27/2025

Step 3: Lateral Analysis

The Computer Program GROUP version 2019 by Ensoft, Inc. was used for the lateral analyses. Pinned head conditions were assumed between the micropiles and proposed pile cap (gravity wall/thrust block location 4). Non-linear EI was assumed in all analyses. Structural engineer shall evaluate the structural adequacy of the micropiles.

Results of Micropile Lateral Analyses for Proposed Gravity Wall/Thrust Block Location 2 (per micropile)						
Proposed Structure	**Load Case**	**Max Shear (kip)**	**Max Lateral Deflection (in)**	**Max Moment Below 3 Feet (kip*ft)^2**	**Max Axial Load (kip)**	**Min Axial Load (kip)**
Gravity Thrust Block Location 1	Ser. I	21.0	0.49	36.8	75.0	35
	Str. I (Max)	28.0	0.74	54.6	100.0	40
	Str. I (Min)	18.9	0.43	32.8	80.0	25
	Ext I (50+100)	24.4	0.60	44.9	70.0	40
	Ext I (100+50)	27.6	0.71	52.7	65.0	45

1) Depth of fixity is approximately 17 feet below the bottom of pile cap, and taken at the 2nd point of zero deflection.
2) Maximum moment below the top 3 feet with loss of 50% casing due to threaded connections.

Step 4: Axial Analysis

Structural Resistance Factors			
Load Case	**Compression**	**Tension**	
Strength	**0.75**	**0.8**	Ref. No. 4 Tb. 10.5.5.2.5-2
Service	**1**	**1**	Ref. No. 4 Section 10.5.5.1
Extreme	**1**	**0.8**	Ref. No. 4 Section 10.5.5.3

Load Demand (from Group)		
Load Case	**Compression (kips)**	**Tension (kips)**
Strength	**100.0**	**0.0**
Service	**75.0**	**0.0**
Extreme	**70.0**	**0.0**

Geotechnical Resistance Factors			
Load Case	**Compression**	**Tension**	
Strength	**0.55**	**0.55**	Ref. No. 4 Tb. 10.5.5.2.5-1
Service	**1**	**1**	Ref. No. 4 Section 10.5.5.1
Extreme	**1**	**0.8**	Ref. No. 4 Section 10.5.5.3

Evaluate the structural resistance of the micropile for axial load only (negating lateral loads).

For micropile cased section (assuming 50% section):

Nominal axial compressive structural resistance (R_n): **648.7 kips** Ref. No. 4 Eq. 10.9.3.10.2a-2

Nominal axial tension structural resistance (R_n): **449.2 kips** Ref. No. 4 Eq. 10.9.3.10.3a-2

Armory Street over CSX Mainline
Bridge No. S-24-016
Micropiles for Gravity Block Wall 4
Springfield, Massachusetts

Calculated by: RAC Date: 1/27/2025
Checked by: BTW Date: 2/27/2025

For micropile uncased section:

Nominal axial compressive structural resistance (R_n):	**306.9 kips**	Ref. No. 4 Eq. 10.9.3.10.2b-2
Nominal axial tension structural resistance (R_n):	**47.1 kips**	Ref. No. 4 Eq. 10.9.3.10.3b-2

Evaluate the geotechnical resistance of the micropile for axial loads.

Grout-to-ground bond strength in Bedrock:	**11 ksf**	Ref. No. 4 Table C10.9.3.5.2-1
Minimum Rock Socket Length:	**7 feet**	assumption
Total Nominal grout-to-ground bond resistance:	**197 Kips**	Ref. No. 4 Eq. 10.9.3.5.2-1

Summary

Check to verify that a 7 foot rock socket is adequate based on the maximum factored axial load.

Geotechnical					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**108.1**	**100.0**	**108.1**	**0.0**	OK
Service	**196.5**	**75.0**	**196.5**	**0.0**	
Extreme	**196.5**	**70.0**	**157.2**	**0.0**	

Check to verify that the cased micropile is *adequate based on the maximum factored axial load (negating lateral loads).

Structural (cased): Check the structural resistance of the micropile					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**486.6**	**100.0**	**359.4**	**0.0**	OK
Service	**648.7**	**75.0**	**449.2**	**0.0**	
Extreme	**648.7**	**70.0**	**359.4**	**0.0**	

*Structural engineer shall evaluate the structural adequacy of the micropiles.

Armory Street over CSX Mainline
Bridge No. S-24-016
Micropiles for Gravity Block Wall 4
Springfield, Massachusetts

Calculated by: RAC Date: 1/27/2025
Checked by: BTW Date: 2/27/2025

Check to verify that the uncased micropile is *adequate based on the maximum factored axial load (negating lateral loads) and to verify that a plunge length is not needed.

Structural (uncased)					
Load Case	Compression (kips)		Tension (kips)		
	Factored Resistance	Max. Factored Axial Load	Factored Resistance	Max. Factored Axial Load	
Strength	**230.2**	**100.0**	**37.7**	**0.0**	OK
Service	**306.9**	**75.0**	**47.1**	**0.0**	
Extreme	**306.9**	**70.0**	**37.7**	**0.0**	

*Structural engineer shall evaluate the structural adequacy of the micropiles.

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 4 Start FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

CONSTANTS

Type of Wall: Wing / Retaining Wall
Type of Backwall: Independent
Type of Foundation: Pile Supported
Footing Constructed on Tremie? N
Type of Backfill: Granular soil backfill only
Type of Lateral Soil Pressure: Temporary Condition: Active Permanent Condition: At-Rest
Method for Calculating Active Earth Pressure: Rankine
Include Lateral Load on Backwall in Case IB? Y
Pile Information: Pile Type: Metal Shell 12" OD Testing: Gates Dynamic Formula
Include: Lateral load from EPS conc cap? N/A Pile Shading for Lateral Resistance? N
Pile Reaction for Top Fnd Reinf.? Y Earth Load for Bottom Fnd Reinf.? Y

Pile Properties:	Default		Overwrite		Final	
Nom. Pile Resistance:	250	K/Pile		K/Pile	250	K/Pile
Resistance Factor:	0.50				0.50	
Factored Pile Resist.:	125	K/Pile		K/Pile	125	K/Pile
Pile Width/Diameter:	12	in		in	12	in
Lateral Pile Resistance:			10	K/Pile	10	K/Pile

Soil Properties:	Default		Overwrite		Final	
Backfill weight, w:	0.120	Kcf	0.125	Kcf	0.125	Kcf
Angle (beta):	0	degrees		degrees	0	degrees
Angle (phi):	30	degrees	33	degrees	33	degrees
Angle (delta):	17	degrees		degrees	17	degrees
Angle (theta):					90	degrees
Active Coeff, K_a:	0.295		0.350		0.350	
At-Rest Coeff, K_o:	0.455		0.460		0.460	
Seismic Coeff, K_{AE}:			0.333			
Seismic Coeff, K_{h0}:			0.225			

Lightweight Fill Properties:	Default		Overwrite		Final	
Lightweight Concrete Weight, w:		Kcf	0.023	Kcf	0.023	Kcf
Lateral Lightweight Concrete Load:		Ksf	0.008	Ksf	0.008	Ksf
Seismic Lateral Lightweight Concrete Load:		Ksf	0.008	Ksf	0.008	Ksf

Structural Material Properties:	Default		Overwrite		Final	
Concrete Strength, f'c:	3	Ksi	4	Ksi	4	Ksi
Concrete Weight, w:	0.150	Kcf		Kcf	0.150	Kcf
	0.145	Kcf		Kcf	0.145	Kcf
Concrete Modulus of Elasticity, Ec:					3987	Ksi
Concrete Modulus of Rupture, fr:					0.48	Ksi
Max Aggregate Size	1.5	in		in	1.500	in
Rebar Strength, Fy:	60	Ksi		Ksi	60	Ksi
Rebar Modulus of Elasticity, Es:					29000	Ksi
Modular Ratio, n:					7	

Miscellaneous Properties: Unit Weight of Water: 0.0624 Kcf

Reinforcement Centerline:	Default		Overwrite		Final	
Wall Back Face:	3	in		in	3	in
Footing Top:	4	in		in	4	in
Footing Bottom:	9	in	14	in	14	in
Wall Increment:	0.50	Ft	1.00	Ft	1.00	Ft

Reinforcement Epoxy Coated? Footing: Y Wall: Y

JOB: Armory Street Bridge No S-24-026 SHEET NO.
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INPUT AND SUMMARY OF RESULTS

Superstructure Bearing Loads:		Vertical Loads: maximum	Vertical Loads: minimum	Horizontal Loads: maximum	Horizontal Loads: minimum	
Self-Weight (Temporary)	DC1:	0.00		0.00		K/Ft
Self-Weight (Permanent)	DC1:	0.00		0.00		K/Ft
Superimposed Dead Loads	DC2:	0.00		0.00		K/Ft
Wearing Surface / Utilities	DW:	0.00		0.00		K/Ft
Post-Tensioning, Creep, Shrinkage	PS+CR+SH:	0.00	0.00	0.00	0.00	K/Ft
Thermal Contraction	TU:	0.00		0.00		K/Ft
Thermal Expansion	TU:	0.00		0.00		K/Ft
Live Loads	LL:	0.00		0.00		K/Ft
Braking	BR:			0.00		K/Ft
Wind on Structure (Service I)	WS:	0.00		0.00		K/Ft
Wind on Structure (Strength III)	WS:	0.00		0.00		K/Ft
Wind on Structure (Strength V)	WS:	0.00		0.00		K/Ft
Wind on Live Load (Service I)	WL:	0.00		0.00		K/Ft
Wind on Live Load (Strength V)	WL:	0.00		0.00		K/Ft

Approach Equivalent Dead Loads:

Depth of equiv fill - temporary	HE =	0.000	Ft
Depth of equiv fill - permanent		1.848	Ft

Wind Load on Wall (wing/retaining walls):

Service I wind load:	0.000	Ksf
Strength III wind load:	0.000	Ksf
Strength V wind load:	0.000	Ksf

Backfill Dimensions:

Temp height of soil (from bott of ftg)	HT =		Ft
Height of EPS concrete cap	HC =	0.000	Ft
Height of lightweight fill		0.000	Ft
Add Height of lightweight fill (vert only)		0.000	Ft
Height of soil below lightweight fill		0.000	Ft
Soil depth at toe	HP =		Ft
Height of water table	HWT =	0.000	Ft

Abutment Stem Wall Dimensions:

Bearing distance	BD =	0.000	Ft
Bearing height	BH =	0.000	Ft
Height of backwall/upper wall	HB =	0.000	Ft
Height of upper wall above grade	HG =	0.000	Ft
Thickness of backwall/upper wall	TB =	0.000	Ft
Location of backwall/upper wall	DB =	0.000	Ft
Height of stem wall	HW =	10.800	Ft
Thickness of stem wall	TW =	4.500	Ft
Railing height on wingwall	HR =	0.000	Ft

Abutment Footing Dimensions:

Height of footing	HF =	2.500	Ft
Total length of footing	LF =	12.500	Ft
Length of footing at toe	L3 =	0.000	Ft
Pile location - First pile from heel:		2.250	Ft

Pile Spacing Dimensions:

Pile Row:	Toe	1	2	3	4	5	Heel
Piles Present in this Row?		Y	N	N	N	Y	
Pile Distance from Toe:		2.25				11.00	Ft
Longitudinal Pile Spacing:		5.250				10.500	Ft
Battered Piles in this Row?		N	N	N	N	N	
Pile Batter:							to 1
Percent of Piles Battered:							

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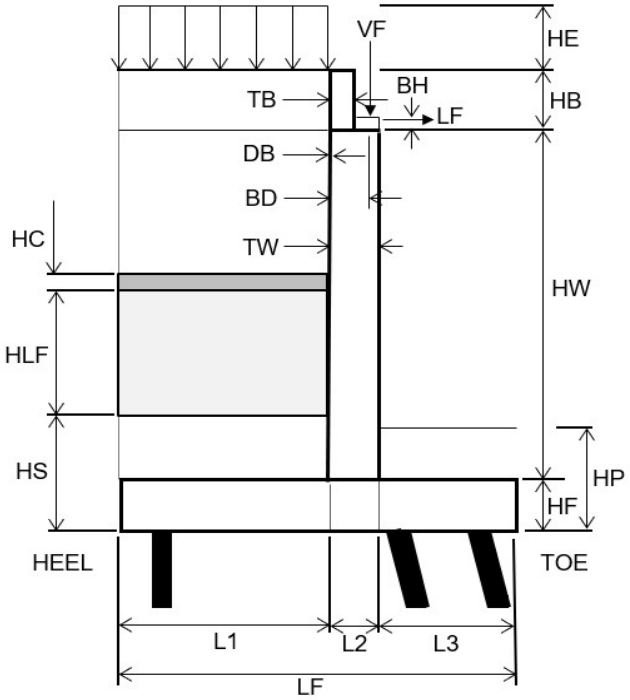
COMP. BY:	AJF	DATE:	12/10/2024	CHK. BY:		DATE:	

INPUT AND SUMMARY OF RESULTS - CONTINUED



L1= 8.000 L2= 4.500 L3= 0.000 Ft

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VERTICAL LOAD CALCULATIONS:

Load No.		Load Description	Unfactored Loads Width Ft	Height Ft	Unit Wt. Kcf	Maximum K/Ft	Minimum K/Ft	Centroid Y from Heel Ft	Moment Arm from CL Ftg Ft
1A	DC	Footing Heel Dead Load	8.00 x	2.50 x	0.150 =	3.00	3.00	4.000	-2.250
1A	DC	Footing Mid Dead Load	4.50 x	2.50 x	0.150 =	1.69	1.69	10.250	4.000
1A	DC	Footing Toe Dead Load	0.00 x	2.50 x	0.150 =	0.00	0.00	0.000	0.000
1B	DC	Stem Wall Dead Load	4.50 x	10.80 x	0.150 =	7.29	7.29	10.250	4.000
1C	DC	Backwall Dead Load	0.00 x	0.00 x	0.150 =	0.00	0.00	0.000	0.000
1C	DC	Backwall Dead Load (Case IB)	0.00 x	0.00 x	0.150 =	0.00	0.00	0.000	0.000
2A	EV	Soil Vertical Load Temp							
2A	EV	Soil Vertical Load 1	8.00 x	10.80 x	0.125 =	10.80	10.80	4.000	-2.250
2B	EV	Soil Vertical Load 2	8.00 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 2 (Case IB)	8.00 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 3	0.00 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 4	0.00 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Load (below lightwt fill)	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00	0.000	0.000
4A	DC1	Super Dead Load Permanent	0.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
4B	DC2	Superimposed Dead Load			=	0.00	0.00	0.000	0.000
4C	DW	Wearing Surface / Utilities			=	0.00	0.00	0.000	0.000
5	LS	Temp DL Surcharge	8.00 x	0.00 x	0.125 =	0.00	0.00	4.000	0.000
5	LS	Equiv DL Surcharge	8.00 x	1.85 x	0.125 =	1.85	1.85	4.000	-2.250
6	LL	Superstructure Live Load			=	0.00	0.00	0.000	0.000
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00	0.000	0.000
7B	TU	Thermal Contraction			=	0.00	0.00	0.000	0.000
7C	TU	Thermal Expansion			=	0.00	0.00	0.000	0.000
8A	EV	Lightweight Fill below Bearing	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
8B	EV	Lightweight Fill above Bearing	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
9A	EV	EPS Concrete Cap below Brg	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
9B	EV	EPS Concrete Cap above Brg	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Heel	8.00 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Mid	4.50 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Toe	0.00 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00	0.000	0.000
	WS	Wind on Structure (Str III)			=	0.00	0.00	0.000	0.000
	WS	Wind on Structure (Str V)			=	0.00	0.00	0.000	0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00	0.000	0.000
	WL	Wind on Live Load (Str V)			=	0.00	0.00	0.000	0.000

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COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

VERTICAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Extreme Event I Load Factors Max	Extreme Event I Load Factors Min
1A	DC	Footing Heel Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1A	DC	Footing Mid Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1A	DC	Footing Toe Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1B	DC	Stem Wall Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1C	DC	Backwall Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1C	DC	Backwall Dead Load (Case IB)	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
2A	EV	Soil Vertical Load Temp	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2A	EV	Soil Vertical Load 1	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 2	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 2 (Case IB)	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 3	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 4	1.00	1.00	1.35	0.00	1.35	0.00	1.00	1.00
2B	EV	Soil Load (below lightwt fill)	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface / Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5	LS	Temp DL Surcharge	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5	LS	Equiv DL Surcharge	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
6	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	1.00	1.00
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	0.50	0.50	0.50	0.50	1.00	1.00
8A	EV	Lightweight Fill below Bearing	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
8B	EV	Lightweight Fill above Bearing	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
9A	EV	EPS Concrete Cap below Brg	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
9B	EV	EPS Concrete Cap above Brg	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
10	WA	Buoyancy Heel	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	WA	Buoyancy Mid	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	WA	Buoyancy Toe	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----

JOB: Armory Street Bridge No S-24-026 SHEET NO.
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HORIZONTAL LOAD CALCULATIONS:

3	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Soil above bearing elevation
3	13.30 ft x 0.125 kcf x 0.460 =	0.765	Ksf	Soil below bearing elevation
3		0.000	Ksf	Soil under lightweight fill
5	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Temporary live load surcharge
5	1.85 ft x 0.125 kcf x 0.460 =	0.106	Ksf	Equivalent live load surcharge
8		0.000	Ksf	Lightweight Fill
9A	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap below Bearing
9B	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap above Bearing
9C	0.00 ft x 0.023 kcf x 0.350 =	0.000	Ksf	Lightweight Fill below Bearing Surcharge
9D	0.00 ft x 0.023 kcf x 0.350 =	0.000	Ksf	Lightweight Fill above Bearing Surcharge
9E	0.00 ft x 0.150 kcf x 0.350 =	0.000	Ksf	EPS Concrete Cap below Bearing Surcharge
9F	0.00 ft x 0.150 kcf x 0.350 =	0.000	Ksf	EPS Concrete Cap above Bearing Surcharge

Load No.		Load Description	Unfactored Loads Height Ft	Load Ksf		Maximum K/Ft	Minimum K/Ft		Moment Arm Ft
3	EH	Soil Lateral Load 1	13.30 x	0.765	/ 2 =	5.09	5.09		4.433
3A	EH	Soil Lateral Load 2	13.30 x	0.000	=	0.00	0.00		6.650
3A	EH	Soil Lateral Load 2 (Case IB)	13.30 x	0.000	=	0.00	0.00		6.650
3B	EH	Soil Lateral Load 3	0.00 x	0.000		0.00	0.00		13.300
3B	EH	Soil Lateral Load 3 (Case IB)	0.00 x	0.000	/ 2 =	0.00	0.00		13.300
3C	EH	Soil Lateral Load 4	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
3D	EH	Soil Lateral Load 5	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6 (Case IB)	0.00 x	0.000	=	0.00	0.00		0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00		13.300
4A	DC1	Super Dead Load Permanent			=	0.00	0.00		13.300
4B	DC2	Superimposed Dead Loads			=	0.00	0.00		13.300
4C	DW	Wearing Surface + Utilities			=	0.00	0.00		13.300
5A	LS	Temp DL Surcharge 1	13.30 x	0.000	=	0.00	0.00		6.650
5B	LS	Temp DL Surcharge 2	0.00 x	0.000	=	0.00	0.00		13.300
5B	LS	Temp DL Surcharge 2 (Case IB	0.00 x	0.000	=	0.00	0.00		13.300
5C	LS	Temp DL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
5A	LS	Equiv DL Surcharge 1	13.30 x	0.106	=	1.41	1.41		6.650
5B	LS	Equiv DL Surcharge 2	0.00 x	0.000	=	0.00	0.00		13.300
5C	LS	Equiv DL Surcharge 3	0.00 x	0.106	=	0.00	0.00		0.000
6A	LL	Superstructure Live Load			=	0.00	0.00		13.300
6B	BR	Braking (Contraction)			=	0.00	0.00		13.300
6C	BR	Braking (Expansion)			=	0.00	0.00		13.300
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00		13.300
7B	TU	Thermal Contraction			=	0.00	0.00		13.300
7C	TU	Thermal Expansion			=	0.00	0.00		13.300
8A	EH	Lightweight Fill below Bearing	0.00^2 x	0.000	/ 2 =	0.00	0.00		0.000
8B	EH	Lightweight Fill above Bearing	0.00 x	0.105	=	0.00	0.00		0.000
9A	EH	EPS Cap below Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9B	EH	EPS Cap above Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9C	EH	Lwt Fill below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9D	EH	Lwt Fill above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9E	EH	EPS Cap below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9F	EH	EPS Cap above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00		13.300
	WS	Wind on Structure (Str III)			=	0.00	0.00		13.300
	WS	Wind on Structure (Str V)			=	0.00	0.00		13.300
12B	WS	Wind on Stem Wall (Serv I)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str III)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str V)	0.00 x	0.000	=	0.00	0.00		0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00		13.300
	WL	Wind on Live Load (Str V)			=	0.00	0.00		13.300
13	EQ	Earthquake Load		0.23 x	24.63 =	5.54	5.54	-----	-----

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COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

HORIZONTAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Strength V Load Factors Max	Strength V Load Factors Min
3	EH	Soil Lateral Load 1	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3C	EH	Soil Lateral Load 4	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3D	EH	Soil Lateral Load 5	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Loads	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface + Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5A	LS	Temp DL Surcharge 1	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Temp DL Surcharge 2	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Temp DL Surcharge 2 (Case IB	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5C	LS	Temp DL Surcharge 3	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5A	LS	Equiv DL Surcharge 1	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Equiv DL Surcharge 2	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5C	LS	Equiv DL Surcharge 3	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
6A	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6B	BR	Braking (Contraction)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6C	BR	Braking (Expansion)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
8A	EH	Lightweight Fill below Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
8B	EH	Lightweight Fill above Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9A	EH	EPS Cap below Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9B	EH	EPS Cap above Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9C	EH	Lwt Fill below Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9D	EH	Lwt Fill above Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9E	EH	EPS Cap below Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9F	EH	EPS Cap above Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12B	WS	Wind on Stem Wall (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Stem Wall (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Stem Wall (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
13	EQ	Earthquake Load	-----	-----	-----	-----	-----	-----	1.00	1.00

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 4 Start FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

EARTHQUAKE HORIZONTAL LOAD CALCULATIONS:

3	0.00 ft x 0.125 kcf x 0.333 =	0.000	Ksf	Soil above bearing elevation
3	13.30 ft x 0.125 kcf x 0.460 =	0.554	Ksf	Soil below bearing elevation
3		0.000	Ksf	Soil under lightweight fill
5	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Temporary live load surcharge
5	1.85 ft x 0.125 kcf x 0.333 =	0.077	Ksf	Equivalent live load surcharge
8		0.000	Ksf	Lightweight Fill
9A	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap below Bearing
9B	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap above Bearing
9C	0.00 ft x 0.0077 ksf =	0.000	Ksf	Lightweight Fill below Bearing Surcharge
9D	0.00 ft x 0.0077 ksf =	0.000	Ksf	Lightweight Fill above Bearing Surcharge
9E	0.00 ft x 0.0077 ksf =	0.000	Ksf	EPS Concrete Cap below Bearing Surcharge
9F	0.00 ft x 0.0077 ksf =	0.000	Ksf	EPS Concrete Cap above Bearing Surcharge

Load No.		Load Description	Unfactored Loads Height Ft	Load Ksf		Maximum K/Ft	Minimum K/Ft		Moment Arm Ft
3	EH	Soil Lateral Load 1	13.30 x	0.765	/ 2 =	5.09	5.09		4.433
3A	EH	Soil Lateral Load 2	13.30 x	0.000	=	0.00	0.00		6.650
3A	EH	Soil Lateral Load 2 (Case IB)	13.30 x	0.000	=	0.00	0.00		6.650
3B	EH	Soil Lateral Load 3	0.00 x	0.000		0.00	0.00		13.300
3B	EH	Soil Lateral Load 3 (Case IB)	0.00 x	0.000	/ 2 =	0.00	0.00		13.300
3C	EH	Soil Lateral Load 4	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
3D	EH	Soil Lateral Load 5	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6 (Case IB)	0.00 x	0.000	=	0.00	0.00		0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00		13.300
4A	DC1	Super Dead Load Permanent			=	0.00	0.00		13.300
4B	DC2	Superimposed Dead Loads			=	0.00	0.00		13.300
4C	DW	Wearing Surface + Utilities			=	0.00	0.00		13.300
5A	LS	Temp DL Surcharge 1	13.30 x	0.000	=	0.00	0.00		6.650
5B	LS	Temp DL Surcharge 2	0.00 x	0.000	=	0.00	0.00		13.300
5B	LS	Temp DL Surcharge 2 (Case IB	0.00 x	0.000	=	0.00	0.00		13.300
5C	LS	Temp DL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
5A	LS	Equiv DL Surcharge 1	13.30 x	0.000	=	0.00	0.00		6.650
5B	LS	Equiv DL Surcharge 2	0.00 x	0.077	=	0.00	0.00		13.300
5C	LS	Equiv DL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
6A	LL	Superstructure Live Load			=	0.00	0.00		13.300
6B	BR	Braking (Contraction)			=	0.00	0.00		13.300
6C	BR	Braking (Expansion)			=	0.00	0.00		13.300
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00		13.300
7B	TU	Thermal Contraction			=	0.00	0.00		13.300
7C	TU	Thermal Expansion			=	0.00	0.00		13.300
8A	EH	Lightweight Fill below Bearing	0.00^2 x	0.0077	/ 2 =	0.00	0.00		0.000
8B	EH	Lightweight Fill above Bearing	0.00 x	0.100	=	0.00	0.00		0.000
9A	EH	EPS Cap below Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9B	EH	EPS Cap above Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9C	EH	Lwt Fill below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9D	EH	Lwt Fill above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9E	EH	EPS Cap below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9F	EH	EPS Cap above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00		13.300
	WS	Wind on Structure (Str III)			=	0.00	0.00		13.300
	WS	Wind on Structure (Str V)			=	0.00	0.00		13.300
12B	WS	Wind on Stem Wall (Serv I)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str III)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str V)	0.00 x	0.000	=	0.00	0.00		0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00		13.300
	WL	Wind on Live Load (Str V)			=	0.00	0.00		13.300
13	EQ	Earthquake Load		0.23 x	22.78 =	5.12	5.12	-----	-----

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 4 Start FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

HORIZONTAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Strength V Load Factors Max	Strength V Load Factors Min
3	EH	Soil Lateral Load 1	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3C	EH	Soil Lateral Load 4	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3D	EH	Soil Lateral Load 5	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Loads	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface + Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5A	LS	Temp DL Surcharge 1	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Temp DL Surcharge 2	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Temp DL Surcharge 2 (Case IB	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5C	LS	Temp DL Surcharge 3	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5A	LS	Equiv DL Surcharge 1	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Equiv DL Surcharge 2	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5C	LS	Equiv DL Surcharge 3	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
6A	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6B	BR	Braking (Contraction)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6C	BR	Braking (Expansion)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
8A	EH	Lightweight Fill below Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
8B	EH	Lightweight Fill above Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9A	EH	EPS Cap below Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9B	EH	EPS Cap above Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9C	EH	Lwt Fill below Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9D	EH	Lwt Fill above Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9E	EH	EPS Cap below Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9F	EH	EPS Cap above Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12B	WS	Wind on Stem Wall (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Stem Wall (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Stem Wall (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
13	EQ	Earthquake Load	-----	-----	-----	-----	-----	-----	1.00	1.00

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 4 Start FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

CASE II **Strength I** **Live Load on Approach** 3.5 feet wide

			SERVICE I		STRENGTH I MAX			STRENGTH I MIN		
Load No.		Load Description	Load	Moment	Factors	Load	Moment	Factors	Load	Moment
			K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft
VERTICAL LOADS:										
1A	DC	Footing Heel Dead Load	3.00	-6.75	1.25	3.75	-8.44	0.90	2.70	-6.08
1A	DC	Footing Mid Dead Load	1.69	6.75	1.25	2.11	8.44	0.90	1.52	6.08
1A	DC	Footing Toe Dead Load	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
1B	DC	Stem Wall Dead Load	7.29	29.16	1.25	9.11	36.45	0.90	6.56	26.24
1C	DC	Backwall Dead Load	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
2A	EV	Soil Vertical Load 1	10.80	-24.30	1.35	14.58	-32.81	1.00	10.80	-24.30
2B	EV	Soil Vertical Load 2	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 3	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 4	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2C	EV	Soil Load (below lightwt fill)	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4B	DC2	Superimposed Dead Load	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4C	DW	Wearing Surface / Utilities	0.00	0.00	1.50	0.00	0.00	0.65	0.00	0.00
5	LS	Equiv DL Surcharge	1.85	-4.16	1.25	2.31	-5.20	0.90	1.66	-3.74
8A	EV	Lightweight Fill below Bearing	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
8B	EV	Lightweight Fill above Bearing	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
9A	EV	EPS Concrete Cap below Brg	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9B	EV	EPS Concrete Cap above Brg	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Heel	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Mid	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Toe	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
Total Vertical:			86.21	24.63	0.70	111.51	31.86	-1.55	81.34	23.24	-1.80
HORIZONTAL LOADS:										
3	EH	Soil Lateral Load 1	5.09	22.55	1.35	6.87	30.44	0.90	4.58	20.29
3A	EH	Soil Lateral Load 2	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3B	EH	Soil Lateral Load 3	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3C	EH	Soil Lateral Load 4	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3D	EH	Soil Lateral Load 5	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3E	EH	Soil Lateral Load 6	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4B	DC2	Superimposed Dead Loads	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4C	DW	Wearing Surface + Utilities	0.00	0.00	1.50	0.00	0.00	0.65	0.00	0.00
5A	LS	Equiv DL Surcharge 1	1.41	9.40	1.25	1.77	11.75	0.90	1.27	8.46
5B	LS	Equiv DL Surcharge 2	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
5C	LS	Equiv DL Surcharge 3	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
8A	EH	Lightweight Fill below Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
8B	EH	Lightweight Fill above Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9A	EH	EPS Cap below Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9B	EH	EPS Cap above Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9C	EH	Lwt Fill below Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9D	EH	Lwt Fill above Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9C	EH	EPS Cap below Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9D	EH	EPS Cap above Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
Total Horizontal:			22.75	6.50	31.94	30.21	8.63	42.18	20.48	5.85	28.75
Moment Grand Total:					32.65			40.63			26.95
					114.28			142.21			94.33

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 4 Start FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

CASE II **Extreme I** **Live Load on Approach**

			SERVICE I		EXTREME I 50% Inertial + 100% PAE			EXTREME I 100% Inertial + 50% PAE		
Load No.		Load Description	Load	Moment	Factors	Load	Moment	Factors	Load	Moment
			K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft
VERTICAL LOADS:										
1A	DC	Footing Heel Dead Load	3.00	-6.75	1.00	3.00	-6.75	1.00	3.00	-6.75
	DC	Footing Mid Dead Load	1.69	6.75	1.00	1.69	6.75	1.00	1.69	6.75
	DC	Footing Toe Dead Load	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
1B	DC	Stem Wall Dead Load	7.29	29.16	1.00	7.29	29.16	1.00	7.29	29.16
	DC	Backwall Dead Load	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2A	EV	Soil Vertical Load 1	10.80	-24.30	1.00	10.80	-24.30	1.00	10.80	-24.30
	EV	Soil Vertical Load 2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	EV	Soil Vertical Load 4	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2C	EV	Soil Load (below lightwt fill)	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4B	DC2	Superimposed Dead Load	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4C	DW	Wearing Surface / Utilities	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5	LS	Equiv DL Surcharge	1.85	-4.16	1.00	1.85	-4.16	1.00	1.85	-4.16
8A	EV	Lightweight Fill below Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
8B	EV	Lightweight Fill above Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9A	EV	EPS Concrete Cap below Brg	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9B	EV	EPS Concrete Cap above Brg	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
10	WA	Buoyancy Heel	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	WA	Buoyancy Mid	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	WA	Buoyancy Toe	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
12A	WS	Wind on Structure (Serv I)	0.00	0.00						
	WS	Wind on Structure (Str V)								
Total Vertical:			24.63	0.70	86.21	24.63	0.70	86.21	24.63	0.70
HORIZONTAL LOADS:										
3	EH	Soil Lateral Load 1	5.09	22.55	1.00	5.09	22.55	1.00	4.26	18.89
3A	EH	Soil Lateral Load 2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3B	EH	Soil Lateral Load 3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3C	EH	Soil Lateral Load 4	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3D	EH	Soil Lateral Load 5	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3E	EH	Soil Lateral Load 6	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4B	DC2	Superimposed Dead Loads	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4C	DW	Wearing Surface + Utilities	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5A	LS	Equiv DL Surcharge 1	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5B	LS	Equiv DL Surcharge 2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5C	LS	Equiv DL Surcharge 3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
8A	EH	Lightweight Fill below Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
8B	EH	Lightweight Fill above Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9A	EH	EPS Cap below Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9B	EH	EPS Cap above Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9C	EH	Lwt Fill below Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9D	EH	Lwt Fill above Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9C	EH	EPS Cap below Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9D	EH	EPS Cap above Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
12A	WS	Wind on Structure (Serv I)	0.00	0.00						
	WS	Wind on Structure (Str V)								
12B	WS	Wind on Stem Wall (Serv I)	0.00	0.00						
	WS	Wind on Stem Wall (Str V)								
13	EQ	Earthquake Load	5.12	0.00	1.00	2.56	0.00	1.00	5.12	0.00
Total Horizontal:			10.21	22.55	26.78	7.65	22.55	32.87	9.39	18.89
Moment Grand Total:				23.25			23.25			19.59
							81.38			68.57

JOB:	Armory Street Bridge No S-24-026			SHEET NO.	
SUBJECT:	Gravity Wall 4 End			FILE NO.	
COMP. BY:	AJF	DATE: 12/10/2024	CHK. BY:	DATE:	

CONSTANTS

Type of Wall: Wing / Retaining Wall
Type of Backwall: Independent
Type of Foundation: Pile Supported
Footing Constructed on Tremie? N
Type of Backfill: Granular soil backfill only
Type of Lateral Soil Pressure: Temporary Condition: Active Permanent Condition: At-Rest
Method for Calculating Active Earth Pressure: Rankine
Include Lateral Load on Backwall in Case IB? Y
Pile Information: Pile Type: Metal Shell 12" OD Testing: Gates Dynamic Formula
Include: Lateral load from EPS conc cap? N/A Pile Shading for Lateral Resistance? N
Pile Reaction for Top Fnd Reinf.? Y Earth Load for Bottom Fnd Reinf.? Y

Pile Properties:	Default		Overwrite		Final	
Nom. Pile Resistance:	250	K/Pile		K/Pile	250	K/Pile
Resistance Factor:	0.50				0.50	
Factored Pile Resist.:	125	K/Pile		K/Pile	125	K/Pile
Pile Width/Diameter:	12	in		in	12	in
Lateral Pile Resistance:			10	K/Pile	10	K/Pile

Soil Properties:	Default		Overwrite		Final	
Backfill weight, w:	0.120	Kcf	0.125	Kcf	0.125	Kcf
Angle (beta):	0	degrees		degrees	0	degrees
Angle (phi):	30	degrees	33	degrees	33	degrees
Angle (delta):	17	degrees		degrees	17	degrees
Angle (theta):					90	degrees
Active Coeff, K_a:	0.295		0.350		0.350	
At-Rest Coeff, K_o:	0.455		0.460		0.460	
Seismic Coeff, K_{AE}:			0.333			
Seismic Coeff, K_{h0}:			0.225			

Lightweight Fill Properties:	Default		Overwrite		Final	
Lightweight Concrete Weight, w:		Kcf	0.023	Kcf	0.023	Kcf
Lateral Lightweight Concrete Load:		Ksf	0.008	Ksf	0.008	Ksf
Seismic Lateral Lightweight Concrete Load:		Ksf	0.008	Ksf	0.008	Ksf

Structural Material Properties:	Default		Overwrite		Final	
Concrete Strength, f'c:	3	Ksi	4	Ksi	4	Ksi
Concrete Weight, w:	0.150	Kcf		Kcf	0.150	Kcf
	0.145	Kcf		Kcf	0.145	Kcf
Concrete Modulus of Elasticity, Ec:					3987	Ksi
Concrete Modulus of Rupture, fr:					0.48	Ksi
Max Aggregate Size	1.5	in		in	1.500	in
Rebar Strength, Fy:	60	Ksi		Ksi	60	Ksi
Rebar Modulus of Elasticity, Es:					29000	Ksi
Modular Ratio, n:					7	

Miscellaneous Properties: Unit Weight of Water: 0.0624 Kcf

Reinforcement Centerline:	Default		Overwrite		Final	
Wall Back Face:	3	in		in	3	in
Footing Top:	4	in		in	4	in
Footing Bottom:	9	in	14	in	14	in
Wall Increment:	0.50	Ft	1.00	Ft	1.00	Ft

Reinforcement Epoxy Coated? Footing: Y Wall: Y

JOB: Armory Street Bridge No S-24-026 SHEET NO.
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INPUT AND SUMMARY OF RESULTS

Superstructure Bearing Loads:		Vertical Loads: maximum	Vertical Loads: minimum	Horizontal Loads: maximum	Horizontal Loads: minimum	
Self-Weight (Temporary)	DC1:	0.00		0.00		K/Ft
Self-Weight (Permanent)	DC1:	0.00		0.00		K/Ft
Superimposed Dead Loads	DC2:	0.00		0.00		K/Ft
Wearing Surface / Utilities	DW:	0.00		0.00		K/Ft
Post-Tensioning, Creep, Shrinkage	PS+CR+SH:	0.00	0.00	0.00	0.00	K/Ft
Thermal Contraction	TU:	0.00		0.00		K/Ft
Thermal Expansion	TU:	0.00		0.00		K/Ft
Live Loads	LL:	0.00		0.00		K/Ft
Braking	BR:			0.00		K/Ft
Wind on Structure (Service I)	WS:	0.00		0.00		K/Ft
Wind on Structure (Strength III)	WS:	0.00		0.00		K/Ft
Wind on Structure (Strength V)	WS:	0.00		0.00		K/Ft
Wind on Live Load (Service I)	WL:	0.00		0.00		K/Ft
Wind on Live Load (Strength V)	WL:	0.00		0.00		K/Ft

Approach Equivalent Dead Loads:

Depth of equiv fill - temporary	HE =	0.000	Ft
Depth of equiv fill - permanent		1.848	Ft

Wind Load on Wall (wing/retaining walls):

Service I wind load:	0.000	Ksf
Strength III wind load:	0.000	Ksf
Strength V wind load:	0.000	Ksf

Backfill Dimensions:

Temp height of soil (from bott of ftg)	HT =		Ft
Height of EPS concrete cap	HC =	0.000	Ft
Height of lightweight fill		0.000	Ft
Add Height of lightweight fill (vert only)		0.000	Ft
Height of soil below lightweight fill		0.000	Ft
Soil depth at toe	HP =		Ft
Height of water table	HWT =	0.000	Ft

Abutment Stem Wall Dimensions:

Bearing distance	BD =	0.000	Ft
Bearing height	BH =	0.000	Ft
Height of backwall/upper wall	HB =	9.300	Ft
Height of upper wall above grade	HG =	0.000	Ft
Thickness of backwall/upper wall	TB =	1.500	Ft
Location of backwall/upper wall	DB =	0.000	Ft
Height of stem wall	HW =	1.500	Ft
Thickness of stem wall	TW =	4.500	Ft
Railing height on wingwall	HR =	0.000	Ft

Abutment Footing Dimensions:

Height of footing	HF =	2.500	Ft
Total length of footing	LF =	12.500	Ft
Length of footing at toe	L3 =	0.000	Ft
Pile location - First pile from heel:		2.250	Ft

Pile Spacing Dimensions:

Pile Row:	Toe	1	2	3	4	5	Heel
Piles Present in this Row?		Y	N	N	N	Y	
Pile Distance from Toe:		2.25				11.00	Ft
Longitudinal Pile Spacing:		5.250				10.500	Ft
Battered Piles in this Row?		N	N	N	N	N	
Pile Batter:							to 1
Percent of Piles Battered:							

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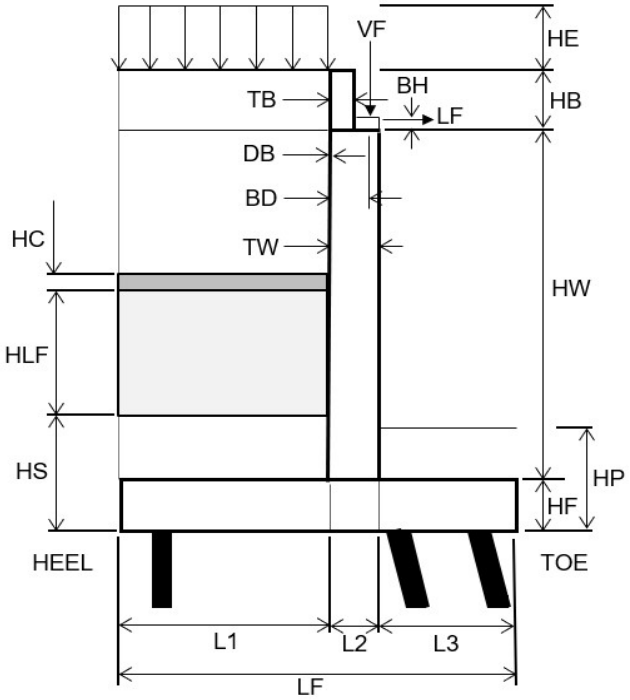
INPUT AND SUMMARY OF RESULTS - CONTINUED



L1= 8.000 L2= 4.500 L3= 0.000 Ft

JOB: Armory Street Bridge No S-24-026 SHEET NO.
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VERTICAL LOAD CALCULATIONS:

Load No.		Load Description	Unfactored Loads Width Ft	Height Ft	Unit Wt. Kcf	Maximum K/Ft	Minimum K/Ft	Centroid Y from Heel Ft	Moment Arm from CL Ftg Ft
1A	DC	Footing Heel Dead Load	8.00 x	2.50 x	0.150 =	3.00	3.00	4.000	-2.250
1A	DC	Footing Mid Dead Load	4.50 x	2.50 x	0.150 =	1.69	1.69	10.250	4.000
1A	DC	Footing Toe Dead Load	0.00 x	2.50 x	0.150 =	0.00	0.00	0.000	0.000
1B	DC	Stem Wall Dead Load	4.50 x	1.50 x	0.150 =	1.01	1.01	10.250	4.000
1C	DC	Backwall Dead Load	1.50 x	9.30 x	0.150 =	2.09	2.09	8.750	2.500
1C	DC	Backwall Dead Load (Case IB)	1.50 x	9.30 x	0.150 =	2.09	2.09	8.750	2.500
2A	EV	Soil Vertical Load Temp							
2A	EV	Soil Vertical Load 1	8.00 x	9.30 x	0.125 =	9.30	9.30	4.000	-2.250
2B	EV	Soil Vertical Load 2	8.00 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 2 (Case IB)	8.00 x	9.30 x	0.125 =	9.30	9.30	4.000	-2.250
2B	EV	Soil Vertical Load 3	0.00 x	9.30 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Vertical Load 4	0.00 x	0.00 x	0.125 =	0.00	0.00	0.000	0.000
2B	EV	Soil Load (below lightwt fill)	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00	0.000	0.000
4A	DC1	Super Dead Load Permanent	0.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
4B	DC2	Superimposed Dead Load			=	0.00	0.00	0.000	0.000
4C	DW	Wearing Surface / Utilities			=	0.00	0.00	0.000	0.000
5	LS	Temp DL Surcharge	8.00 x	0.00 x	0.125 =	0.00	0.00	4.000	0.000
5	LS	Equiv DL Surcharge	8.00 x	1.85 x	0.125 =	1.85	1.85	4.000	-2.250
6	LL	Superstructure Live Load			=	0.00	0.00	0.000	0.000
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00	0.000	0.000
7B	TU	Thermal Contraction			=	0.00	0.00	0.000	0.000
7C	TU	Thermal Expansion			=	0.00	0.00	0.000	0.000
8A	EV	Lightweight Fill below Bearing	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
8B	EV	Lightweight Fill above Bearing	8.00 x	9.30 x	0.000 =	0.00	0.00	0.000	0.000
9A	EV	EPS Concrete Cap below Brg	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
9B	EV	EPS Concrete Cap above Brg	8.00 x	0.00 x	0.000 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Heel	8.00 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Mid	4.50 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
10	WA	Buoyancy Toe	0.00 x	0.00 x	-0.062 =	0.00	0.00	0.000	0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00	0.000	0.000
	WS	Wind on Structure (Str III)			=	0.00	0.00	0.000	0.000
	WS	Wind on Structure (Str V)			=	0.00	0.00	0.000	0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00	0.000	0.000
	WL	Wind on Live Load (Str V)			=	0.00	0.00	0.000	0.000

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VERTICAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Extreme Event I Load Factors Max	Extreme Event I Load Factors Min
1A	DC	Footing Heel Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1A	DC	Footing Mid Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1A	DC	Footing Toe Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1B	DC	Stem Wall Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1C	DC	Backwall Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
1C	DC	Backwall Dead Load (Case IB)	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
2A	EV	Soil Vertical Load Temp	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2A	EV	Soil Vertical Load 1	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 2	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 2 (Case IB)	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 3	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
2B	EV	Soil Vertical Load 4	1.00	1.00	1.35	0.00	1.35	0.00	1.00	1.00
2B	EV	Soil Load (below lightwt fill)	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Load	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface / Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5	LS	Temp DL Surcharge	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5	LS	Equiv DL Surcharge	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
6	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	1.00	1.00
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	0.50	0.50	0.50	0.50	1.00	1.00
8A	EV	Lightweight Fill below Bearing	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
8B	EV	Lightweight Fill above Bearing	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
9A	EV	EPS Concrete Cap below Brg	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
9B	EV	EPS Concrete Cap above Brg	1.00	1.00	1.35	1.00	1.35	1.00	1.00	1.00
10	WA	Buoyancy Heel	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	WA	Buoyancy Mid	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	WA	Buoyancy Toe	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----

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HORIZONTAL LOAD CALCULATIONS:

3	9.30 ft x 0.125 kcf x 0.460 =	0.535	Ksf	Soil above bearing elevation
3	4.00 ft x 0.125 kcf x 0.460 =	0.230	Ksf	Soil below bearing elevation
3		0.000	Ksf	Soil under lightweight fill
5	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Temporary live load surcharge
5	1.85 ft x 0.125 kcf x 0.460 =	0.106	Ksf	Equivalent live load surcharge
8		0.000	Ksf	Lightweight Fill
9A	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap below Bearing
9B	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap above Bearing
9C	0.00 ft x 0.023 kcf x 0.350 =	0.000	Ksf	Lightweight Fill below Bearing Surcharge
9D	9.30 ft x 0.023 kcf x 0.350 =	0.075	Ksf	Lightweight Fill above Bearing Surcharge
9E	0.00 ft x 0.150 kcf x 0.350 =	0.000	Ksf	EPS Concrete Cap below Bearing Surcharge
9F	0.00 ft x 0.150 kcf x 0.350 =	0.000	Ksf	EPS Concrete Cap above Bearing Surcharge

Load No.		Load Description	Unfactored Loads Height Ft	Load Ksf		Maximum K/Ft	Minimum K/Ft		Moment Arm Ft
3	EH	Soil Lateral Load 1	4.00 x	0.230	/ 2 =	0.46	0.46		1.333
3A	EH	Soil Lateral Load 2	4.00 x	0.535	=	2.14	2.14		2.000
3A	EH	Soil Lateral Load 2 (Case IB)	4.00 x	0.535	=	2.14	2.14		2.000
3B	EH	Soil Lateral Load 3	9.30 x	0.535		4.97	4.97		7.100
3B	EH	Soil Lateral Load 3 (Case IB)	0.00 x	0.535	/ 2 =	0.00	0.00		13.300
3C	EH	Soil Lateral Load 4	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
3D	EH	Soil Lateral Load 5	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6 (Case IB)	0.00 x	0.000	=	0.00	0.00		0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00		4.000
4A	DC1	Super Dead Load Permanent			=	0.00	0.00		4.000
4B	DC2	Superimposed Dead Loads			=	0.00	0.00		4.000
4C	DW	Wearing Surface + Utilities			=	0.00	0.00		4.000
5A	LS	Temp DL Surcharge 1	4.00 x	0.000	=	0.00	0.00		2.000
5B	LS	Temp DL Surcharge 2	9.30 x	0.000	=	0.00	0.00		8.650
5B	LS	Temp DL Surcharge 2 (Case IB	9.30 x	0.000	=	0.00	0.00		8.650
5C	LS	Temp DL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
5A	LS	Equiv DL Surcharge 1	4.00 x	0.106	=	0.43	0.43		2.000
5B	LS	Equiv DL Surcharge 2	9.30 x	0.106	=	0.99	0.99		8.650
5C	LS	Equiv DL Surcharge 3	0.00 x	0.106	=	0.00	0.00		0.000
6A	LL	Superstructure Live Load			=	0.00	0.00		4.000
6B	BR	Braking (Contraction)			=	0.00	0.00		4.000
6C	BR	Braking (Expansion)			=	0.00	0.00		4.000
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00		4.000
7B	TU	Thermal Contraction			=	0.00	0.00		4.000
7C	TU	Thermal Expansion			=	0.00	0.00		4.000
8A	EH	Lightweight Fill below Bearing	9.30^2 x	0.000	/ 2 =	0.00	0.00		0.000
8B	EH	Lightweight Fill above Bearing	0.00 x	0.105	=	0.00	0.00		0.000
9A	EH	EPS Cap below Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9B	EH	EPS Cap above Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9C	EH	Lwt Fill below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9D	EH	Lwt Fill above Brg Surcharge	0.00 x	0.075	=	0.00	0.00		0.000
9E	EH	EPS Cap below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9F	EH	EPS Cap above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00		4.000
	WS	Wind on Structure (Str III)			=	0.00	0.00		4.000
	WS	Wind on Structure (Str V)			=	0.00	0.00		4.000
12B	WS	Wind on Stem Wall (Serv I)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str III)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str V)	0.00 x	0.000	=	0.00	0.00		0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00		4.000
	WL	Wind on Live Load (Str V)			=	0.00	0.00		4.000
13	EQ	Earthquake Load		0.23 x	30.33 =	6.82	6.82	-----	-----

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 4 End FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

HORIZONTAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Strength V Load Factors Max	Strength V Load Factors Min
3	EH	Soil Lateral Load 1	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3C	EH	Soil Lateral Load 4	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3D	EH	Soil Lateral Load 5	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Loads	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface + Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5A	LS	Temp DL Surcharge 1	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Temp DL Surcharge 2	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Temp DL Surcharge 2 (Case IB	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5C	LS	Temp DL Surcharge 3	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5A	LS	Equiv DL Surcharge 1	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Equiv DL Surcharge 2	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5C	LS	Equiv DL Surcharge 3	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
6A	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6B	BR	Braking (Contraction)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6C	BR	Braking (Expansion)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
8A	EH	Lightweight Fill below Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
8B	EH	Lightweight Fill above Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9A	EH	EPS Cap below Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9B	EH	EPS Cap above Bearing	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9C	EH	Lwt Fill below Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9D	EH	Lwt Fill above Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9E	EH	EPS Cap below Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
9F	EH	EPS Cap above Brg Surcharge	1.00	1.00	1.50	0.90	1.35	0.90	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12B	WS	Wind on Stem Wall (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Stem Wall (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Stem Wall (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
13	EQ	Earthquake Load	-----	-----	-----	-----	-----	-----	1.00	1.00

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 4 End FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

EARTHQUAKE HORIZONTAL LOAD CALCULATIONS:

3	9.30 ft x 0.125 kcf x 0.333 =	0.387	Ksf	Soil above bearing elevation
3	4.00 ft x 0.125 kcf x 0.460 =	0.167	Ksf	Soil below bearing elevation
3		0.000	Ksf	Soil under lightweight fill
5	0.00 ft x 0.125 kcf x 0.460 =	0.000	Ksf	Temporary live load surcharge
5	1.85 ft x 0.125 kcf x 0.333 =	0.077	Ksf	Equivalent live load surcharge
8		0.000	Ksf	Lightweight Fill
9A	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap below Bearing
9B	0.00 ft x 0.150 kcf =	0.000	Ksf	EPS Concrete Cap above Bearing
9C	0.00 ft x 0.0077 ksf =	0.000	Ksf	Lightweight Fill below Bearing Surcharge
9D	9.30 ft x 0.0077 ksf =	0.075	Ksf	Lightweight Fill above Bearing Surcharge
9E	0.00 ft x 0.0077 ksf =	0.000	Ksf	EPS Concrete Cap below Bearing Surcharge
9F	0.00 ft x 0.0077 ksf =	0.000	Ksf	EPS Concrete Cap above Bearing Surcharge

Load No.		Load Description	Unfactored Loads Height Ft	Load Ksf		Maximum K/Ft	Minimum K/Ft		Moment Arm Ft
3	EH	Soil Lateral Load 1	4.00 x	0.230	/ 2 =	0.46	0.46		1.333
3A	EH	Soil Lateral Load 2	4.00 x	0.535	=	2.14	2.14		2.000
3A	EH	Soil Lateral Load 2 (Case IB)	4.00 x	0.535	=	2.14	2.14		2.000
3B	EH	Soil Lateral Load 3	9.30 x	0.535		4.97	4.97		7.100
3B	EH	Soil Lateral Load 3 (Case IB)	0.00 x	0.535	/ 2 =	0.00	0.00		13.300
3C	EH	Soil Lateral Load 4	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
3D	EH	Soil Lateral Load 5	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6	0.00 x	0.000	=	0.00	0.00		0.000
3E	EH	Soil Lateral Load 6 (Case IB)	0.00 x	0.000	=	0.00	0.00		0.000
4A	DC1	Super Dead Load Temporary			=	0.00	0.00		4.000
4A	DC1	Super Dead Load Permanent			=	0.00	0.00		4.000
4B	DC2	Superimposed Dead Loads			=	0.00	0.00		4.000
4C	DW	Wearing Surface + Utilities			=	0.00	0.00		4.000
5A	LS	Temp DL Surcharge 1	4.00 x	0.000	=	0.00	0.00		2.000
5B	LS	Temp DL Surcharge 2	9.30 x	0.000	=	0.00	0.00		8.650
5B	LS	Temp DL Surcharge 2 (Case IB	9.30 x	0.000	=	0.00	0.00		8.650
5C	LS	Temp DL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
5A	LS	Equiv DL Surcharge 1	4.00 x	0.000	=	0.00	0.00		2.000
5B	LS	Equiv DL Surcharge 2	9.30 x	0.077	=	0.72	0.72		8.650
5C	LS	Equiv DL Surcharge 3	0.00 x	0.000	=	0.00	0.00		0.000
6A	LL	Superstructure Live Load			=	0.00	0.00		4.000
6B	BR	Braking (Contraction)			=	0.00	0.00		4.000
6C	BR	Braking (Expansion)			=	0.00	0.00		4.000
7A	PS	Post-tension + Creep + Shrink			=	0.00	0.00		4.000
7B	TU	Thermal Contraction			=	0.00	0.00		4.000
7C	TU	Thermal Expansion			=	0.00	0.00		4.000
8A	EH	Lightweight Fill below Bearing	9.30^2 x	0.0077	/ 2 =	0.00	0.00		0.000
8B	EH	Lightweight Fill above Bearing	0.00 x	0.100	=	0.00	0.00		0.000
9A	EH	EPS Cap below Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9B	EH	EPS Cap above Bearing	0.00 x	0.000	/ 2 =	0.00	0.00		0.000
9C	EH	Lwt Fill below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9D	EH	Lwt Fill above Brg Surcharge	0.00 x	0.075	=	0.00	0.00		0.000
9E	EH	EPS Cap below Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
9F	EH	EPS Cap above Brg Surcharge	0.00 x	0.000	=	0.00	0.00		0.000
12A	WS	Wind on Structure (Serv I)			=	0.00	0.00		4.000
	WS	Wind on Structure (Str III)			=	0.00	0.00		4.000
	WS	Wind on Structure (Str V)			=	0.00	0.00		4.000
12B	WS	Wind on Stem Wall (Serv I)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str III)	0.00 x	0.000	=	0.00	0.00		0.000
	WS	Wind on Stem Wall (Str V)	0.00 x	0.000	=	0.00	0.00		0.000
12C	WL	Wind on Live Load (Serv I)			=	0.00	0.00		4.000
	WL	Wind on Live Load (Str V)			=	0.00	0.00		4.000
13	EQ	Earthquake Load		0.23 x	19.19 =	4.32	4.32	-----	-----

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 4 End FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

HORIZONTAL LOAD CALCULATIONS - CONTINUED:

Load No.		Load Description	Service I Load Factors Max	Service I Load Factors Min	Strength I Load Factors Max	Strength I Load Factors Min	Strength III Load Factors Max	Strength III Load Factors Min	Strength V Load Factors Max	Strength V Load Factors Min
3	EH	Soil Lateral Load 1	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3A	EH	Soil Lateral Load 2 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3B	EH	Soil Lateral Load 3 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3C	EH	Soil Lateral Load 4	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3D	EH	Soil Lateral Load 5	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
3E	EH	Soil Lateral Load 6 (Case IB)	1.00	1.00	1.35	0.90	1.35	0.90	1.00	1.00
4A	DC1	Super Dead Load Temporary	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4A	DC1	Super Dead Load Permanent	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4B	DC2	Superimposed Dead Loads	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
4C	DW	Wearing Surface + Utilities	1.00	1.00	1.50	0.65	1.50	0.65	1.00	1.00
5A	LS	Temp DL Surcharge 1	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Temp DL Surcharge 2	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Temp DL Surcharge 2 (Case IB	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5C	LS	Temp DL Surcharge 3	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5A	LS	Equiv DL Surcharge 1	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5B	LS	Equiv DL Surcharge 2	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
5C	LS	Equiv DL Surcharge 3	1.00	1.00	1.25	0.90	1.25	0.90	1.00	1.00
6A	LL	Superstructure Live Load	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6B	BR	Braking (Contraction)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
6C	BR	Braking (Expansion)	1.00	1.00	1.75	1.75	-----	-----	0.50	0.50
7A	PS	Post-tension + Creep + Shrink	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7B	TU	Thermal Contraction	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
7C	TU	Thermal Expansion	1.00	1.00	1.20	0.50	1.20	0.50	1.00	1.00
8A	EH	Lightweight Fill below Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
8B	EH	Lightweight Fill above Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9A	EH	EPS Cap below Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9B	EH	EPS Cap above Bearing	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9C	EH	Lwt Fill below Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9D	EH	Lwt Fill above Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9E	EH	EPS Cap below Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
9F	EH	EPS Cap above Brg Surcharge	1.00	1.00	1.50	0.90	1.50	0.90	1.00	1.00
12A	WS	Wind on Structure (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Structure (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Structure (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12B	WS	Wind on Stem Wall (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WS	Wind on Stem Wall (Str III)	-----	-----	-----	-----	1.00	1.00	-----	-----
	WS	Wind on Stem Wall (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
12C	WL	Wind on Live Load (Serv I)	1.00	1.00	-----	-----	-----	-----	-----	-----
	WL	Wind on Live Load (Str V)	-----	-----	-----	-----	-----	-----	-----	-----
13	EQ	Earthquake Load	-----	-----	-----	-----	-----	-----	1.00	1.00

JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 4 End FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

CASE II **Strength I** **Live Load on Approach** 5.43 feet wide 9.30 feet wide

			SERVICE I		STRENGTH I MAX			STRENGTH I MIN		
Load No.		Load Description	Load	Moment	Factors	Load	Moment	Factors	Load	Moment
			K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft		K/Ft	K-Ft/Ft
VERTICAL LOADS:										
1A	DC	Footing Heel Dead Load	3.00	-6.75	1.25	3.75	-8.44	0.90	2.70	-6.08
1A	DC	Footing Mid Dead Load	1.69	6.75	1.25	2.11	8.44	0.90	1.52	6.08
1A	DC	Footing Toe Dead Load	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
1B	DC	Stem Wall Dead Load	1.01	4.05	1.25	1.27	5.06	0.90	0.91	3.65
1C	DC	Backwall Dead Load	2.09	5.23	1.25	2.62	6.54	0.90	1.88	4.71
2A	EV	Soil Vertical Load 1	9.30	-20.93	1.35	12.56	-28.25	1.00	9.30	-20.93
2B	EV	Soil Vertical Load 2	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 3	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 4	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
2C	EV	Soil Load (below lightwt fill)	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4B	DC2	Superimposed Dead Load	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4C	DW	Wearing Surface / Utilities	0.00	0.00	1.50	0.00	0.00	0.65	0.00	0.00
5	LS	Equiv DL Surcharge	1.85	-4.16	1.25	2.31	-5.20	0.90	1.66	-3.74
8A	EV	Lightweight Fill below Bearing	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
8B	EV	Lightweight Fill above Bearing	0.00	0.00	1.35	0.00	0.00	1.00	0.00	0.00
9A	EV	EPS Concrete Cap below Brg	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9B	EV	EPS Concrete Cap above Brg	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Heel	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Mid	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
10	WA	Buoyancy Toe	0.00	0.00	1.00	0.00	0.00	0.90	0.00	0.00
(18.94+24.63)/2=21.79=> 202.6						(17.98+23.24)/2=20.61=> 191.67				
Total Vertical:			102.85	18.94 -15.80		133.63	24.61 -21.84		97.63	17.98 -16.31
					(24.61+31.86)/2=28.24=> 262.59					
HORIZONTAL LOADS:										
3	EH	Soil Lateral Load 1	0.46	0.61	1.35	0.62	0.83	0.90	0.41	0.55
3A	EH	Soil Lateral Load 2	2.14	4.28	1.35	2.89	5.78	0.90	1.93	3.85
3B	EH	Soil Lateral Load 3	4.97	35.31	1.35	6.71	47.67	0.90	4.48	31.78
3C	EH	Soil Lateral Load 4	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3D	EH	Soil Lateral Load 5	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
3E	EH	Soil Lateral Load 6	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4B	DC2	Superimposed Dead Loads	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
4C	DW	Wearing Surface + Utilities	0.00	0.00	1.50	0.00	0.00	0.65	0.00	0.00
5A	LS	Equiv DL Surcharge 1	0.43	0.85	1.25	0.53	1.06	0.90	0.38	0.77
5B	LS	Equiv DL Surcharge 2	0.99	8.55	1.25	1.24	10.69	0.90	0.89	7.69
5C	LS	Equiv DL Surcharge 3	0.00	0.00	1.25	0.00	0.00	0.90	0.00	0.00
8A	EH	Lightweight Fill below Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
8B	EH	Lightweight Fill above Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9A	EH	EPS Cap below Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9B	EH	EPS Cap above Bearing	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9C	EH	Lwt Fill below Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9D	EH	Lwt Fill above Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9C	EH	EPS Cap below Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
9D	EH	EPS Cap above Brg Surcharge	0.00	0.00	1.35	0.00	0.00	0.90	0.00	0.00
(8.99+6.5)/2=7.75=> 72.03					(11.99+8.63)/2=10.31=> 95.88			(8.09+5.85)/2=6.97=> 64.82		
Total Horizontal:			48.82	8.99 49.60		65.11	11.99 66.02		43.93	8.09 44.64
Moment Grand Total:				33.80			44.17			28.33
(33.8+32.65)/2=33.22=> 308.99				183.54			239.85			153.83
					(44.17+40.63)/2=42.4=> 394.32			(28.33+26.95)/2=27.64=> 257.05		

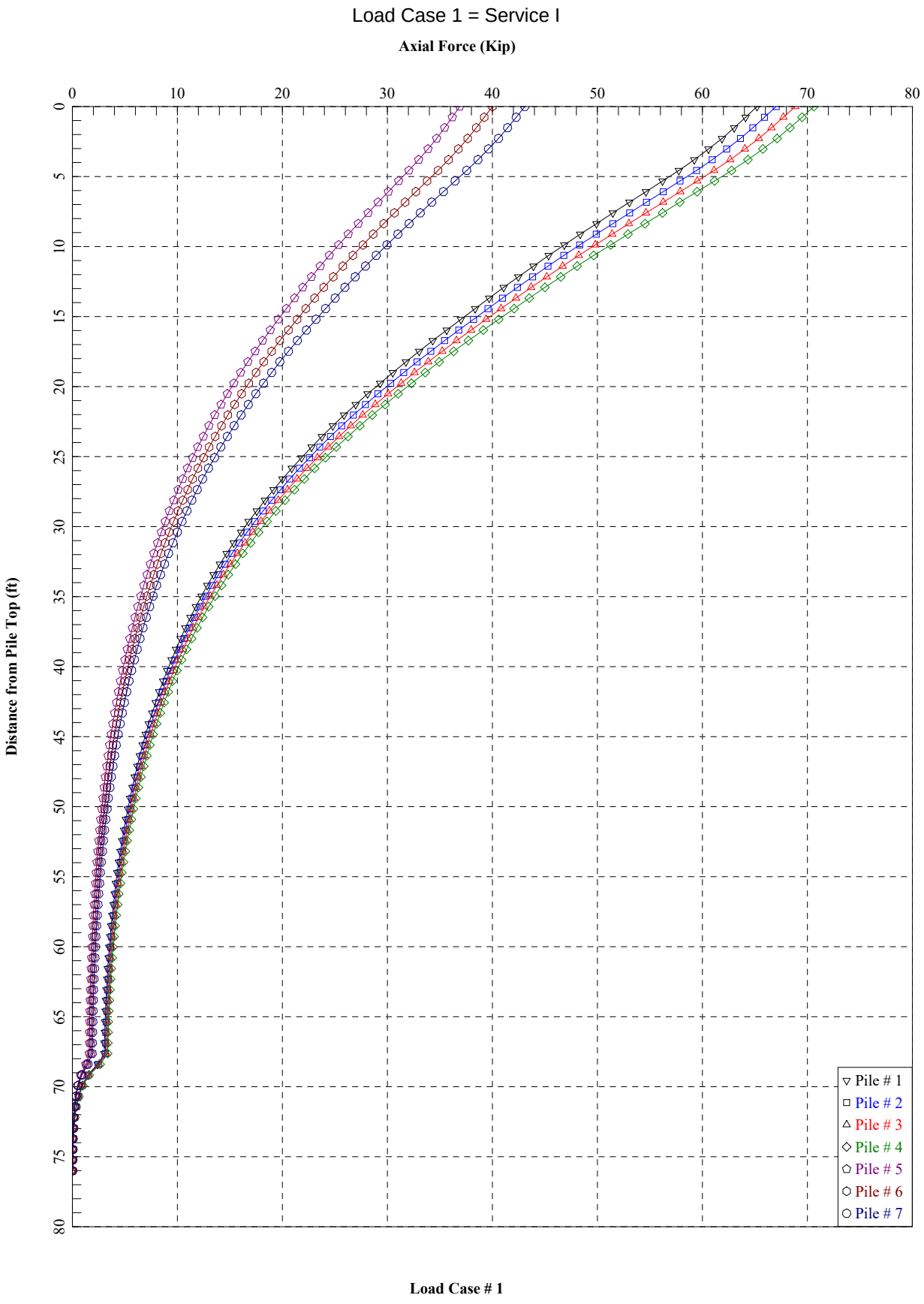
JOB: Armory Street Bridge No S-24-026 SHEET NO.
SUBJECT: Gravity Wall 4 End FILE NO.
COMP. BY: AJF DATE: 12/10/2024 CHK. BY: DATE:

CASE II Extreme I Live Load on Approach

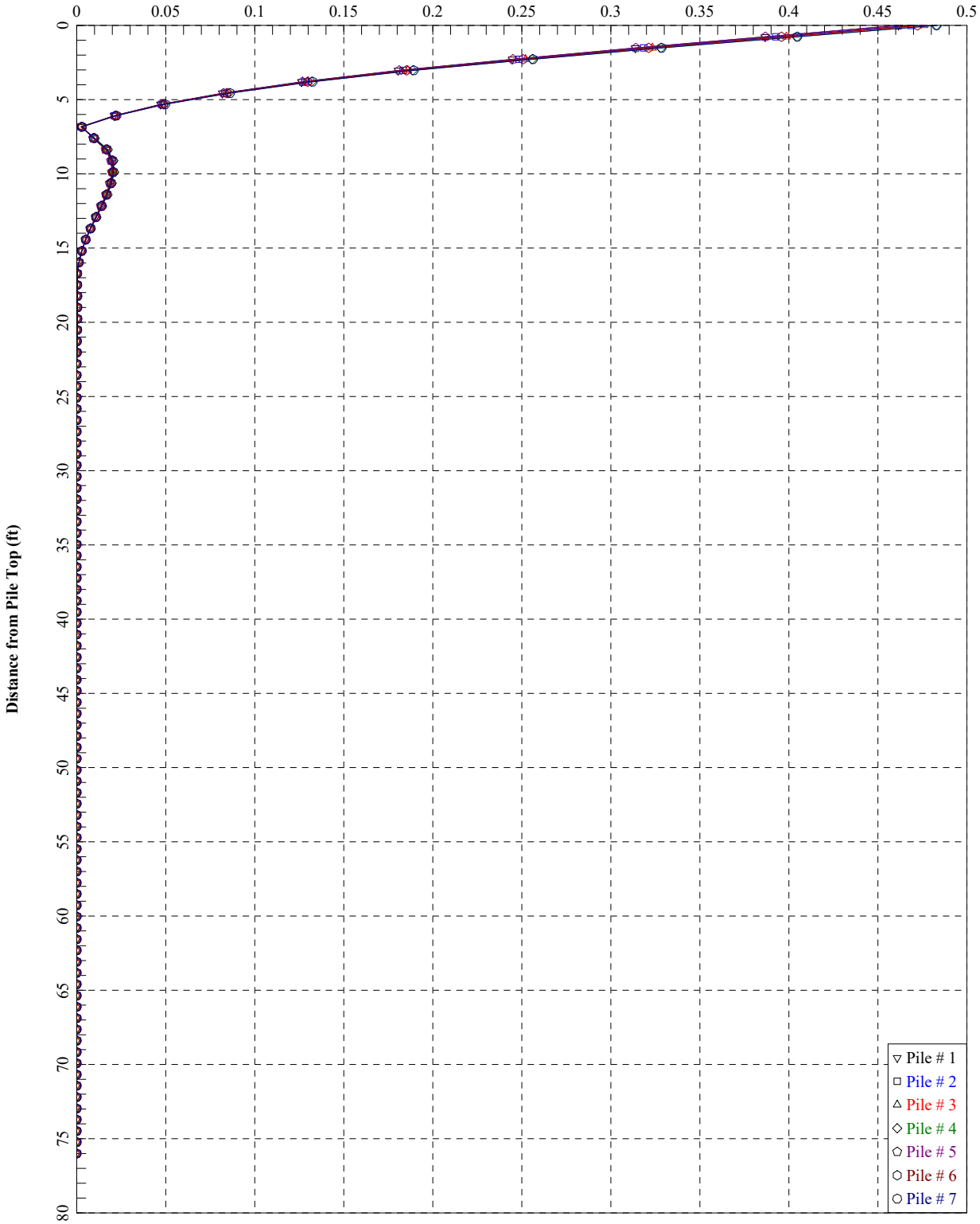
Load No.		Load Description	SERVICE I Load K/Ft	SERVICE I Moment K-Ft/Ft	EXTREME I 50% Inertial + 100% PAE Factors	EXTREME I 50% Inertial + 100% PAE Load K/Ft	EXTREME I 50% Inertial + 100% PAE Moment K-Ft/Ft	EXTREME I 100% Inertial + 50% PAE Factors	EXTREME I 100% Inertial + 50% PAE Load K/Ft	EXTREME I 100% Inertial + 50% PAE Moment K-Ft/Ft
VERTICAL LOADS:										
1A	DC	Footing Heel Dead Load	3.00	-6.75	1.00	3.00	-6.75	1.00	3.00	-6.75
	DC	Footing Mid Dead Load	1.69	6.75	1.00	1.69	6.75	1.00	1.69	6.75
	DC	Footing Toe Dead Load	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
1B	DC	Stem Wall Dead Load	1.01	4.05	1.00	1.01	4.05	1.00	1.01	4.05
	DC	Backwall Dead Load	2.09	5.23	1.00	2.09	5.23	1.00	2.09	5.23
2A	EV	Soil Vertical Load 1	9.30	-20.93	1.00	9.30	-20.93	1.00	9.30	-20.93
	EV	Soil Vertical Load 2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2B	EV	Soil Vertical Load 3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	EV	Soil Vertical Load 4	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2C	EV	Soil Load (below lightwt fill)	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4B	DC2	Superimposed Dead Load	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4C	DW	Wearing Surface / Utilities	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5	LS	Equiv DL Surcharge	1.85	-4.16	1.00	1.85	-4.16	1.00	1.85	-4.16
8A	EV	Lightweight Fill below Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
8B	EV	Lightweight Fill above Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9A	EV	EPS Concrete Cap below Brg	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9B	EV	EPS Concrete Cap above Brg	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
10	WA	Buoyancy Heel	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	WA	Buoyancy Mid	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
	WA	Buoyancy Toe	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
12A	WS	Wind on Structure (Serv I)	0.00	0.00						
	WS	Wind on Structure (Str V)								
		(18.94+24.63)/2=21.79=> 202.6						(18.94+24.63)/2=21.79=> 202.6		
Total Vertical:			18.94	-15.80	102.85	18.94	-15.80	102.85	18.94	-15.80
HORIZONTAL LOADS:										
3	EH	Soil Lateral Load 1	0.46	0.61	1.00	0.46	0.61	1.00	0.39	0.51
3A	EH	Soil Lateral Load 2	2.14	4.28	1.00	2.14	4.28	1.00	1.79	3.58
3B	EH	Soil Lateral Load 3	4.97	35.31	1.00	4.97	35.31	1.00	4.17	29.58
3C	EH	Soil Lateral Load 4	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3D	EH	Soil Lateral Load 5	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
3E	EH	Soil Lateral Load 6	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4A	DC1	Super Dead Load Permanent	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4B	DC2	Superimposed Dead Loads	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
4C	DW	Wearing Surface + Utilities	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5A	LS	Equiv DL Surcharge 1	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
5B	LS	Equiv DL Surcharge 2	0.72	6.19	1.00	0.72	6.19	1.00	0.60	5.18
5C	LS	Equiv DL Surcharge 3	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
8A	EH	Lightweight Fill below Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
8B	EH	Lightweight Fill above Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9A	EH	EPS Cap below Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9B	EH	EPS Cap above Bearing	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9C	EH	Lwt Fill below Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9D	EH	Lwt Fill above Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9C	EH	EPS Cap below Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
9D	EH	EPS Cap above Brg Surcharge	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
12A	WS	Wind on Structure (Serv I)	0.00	0.00						
	WS	Wind on Structure (Str V)								
12B	WS	Wind on Stem Wall (Serv I)	0.00	0.00						
	WS	Wind on Stem Wall (Str V)								
13	EQ	Earthquake Load	4.32	0.00	1.00	2.16	0.00	1.00	4.32	0.00
		(10.45+7.65)/2=9.05=> 84.17						(11.26+9.39)/2=10.33=> 96.02		
Total Horizontal:			12.60	46.39	56.75	10.45	46.39	61.14	11.26	38.87
Moment Grand Total:				30.59			30.59			23.06

(30.59+23.25)/2=26.92=> 250.36 166.10 125.22

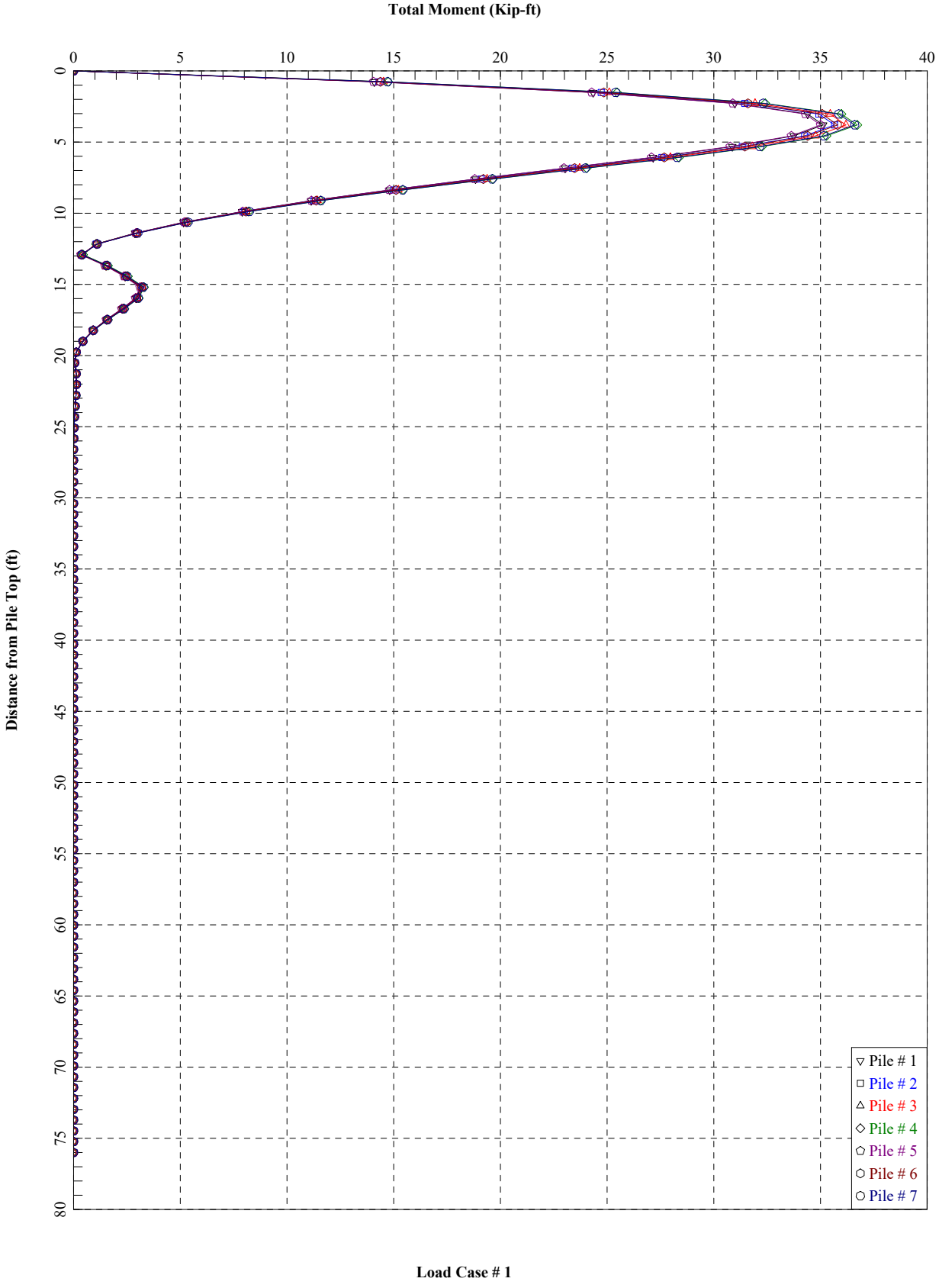
(23.06+19.59)/2=21.33=> 198.32


Load Case 1 = Service I
Axial Force (Kip)
0
10
20
30
40
50
60
70
80
Distance from Pile Top (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Pile # 1
Pile # 2
Pile # 3
Pile # 4
Pile # 5
Pile # 6
Pile # 7
Load Case # 1

Load Case 1 = Service I

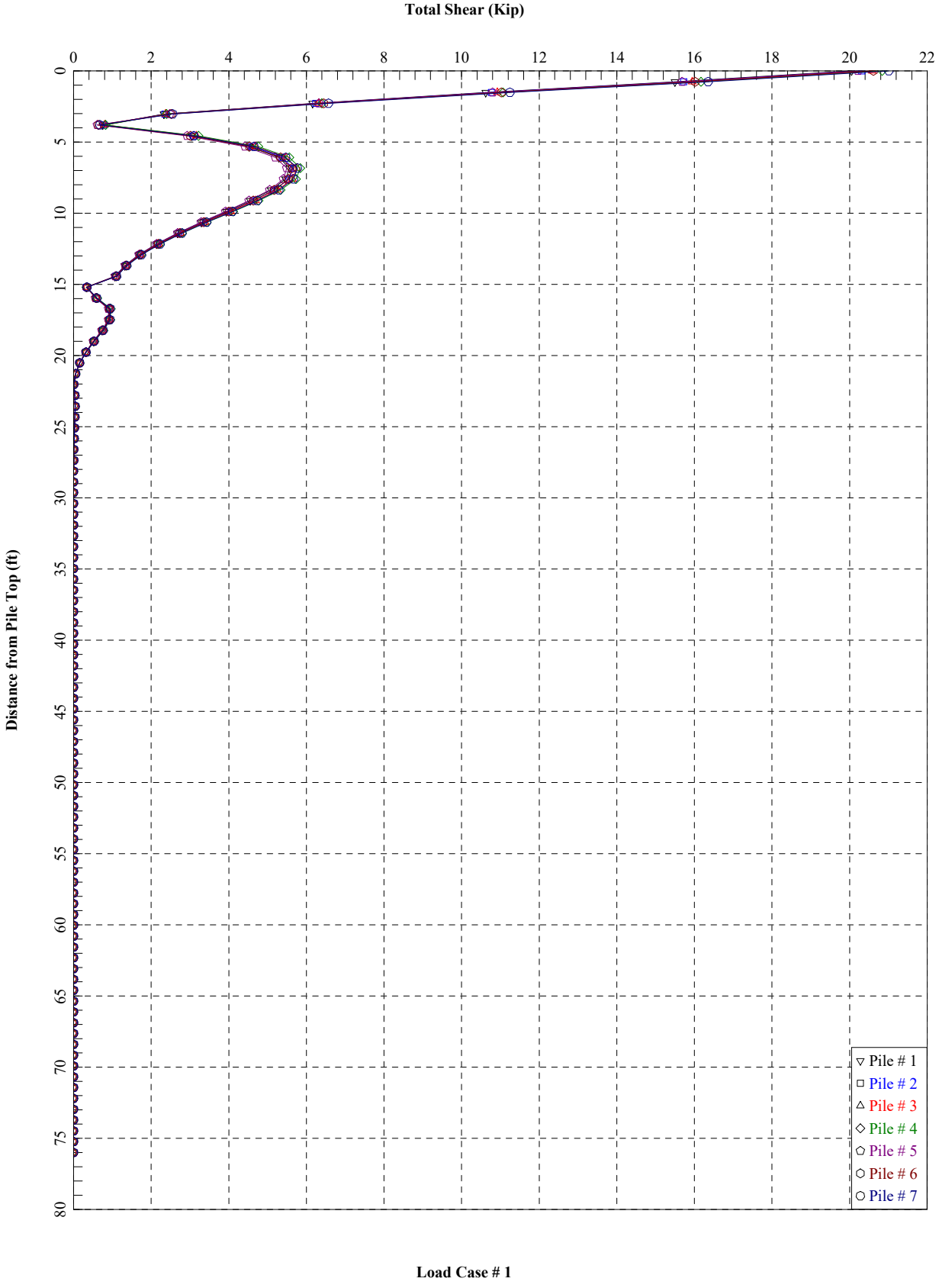


Load Case 1 = Service I

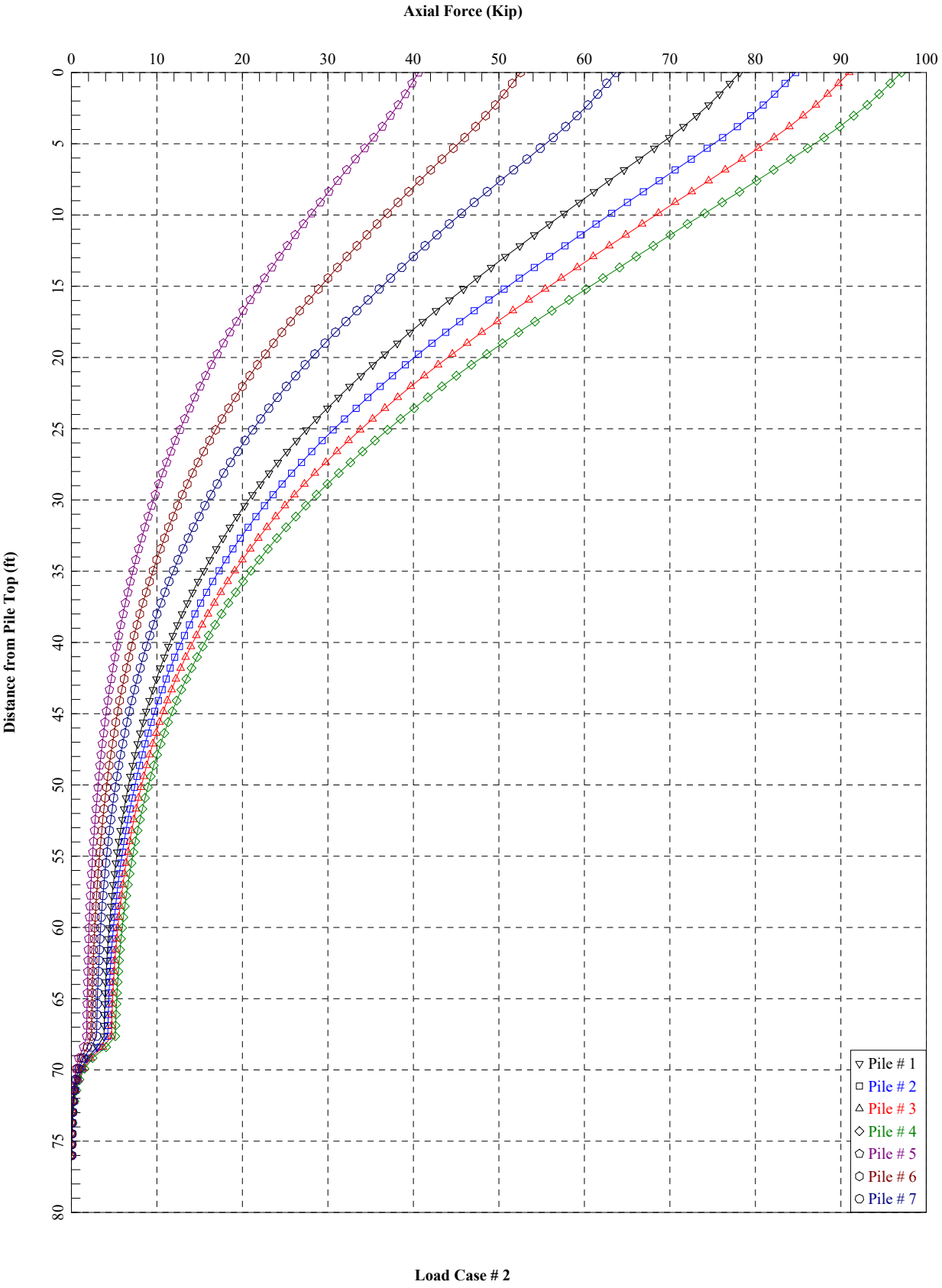


Load Case # 1

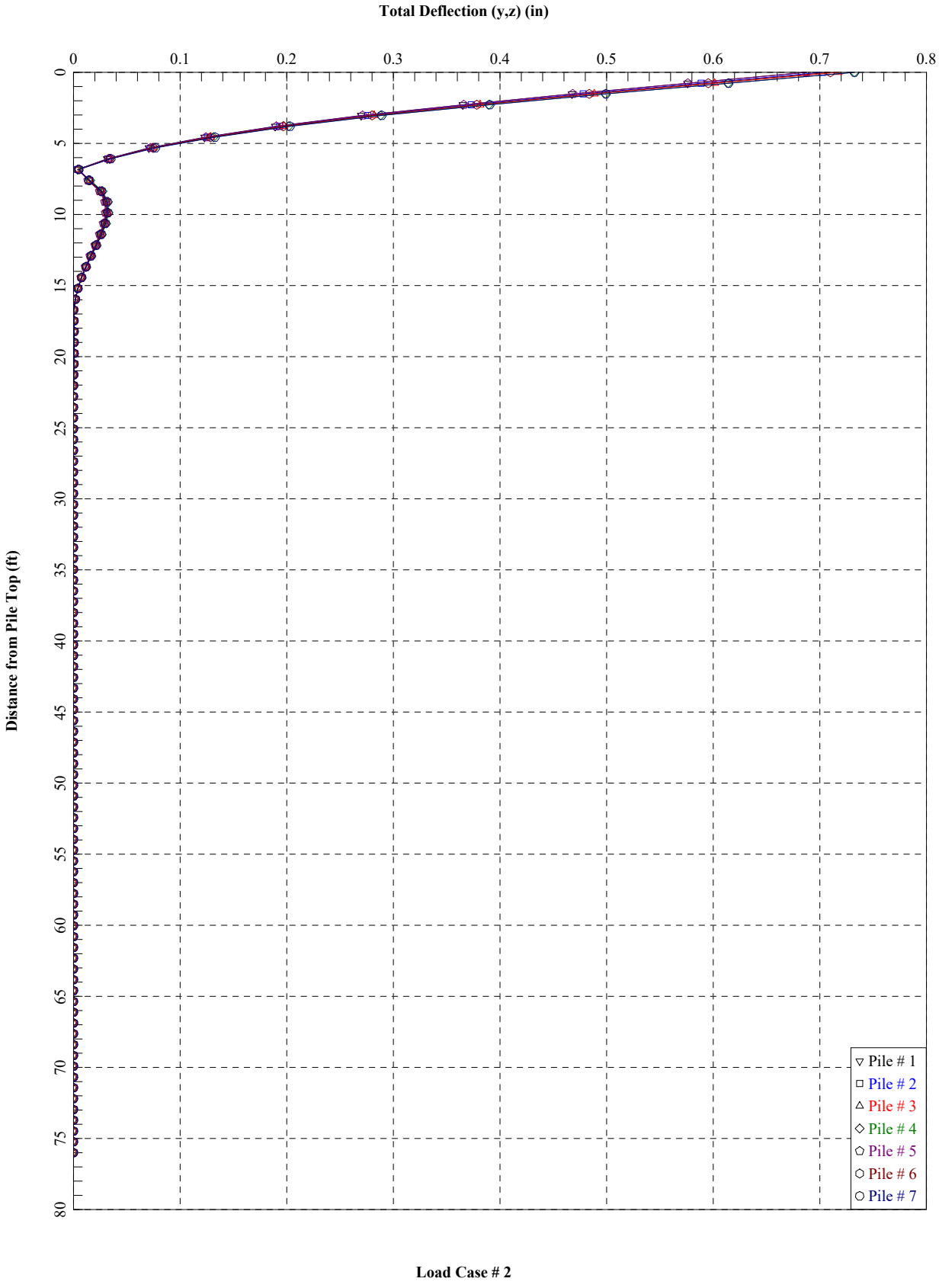
Load Case 1 = Service I



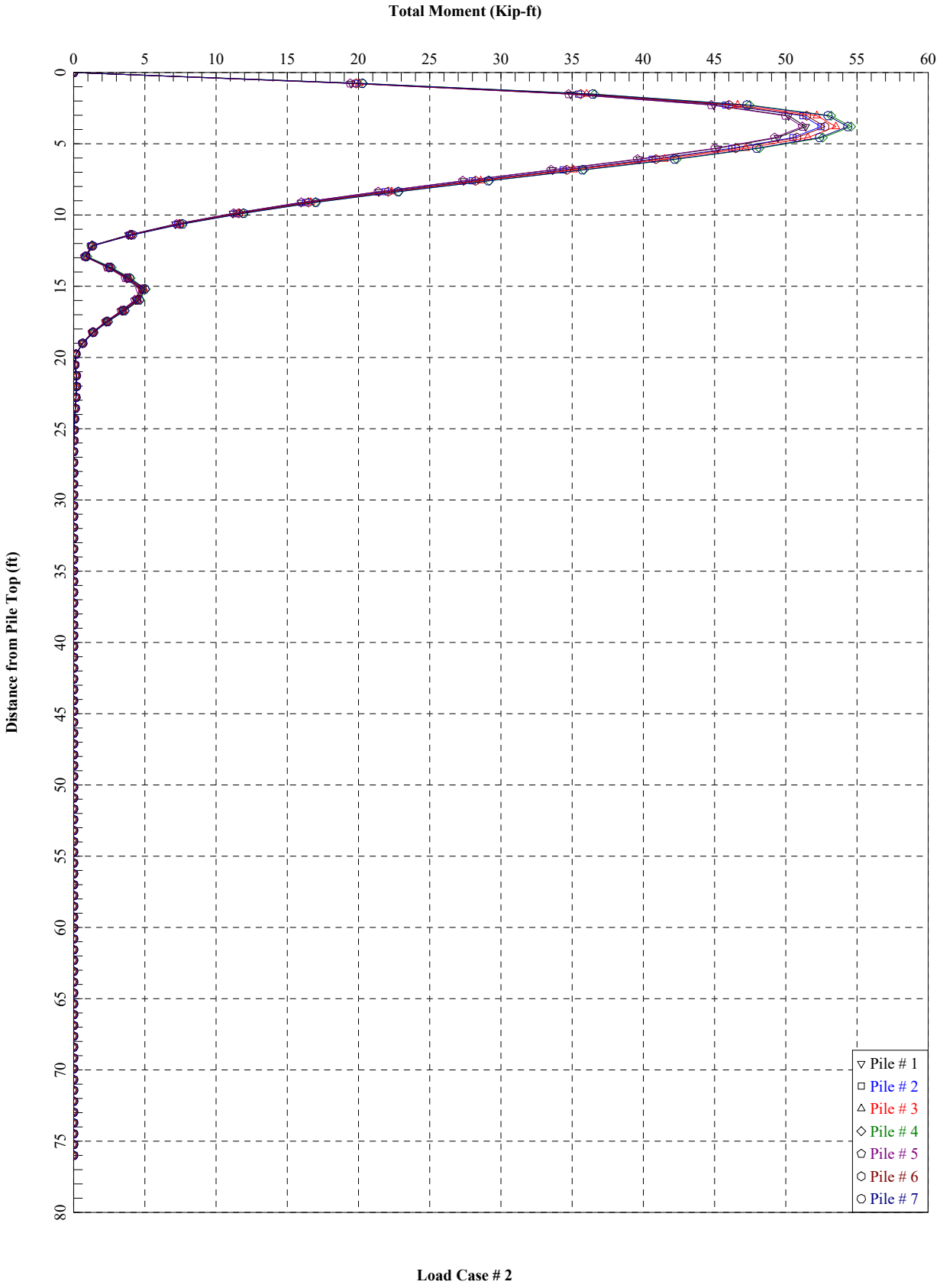
Load Case 2 = Strength I (Max)



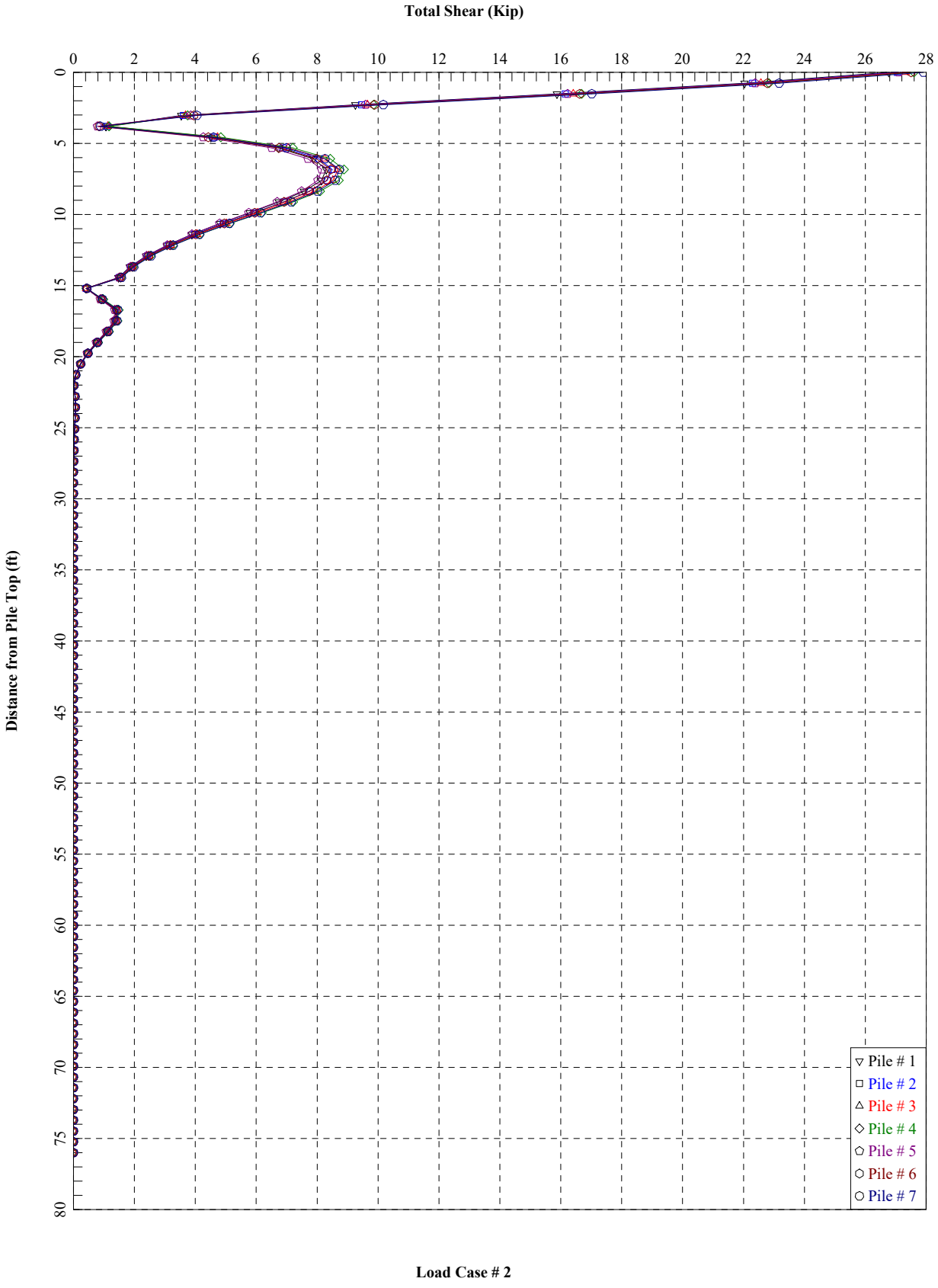
Load Case 2 = Strength I (Max)



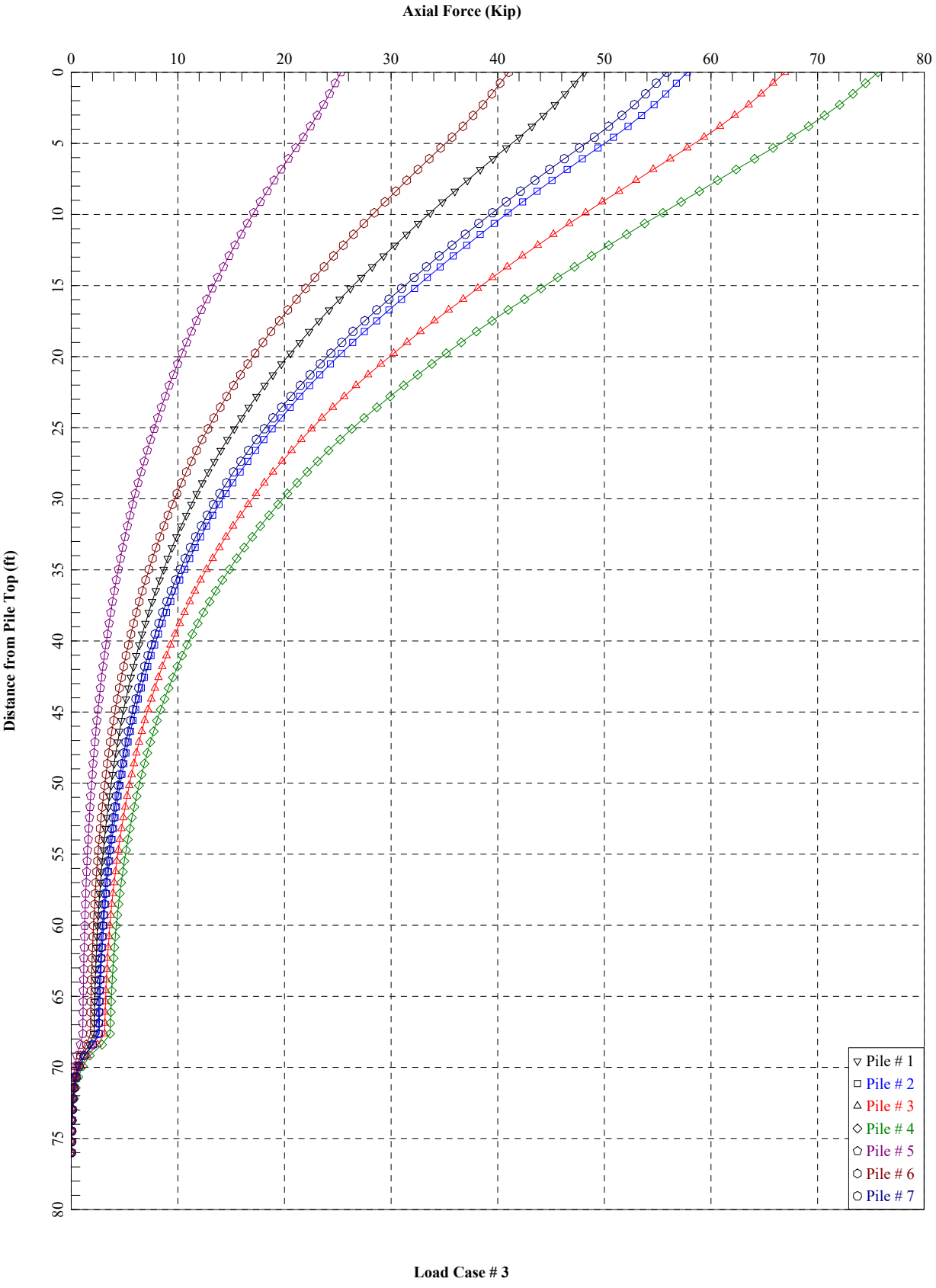
Load Case 2 = Strength I (Max)



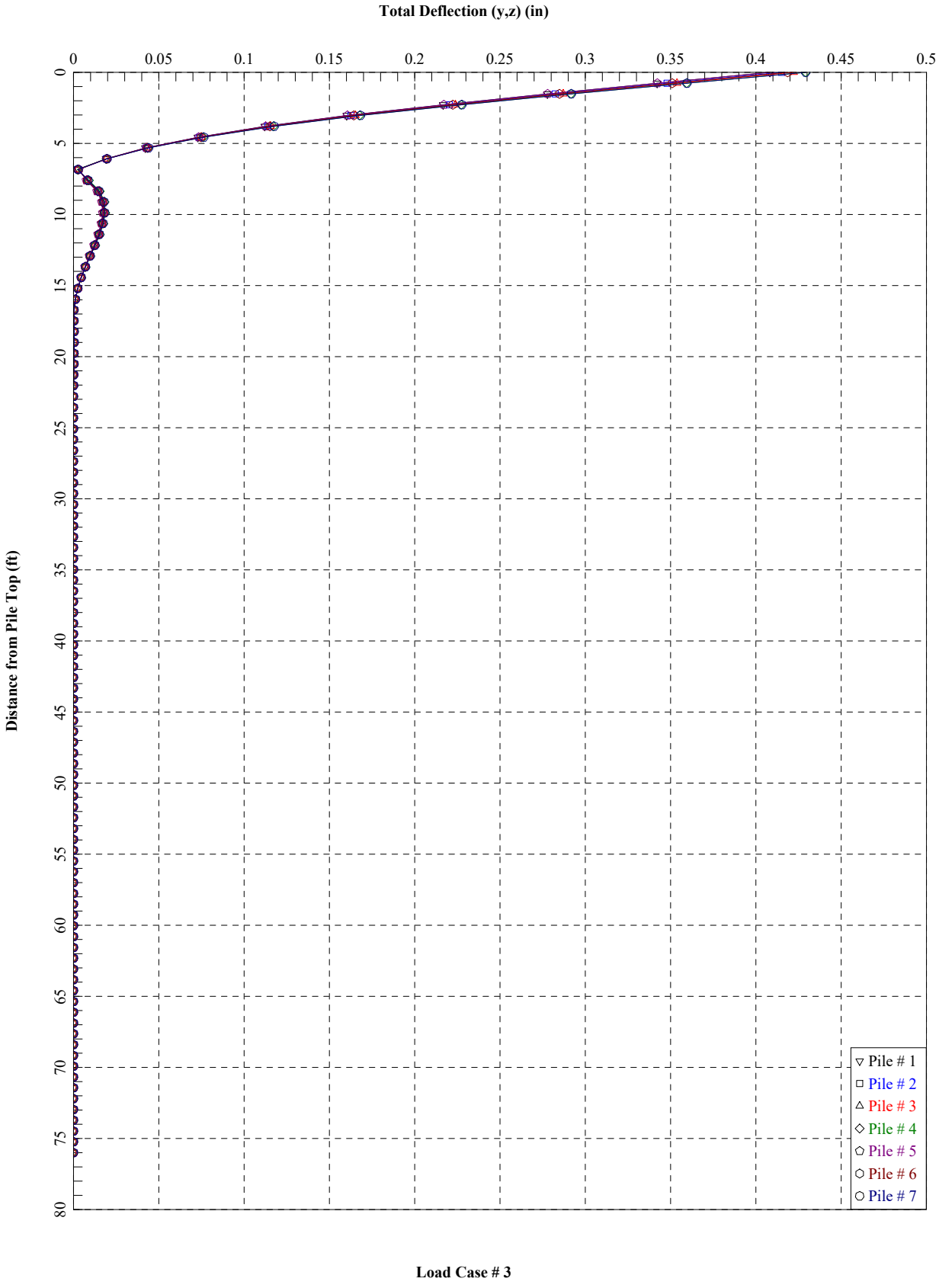
Load Case 2 = Strength I (Max)



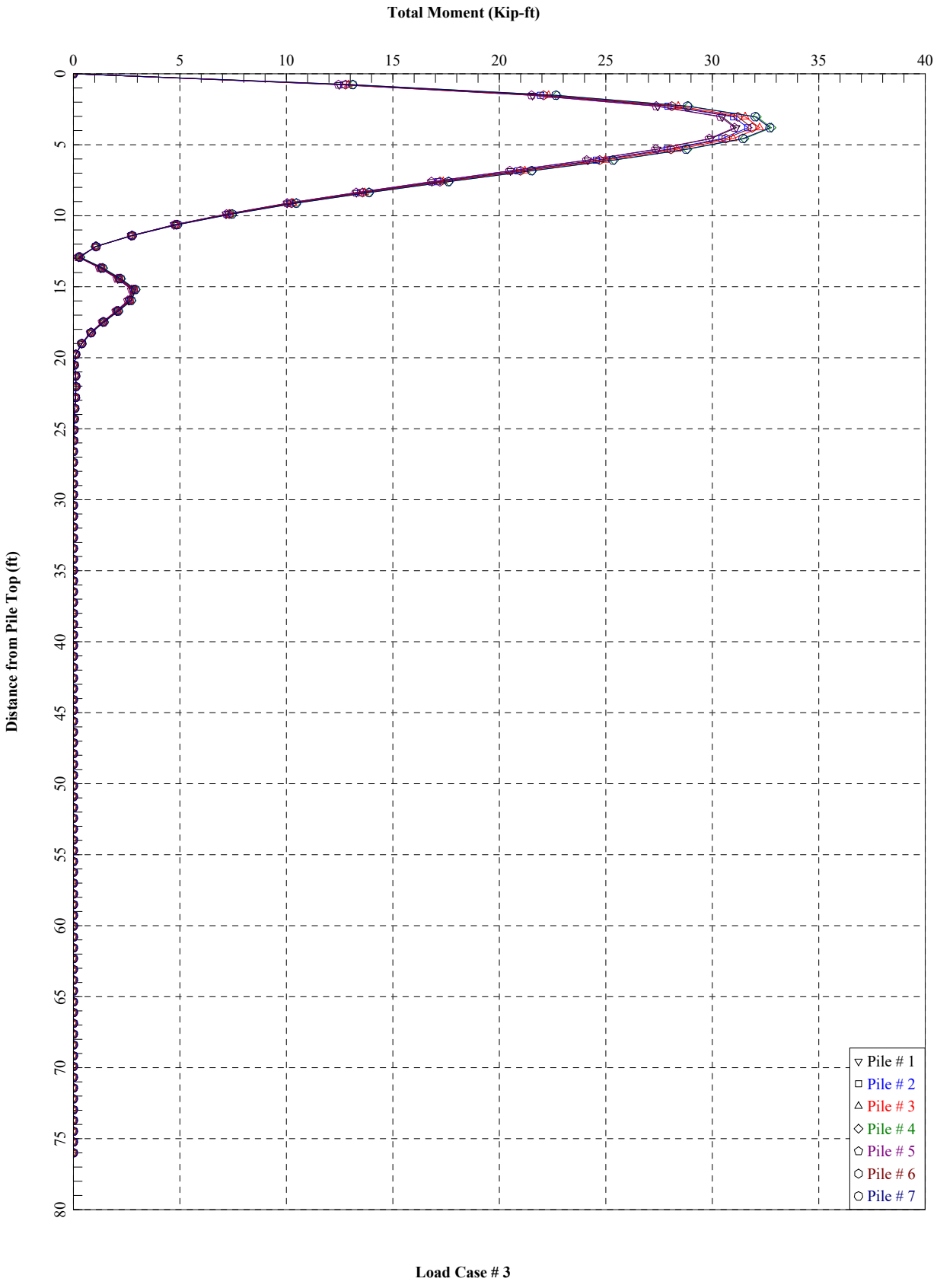
Load Case 3 = Strength I (Min)



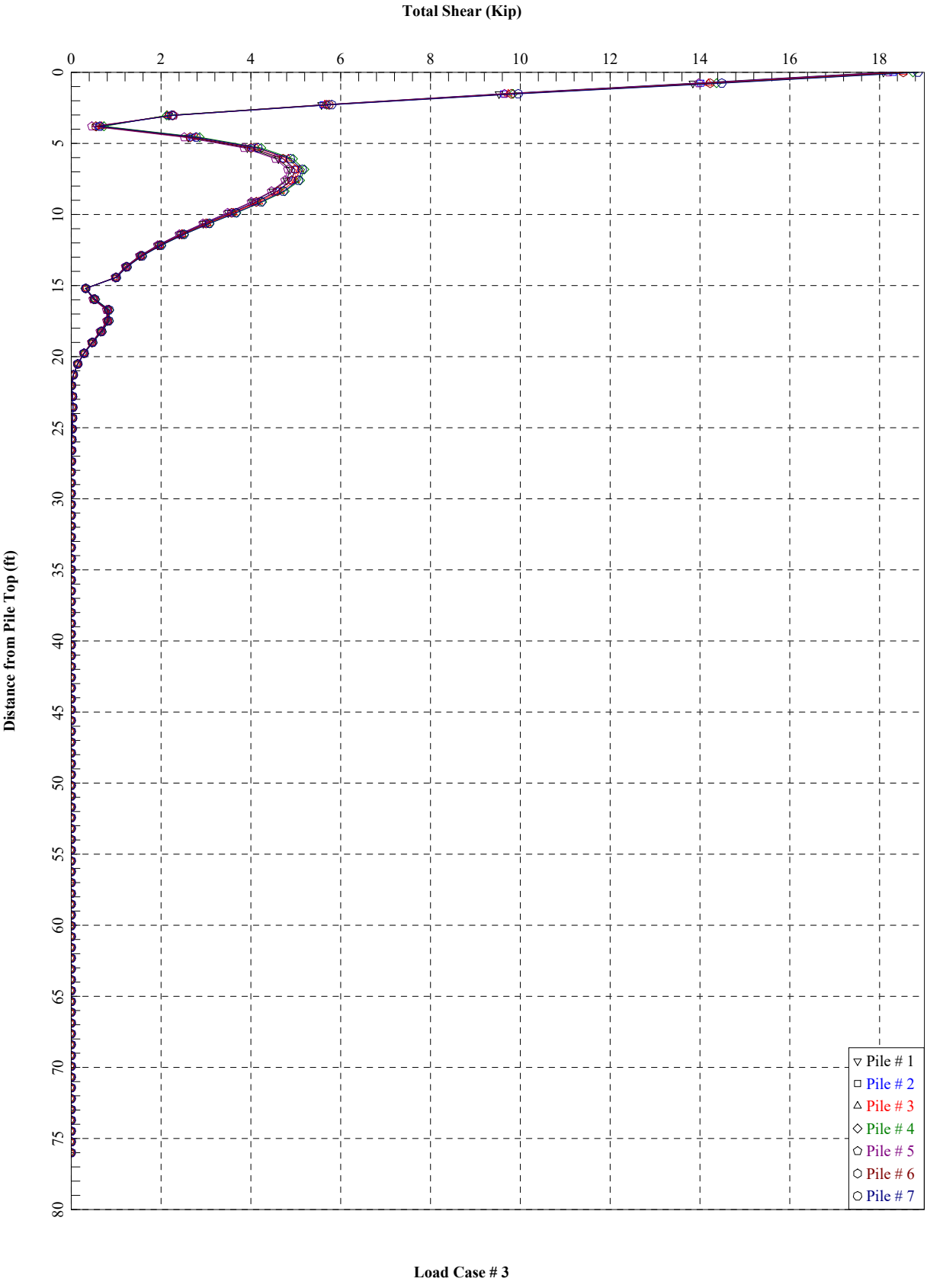
Load Case 3 = Strength I (Min)



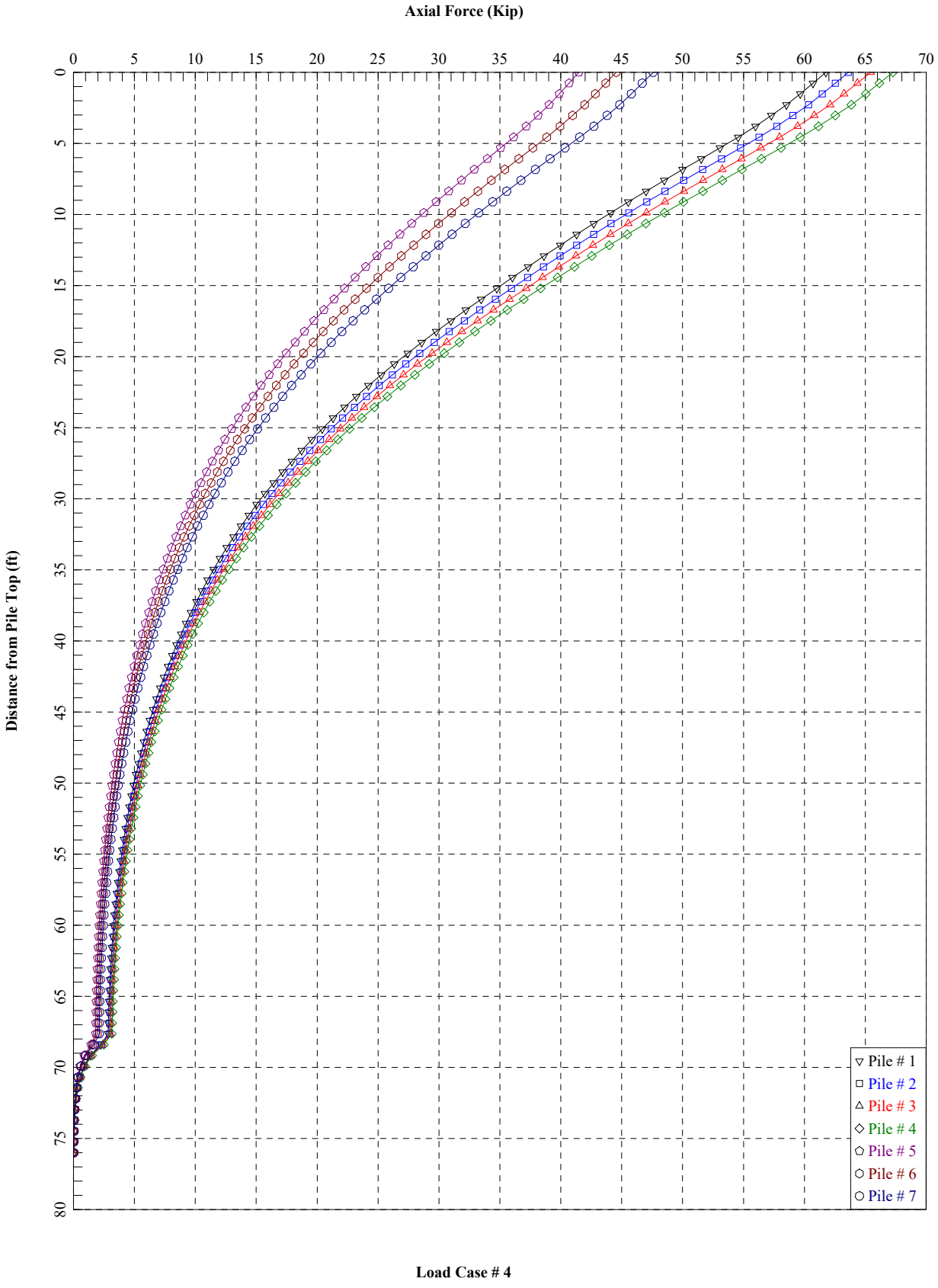
Load Case 3 = Strength I (Min)



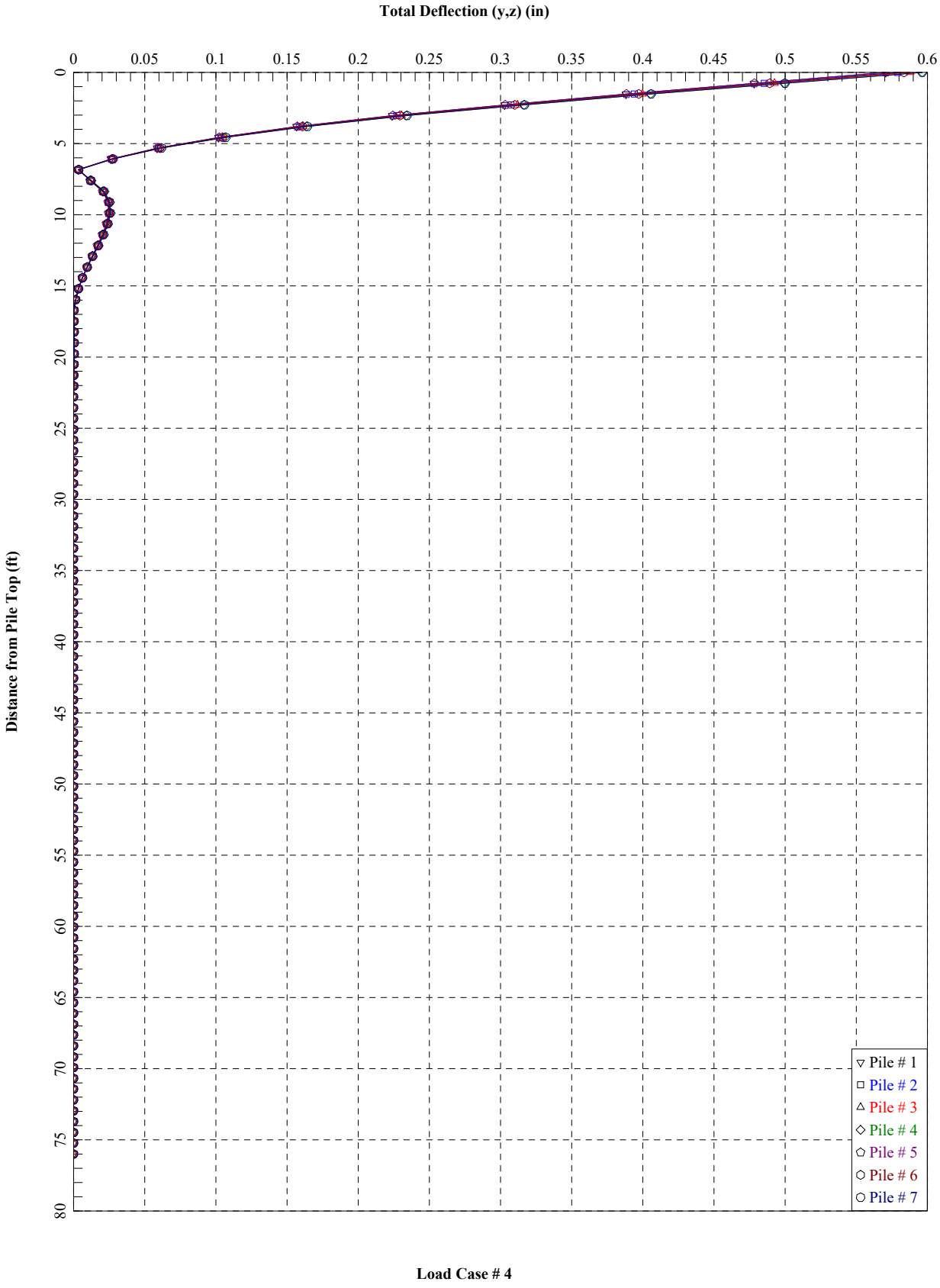
Load Case 3 = Strength I (Min)



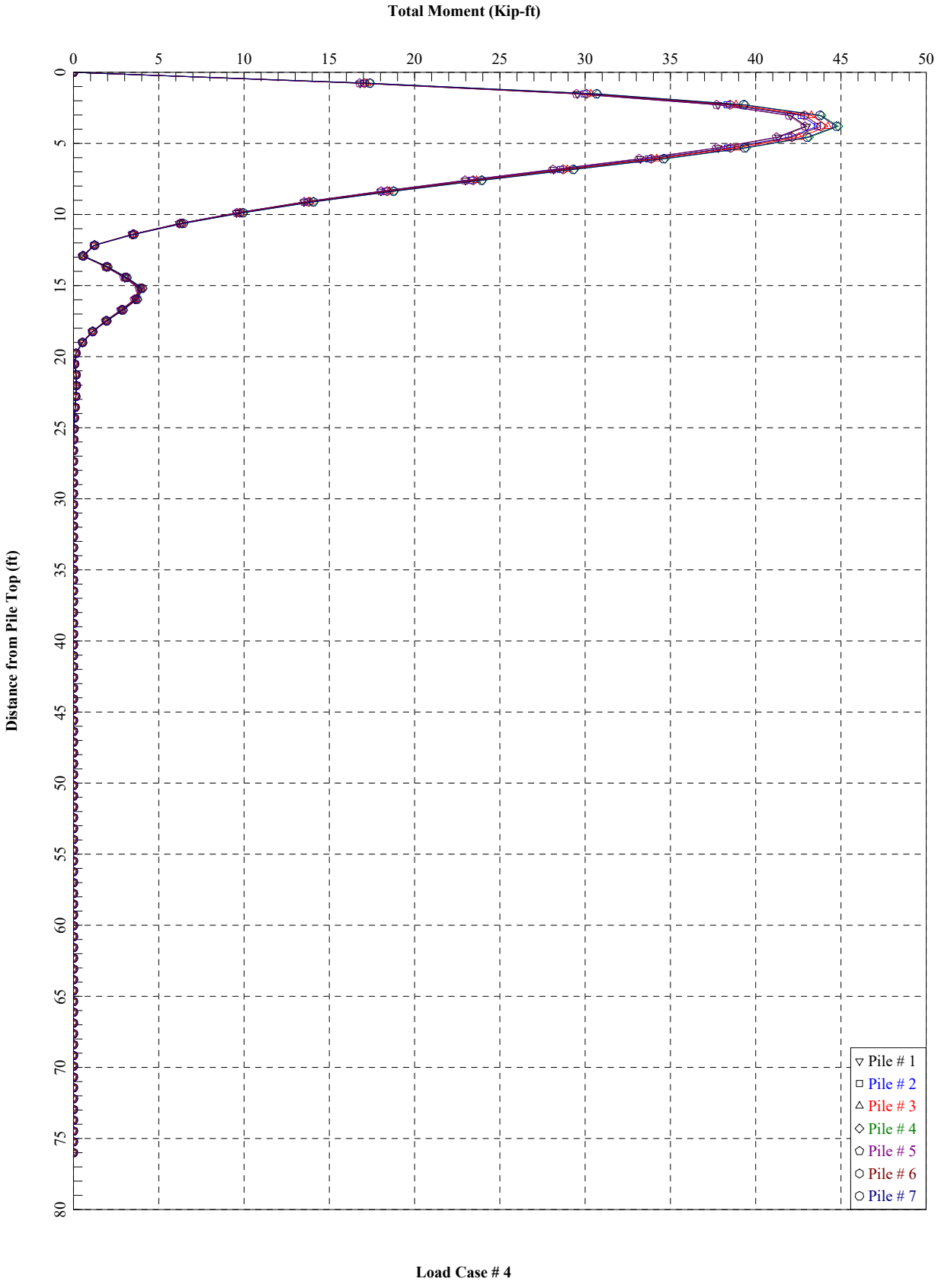
Load Case 4 = Extreme I (50+100)



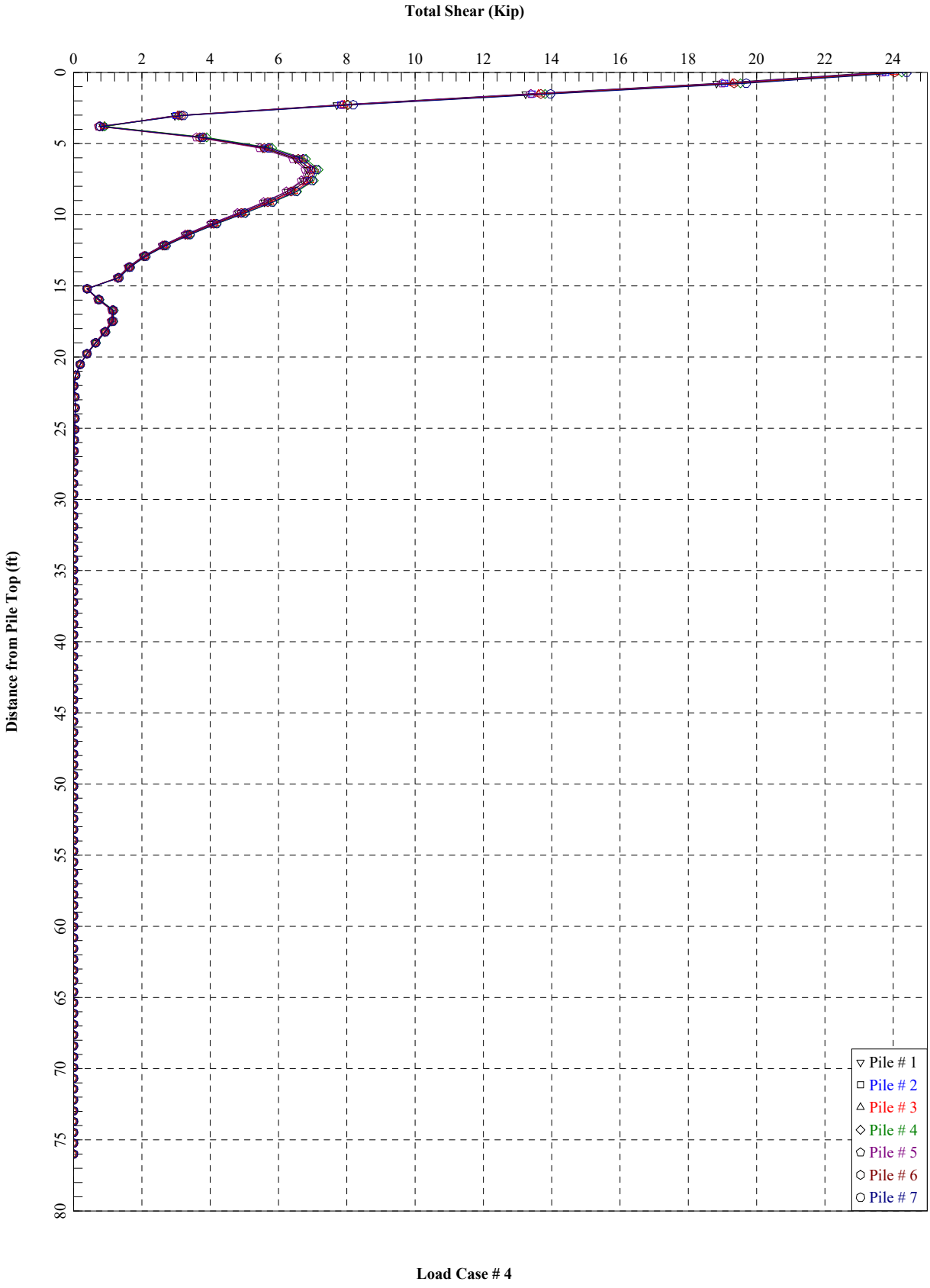
Load Case 4 = Extreme I (50+100)



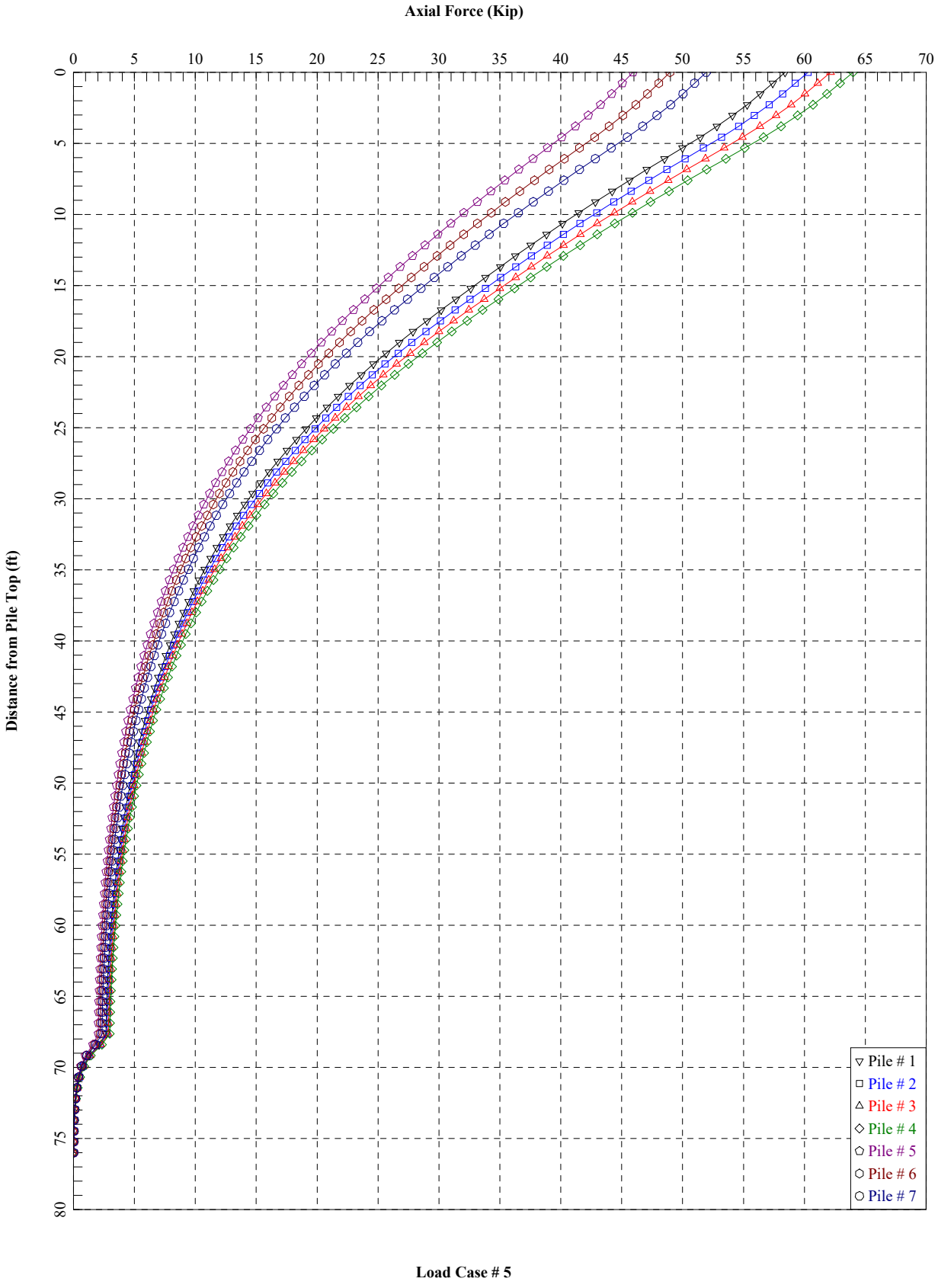
Load Case 4 = Extreme I (50+100)



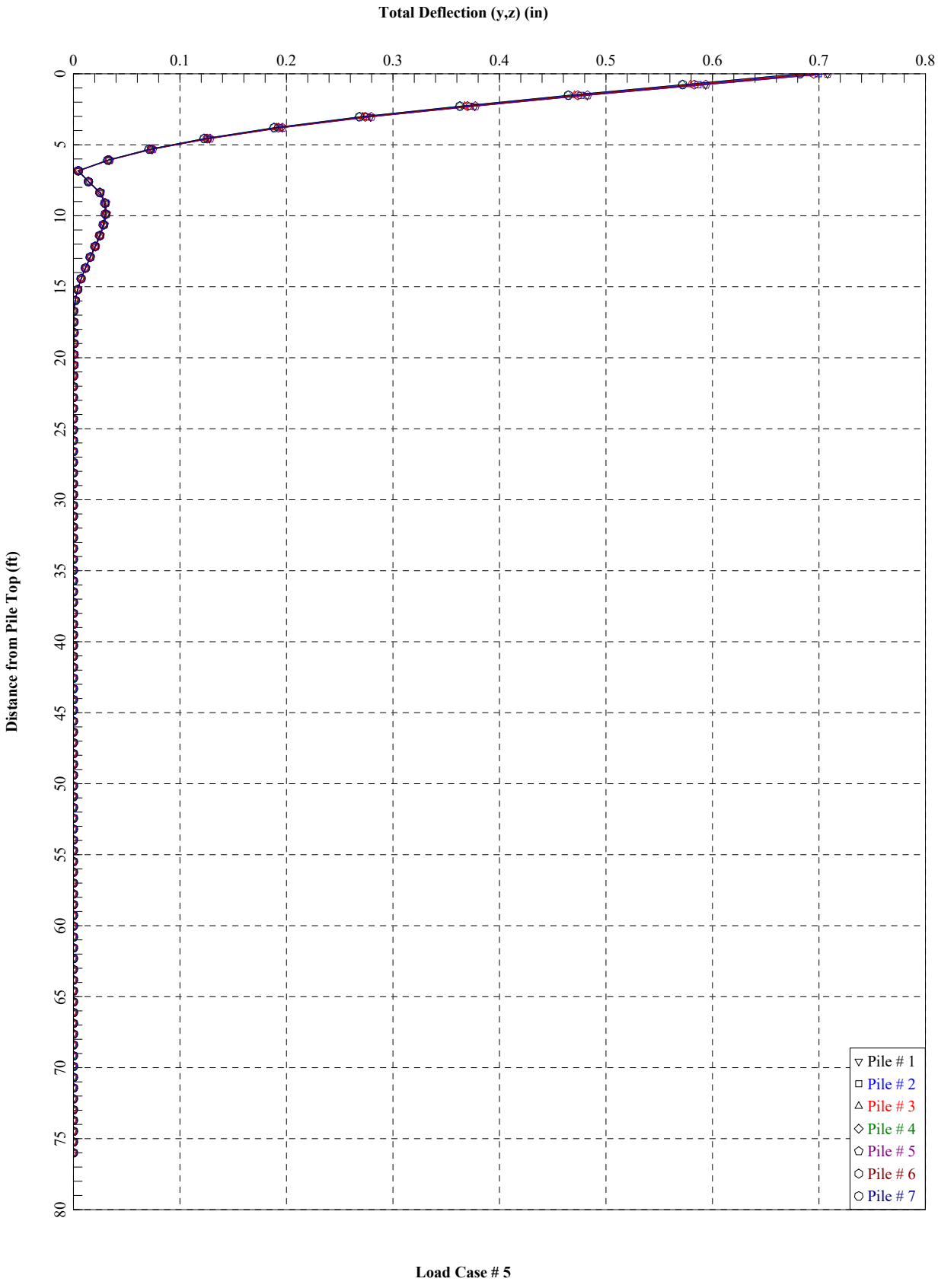
Load Case 4 = Extreme I (50+100)



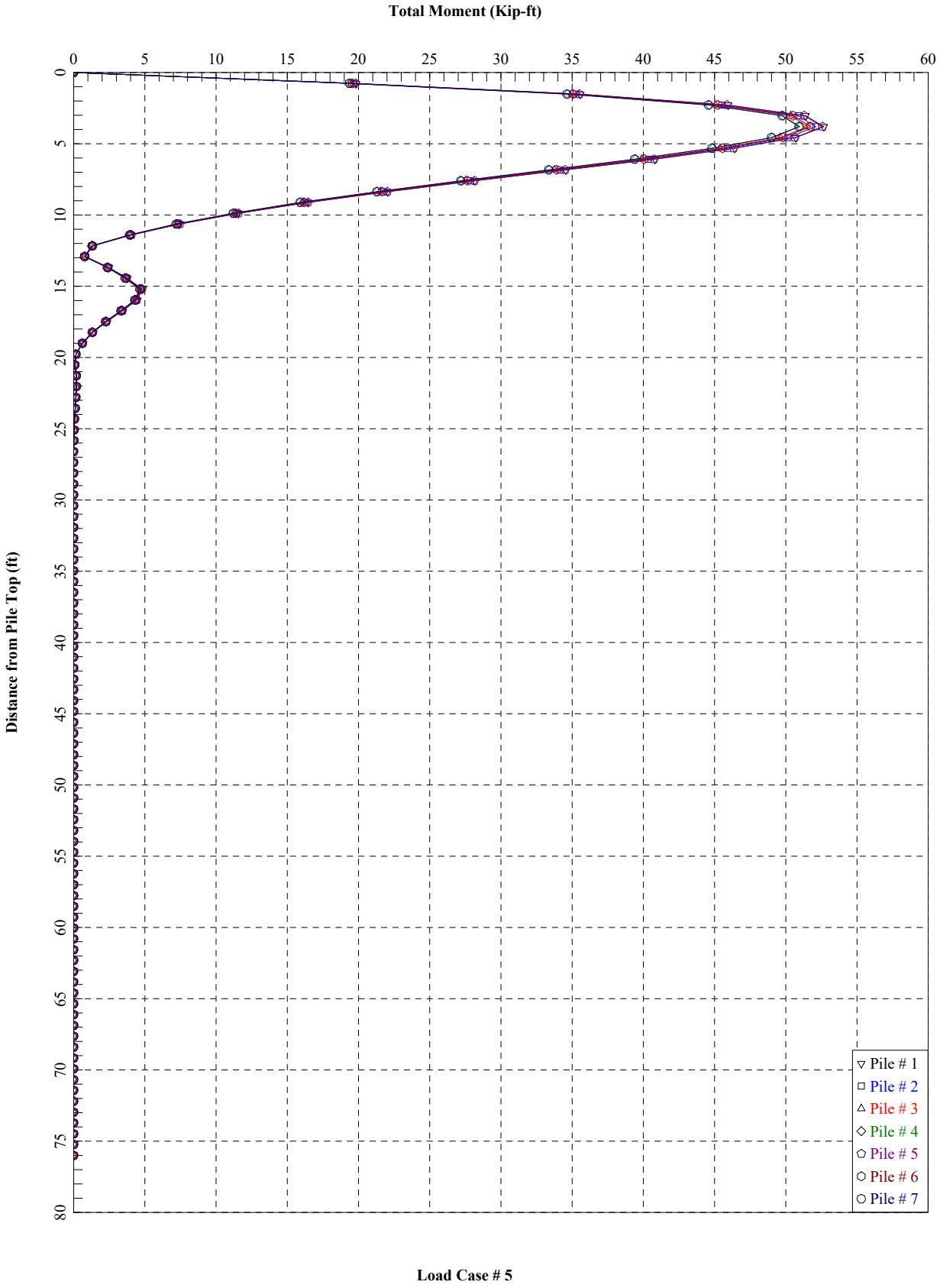
Load Case 5 = Extreme I (100+50)



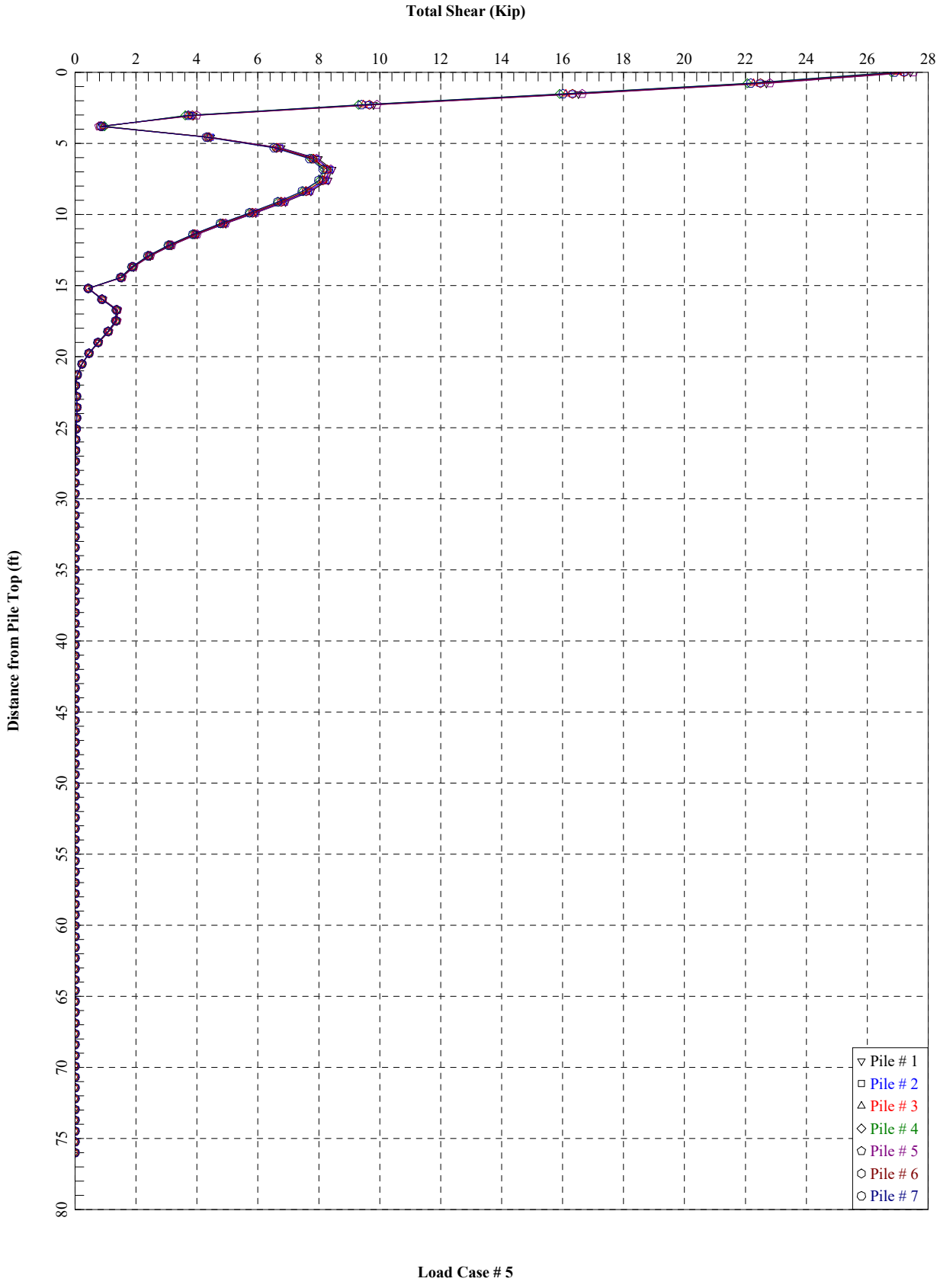
Load Case 5 = Extreme I (100+50)



Load Case 5 = Extreme I (100+50)



Load Case 5 = Extreme I (100+50)



```
     ======================================================================

                    GROUP for Windows, Version 2022.12.4

                     Serial Number : 546958378

                     Analysis of A Group of Piles
                   Subjected to Axial and Lateral Loading

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     ======================================================================


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     Nobis Engineering, Inc.
     Lowell, MA, USA

     Path to file locations      : J:\094184.100-MassDOT Armory Street Bridges, Springfield\Calculations\Axial-Lateral Pile Analysis\S-24-026\Updated
Gravity Block 3 and 4\Group\
     Name of input data file     : Thrust Block Location 4.gp12r
     Name of output echo file    : Thrust Block Location 4.gp12e
     Name of output results file : Thrust Block Location 4.gp12o
     Name of output summary file : Thrust Block Location 4.gp12t
     Name of plot output file    : Thrust Block Location 4.gp12p
     Name of runtime file        : Thrust Block Location 4.gp12r


     ------------------------------------------------------------------------
                          Time and Date of Analysis
     ------------------------------------------------------------------------

               Date:  March 05, 2025     Time:  08:53:34




                *****     INPUT INFORMATION     *****


     94184.100 - Armory Street - Thrust Block Location 4

     ANALYSIS TYPE = 3D ANALYSIS

     ADJUST DEPTH FOR BATTER PILES

     GENERATE LOAD-DISP (AND T-R) CURVES BASED ON SOIL PROFILE

     EXTEND INTERPOLATION FOR L-DP (AND T-R) CURVES

     UNITS SYSTEM  = ENGL



     * TABLE B *  PILE CAP OPTIONS

     LENGTH,YY    ( FT ) =    12.50
     WIDTH, ZZ    ( FT ) =    18.23
     THICKNESS,XX ( FT ) =    12.00

     * PILE CAP DIMENSIONS ARE NOT CONSIDERED
       FOR THE PILE GROUP ANALYSIS




     * TABLE C *  LOAD AND CONTROL PARAMETERS


     ** LOAD CASES **


     NUMBER OF LOAD CASES :    5


     LOAD CASE    :     1
     CASE NAME    : Service I
     LOAD TYPE    : Dead, DL
     SCALE FACTOR :       1.0000

     * CONCENTRATED LOADS *

    NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
          LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
     1   8.62E+04  2.28E+04      0.00      0.00      0.00 -1.37E+06      0.00      0.00      7.36
     2   1.03E+05  4.88E+04      0.00      0.00      0.00 -2.20E+06      0.00      0.00     -6.40
     3   2.03E+05  7.20E+04      0.00      0.00      0.00 -3.71E+06      0.00      0.00      1.74
```

```
4  -3.00E+04      0.00      0.00      0.00      0.00      0.00     -13.7      4.42      5.60
5   3.00E+04      0.00      0.00      0.00      0.00      0.00     -4.00      4.42     -4.11
6       0.00      0.00 -1.24E+04      0.00      0.00      0.00     -13.7      4.42      5.60
7       0.00      0.00  1.24E+04      0.00      0.00      0.00     -4.00      4.42     -4.11


* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

       VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
          3.91660E+05       1.43600E+05           0.00000

       MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
          2.34745E+05      -9.89800E+05      -7.28172E+06


* THE LOADING IS STATIC *


* CONTROL PARAMETERS *
    TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-03
    TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-03 IN
    MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
    MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
    FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
    MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
    INCLUDE VARIATION OF AXIAL LOAD AT PILES
    * NOT FOR USER DEFINED LOAD SETTL. CURVE
    - PRINT RESULTS AT PILE CAP


LOAD CASE    :     2
CASE NAME    : Strength I (Max)
LOAD TYPE    : Dead, DL
SCALE FACTOR :       1.0000

* CONCENTRATED LOADS *

NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
       LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
1   1.12E+05  3.02E+04      0.00      0.00      0.00 -1.71E+06      0.00      0.00      7.36
2   1.34E+05  6.51E+04      0.00      0.00      0.00 -2.88E+06      0.00      0.00     -6.40
3   2.63E+05  9.59E+04      0.00      0.00      0.00 -4.73E+06      0.00      0.00      1.74
4  -5.25E+04      0.00      0.00      0.00      0.00      0.00     -13.7      4.42      5.60
5   5.25E+04      0.00      0.00      0.00      0.00      0.00     -4.00      4.42     -4.11
6       0.00      0.00 -2.17E+04      0.00      0.00      0.00     -13.7      4.42      5.60
7       0.00      0.00  2.17E+04      0.00      0.00      0.00     -4.00      4.42     -4.11


* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

       VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
          5.07730E+05       1.91200E+05           0.00000

       MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
          3.28514E+05      -3.57044E+06      -9.31656E+06


* THE LOADING IS STATIC *


* CONTROL PARAMETERS *
    TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
    TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-03 IN
    MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
    MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
    FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
    MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
    INCLUDE VARIATION OF AXIAL LOAD AT PILES
    * NOT FOR USER DEFINED LOAD SETTL. CURVE
    - PRINT RESULTS AT PILE CAP


LOAD CASE    :     3
CASE NAME    : Strength I (Min)
LOAD TYPE    : Dead, DL
SCALE FACTOR :       1.0000

* CONCENTRATED LOADS *

NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
       LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
1   8.13E+04  2.05E+04      0.00      0.00      0.00 -1.13E+06      0.00      0.00      7.36
2   9.76E+04  4.39E+04      0.00      0.00      0.00 -1.85E+06      0.00      0.00     -6.40
3   1.92E+05  6.48E+04      0.00      0.00      0.00 -3.08E+06      0.00      0.00      1.74
4  -5.25E+04      0.00      0.00      0.00      0.00      0.00     -13.7      4.42      5.60
5   5.25E+04      0.00      0.00      0.00      0.00      0.00     -4.00      4.42     -4.11
6       0.00      0.00 -2.17E+04      0.00      0.00      0.00     -13.7      4.42      5.60
7       0.00      0.00  2.17E+04      0.00      0.00      0.00     -4.00      4.42     -4.11


* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *
```

```
        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           3.70640E+05       1.29230E+05           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
           2.10360E+05      -4.95287E+06      -6.06252E+06


 * THE LOADING IS STATIC *


 * CONTROL PARAMETERS *
     TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
     TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-03 IN
     MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
     MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
     FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
     MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
     INCLUDE VARIATION OF AXIAL LOAD AT PILES
     * NOT FOR USER DEFINED LOAD SETTL. CURVE
     - PRINT RESULTS AT PILE CAP


 LOAD CASE    :     4
 CASE NAME    : Extreme I (50%+100%PAE)
 LOAD TYPE    : Dead, DL
 SCALE FACTOR :       1.0000

 * CONCENTRATED LOADS *

NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
       LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
 1   8.62E+04  2.68E+04      0.00      0.00      0.00 -9.77E+05      0.00      0.00      7.36
 2   1.03E+05  5.68E+04      0.00      0.00      0.00 -1.99E+06      0.00      0.00     -6.40
 3   2.03E+05  8.42E+04      0.00      0.00      0.00 -3.00E+06      0.00      0.00      1.74
 4  -3.00E+04      0.00      0.00      0.00      0.00      0.00     -13.7      4.42      5.60
 5   3.00E+04      0.00      0.00      0.00      0.00      0.00     -4.00      4.42     -4.11
 6       0.00      0.00 -1.24E+04      0.00      0.00      0.00     -13.7      4.42      5.60
 7       0.00      0.00  1.24E+04      0.00      0.00      0.00     -4.00      4.42     -4.11


 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           3.91660E+05       1.67700E+05           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
           2.34114E+05      -9.89800E+05      -5.97408E+06


 * THE LOADING IS STATIC *


 * CONTROL PARAMETERS *
     TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
     TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-04 IN
     MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
     MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
     FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
     MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
     INCLUDE VARIATION OF AXIAL LOAD AT PILES
     * NOT FOR USER DEFINED LOAD SETTL. CURVE
     - PRINT RESULTS AT PILE CAP


 LOAD CASE    :     5
 CASE NAME    : Extreme I (100%+50%PAE)
 LOAD TYPE    : Dead, DL
 SCALE FACTOR :       1.0000

 * CONCENTRATED LOADS *

NL  VERT.LOAD HR.LOAD Y HR.LOAD Z  MOMENT X  MOMENT Y  MOMENT Z   COORD X   COORD Y   COORD Z
       LBS       LBS       LBS      LBS-IN    LBS-IN    LBS-IN      FT        FT        FT
 1   8.62E+04  3.29E+04      0.00      0.00      0.00 -8.23E+05      0.00      0.00      7.36
 2   1.03E+05  6.11E+04      0.00      0.00      0.00 -1.50E+06      0.00      0.00     -6.40
 3   2.03E+05  9.60E+04      0.00      0.00      0.00 -2.38E+06      0.00      0.00      1.74
 4  -3.00E+04      0.00      0.00      0.00      0.00      0.00     -13.7      4.42      5.60
 5   3.00E+04      0.00      0.00      0.00      0.00      0.00     -4.00      4.42     -4.11
 6       0.00      0.00 -1.24E+04      0.00      0.00      0.00     -13.7      4.42      5.60
 7       0.00      0.00  1.24E+04      0.00      0.00      0.00     -4.00      4.42     -4.11


 * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

        VER.LOAD X,LBS     HOR.LOAD Y,LBS     HOR.LOAD Z,LBS
           3.91660E+05       1.90030E+05           0.00000

        MOMENT X,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
          -2.14396E+05      -9.89800E+05      -4.70532E+06
```

```
* THE LOADING IS STATIC *


* CONTROL PARAMETERS *
    TOLERANCE ON CONVERGENCE OF PILE CAP MOVEMENT        =  1.00000E-04
    TOLERANCE ON DETERMINATION OF PILE DEFLECTIONS       =  1.00000E-04 IN
    MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS =      100
    MAXIMUM NO OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =      100
    FACTOR TO APPLY THE LOAD IN INCREMENTS               =   1.0000
    MINIMUM FACTOR FOR LOAD INCREMENTS                   =   1.0000
    INCLUDE VARIATION OF AXIAL LOAD AT PILES
    * NOT FOR USER DEFINED LOAD SETTL. CURVE
    - PRINT RESULTS AT PILE CAP



* TABLE D *   ARRANGEMENT OF PILE GROUPS

GROUP  CONN.Z-Z   CONN.Y-Y   PILE PROP  P-Y CURVE  L-S CURVE  T-R CURVE  R-F-L SET
  1       PIN        PIN         1          0          1 G        1 G        0
  2       PIN        PIN         1          0          1 G        1 G        0
  3       PIN        PIN         1          0          1 G        1 G        0
  4       PIN        PIN         1          0          1 G        1 G        0
  5       PIN        PIN         1          0          1 G        1 G        0
  6       PIN        PIN         1          0          1 G        1 G        0
  7       PIN        PIN         1          0          1 G        1 G        0

GROUP   CorX,FT    CorY,FT    CorZ,FT  ALPHA,DEG   BETA,DEG  THETA,DEG  GROUND,FT SPz,LBS-IN SPy,LBS-IN
  1       0.000      4.000      6.750      0.000      90.00      0.000     -4.000      0.000      0.000
  2       0.000      4.000      2.250      0.000      90.00      0.000     -4.000      0.000      0.000
  3       0.000      4.000     -2.250      0.000      90.00      0.000     -4.000      0.000      0.000
  4       0.000      4.000     -6.750      0.000      90.00      0.000     -4.000      0.000      0.000
  5       0.000     -4.000      6.750      0.000      90.00      0.000     -4.000      0.000      0.000
  6       0.000     -4.000      0.000      0.000      90.00      0.000     -4.000      0.000      0.000
  7       0.000     -4.000     -6.750      0.000      90.00      0.000     -4.000      0.000      0.000



* TABLE E *   PILE GEOMETRY AND PROPERTIES
              PILE TYPE = 1 - DRIVEN PILE
                        = 2 - DRILLED SHAFT

  PROP   SECTS   INC     PILE TYPE      LENGTH, FT
    1      3     100          2            76.000

* PILE SECTIONS *

  PROP    SECT      FROM,FT         TO,FT    CROSS SECT
    1       1       0.00000        3.00000       1
    1       2       3.00000        69.0000       2
    1       3       69.0000        76.0000       3

* PILE CROSS SECTIONS *

 CROSS SECTION       :     1
 SECTION NAME        : 10.75-inch
 TYPE                :  NONLINEAR
 CROSS SECTION TYPE  : ROUND CONC. SHAFT, CASING (AND STEEL SECTION)
 CONCRETE DIAMETER   :       9.75000 IN
 CONCRETE FC         :       5000.00 LBS/IN**2
 DIAMETER CASING     :       10.6250 IN
 THICKNESS CASING    :       0.43750 IN
 ES CASING           :   2.90000E+07 LBS/IN**2
 FY CASING           :       52000.0 LBS/IN**2
 EMBEDDED STEEL SECT : NONE
 NUMBER REBARS       :             1
 ES REINFORCEMENT    :   2.90000E+07 LBS/IN**2
 FY REINFORCEMENT    :       60000.0 LBS/IN**2
 REINF. LAYOUT       :       MANUAL
 REINF. A , D, COORDS:        IN^2             IN              IN              IN
 - REBAR    1        :       0.79000         1.00000         0.00000         0.00000
 EQ. YOUNG MODULUS   :   8.19627E+06 LBS/IN**2

 CROSS SECTION       :     2
 SECTION NAME        : 10.75-inch
 TYPE                :  NONLINEAR
 CROSS SECTION TYPE  : ROUND CONC. SHAFT, CASING (AND STEEL SECTION)
 CONCRETE DIAMETER   :       9.75000 IN
 CONCRETE FC         :       5000.00 LBS/IN**2
 DIAMETER CASING     :       10.2500 IN
 THICKNESS CASING    :       0.25000 IN
 ES CASING           :   2.90000E+07 LBS/IN**2
 FY CASING           :       52000.0 LBS/IN**2
 EMBEDDED STEEL SECT : NONE
 NUMBER REBARS       :             1
 ES REINFORCEMENT    :   2.90000E+07 LBS/IN**2
 FY REINFORCEMENT    :       60000.0 LBS/IN**2
 REINF. LAYOUT       :       MANUAL
 REINF. A , D, COORDS:        IN^2             IN              IN              IN
 - REBAR    1        :       0.79000         1.00000         0.00000         0.00000
```

```
 EQ. YOUNG MODULUS   :   6.64620E+06 LBS/IN**2

 CROSS SECTION       :     3
 SECTION NAME        : 9.75-inch
 TYPE                :  NONLINEAR
 CROSS SECTION TYPE  : ROUND CONCRETE SHAFT
 EXTERNAL DIAMETER   :       9.75000 IN
 CONCRETE FC         :       5000.00 LBS/IN**2
 NUMBER REBARS       :             1
 ES REINFORCEMENT    :   2.90000E+07 LBS/IN**2
 FY REINFORCEMENT    :       60000.0 LBS/IN**2
 REINF. LAYOUT       :       MANUAL
 REINF. A , D, COORDS:        IN^2             IN              IN              IN
 - REBAR    1        :       0.79000         1.00000         0.00000         0.00000
 EQ. YOUNG MODULUS   :   4.29471E+06 LBS/IN**2

* PILE CROSS SECTIONS PROPERTIES *

         NONLINEAR SECTIONS

SECT    DIAM,IN   PERIM,IN AREA,IN**2   Iz,IN**4   Iy,IN**4  GJ,LBS-IN**2   EIz IND  EIy IND   Mn,LBS-IN    Vn,LBS
  1      10.625     33.379     88.664     0.0000     0.0000   5.4901E+09      0        0         0.0000     0.0000
  2      10.250     32.201     82.516     0.0000     0.0000   3.6218E+09      0        0         0.0000     0.0000
  3      9.7500     30.631     74.662     0.0000     0.0000   1.4303E+09      0        0         0.0000     0.0000


* TABLE F *   SOIL DATA


 SOILS INFORMATION

     GROUND SURFACE          =     -4.00000  FT

     6 LAYER(S) OF SOIL

     LAYER  1
     THE SOIL IS A SAND
                                                TOP OF LAYER    BOTTOM OF LAYER
     X COORDINATE                        (FT)       -4.00000          5.00000
     EFFECTIVE UNIT WEIGHT         (LBS/FT**3)        115.000          115.000
     FRICTION ANGLE                  (DEGREES)        33.0000          33.0000
     P-Y SUBGRADE MODULUS          (LBS/IN**3)        25.0000          25.0000
     ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)        11.5000 (S)      1133.32 (S)
     ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)        0.00000          0.00000

     LAYER  2
     THE SOIL IS A SAND
                                                TOP OF LAYER    BOTTOM OF LAYER
     X COORDINATE                        (FT)        5.00000          15.0000
     EFFECTIVE UNIT WEIGHT         (LBS/FT**3)        52.6000          52.6000
     FRICTION ANGLE                  (DEGREES)        33.0000          33.0000
     P-Y SUBGRADE MODULUS          (LBS/IN**3)        20.0000          20.0000
     ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)        1133.32 (S)      1422.93 (S)
     ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)        0.00000          0.00000

     LAYER  3
     THE SOIL IS A SILT
                                                TOP OF LAYER    BOTTOM OF LAYER
     X COORDINATE                        (FT)        15.0000          45.5000
     EFFECTIVE UNIT WEIGHT         (LBS/FT**3)        57.6000          57.6000
     UNDRAINED COHESION, C         (LBS/FT**2)        130.000          130.000
     FRICTION ANGLE                  (DEGREES)        22.0000          22.0000
     P-Y SUBGRADE MODULUS          (LBS/IN**3)        100.000          100.000
     STRAIN AT 50% STRESS                        1.00000E-02      1.00000E-02
     ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)        1494.43 (S)      1896.92 (S)
     ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)        0.00000          0.00000

     LAYER  4
     THE SOIL IS A SAND
                                                TOP OF LAYER    BOTTOM OF LAYER
     X COORDINATE                        (FT)        45.5000          62.5000
     EFFECTIVE UNIT WEIGHT         (LBS/FT**3)        57.6000          57.6000
     FRICTION ANGLE                  (DEGREES)        26.0000          26.0000
     P-Y SUBGRADE MODULUS          (LBS/IN**3)        50.0000          50.0000
     ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)        1825.42 (S)      1714.97 (S)
     ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)        0.00000          0.00000

     LAYER  5
     THE SOIL IS A SAND
                                                TOP OF LAYER    BOTTOM OF LAYER
     X COORDINATE                        (FT)        62.5000          68.0000
     EFFECTIVE UNIT WEIGHT         (LBS/FT**3)        72.6000          72.6000
     FRICTION ANGLE                  (DEGREES)        37.0000          37.0000
     P-Y SUBGRADE MODULUS          (LBS/IN**3)        125.000          125.000
     ULTIMATE UNIT SIDE FRICTION   (LBS/FT**2)        1714.97 (S)      1664.78 (S)
     ULTIMATE UNIT TIP RESISTANCE  (LBS/FT**2)        0.00000          0.00000

     LAYER  6
     THE LAYER IS A VUGGY LIMESTONE
                                                TOP OF LAYER    BOTTOM OF LAYER
```

X COORDINATE	(FT)	68.0000	100.000
EFFECTIVE UNIT WEIGHT	(LBS/FT**3)	101.600	101.600
UNIAXIAL COMPRESSIVE STRENGTH	(LBS/IN**2)	7500.00	7500.00
ULTIMATE UNIT SIDE FRICTION	(LBS/FT**2)	1.08000E+05 (S)	1.08000E+05 (S)
ULTIMATE UNIT TIP RESISTANCE	(LBS/FT**2)	9.72000E+06 (T)	9.72000E+06 (T)

Notes : Program estimated values for listed parameters
if zero input values were entered:
(S) ULTIMATE UNIT SIDE FRICTION for Drilled Shafts
(T) ULTIMATE UNIT TIP RESISTANCE for Drilled Shafts

* TABLE H * AXIAL LOAD VS DISPLACEMENT

AXIAL LOAD-DISPLACEMENT CURVES GENERATED INTERNALLY

NUM OF CURVES 1

CURVE 1 NUM OF POINTS 19

DISPLACEMENT, IN	AXIAL LOAD,LBS
-5.20552	-2.15318E+06
-4.21095	-2.15637E+06
-3.82779	-2.22874E+06
-3.57565	-2.31933E+06
-3.55511	-2.33796E+06
-3.14220	-2.12204E+06
-2.77703	-1.90996E+06
-1.81991	-1.32886E+06
-0.53544	-4.99366E+05
0.00000	0.00000
1.03643	8.28411E+05
2.49439	1.74246E+06
3.49156	2.32487E+06
4.02158	2.62538E+06
6.72979	4.14212E+06
8.21092	4.95551E+06
12.2514	7.02865E+06
12.9342	7.13257E+06
14.2114	7.29068E+06

DISPL. TIP , IN	AXIAL TIP ,LBS
-2.00000	-6.88103
-1.00000	-6.66926
-0.50000	-6.50779
-0.10000	-3.64897
-0.0500000	-2.50941
-1.00000E-02	-0.50188
-5.00000E-03	-0.25094
-1.00000E-03	-0.0501882
-1.00000E-04	-5.01882E-03
0.00000	0.00000
1.00000E-04	3747.15
1.00000E-03	37471.5
5.00000E-03	1.87357E+05
1.00000E-02	3.74715E+05
0.0500000	1.87357E+06
0.10000	2.72439E+06
0.50000	4.85884E+06
1.00000	4.97940E+06
2.00000	5.13751E+06

* TABLE I * TORS. MOM. VS ANGLE ROT.

TORQUE-ROTATION CURVES GENERATED INTERNALLY

NUM OF CURVES 1

CURVE 1 NUM OF POINTS 19

ROT. ANGLE,Rad.	TORS.MOMEN,LBS-IN
-3.02205	-1.14358E+07
-2.83574	-1.14427E+07
-2.78767	-1.16141E+07
-2.78317	-1.18807E+07
-2.78701	-1.19314E+07
-2.66983	-1.15463E+07
-2.53368	-1.10635E+07
-2.21714	-9.92254E+06
-1.69664	-7.96118E+06
0.00000	0.00000
1.69664	7.96118E+06
2.21714	9.92254E+06
2.53368	1.10635E+07
2.66983	1.15463E+07
2.78701	1.19314E+07
2.78317	1.18807E+07
2.78767	1.16141E+07

2.83574	1.14427E+07
3.02205	1.14358E+07

* TABLE K * REDUCTION FACTORS

AVERAGE DIAMETER IS USED TO GET RATIO S/B

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS ALONG Y-DIRECTION
ESTIMATED ASSUMING MOVEMENT IN THE DIRECTION OF Y-FORCE (+)

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	1.0000	1.0000
3	1.0000	1.0000
4	1.0000	1.0000
5	1.0000	1.0000
6	1.0000	1.0000
7	1.0000	1.0000

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS ALONG Z-DIRECTION
ESTIMATED ASSUMING MOVEMENT IN THE DIRECTION OF Z-FORCE (+)

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	0.8903	1.0000
3	0.8903	1.0000
4	0.8903	1.0000
5	1.0000	1.0000
6	1.0000	1.0000
7	1.0000	1.0000

```
     ======================================================================

                    GROUP for Windows, Version 2022.12.4

                     Serial Number : 546958378

                     Analysis of A Group of Piles
                   Subjected to Axial and Lateral Loading

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     ======================================================================


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     Path to file locations      : J:\094184.100-MassDOT Armory Street Bridges, Springfield\Calculations\Axial-Lateral Pile Analysis\S-24-026\Updated
Gravity Block 3 and 4\Group\
     Name of input data file     : Thrust Block Location 4.gp12d
     Name of output echo file    : Thrust Block Location 4.gp12e
     Name of output results file : Thrust Block Location 4.gp12o
     Name of output summary file : Thrust Block Location 4.gp12t
     Name of plot output file    : Thrust Block Location 4.gp12p
     Name of runtime file        : Thrust Block Location 4.gp12r


     ----------------------------------------------------------------------
                         Time and Date of Analysis
     ----------------------------------------------------------------------

               Date:  March 05, 2025     Time:  08:53:34



                *****     COMPUTATION RESULTS     *****


     94184.100 - Armory Street - Thrust Block Location 4



                *****     LOAD CASES RESULTS      *****


     LOAD CASE :     1
     CASE NAME : Service I
     LOAD TYPE : Dead, DL

       REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
       ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

            GROUP NO     P-FACTOR     Y-FACTOR

                1           1.0000       1.0000
                2           1.0000       1.0000
                3           1.0000       1.0000
                4           1.0000       1.0000
                5           1.0000       1.0000
                6           1.0000       1.0000
                7           1.0000       1.0000


     * TABLE L *   COMPUTATION ON PILE CAP


     * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *


          VERT. LOAD, LBS    HOR. LOAD Y, LBS   HOR. LOAD Z, LBS
            3.91660E+05        1.43600E+05            0.00000

         MOMENT X ,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
            2.34745E+05       -9.89800E+05       -7.28172E+06


     * DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *


           VERTICAL ,IN      HORIZONTAL Y,IN     HORIZONTAL Z,IN
              0.0247591            0.47223       -8.85280E-04

         ANGLE ROT. X,RAD    ANGLE ROT. Y,RAD    ANGLE ROT. Z,RAD
```

```
       1.32160E-04       -1.79888E-05       -1.45640E-04


    NUMBER OF GLOBAL ITERATIONS =    4


LOAD CASE :     2
CASE NAME : Strength I (Max)
LOAD TYPE : Dead, DL

  REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
  ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

      GROUP NO     P-FACTOR     Y-FACTOR

          1           1.0000       1.0000
          2           1.0000       1.0000
          3           1.0000       1.0000
          4           1.0000       1.0000
          5           1.0000       1.0000
          6           1.0000       1.0000
          7           1.0000       1.0000


* TABLE L *   COMPUTATION ON PILE CAP


* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *


     VERT. LOAD, LBS    HOR. LOAD Y, LBS   HOR. LOAD Z, LBS
       5.07730E+05        1.91200E+05            0.00000

    MOMENT X ,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
       3.28514E+05       -3.57044E+06       -9.31656E+06


* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *


      VERTICAL ,IN      HORIZONTAL Y,IN     HORIZONTAL Z,IN
         0.0334698            0.70971       -1.85318E-03

    ANGLE ROT. X,RAD    ANGLE ROT. Y,RAD    ANGLE ROT. Z,RAD
       2.79353E-04       -7.06149E-05       -2.02013E-04


    NUMBER OF GLOBAL ITERATIONS =    5


LOAD CASE :     3
CASE NAME : Strength I (Min)
LOAD TYPE : Dead, DL

  REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
  ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

      GROUP NO     P-FACTOR     Y-FACTOR

          1           1.0000       1.0000
          2           1.0000       1.0000
          3           1.0000       1.0000
          4           1.0000       1.0000
          5           1.0000       1.0000
          6           1.0000       1.0000
          7           1.0000       1.0000


* TABLE L *   COMPUTATION ON PILE CAP


* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *


     VERT. LOAD, LBS    HOR. LOAD Y, LBS   HOR. LOAD Z, LBS
       3.70640E+05        1.29230E+05            0.00000

    MOMENT X ,LBS-IN    MOMENT Y,LBS-IN    MOMENT Z,LBS-IN
       2.10360E+05       -4.95287E+06       -6.06252E+06


* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *


      VERTICAL ,IN      HORIZONTAL Y,IN     HORIZONTAL Z,IN
         0.0235317            0.41862       -8.70625E-04
```

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
1.29215E-04	-8.88194E-05	-1.10086E-04

NUMBER OF GLOBAL ITERATIONS = 4

LOAD CASE : 4
CASE NAME : Extreme I (50%+100%PAE)
LOAD TYPE : Dead, DL

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	1.0000	1.0000
3	1.0000	1.0000
4	1.0000	1.0000
5	1.0000	1.0000
6	1.0000	1.0000
7	1.0000	1.0000

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD, LBS	HOR. LOAD Y, LBS	HOR. LOAD Z, LBS
3.91660E+05	1.67700E+05	0.00000

MOMENT X ,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
2.34114E+05	-9.89800E+05	-5.97408E+06

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0249242	0.58346	-1.06183E-03

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
1.57548E-04	-1.79372E-05	-1.04374E-04

NUMBER OF GLOBAL ITERATIONS = 5

LOAD CASE : 5
CASE NAME : Extreme I (100%+50%PAE)
LOAD TYPE : Dead, DL

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	1.0000	1.0000
3	1.0000	1.0000
4	1.0000	1.0000
5	1.0000	1.0000
6	1.0000	1.0000
7	1.0000	1.0000

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD, LBS	HOR. LOAD Y, LBS	HOR. LOAD Z, LBS
3.91660E+05	1.90030E+05	0.00000

MOMENT X ,LBS-IN	MOMENT Y,LBS-IN	MOMENT Z,LBS-IN
-2.14396E+05	-9.89800E+05	-4.70532E+06

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0251143	0.69509	1.07460E-03

```
ANGLE ROT. X,RAD    ANGLE ROT. Y,RAD    ANGLE ROT. Z,RAD
  -1.58411E-04        -1.79533E-05        -6.43120E-05

NUMBER OF GLOBAL ITERATIONS =    5
```

APPENDIX E.7 – Earth Pressure for Proposed Pile Caps

Project No.:	94184.00	**Page:**	1 of 1
Project Title:	Armory Street over CSX Mainline		
Calculated by:	SAK	**Date**:	02/05/2021
Checked by:	BTW	**Date**:	02/08/2021

Earth Pressure Coefficients

Objective: Estimate earth pressure coefficients for the proposed pile caps for the Armory Street bridge over the active CSX mainline.

Approach: Determine design earth pressure coefficients in accordance with MassDOT LRFD Bridge Manual.

References:
1. Topographic Survey (AutoCAD) provided by Tetra Tech.
2. MassDOT LRFD Bridge Manual, 2020.
3. Principles of Foundation Engineering, Second Edition, Das
4. AASHTO Bridge Design Specifications, 9th Edition, 2020.

Assumptions:
1. Retained soil is granular with an effective friction angle of 33°

At-Rest Earth Pressure

$K_o = 1 - \sin(\phi)$

K_o = 0.46 Effective friction angle of soil: $\phi = 33°$

Design Earth Pressures (from MassDOT LRFD Bridge Manual, Section 3.1.6)

Earth Pressure Coefficient = K_o

Earth Pressure Coefficient = 0.46 **(Use for proposed pile caps)**

APPENDIX E.8 – Bearing Resistance, Global Stability, and Settlement for Existing and Proposed Retaining Walls

Armory Street over Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 94184.100

Calculated by: SAK Date: 11/13/2023
Checked by: KJ Date: 11/27/2023

Bearing Resistance Calculations - Existing Gravity Wall #5 @ STA 15+50

Bottom of Wall @ El. 149

Objective: Evaluate bearing resistance for the existing gravity Retaining Wall 5 that is located along the east side of Armory Street in Springfield, Massachusetts.

References:
1) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
2) Subsurface explorations observed by Nobis in 2019 and 2022.
3) Grading Plans and Cross Sections provided by Tetra Tech in October 2023.
4) A Topographic Survey provided in AutoCAD format by Tetra Tech on November 29, 2018.
5) A plan entitled "Approaches to Armory Street Bridge over New York, New Haven, and Hartford Railroad" dated September 1934, and provided to Nobis by Tetra Tech.

Assumptions:
1) Soil and groundwater conditions encountered in Reference No. 2 are representative of subsurface conditions at the site.
2) Soil conditions encountered in borings closest to Station 15+50 (BB-2, WB-1) were used to estimate the bearing resistance.
3) Cross-section 15+50 was used to estimate the bearing resistance.

Solution:

Bearing Soil Properties/Subsurface Information

Unit Weight of Bearing Soil (γ):	115	pcf	Estimated, Reference No. 2
Unit Weight of Soil Above Footing (γ):	115	pcf	Estimated, Reference No. 2
Cohesion of Bearing Soil (c):	0	psf	Estimated, Reference No. 2
Friction Angle of Bearing Soil (ϕ'):	33	degrees	Estimated, Reference No. 2

Soil Description: Bearing on existing embankment fill.

Footing Elevation:	149	ft, NAVD-88	Reference No. 5
Ground Surface (GS) Elevation:	152.6	ft, NAVD-88	Reference No. 3
Groundwater Elevation:	131	ft, NAVD-88	Estimated based on Reference No. 2 (Design Groundwater Elevation)

Footing Geometry

Footing Embedment Depth (D_f):	3.6	ft	Calculated
Groundwater Depth Below GS (D_w):	21.6	ft	Calculated
Width (B):	4.6	ft	Reference No. 5
Length (L):	159	ft	Reference No. 5
Width Eccentricity (e_B):	0.77	ft	See note 1
Length Eccentricity (e_L):	0	ft	Assumed
Effective Width (B'):	3.07	ft	Calculated
Effective Length (L'):	159	ft	Calculated

Notes:
1) Width eccentricity (eB) is assumed to be B/6.
2) Bearing resistance calculation can be found on page 4.

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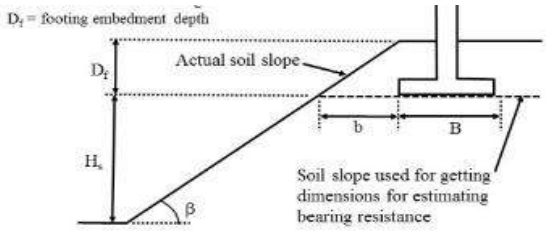
Armory Street over Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 94184.100
Page: 2 of 10

Calculated by: SAK Date: 11/13/2023
Checked by: KJ Date: 11/27/2023

Bearing Resistance Calculations - Existing Gravity Wall #5 @ STA 15+50

Bottom of Wall @ El. 149

Friction Angle =	33	deg.	(phi)
Footing Width =	3.1	ft	(B')
Slope to footing distance =	6.8	ft	(b)
Slope Height =	9.7	ft	(H)
Slope Angle =	40	deg.	(Beta)



phi	B/H	b/B	Beta
33	0.3162	2.2174	40.0

Interpolation

Beta	b/B	B/H	phi
40.0	2.2174	0.31615	33
1	0.7739	0.38717	0.3
OK	OK	OK	OK

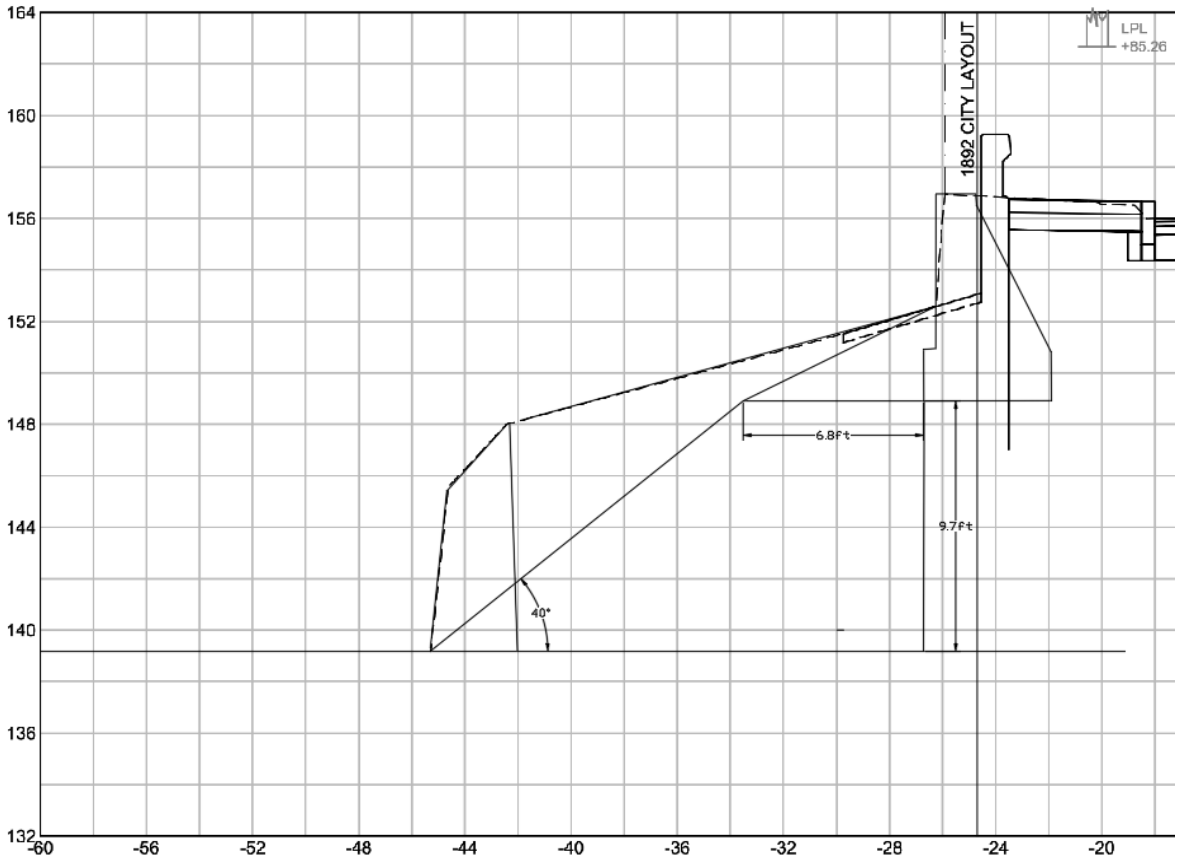
phi	B/H	b/B	Beta	Table				
30	0.2	1.25	30	0.38				
			40	0.00	0			
		2.5	30	0.74		0		
			40	0.00	0			
	0.5	1.25	30	0.45			0.000	
			40	0.00	0			
		2.5	30	0.80		0		
			40	0.00	0			**0.117**
40	0.2	1.25	30	0.39				
			40	0.25	0.25			
		2.5	30	0.62		0.428		
			40	0.48	0.48			
	0.5	1.25	30	0.40			0.389	
			40	0.18	0.18			
		2.5	30	0.60		0.327		
			40	0.37	0.37			

Reduction Factor = 0.117

Armory Street over Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 94184.100
Page: 3 of 10

Calculated by: SAK Date: 11/13/2023
Checked by: KJ Date: 11/27/2023

Bearing Resistance Calculations - Existing Gravity Wall #5 @ STA 15+50
Bottom of Wall @ El. 149



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Armory Street over Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 94184.100
Page: 4 of 10

Calculated by: SAK Date: 11/13/2023
Checked by: KJ Date: 11/27/2023

Bearing Resistance Calculations - Existing Gravity Wall #5 @ STA 15+50

Bottom of Wall @ El. 149

Factored Bearing Resistance: $q_R = q_n * \phi_b$		Eq. 10.6.3.1.1-1
Resistance Factor (ϕ_b) =	0.55	Tb. 10.5.5.2.2-1 or 11.5.7-1
Nominal Resistance (q_n) =		
$q_{n\text{-sloping-ground}} = RC_{BN}*(c*N_{cm} + 0.5*\gamma*B'*N_{\gamma m}*C_{w\gamma})$		Eq. 10.6.3.1.2c-1
$N_{cm} = N_c*s_c*i_c$		Eq. 10.6.3.1.2a-2
Bearing Capacity Factor (N_c)	38.6	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_c)	1.00	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_c)	1.00	Assumed or Eq. 10.6.3.1.2a-5 or -6
N_{cm} =	38.60	
$N_{\gamma m} = N_\gamma*s_\gamma*i_\gamma$		Eq. 10.6.3.1.2a-4
Bearing Capacity Factor (N_γ or $N_{\gamma q}$)	35.2	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_γ)	0.99	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_γ)	1.00	Assumed or Eq. 10.6.3.1.2a-8 and -9
$N_{\gamma m}$=	34.93	
Groundwater Coefficients		
C_{wq} =	1.00	Tb. 10.6.3.1.2a-2
$C_{w\gamma}$ =	1.00	Tb. 10.6.3.1.2a-2
Nominal Bearing Resistance, q_n=	6.2 ksf	
Slope Reduction Coefficient, RC_{BC}=	0.117	Calculation and Tb. 10.6.3.1.2c-2
Nominal Bearing Resistance, $q_{n\text{-sloping-ground}}$=	0.7 ksf	q_n*RC_{BC}
Factored Geotechnical Bearing Resistance, q_R=	**0.4 ksf**	φ_b * $q_{n\text{-sloping ground}}$

$$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma \quad BN_{\gamma m} C_{w\gamma} \qquad (10.6.3.1.2a\text{-}1)$$

$$N_{cm} = N_c s_c i_c \qquad (10.6.3.1.2a\text{-}2)$$

$$N_{qm} = N_q s_q d_q i_q \qquad (10.6.3.1.2a\text{-}3)$$

$$N_\gamma m = N_\gamma s_\gamma i_\gamma \qquad (10.6.3.1.2a\text{-}4)$$

c	=	cohesion, taken as undrained shear strength (ksf)
N_c	=	cohesion term (undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)
N_q	=	surcharge (embedment) term (drained or undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)
N_γ	=	unit weight (footing width) term (drained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)
γ	=	total (moist) unit weight of soil above or below the bearing depth of the footing (kcf)
D_f	=	footing embedment depth (ft)
B	=	footing width (ft)
$C_{wq}, C_{w\gamma}$	=	correction factors to account for the location of the groundwater table as specified in Table 10.6.3.1.2a-2 (dim)
s_c, s_γ, s_q	=	footing shape correction factors as specified in Table 10.6.3.1.2a-3 (dim)
d_q	=	correction factor to account for the shearing resistance along the failure surface passing through cohesionless material above the bearing elevation as specified in Table 10.6.3.1.2a-4 (dim)
i_c, i_γ, i_q	=	load inclination factors determined from Eqs. 10.6.3.1.2a-5 or 10.6.3.1.2a-6, and 10.6.3.1.2a-7 and 10.6.3.1.2a-8 (dim)

Table 10.6.3.1.2a-4—Depth Correction Factor d_q

Friction Angle, ϕ_f (degrees)	D_f/B	d_q
32	1	1.20
	2	1.30
	4	1.35
	8	1.40
37	1	1.20
	2	1.25
	4	1.30
	8	1.35
42	1	1.15
	2	1.20
	4	1.25
	8	1.30

For $\phi_f = 0$:

$$i_c = 1 - (mH/cBLN_c) \qquad (10.6.3.1.2a\text{-}5)$$

For $\phi_f > 0$:

$$i_c = i_q - [(1 - i_q)/(N_q - 1)] \qquad (10.6.3.1.2a\text{-}6)$$

in which:

$$i_q = \left[1 - \frac{H}{(V + cBL\cot\phi_f)}\right]^n \qquad (10.6.3.1.2a\text{-}7)$$

$$i_\gamma = \left[1 - \frac{H}{V + cBL\cot\phi_f)}\right]^{(n+1)} \qquad (10.6.3.1.2a\text{-}8)$$

Table 10.6.3.1.2a-3—Shape Correction Factors s_c, s_γ, s_q

Factor	Friction Angle	Cohesion Term (s_c)	Unit Weight Term (s_γ)	Surcharge Term (s_q)
Shape Factors s_c, s_γ, s_q	$\phi_f = 0$	$1 + \left(\frac{B}{5L}\right)$	1.0	1.0
	$\phi_f > 0$	$1 + \left(\frac{B}{L}\right)\left(\frac{N_q}{N_c}\right)$	$1 - 0.4\left(\frac{B}{L}\right)$	$1 + \left(\frac{B}{L}\tan\phi_f\right)$

Table 10.6.3.1.2a-1—Bearing Capacity Factors N_c (Prandtl, 1921), N_q (Reissner, 1924), and N_γ (Vesic, 1975)

ϕ_f	N_c	N_q	N_γ	ϕ_f	N_c	N_q	N_γ
0	5.14	1.0	0.0	23	18.1	8.7	8.2
1	5.4	1.1	0.1	24	19.3	9.6	9.4
2	5.6	1.2	0.2	25	20.7	10.7	10.9
3	5.9	1.3	0.2	26	22.3	11.9	12.5
4	6.2	1.4	0.3	27	23.9	13.2	14.5
5	6.5	1.6	0.5	28	25.8	14.7	16.7
6	6.8	1.7	0.6	29	27.9	16.4	19.3
7	7.2	1.9	0.7	30	30.1	18.4	22.4
8	7.5	2.1	0.9	31	32.7	20.6	26.0
9	7.9	2.3	1.0	32	35.5	23.2	30.2
10	8.4	2.5	1.2	33	38.6	26.1	35.2
11	8.8	2.7	1.4	34	42.2	29.4	41.1
12	9.3	3.0	1.7	35	46.1	33.3	48.0
13	9.8	3.3	2.0	36	50.6	37.8	56.3
14	10.4	3.6	2.3	37	55.6	42.9	66.2
15	11.0	3.9	2.7	38	61.4	48.9	78.0
16	11.6	4.3	3.1	39	67.9	56.0	92.3
17	12.3	4.8	3.5	40	75.3	64.2	109.4
18	13.1	5.3	4.1	41	83.9	73.9	130.2
19	13.9	5.8	4.7	42	93.7	85.4	155.6
20	14.8	6.4	5.4	43	105.1	99.0	186.5
21	15.8	7.1	6.2	44	118.4	115.3	224.6
22	16.9	7.8	7.1	45	133.9	134.9	271.8

Table 10.6.3.1.2a-2—Coefficients C_{wq} and $C_{w\gamma}$ for Various Groundwater Depths

D_w	C_{wq}	$C_{w\gamma}$
0.0	0.5	0.5
D_f	1.0	0.5
$>1.5B + D_f$	1.0	1.0

Table 10.5.5.2.2-1—Resistance Factors for Geotechnical Resistance of Shallow Foundations at the Strength Limit State

Method/Soil/Condition			Resistance Factor
Bearing Resistance	φ_b	Theoretical method (Munfakh et al., 2001), in clay	0.50
		Theoretical method (Munfakh et al., 2001), in sand, using *CPT*	0.50
		Theoretical method (Munfakh et al., 2001), in sand, using *SPT*	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footings on rock	0.45
		Plate Load Test	0.55
Sliding	φ_τ	Precast concrete placed on sand	0.90
		Cast-in-Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on Clay	0.85
		Soil on soil	0.90
	φ_{ep}	Passive earth pressure component of sliding resistance	0.50

Table 11.5.7-1—Strength Limit State Resistance Factors for Permanent Retaining Walls

Wall-Type and Condition		Resistance Factor
Nongravity Cantilevered and Anchored Walls		
Axial compressive resistance of vertical elements		Article 10.5 applies
Passive resistance of vertical elements		0.75
Pullout resistance of anchors [1]	• Cohesionless (granular) soils • Cohesive soils • Rock	0.65 [1] 0.70 [1] 0.50 [1]
Pullout resistance of anchors [2]	• Where proof tests are conducted	1.0 [2]
Tensile resistance of anchor tendon	• Mild steel (e.g., ASTM A615 bars) • High-strength steel (e.g., ASTM A722 bars)	0.90 [3] 0.80 [3]
Overall stability, soil failure		Article 11.6.3.7 applies
Flexural capacity of vertical elements		0.90
Mechanically Stabilized Earth Walls, Gravity Walls, and Semigravity Walls		
Bearing resistance	• Gravity and semigravity walls • MSE walls	0.55 0.65
Sliding		1.0
Tensile resistance of metallic reinforcement and connectors	Strip reinforcements [4] Grid reinforcements [4] [5]	0.75 0.65
Tensile resistance of geosynthetic reinforcement and connectors	• Geotextile and geogrid reinforcements • Geostrip reinforcements	0.80 0.55
Pullout resistance of metallic reinforcement Pullout resistance of geosynthetic reinforcement	• Steel strip reinforcements • Steel grid reinforcements • Geotextiles and geogrids • Geostrip reinforcements	0.90 0.90 0.70 0.70
Service Limit, for soil failure using stiffness method		1.0
Overall and compound stability, soil failure		Article 11.6.3.7 applies
Prefabricated Modular Walls		
Bearing		Article 10.5 applies
Sliding		Article 10.5 applies
Passive resistance		Article 10.5 applies
Overall stability, soil failure		Article 11.6.3.7 applies
Soil Nail Walls [6]		
Lateral sliding		1.00
Overall and Compound stability, soil failure		Article 11.6.3.7 applies
Tensile resistance of nail tendon	Mild steel bars (Grade 75) High resistance bars (Grades 95 and 150)	0.75 0.65
Pullout resistance of nail		0.65
Facing flexure	Initial and final facing	0.90
Facing punching shear	Initial and final facing	0.90
Tensile resistance of headed stud	A307 steel bolt [7] A325 steel bolt	0.70 0.80

(1) Apply to presumptive ultimate unit bond stresses for preliminary design only in Article C11.9.4.2.

10.6.3.1.2c—Considerations for Footings on Slopes

For footings constructed on or adjacent to slopes, the nominal bearing resistance shall be determined using a reduction coefficient (RC_{BC}) as presented in Tables 10.6.3.1.2c-1 and 10.6.3.1.2c-2. The reduction coefficient should be applied directly to the nominal bearing resistance calculated from Eq.10.6.3.1.2a-1 for footings on level ground and supported on the same foundation soil conditions.

The nominal resistance of footings on or adjacent to slopes shall be taken as:

$$q_{n-sloping\ ground} = RC_{BC} q_n = RC_{BC}\left(cN_c + 0.5\gamma BN_\gamma\right) \quad (10.6.3.1.2c\text{-}1)$$

where:

$q_{n\text{-}sloping\ ground}$ = the nominal footing bearing resistance considering the effect of sloping ground (ksf)
RC_{BC} = reduction coefficient for bearing resistance due to slope effects (dim)

and other variables are as defined in Article 10.6.3.1.2a and Figure 10.6.3.1.2c-1. The bearing capacity factors N_c and N_γ are obtained in accordance with Article 10.6.3.1.2a.

Reduction coefficients (RC_{BC}) should be determined using the definitions illustrated in Figure 10.6.3.1.2c-1

C10.6.3.1.2c

A rational approach for determining a modified bearing resistance for footings on or adjacent to a slope is presented in Leshchinsky (2015) and Leshchinsky and Xie (2016). These methods are considered valid and applicable to structure foundations in addition to the MSE retaining wall example presented in the reference papers. The reduction coefficients provided in Tables 10.6.3.1.2c-1 and 10.6.3.1.2c-2 are modified and reconfigured by the author of the cited papers to allow for more convenient use in practice. See the original papers for the complete tabulation of reduction coefficient values.

The reduction coefficients are applicable to purely cohesive, purely cohesionless and c-ϕ soils. The RC_{BC} factors are based on no footing embedment for footings either on or adjacent to slopes and may be conservative for deep footing embedment depths.

Limit analysis, or limit equilibrium analysis, should be considered to estimate the nominal bearing resistance of footings on or adjacent to slopes composed of soils and/or site conditions that are not consistent with the parameters and conditions described in the reference documents (i.e. embedment >0, layered soils, steeper slopes).

The schematic shown in Figure 10.6.3.1.2c-1 is provided only for illustrating and defining the terms used in the design equations and tables. This figure should not be used as the basis for locating footings on slopes regarding embedment depth and setback.

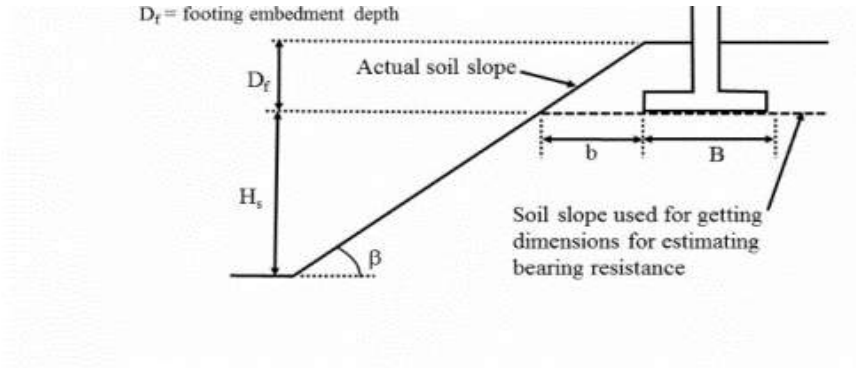


Figure 10.6.3.1.2c-1—Definition of Footing and Slope Geometric Parameters for Determination of RC_{BC}

Table 10.6.3.1.2c-2—Reduction Coefficients (RC_{BC}) for Footings Placed Adjacent to Slopes Composed of either Purely Cohesive Soils, ($\phi = 0$); Purely Cohesionless Soils ($c'=0$); or Soils with both Cohesive and Cohesionless Strength Components

			β=10°				β=20°				β=30°				β=40°			
			Ns				*Ns*				*Ns*				*Ns*			
φ (°)	***B/H***	***b/B***	**0**	**2**	**4**	***c'*=0**	**0**	**2**	**4**	***c'*=0**	**0**	**2**	**4**	***c'*=0**	**0**	**2**	**4**	***c'*=0**
0	0.2	0	0.89	0.88	0.88	0.00	0.89	0.87	0.86	0.00	0.82	0.81	0.78	0.00	0.76	0.73	0.69	0.00
		0.5	0.97	0.96	0.96	0.00	0.95	0.93	0.91	0.00	0.92	0.89	0.87	0.00	0.86	0.83	0.76	0.00
		1.25	1.00	0.99	0.98	0.00	1.00	0.98	0.96	0.00	1.00	0.97	0.95	0.00	0.95	0.91	0.81	0.00
		2.5	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	0.97	0.84	0.00
		5	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	0.89	0.00
		10	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
	0.5	0	0.92	0.91	0.88	0.00	0.85	0.82	0.76	0.00	0.77	0.73	0.63	0.00	0.71	0.65	0.52	0.00
		0.5	0.96	0.95	0.89	0.00	0.92	0.89	0.78	0.00	0.87	0.84	0.68	0.00	0.83	0.76	0.56	0.00
		1.25	0.98	0.97	0.90	0.00	0.96	0.94	0.80	0.00	0.94	0.92	0.71	0.00	0.90	0.83	0.58	0.00
		2.5	1.00	1.00	1.00	0.00	1.00	1.00	0.86	0.00	1.00	1.00	0.79	0.00	1.00	0.93	0.68	0.00
		5	1.00	1.00	1.00	0.00	1.00	1.00	0.95	0.00	1.00	1.00	0.93	0.00	1.00	1.00	0.88	0.00
		10	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
	1	0	0.87	0.84	0.75	0.00	0.87	0.79	0.56	0.00	0.80	0.66	0.42	0.00	0.73	0.56	0.33	0.00
		0.5	0.95	0.91	0.82	0.00	0.92	0.83	0.65	0.00	0.86	0.73	0.46	0.00	0.81	0.67	0.40	0.00
		1.25	0.97	0.94	0.83	0.00	0.95	0.87	0.67	0.00	0.92	0.81	0.50	0.00	0.89	0.76	0.46	0.00
		2.5	1.00	0.98	0.88	0.00	1.00	0.97	0.77	0.00	1.00	1.00	0.84	0.00	0.99	0.92	0.63	0.00
		5	1.00	1.00	0.95	0.00	1.00	1.00	0.90	0.00	1.00	1.00	0.84	0.00	1.00	1.00	0.83	0.00
		10	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
	2	0	0.87	0.79	0.57	0.00	0.87	0.71	0.44	0.00	0.81	0.62	0.35	0.00	0.75	0.56	0.29	0.00
		0.5	0.97	0.93	0.65	0.00	0.94	0.79	0.49	0.00	0.89	0.72	0.42	0.00	0.85	0.69	0.37	0.00
		1.25	0.99	0.98	0.73	0.00	0.99	0.91	0.57	0.00	0.98	0.86	0.51	0.00	0.96	0.83	0.47	0.00
		2.5	1.00	0.99	0.82	0.00	1.00	0.96	0.69	0.00	1.00	0.95	0.64	0.00	1.00	0.95	0.61	0.00
		5	1.00	1.00	0.96	0.00	1.00	1.00	0.87	0.00	1.00	1.00	0.84	0.00	1.00	1.00	0.81	0.00
		10	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
20	0.2	0	0.90	0.89	0.90	0.68	0.75	0.73	0.72	0.21	0.62	0.59	0.56	0.00	0.52	0.49	0.45	0.00
		0.5	0.78	0.87	0.86	0.70	0.74	0.76	0.74	0.40	0.63	0.65	0.63	0.00	0.52	0.56	0.52	0.00
		1.25	0.86	0.92	0.92	0.82	0.83	0.84	0.83	0.70	0.74	0.75	0.74	0.00	0.63	0.66	0.63	0.00
		2.5	0.96	0.98	0.99	0.83	0.95	0.94	0.95	0.84	0.90	0.89	0.90	0.00	0.78	0.81	0.78	0.00
		5	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	0.96	0.98	0.96	0.00
		10	1.00	1.00	1.00	0.84	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	0.99	0.99	1.00	0.00
	0.5	0	0.86	0.86	0.84	0.60	0.73	0.70	0.67	0.22	0.62	0.56	0.51	0.00	0.52	0.45	0.39	0.00
		0.5	0.84	0.91	0.92	0.71	0.80	0.80	0.79	0.40	0.70	0.68	0.67	0.00	0.62	0.59	0.56	0.00
		1.25	0.88	1.00	0.97	0.82	0.85	0.88	0.86	0.70	0.76	0.75	0.75	0.00	0.68	0.66	0.64	0.00
		2.5	0.97	1.00	1.00	0.81	0.95	0.97	0.98	0.84	0.90	0.94	0.96	0.00	0.84	0.86	0.87	0.00
		5	1.00	1.00	1.00	0.84	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
		10	1.00	1.00	1.00	0.84	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
	1	0	0.85	0.82	0.78	0.58	0.72	0.64	0.58	0.26	0.61	0.50	0.42	0.00	0.52	0.39	0.30	0.00
		0.5	0.84	0.91	0.91	0.71	0.81	0.80	0.79	0.46	0.70	0.69	0.67	0.00	0.64	0.62	0.60	0.00
		1.25	0.87	0.95	0.96	0.82	0.85	0.85	0.85	0.73	0.76	0.76	0.75	0.00	0.71	0.70	0.69	0.00
		2.5	0.97	1.00	1.00	0.82	0.95	0.97	0.98	0.83	0.90	0.94	0.97	0.00	0.86	0.89	0.91	0.00
		5	1.00	1.00	1.00	0.83	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
		10	1.00	1.00	1.00	0.83	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
	2	0	0.90	0.90	0.90	0.58	0.87	0.86	0.84	0.33	0.84	0.81	0.78	0.00	0.81	0.77	0.74	0.00
		0.5	0.90	0.93	0.93	0.70	0.88	0.88	0.87	0.54	0.84	0.83	0.81	0.00	0.84	0.82	0.81	0.00
		1.25	0.92	0.97	0.99	0.81	0.90	0.92	0.92	0.77	0.86	0.86	0.86	0.00	0.85	0.85	0.84	0.00
		2.5	0.98	1.00	1.00	0.81	0.97	0.98	1.00	0.81	0.93	0.97	1.00	0.00	0.92	0.96	0.99	0.00
		5	1.00	1.00	1.00	0.82	1.00	1.00	1.00	0.84	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
		10	1.00	1.00	1.00	0.82	1.00	1.00	1.00	0.84	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00

Table 10.6.3.1.2c-2 (cont.)

			β=10°				β=20°				β=30°				β=40°			
			Ns				Ns				Ns				Ns			
ϕ (°)	B/H	b/B	0	2	4	c'=0	0	2	4	c'=0	0	2	4	c'=0	0	2	4	c'=0
30	0.2	0	0.93	0.92	0.91	0.76	0.65	0.64	0.63	0.39	0.51	0.50	0.48	0.11	0.40	0.37	0.36	0.00
		0.5	0.74	0.81	0.80	0.75	0.70	0.66	0.65	0.50	0.57	0.52	0.49	0.21	0.47	0.42	0.39	0.00
		1.25	0.78	0.85	0.86	0.86	0.74	0.73	0.72	0.72	0.63	0.60	0.59	0.38	0.54	0.50	0.47	0.00
		2.5	0.84	0.92	0.93	0.99	0.81	0.82	0.83	0.94	0.72	0.73	0.74	0.74	0.64	0.62	0.61	0.00
		5	0.95	1.00	1.00	1.00	0.93	0.98	1.00	1.00	0.88	0.95	1.00	0.97	0.80	0.85	0.87	0.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
	0.5	0	0.79	0.79	0.78	0.70	0.63	0.59	0.55	0.36	0.50	0.43	0.39	0.13	0.39	0.32	0.27	0.00
		0.5	0.76	0.87	0.87	0.74	0.72	0.71	0.70	0.51	0.58	0.56	0.54	0.24	0.49	0.46	0.43	0.00
		1.25	0.79	0.85	0.92	0.87	0.75	0.73	0.76	0.72	0.63	0.62	0.61	0.45	0.54	0.52	0.50	0.00
		2.5	0.87	0.91	1.00	0.99	0.84	0.85	0.90	0.98	0.74	0.78	0.80	0.80	0.67	0.70	0.71	0.00
		5	0.97	1.00	1.00	1.00	0.95	1.00	1.00	1.00	0.90	1.00	1.00	1.00	0.85	0.94	0.98	0.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
	1	0	0.79	0.75	0.73	0.67	0.63	0.53	0.49	0.41	0.55	0.41	0.35	0.24	0.48	0.33	0.26	0.00
		0.5	0.78	0.87	0.89	0.74	0.75	0.74	0.74	0.51	0.64	0.62	0.60	0.35	0.59	0.56	0.54	0.00
		1.25	0.81	0.90	0.91	0.88	0.78	0.78	0.78	0.72	0.68	0.67	0.66	0.58	0.64	0.62	0.61	0.00
		2.5	0.88	0.99	1.00	0.96	0.85	0.90	0.92	0.95	0.78	0.81	0.84	0.88	0.75	0.78	0.80	0.00
		5	0.97	1.00	1.00	1.00	0.96	1.00	1.00	1.00	0.92	1.00	1.00	1.00	0.89	0.98	1.00	0.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
	2	0	0.88	0.88	0.87	0.65	0.87	0.85	0.83	0.48	0.85	0.82	0.80	0.38	0.83	0.80	0.76	0.00
		0.5	0.89	0.91	0.91	0.75	0.89	0.89	0.87	0.58	0.88	0.86	0.84	0.51	0.87	0.85	0.82	0.00
		1.25	0.90	0.92	0.93	0.88	0.90	0.90	0.90	0.75	0.89	0.87	0.87	0.70	0.89	0.87	0.86	0.00
		2.5	0.97	1.00	1.00	1.00	0.96	0.97	0.98	0.98	0.92	0.94	0.96	0.95	0.91	0.92	0.94	0.00
		5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
40	0.2	0	0.69	0.69	0.69	0.78	0.51	0.48	0.47	0.37	0.37	0.33	0.30	0.16	0.27	0.23	0.20	0.05
		0.5	0.65	0.73	0.71	0.74	0.60	0.55	0.53	0.38	0.64	0.38	0.35	0.25	0.34	0.29	0.25	0.13
		1.25	0.68	0.77	0.75	0.86	0.63	0.60	0.58	0.55	0.74	0.44	0.42	0.39	0.39	0.34	0.31	0.25
		2.5	0.72	0.83	0.84	1.00	0.68	0.68	0.68	0.76	0.87	0.53	0.53	0.62	0.45	0.43	0.41	0.48
		5	0.80	0.93	0.95	1.00	0.76	0.82	0.85	1.00	1.00	0.72	0.76	1.00	0.57	0.61	0.63	0.94
		10	0.94	1.00	1.00	1.00	0.91	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.76	0.93	1.00	1.00
	0.5	0	0.67	0.69	0.67	0.69	0.50	0.45	0.43	0.35	0.36	0.30	0.26	0.17	0.27	0.20	0.17	0.07
		0.5	0.68	0.81	0.81	0.73	0.63	0.62	0.61	0.46	0.47	0.44	0.41	0.25	0.39	0.35	0.32	0.09
		1.25	0.70	0.82	0.84	0.85	0.65	0.65	0.66	0.60	0.51	0.49	0.47	0.40	0.43	0.41	0.39	0.18
		2.5	0.76	0.92	0.96	1.00	0.72	0.77	0.80	0.81	0.59	0.62	0.63	0.60	0.54	0.56	0.56	0.37
		5	0.84	1.00	1.00	1.00	0.81	0.91	0.94	1.00	0.71	0.82	0.88	1.00	0.67	0.77	0.83	0.84
		10	0.96	1.00	1.00	1.00	0.94	1.00	1.00	1.00	0.89	1.00	1.00	1.00	0.86	1.00	1.00	1.00
	1	0	0.69	0.64	0.62	0.70	0.63	0.48	0.43	0.45	0.58	0.39	0.33	0.32	0.54	0.33	0.27	0.24
		0.5	0.77	0.81	0.82	0.74	0.75	0.73	0.72	0.49	0.71	0.66	0.62	0.38	0.68	0.62	0.57	0.30
		1.25	0.78	0.84	0.85	0.84	0.77	0.76	0.75	0.64	0.73	0.69	0.66	0.55	0.71	0.66	0.63	0.48
		2.5	0.83	0.92	0.95	1.00	0.81	0.85	0.87	0.85	0.76	0.78	0.79	0.76	0.75	0.76	0.77	0.72
		5	0.89	1.00	1.00	1.00	0.87	0.95	0.98	1.00	0.80	0.90	0.95	1.00	0.80	0.89	0.94	1.00
		10	0.98	1.00	1.00	1.00	0.97	1.00	1.00	1.00	0.94	1.00	1.00	1.00	0.93	1.00	1.00	1.00
	2	0	0.93	0.92	0.89	0.45	0.92	0.90	0.87	0.60	0.91	0.88	0.84	0.53	0.89	0.85	0.81	0.47
		0.5	0.93	0.95	0.93	0.76	0.93	0.92	0.90	0.65	0.92	0.89	0.87	0.64	0.92	0.89	0.86	0.60
		1.25	0.93	0.95	0.94	0.86	0.93	0.93	0.92	0.78	0.93	0.91	0.89	0.74	0.93	0.90	0.88	0.74
		2.5	0.94	0.99	1.00	1.00	0.94	0.98	0.98	0.92	0.94	0.97	0.97	0.87	0.94	0.96	0.96	0.88
		5	0.95	1.00	1.00	1.00	0.96	1.00	1.00	1.00	0.98	1.00	1.00	1.00	0.96	1.00	1.00	1.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00

Armory Street Over Abandoned CSX Spur
Bridge No. S-24-026
Springfield, Massachusetts

Discipline: Geotechnical

Title: Global Stability Analysis for the Existing Wall #5

MassDOT Contract No. 115769

MassDOT Project File No. 609409

Design Basis/Assumptions:

Purpose: Perform global stability analyses on the existing gravity retaining wall designated Wall #5.

Assumptions:

1) Engineering properties for existing fill, reworked silt and clay, varved silt and clay, silt, glacial till, and bedrock encountered in the subsurface explorations (Reference 3).
2) Groundwater conditions are the same or similar to those observed in the subsurface explorations by Nobis.
3) Surcharge loading of 250 psf (Reference 4).
4) Seismic loading 0.074g (A_s x 0.5 = 0.148 x 0.5) (Reference 5).

Approach:

Use the computer slope stability analysis software Slide2, by RocScience, Inc., to perform global stability analyses on the existing retaining wall based on the results of the subsurface explorations performed by Nobis and information obtained from an AutoCAD drawing provided by Tetra Tech (Reference 1) and historic drawings showing retaining wall 5 (Reference 2).

References:

1) Topographic Survey and Bridge Plans and Profile (AutoCAD) drawing prepared by Tetra Tech, Inc. and provided to Nobis in June and October 2022.
2) A plan entitled "Approaches to Armory Street Bridge over New York, New Haven, and Hartford Railroad" dated September 1934, and provided to Nobis by Tetra Tech.
3) Standard Penetration Test (SPT) data and subsurface explorations observed by Nobis in 2019 and 2022 (BB-2 and WB-1).
4) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
5) Seismic site classification and seismic parameters developed by Nobis.

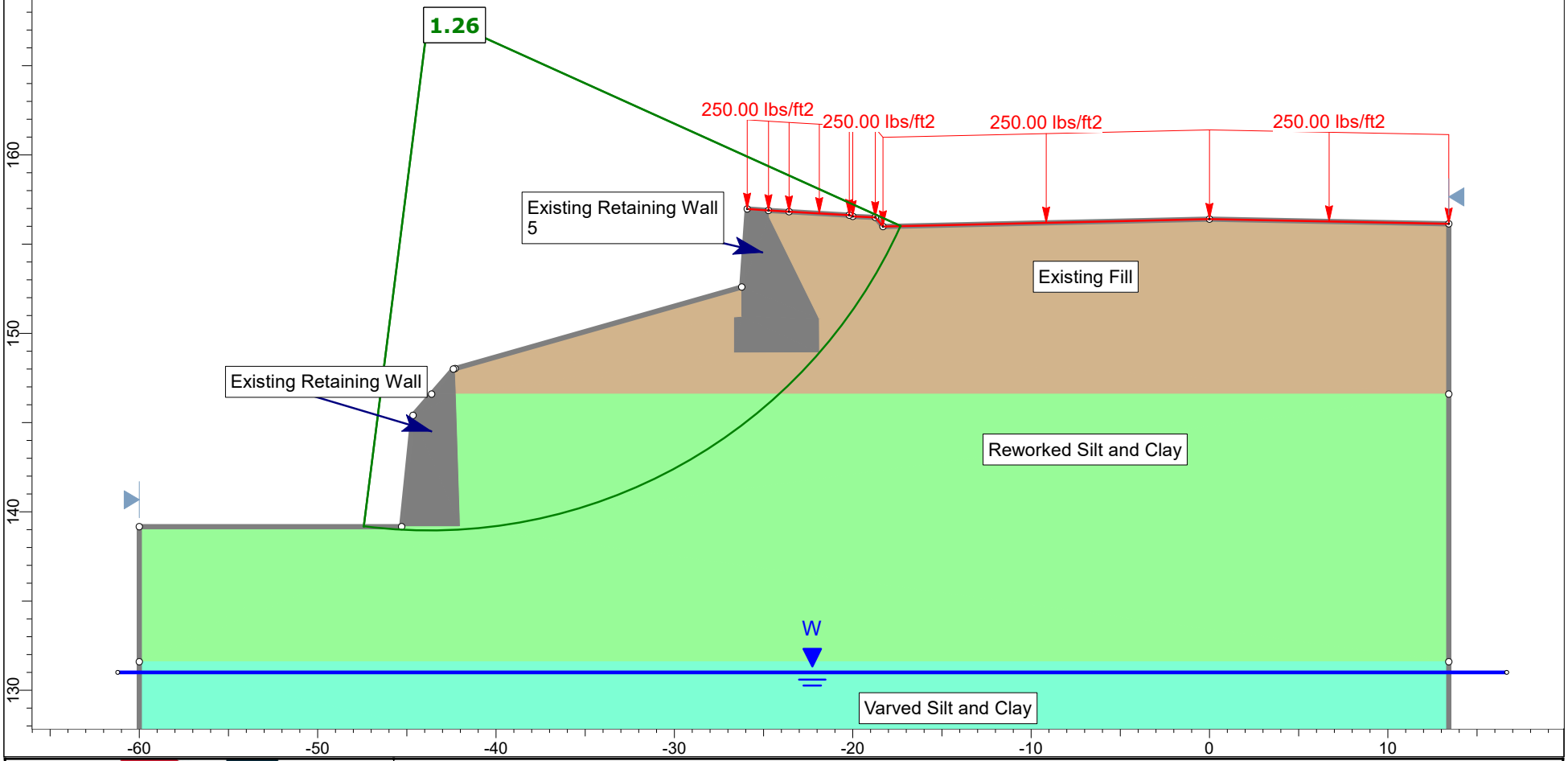
Remarks/Conclusions:

The minimum required FOS for global stability is at least 1.3 and 1.1 under static and seismic conditions, respectively, for the existing retaining wall. Based on the Slide2 analysis, the minimum factor of safety against global stability failure is at least 1.26 and 1.1 under static and seismic conditions, respectively, for the existing Wall #5.

Originated By: Sarah Kurtzer, EIT Date: 11/13/2023

Reviewed By: Kurt Jelinek, PE Date: 11/27/2023

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)
Existing Retaining Wall		150	Infinite Strength		
Existing Fill		115	Mohr-Coulomb	0	33
Reworked Silt and Clay		120	Mohr-Coulomb	130	22
Varved Silt and Clay		120	Mohr-Coulomb	130	22

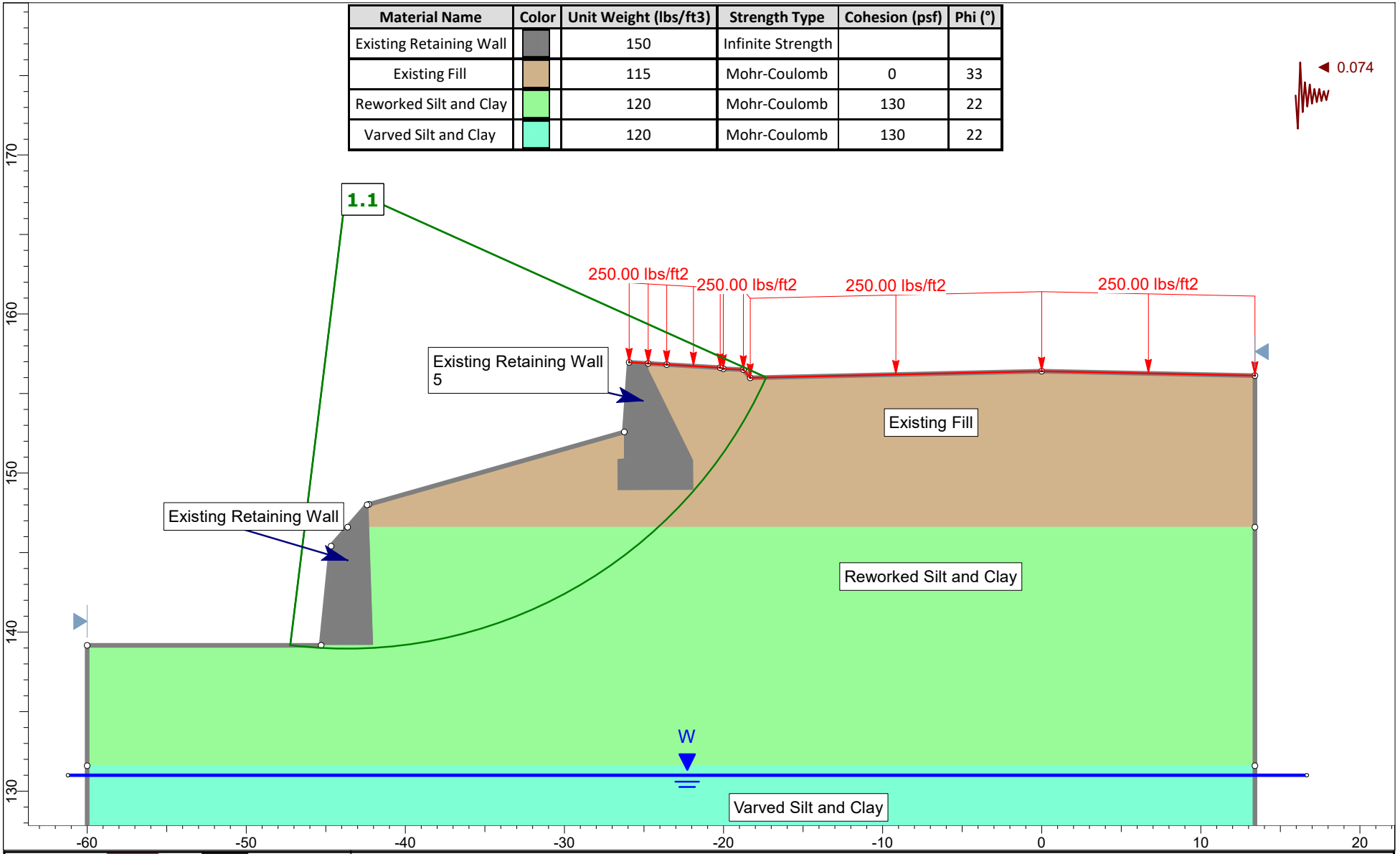


SLIDEINTERPRET 9.031

nobis

Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Global Slope Stability - Existing Retaining Wall 5		Static
Drawn By	SAK Checked by: KJ	Scale 1:100	Company Nobis Group
Date	11/27/2023		File Name 15+50 - Existing.slmd

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)
Existing Retaining Wall		150	Infinite Strength		
Existing Fill		115	Mohr-Coulomb	0	33
Reworked Silt and Clay		120	Mohr-Coulomb	130	22
Varved Silt and Clay		120	Mohr-Coulomb	130	22



SLIDEINTERPRET 9.031

Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Global Slope Stability - Existing Retaining Wall 5		Seismic
Drawn By	SAK Checked by: KJ	Scale 1:100	Company Nobis Group
Date	11/27/2023		File Name 15+50 - Existing.slmd

Armory Street over Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 094184.100

Calculated by: SAK Date: 03/30/2023
Checked by: KJ Date: 03/31/2023

Bearing Resistance Calculation for the existing masonry block retaining wall designated Wall #7.

Objective: Estimate the bearing resistance for the upper layer of the two layer system (q_1).

References:
1) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
2) Subsurface explorations observed by Nobis in 2019 (BB-6, BB-8, and BB-8A).
3) Drawings in AutoCAD format provided by Tetra Tech in October and June of 2022.
4) Cores through Wall #7 performed by Nobis in February 2023.

Assumptions: 1) Soil and groundwater conditions encountered in the Nobis borings are representative of subsurface conditions at the site. Based on the borings, there is a layer of existing fill in the general area of the existing retaining wall. There are two types of fill. The upper layer consists of granular fill and the lower layer is reworked silt and clay.

Solution:

Bearing Soil Properties/Subsurface Information

Unit Weight of Bearing Soil (γ):	115	pcf	Estimated
Unit Weight of Soil Above Footing (γ):	115	pcf	Estimated
Cohesion of Bearing Soil (c):	0	psf	Estimated
Friction Angle of Bearing Soil (ϕ'):	33	degrees	Estimated

Soil Description: Very loose to loose fine to coarse sand with varying amounts of silt.

Footing Elevation:	141.2	ft, NAVD88	Reference 4
Ground Surface (GS) Elevation:	145.2	ft, NAVD88	Reference 2 and 3
Groundwater Elevation:	131	ft, NAVD88	Reference 2

Footing Geometry

Footing Depth (D_f):	4.0	ft	Calculated
Groundwater Depth Below GS:	14.2	ft	Calculated
Width (B):	6.7	ft	Reference 2
Length (L):	18.0	ft	Assumed from Reference 3
Width Eccentricity (e_B):	1.1	ft	Assumed, see Note 2
Length Eccentricity (e_L):	0	ft	Assumed
Effective Width (B'):	4.5	ft	
Effective Length (L'):	18	ft	

Notes:
1) Example bearing resistance calculation can be found on page 2.
2) Width eccentricity (e_B) is assumed to be B/6.

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Armory Street over Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 094184.100

Calculated by: SAK Date: 03/30/2023
Checked by: KJ Date: 03/31/2023

Example Bearing Resistance Calculation

Factored Bearing Resistance: $q_R = q_n * \phi_b$		Eq. 10.6.3.1.1-1
Resistance Factor (ϕ_b) =	0.55	Tb. 11.5.7-1
Nominal Resistance (q_n) =		
$q_n = c*N_{cm} + \gamma*D_f*N_m*C_{wq} + 0.5*\gamma*B'*N_{\gamma m}*C_{w\gamma}$		Eq. 10.6.3.1.2a-1
$N_{qm} = N_q*s_q*d_q*i_q$		Eq. 10.6.3.1.2a-3
Bearing Capacity Factor (N_q)	26.1	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_q)	1.16	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_q)	1.0	Assumed
Depth Correction Factor (d_q)	1.0	Tb. 10.6.3.1.2a-4
N_{qm}=	30.31	
$N_{cm} = N_c*s_c*i_c$		Eq. 10.6.3.1.2a-2
Bearing Capacity Factor (N_c)	38.6	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_c)	1.17	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_c)	1.0	Assumed
N_{cm} =	45.08	
$N_{\gamma m} = N_\gamma*s_\gamma*i_\gamma$		Eq. 10.6.3.1.2a-4
Bearing Capacity Factor (N_γ)	35.2	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_γ)	0.90	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_γ)	1.0	Assumed
$N_{\gamma m}$=	31.71	
Groundwater Coefficients		Tb. 10.6.3.1.2a-2
(C_{wq})	1.00	
($C_{w\gamma}$)	1.00	
q_n=	**22.1 ksf**	
q_R=	**12.1 ksf**	

Armory Street over Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 094184.100

Calculated by: SAK Date: 03/30/2023
Checked by: KJ Date: 03/31/2023

Bearing Resistance Calculation for the existing masonry block retaining wall designated Wall #7.

Objective: Estimate the bearing resistance for the lower layer of the two layer system (q_2).

References:
1) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
2) Subsurface explorations observed by Nobis in 2019 (BB-6, BB-8, and BB-8A).
3) Drawings in AutoCAD format provided by Tetra Tech in October and June of 2022.
4) Cores through Wall #7 performed by Nobis in February 2023.

Assumptions: 1) Soil and groundwater conditions encountered in the Nobis borings are representative of subsurface conditions at the site. Based on the borings, there is a layer of existing fill in the general area of the existing retaining wall. There are two types of fill. The upper layer consists of granular fill and the lower layer is reworked silt and clay.

Solution:

Bearing Soil Properties/Subsurface Information

Unit Weight of Bearing Soil (γ):	120	pcf	Estimated
Unit Weight of Soil Above Footing (γ):	115	pcf	Estimated
Cohesion of Bearing Soil (c):	130	psf	Estimated
Friction Angle of Bearing Soil (ϕ'):	22	degrees	Estimated

Soil Description: Native, medium stiff, brown to gray, Clayey Silt and/or Silt with varying amounts of fine sand.

Footing Elevation:	141.2	ft, NAVD88	Reference 4
Ground Surface (GS) Elevation:	145.2	ft, NAVD88	Reference 2 and 3
Groundwater Elevation:	131	ft, NAVD88	Reference 2

Footing Geometry

Footing Depth (D_f):	4.0	ft	Calculated
Groundwater Depth Below GS:	14.2	ft	Calculated
Width (B):	6.7	ft	Reference 2
Length (L):	18.0	ft	Assumed from Reference 3
Width Eccentricity (e_B):	1.1	ft	Assumed, see Note 2
Length Eccentricity (e_L):	0	ft	Assumed
Effective Width (B'):	4.5	ft	
Effective Length (L'):	18	ft	

Notes:
1) Example bearing resistance calculation can be found on page 2.
2) Width eccentricity (e_B) is assumed to be B/6.

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Armory Street over Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 094184.100

Calculated by: SAK Date: 03/30/2023
Checked by: KJ Date: 03/31/2023

Example Bearing Resistance Calculation

Factored Bearing Resistance: $q_R = q_n * \phi_b$		Eq. 10.6.3.1.1-1
Resistance Factor (ϕ_b) =	0.55	Tb. 11.5.7-1
Nominal Resistance (q_n) =		
$q_n = c*N_{cm} + \gamma*D_f*N_m*C_{wq} + 0.5*\gamma*B'*N_{\gamma m}*C_{w\gamma}$		Eq. 10.6.3.1.2a-1
$N_{qm} = N_q*s_q*d_q*i_q$		Eq. 10.6.3.1.2a-3
Bearing Capacity Factor (N_q)	7.8	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_q)	1.10	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_q)	1.0	Assumed
Depth Correction Factor (d_q)	1.0	Tb. 10.6.3.1.2a-4
N_{qm}=	8.58	
$N_{cm} = N_c*s_c*i_c$		Eq. 10.6.3.1.2a-2
Bearing Capacity Factor (N_c)	16.9	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_c)	1.11	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_c)	1.0	Assumed
N_{cm} =	18.84	
$N_{\gamma m} = N_\gamma*s_\gamma*i_\gamma$		Eq. 10.6.3.1.2a-4
Bearing Capacity Factor (N_γ)	7.1	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_γ)	0.90	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_γ)	1.0	Assumed
$N_{\gamma m}$=	6.40	
Groundwater Coefficients		Tb. 10.6.3.1.2a-2
(C_{wq})	1.00	
($C_{w\gamma}$)	1.00	
q_n=	**8.1 ksf**	
q_R=	**4.5 ksf**	

Armory Street over Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 094184.100
Page: 1 of 1

Calculated by: SAK Date: 03/30/2023
Checked by: KJ Date: 03/31/2023

Bearing Resistance Calculation for the existing masonry block retaining wall designated Wall #7.

Objective: Estimate the critical height (H_{cr}) and nominal bearing resistance (q_n) for Wall #7.

References:
1) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
2) Subsurface explorations observed by Nobis in 2019 (BB-6, BB-8, and BB-8A).
3) Drawings in AutoCAD format provided by Tetra Tech in October and June of 2022.
4) Cores through Wall #7 performed by Nobis in February 2023.

Assumptions: 1) Soil and groundwater conditions encountered in the Nobis borings are representative of subsurface conditions at the site. Based on the borings, there is a layer of existing fill in the general area of the existing retaining wall. There are two types of fill. The upper layer consists of granular fill and the lower layer is reworked silt and clay.

Solution:

$$H_{crit} = \frac{(3B)\ \ln\left(\frac{q_1}{q_2}\right)}{2\left(1+\frac{B}{L}\right)} \qquad (10.6.3.1.2d\text{-}1)$$

where:

q_1 = nominal bearing resistance of footing supported in the upper layer of a two-layer system, assuming the upper layer is infinitely thick (ksf)
q_2 = nominal bearing resistance of a fictitious footing of the same size and shape as the actual footing but supported on surface of the second (lower) layer of a two-layer system (ksf)
B = footing width (ft)
L = footing length (ft)

q_1	12.1	ksf
q_2	4.5	ksf
B	6.7	feet
L	18	feet
H_{cr}	7.3	feet

BOF El.: 141.2 ft
Layer 2 El.: 132.5 ft
8.7 ft to layer 2

Is layer 2 within H_{cr} of layer 1? no, qn = q1

Use: qn = q1 = 12.1 ksf

Armory Street Over Abandoned CSX Spur
Bridge No. S-24-026
Springfield, Massachusetts

Discipline: Geotechnical

Title: Global Stability Analysis for the Existing Wall #7

MassDOT Contract No. 115769

MassDOT Project File No. 609409

Design Basis/Assumptions:

Purpose: Perform global stability analyses on the existing masonry block retaining wall designated Wall #7.

Assumptions:

1) Engineering properties for existing fill, reworked silt and clay, varved silt and clay, silt, glacial till, and bedrock encountered in the subsurface explorations (Reference 2).
2) Groundwater conditions the same or similar to those observed in the subsurface explorations by Nobis.
3) Surcharge loading of 250 psf (Reference 3).
4) Seismic loading 0.074g (A_s x 0.5 = 0.148 x 0.5) (Reference 4).

Approach:

Use the computer slope stability analysis software Slide2, by RocScience, Inc., to perform global stability analyses on the existing retaining wall based on the results of the subsurface explorations performed by Nobis and information obtained from an AutoCAD drawing provided by Tetra Tech (Reference 1).

References:

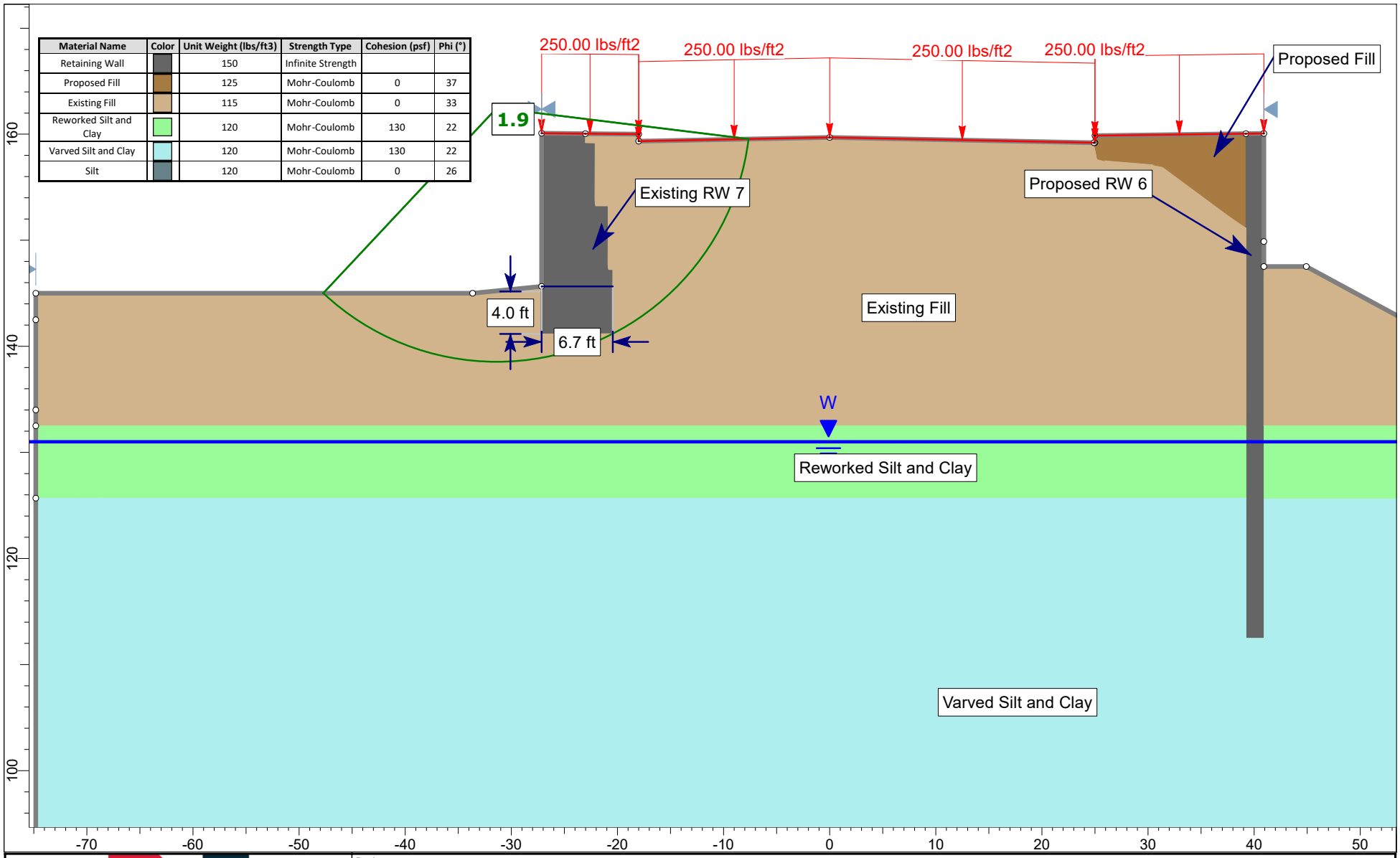
1) Topographic Survey and Bridge Plans and Profile (AutoCAD) drawing prepared by Tetra Tech, Inc. and provided to Nobis in June and October 2022.
2) Standard Penetration Test (SPT) data and subsurface explorations observed by Nobis in 2019 (BB-6, BB-8, and BB-8A).
3) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
4) Seismic site classification and seismic parameters developed by Nobis.

Remarks/Conclusions:

Based on the Slide2 analysis, the minimum factor of safety against global slope failure is at least 1.9 and 1.7 under static and seismic conditions, respectively, for the existing Wall #7. The minimum factor of safety against global slope failure is at least 1.3 and 1.1 under static and seismic conditions, respectively, for the existing retaining wall.

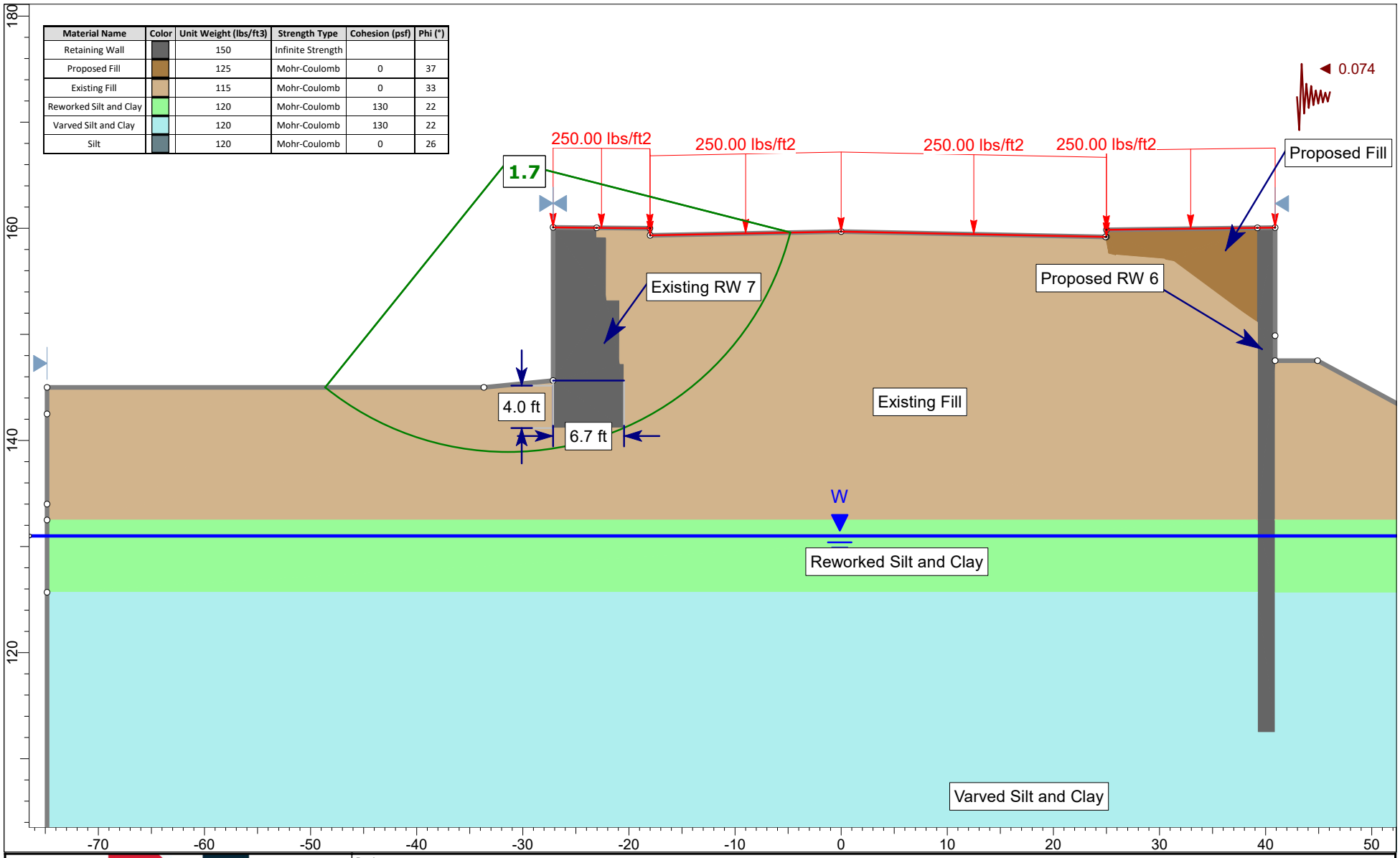
Originated By: Sarah Kurtzer, EIT Date: 03/30/2023

Reviewed By: Kurt Jelinek, PE Date: 03/31/2023



Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Global Slope Stability - Station # 17+00		RW 7 - Static
Drawn By	SAK	Scale 1:150	Company Nobis Group
Date	11/13/2023		File Name 17+00 - 2.slmd

SLIDEINTERPRET 9.031



Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Global Slope Stability - Station # 17+00		RW 7 - Seismic
Drawn By	SAK	Scale 1:150	Company Nobis Group
Date	11/13/2023		File Name 17+00 - 2.slmd

SLIDEINTERPRET 9.031

Armory Street over Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 94184.100

Calculated by: PCC Date: 11/23/2023
Checked by: SAK Date: 11/27/2023

Bearing Resistance Calculations - Proposed Cantilever Wall #4 @ STA 16+00

Bottom of Wall @ El. 142.1

Objective: Evaluate bearing resistance for the proposed Cantilever Retaining Wall 4 that is part of the reconstruction of Armory Street in Springfield, Massachusetts.

References:
1) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
2) Subsurface explorations observed by Nobis in 2019 and 2022.
3) Grading Plans and Cross Sections provided by Tetra Tech in October 2023.
4) MassDOT Standard Drawings for Cantilever Retaining Walls (drawing numbers 305.1 and 305.3).
5) Site plan (AutoCAD) provided by Tetra Tech on November 15, 2023.

Assumptions:
1) Soil and groundwater conditions encountered in Reference No. 2 are representative of subsurface conditions at the site.
2) Soil conditions used ot estimate the bearing resistance were interpolated from WB-1 and BB-5. Refer to subsurface profile, Figure 7.
3) Critical section at approximately STA 16+00

Solution:

Bearing Soil Properties/Subsurface Information

Unit Weight of Bearing Soil (γ):	115	pcf	Estimated, Reference No. 2
Unit Weight of Soil Above Footing (γ):	125	pcf	Estimated
Cohesion of Bearing Soil (c):	0	psf	Estimated, Reference No. 2
Friction Angle of Bearing Soil (ϕ'):	33	degrees	Estimated, Reference No. 2

Soil Description: A minimum of 12 inches of compacted Gravel Borrow or Crushed Stone over proof-compacted existing embankment fill.

Footing Elevation:	142.1	ft, NAVD-88	Reference No. 3 and 4
Ground Surface (GS) Elevation:	146.1	ft, NAVD-88	Reference No. 3 and 4
Groundwater Elevation:	131	ft, NAVD-88	Estimated, Reference No. 2

Footing Geometry

Footing Embedment Depth (D_f):	4.0	ft	Calculated
Groundwater Depth Below GS (D_w):	15.1	ft	Calculated
Width (B):	8.5	ft	Reference No. 4
Length (L):	117	ft	Reference No. 5
Width Eccentricity (e_B):	1.42	ft	See Note 1
Length Eccentricity (e_L):	0	ft	Assumed
Effective Width (B'):	5.67	ft	Calculated
Effective Length (L'):	117	ft	Calculated

Notes:
1) Width eccentricity (e_B) is assumed to be B/6.
2) Bearing resistance calculation can be found on page 4.

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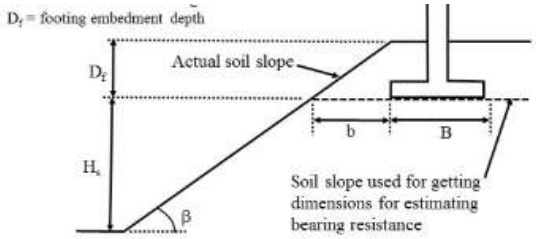
Armory Street over
Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 94184.100

Calculated by: PCC Date: 11/23/2023
Checked by: SAK Date: 11/27/2023

Bearing Resistance Calculations - Proposed Cantilever Wall #4 @ STA 16+00

Bottom of Wall @ El. 142.1

Friction Angle =	33	deg.	(phi)
Footing Width =	5.7	ft	(B')
Slope to footing distance =	7.3	ft	(b)
Slope Height =	3	ft	(H)
Slope Angle =	35	deg.	(Beta)



Interpolation

phi	B/H	b/B	Beta
33	1.8889	1.2882	35.0

Beta	b/B	B/H	phi
35.0	1.2882	1.88889	33
0.5	0.0306	0.88889	0.3
OK	OK	OK	OK

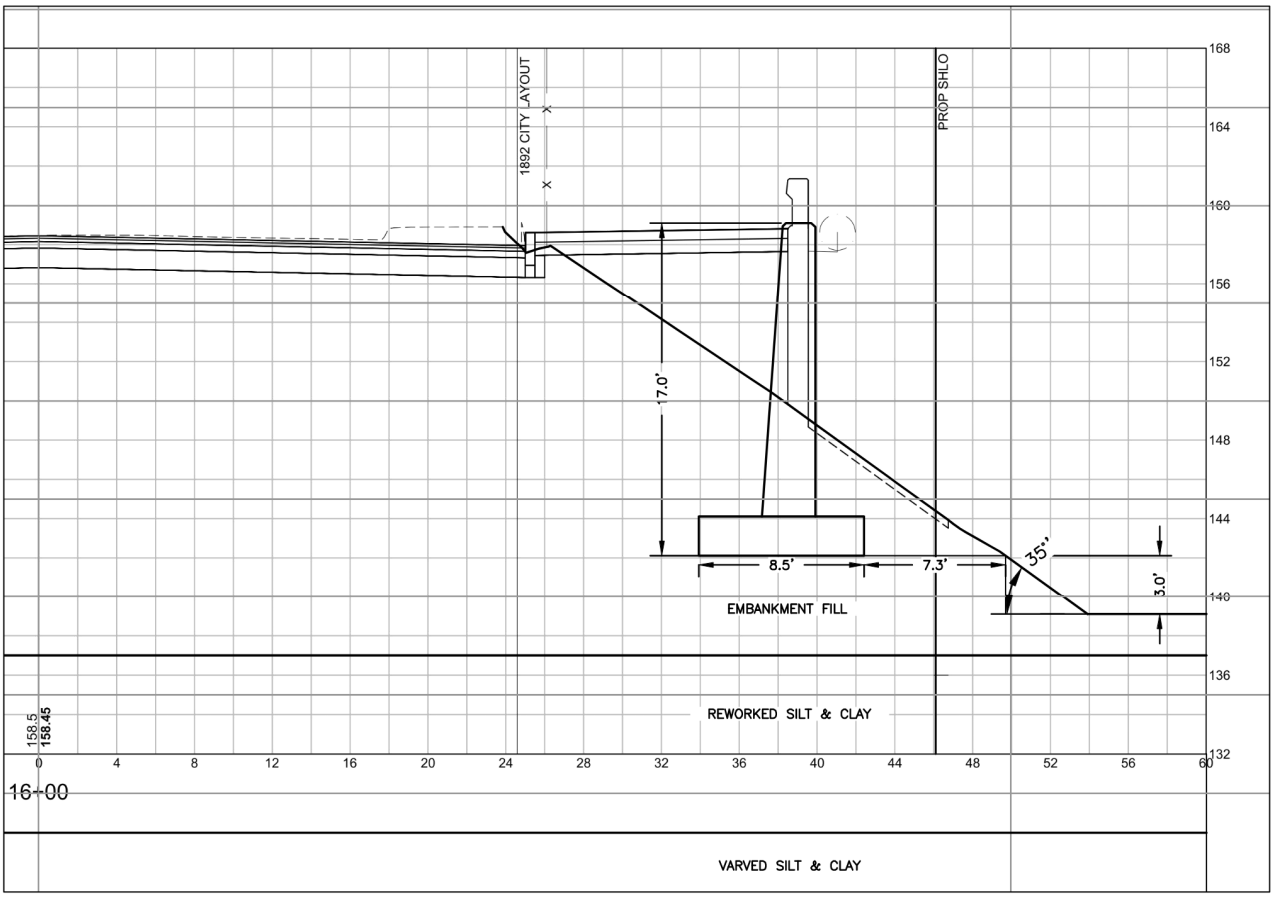
phi	B/H	b/B	Beta	Table				
30	1	1.25	30	0.58	0.29			
			40	0.00		0.2946		
		2.5	30	0.88	0.44			
			40	0.00			0.347	
	2	1.25	30	0.70	0.35			
			40	0.00		0.3538		
		2.5	30	0.95	0.475			
			40	0.00				**0.459**
40	1	1.25	30	0.55	0.515			
			40	0.48		0.5219		
		2.5	30	0.76	0.74			
			40	0.72			0.719	
	2	1.25	30	0.74	0.74			
			40	0.74		0.744		
		2.5	30	0.87	0.875			
			40	0.88				

Reduction Factor = 0.459

Armory Street over
Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 94184.100

Calculated by: PCC Date: 11/23/2023
Checked by: SAK Date: 11/27/2023

Bearing Resistance Calculations - Proposed Cantilever Wall #4 @ STA 16+00
Bottom of Wall @ El. 142.1



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Armory Street over
Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 94184.100

Calculated by: PCC Date: 11/23/2023
Checked by: SAK Date: 11/27/2023

Bearing Resistance Calculations - Proposed Cantilever Wall #4 @ STA 16+00

Bottom of Wall @ El. 142.1

Factored Bearing Resistance: $q_R = q_n * \phi_b$			Eq. 10.6.3.1.1-1
Resistance Factor (ϕ_b) =		0.55	Tb. 10.5.5.2.2-1 or 11.5.7-1
Nominal Resistance (q_n) =			
$q_{n\text{-sloping-ground}} = RC_{BN}*(c*N_{cm} + 0.5*\gamma*B'*N_{\gamma m}*C_{w\gamma})$			Eq. 10.6.3.1.2c-1
$N_{cm} = N_c*s_c*i_c$			Eq. 10.6.3.1.2a-2
Bearing Capacity Factor (N_c)		38.6	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_c)		1.00	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_c)		1.00	Assumed or Eq. 10.6.3.1.2a-5 or -6
N_{cm} =		38.60	
$N_{\gamma m} = N_\gamma*s_\gamma*i_\gamma$			Eq. 10.6.3.1.2a-4
Bearing Capacity Factor (N_γ or $N_{\gamma q}$)		35.2	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_γ)		0.98	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_γ)		1.00	Assumed or Eq. 10.6.3.1.2a-8 and -9
$N_{\gamma m}$=		34.52	
Groundwater Coefficients			
C_{wq} =		1.00	Tb. 10.6.3.1.2a-2
$C_{w\gamma}$ =		1.00	Tb. 10.6.3.1.2a-2
Nominal Bearing Resistance, q_n=		11.2 ksf	
Slope Reduction Coefficient, RC_{BC}=		0.459	Calculation and Tb. 10.6.3.1.2c-2
Nominal Bearing Resistance, $q_{n\text{-sloping-ground}}$=		5.2 ksf	q_n*RC_{BC}
Factored Geotechnical Bearing Resistance, q_R=		**2.8 ksf**	φ_b * $q_{n\text{-sloping ground}}$

Armory Street over Abandoned CSX Spur
Springfield, Massachusetts
Nobis Project No.: 94184.100

Calculated by: PCC Date: 11/21/2023
Checked by: SAK Date: 11/27/2023

Bearing Resistance Calculations - Proposed Cantilever Wall #5 @ STA 16+00

Bottom of Wall @ El. 145

Objective: Evaluate bearing resistance for the proposed Cantilever Retaining Wall 5 that is part of the reconstruction of Armory Street in Springfield, Massachusetts.

References:
1) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
2) Subsurface explorations observed by Nobis in 2019 and 2022.
3) Grading Plans and Cross Sections provided by Tetra Tech in October 2023.
4) MassDOT Standard Drawings for Cantilever Retaining Walls (drawing numbers 305.1 and 305.3).
5) Site plan (AutoCAD) provided by Tetra Tech on November 15, 2023.

Assumptions:
1) Soil and groundwater conditions encountered in Reference No. 2 are representative of subsurface conditions at the site.
2) Soil conditions used to estimate the bearing resistance were interpolated from WB-1 and BB-5. Refer to subsurface profile, Figure 7.
3) Critical section at approximately STA 16+00

Solution:

Bearing Soil Properties/Subsurface Information

Unit Weight of Bearing Soil (γ):	115	pcf	Estimated, Reference No. 2
Unit Weight of Soil Above Footing (γ):	125	pcf	Estimated
Cohesion of Bearing Soil (c):	0	psf	Estimated, Reference No. 2
Friction Angle of Bearing Soil (ϕ'):	33	degrees	Estimated, Reference No. 2

Soil Description: A minimum of 12 inches of compacted Gravel Borrow or Crushed Stone over proof-compacted existing embankment fill.

Footing Elevation:	145	ft, NAVD-88	Reference No. 3 and 4
Ground Surface (GS) Elevation:	149	ft, NAVD-88	Reference No. 3 and 4
Groundwater Elevation:	131	ft, NAVD-88	Estimated, Reference No. 2

Footing Geometry

Footing Embedment Depth (D_f):	4.0	ft	Calculated
Groundwater Depth Below GS (D_w):	18.0	ft	Calculated
Width (B):	7	ft	Reference No. 4
Length (L):	117	ft	Reference No. 5
Width Eccentricity (e_B):	1.17	ft	See Note 1
Length Eccentricity (e_L):	0	ft	Assumed
Effective Width (B'):	4.67	ft	Calculated
Effective Length (L'):	117	ft	Calculated

Notes:
1) Width eccentricity (e_B) is assumed to be B/6.
2) Bearing resistance calculation can be found on page 4.

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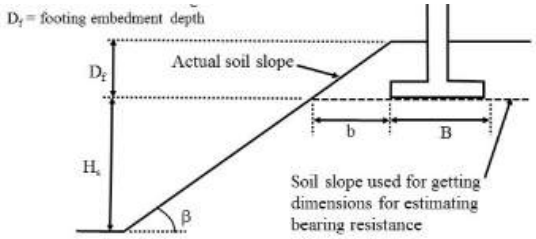
Bearing Resistance Calculations - Proposed Cantilever Wall #5 @ STA 16+00

Bottom of Wall @ El. 145

Friction Angle =	33	deg.	(phi)
Footing Width =	4.7	ft	(B')
Slope to footing distance =	8.2	ft	(b)
Slope Height =	5.8	ft	(H)
Slope Angle =	31	deg.	(Beta)



phi	B/H	b/B	Beta
33	0.8046	1.7571	31.0

Interpolation

Beta	b/B	B/H	phi
31.0	1.7571	0.8046	33
0.1	0.4057	0.6092	0.3
OK	OK	OK	OK

phi	B/H	b/B	Beta	Table				
30	0.5	1.25	30	0.45	0.405			
			40	0.00		0.5328		
		2.5	30	0.80	0.72			
			40	0.00			0.593	
	1	1.25	30	0.58	0.522			
			40	0.00		0.6315		
		2.5	30	0.88	0.792			
			40	0.00				**0.584**
40	0.5	1.25	30	0.40	0.378			
			40	0.18		0.4587		
		2.5	30	0.60	0.577			
			40	0.37			0.563	
	1	1.25	30	0.55	0.543			
			40	0.48		0.629		
		2.5	30	0.76	0.756			
			40	0.72				

Reduction Factor = 0.584

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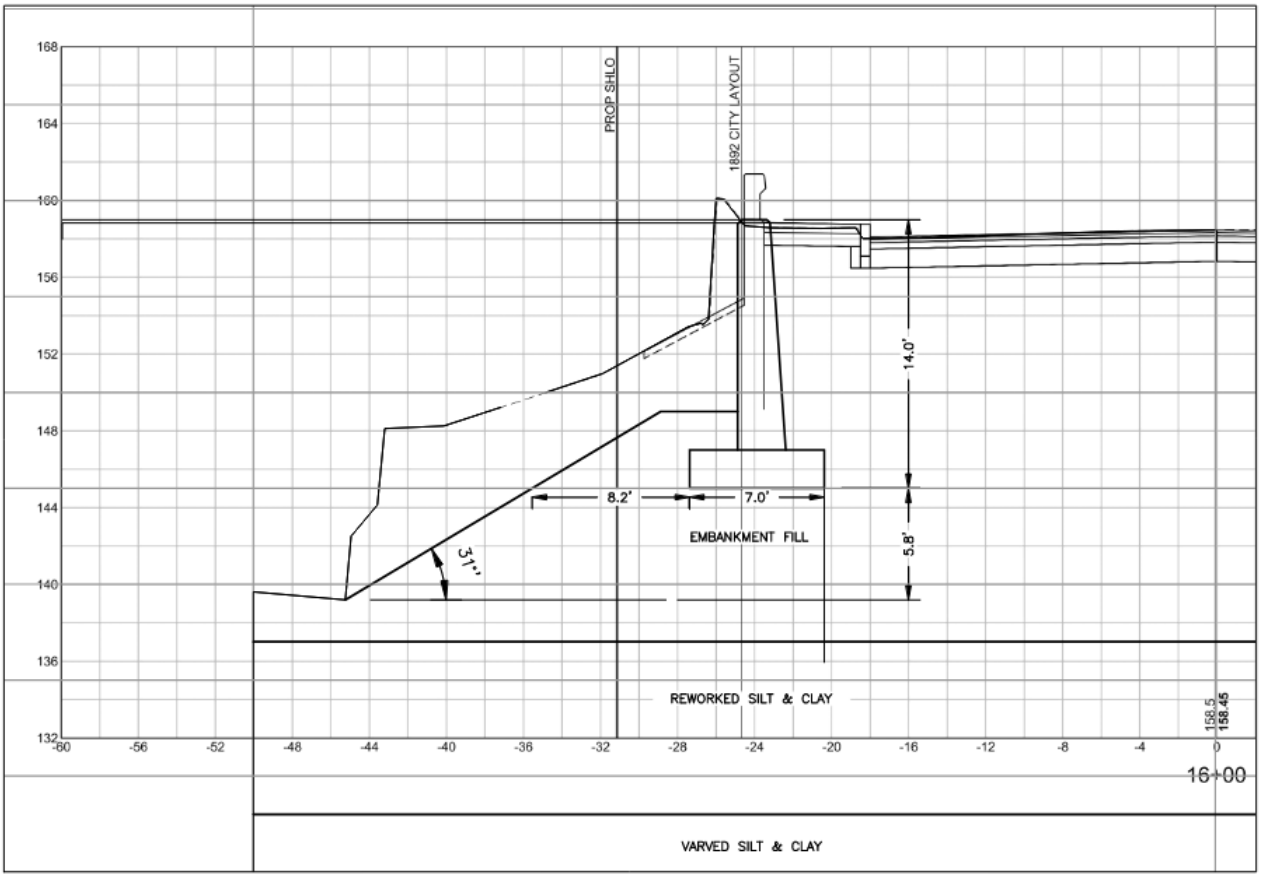
Bottom of Wall @ El. 145



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Bearing Resistance Calculations - Proposed Cantilever Wall #5 @ STA 16+00

Bottom of Wall @ El. 145

Factored Bearing Resistance: $q_R = q_n * \phi_b$		Eq. 10.6.3.1.1-1
Resistance Factor (ϕ_b) =	0.55	Tb. 10.5.5.2.2-1 or 11.5.7-1
Nominal Resistance (q_n) =		
$q_{n\text{-sloping-ground}} = RC_{BN}*(c*N_{cm} + 0.5*\gamma*B'*N_{\gamma m}*C_{w\gamma})$		Eq. 10.6.3.1.2c-1
$N_{cm} = N_c*s_c*i_c$		Eq. 10.6.3.1.2a-2
Bearing Capacity Factor (N_c)	38.6	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_c)	1.00	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_c)	1.00	Assumed or Eq. 10.6.3.1.2a-5 or -6
N_{cm} =	38.60	
$N_{\gamma m} = N_\gamma*s_\gamma*i_\gamma$		Eq. 10.6.3.1.2a-4
Bearing Capacity Factor (N_γ or $N_{\gamma q}$)	35.2	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_γ)	0.98	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_γ)	1.00	Assumed or Eq. 10.6.3.1.2a-8 and -9
$N_{\gamma m}$=	34.64	
Groundwater Coefficients		
C_{wq} =	1.00	Tb. 10.6.3.1.2a-2
$C_{w\gamma}$ =	1.00	Tb. 10.6.3.1.2a-2
Nominal Bearing Resistance, q_n=	9.3 ksf	
Slope Reduction Coefficient, RC_{BC}=	0.584	Calculation and Tb. 10.6.3.1.2c-2
Nominal Bearing Resistance, $q_{n\text{-sloping-ground}}$=	5.4 ksf	q_n*RC_{BC}
Factored Geotechnical Bearing Resistance, q_R=	**3.0 ksf**	$\varphi_b * q_{n\text{-sloping ground}}$

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Bearing Resistance Calculations - Proposed Cantilever Wall #6 @ STA 17+30

Bottom of Wall @ El. 145

Objective: Evaluate bearing resistance for the proposed Cantilever Retaining Wall 6 that is part of the reconstruction of Armory Street in Springfield, Massachusetts.

References:
1) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
2) Subsurface explorations observed by Nobis in 2019 and 2022.
3) Grading Plans and Cross Sections provided by Tetra Tech in October 2023.
4) MassDOT Standard Drawings for Cantilever Retaining Walls (drawing numbers 305.1 and 305.3).
5) Site plan (AutoCAD) provided by Tetra Tech on November 15, 2023.

Assumptions:
1) Soil and groundwater conditions encountered in Reference No. 2 are representative of subsurface conditions at the site.
2) Soil conditions used to estimate the bearing resistance were interpolated from BB-6, BB-8A, and WB-6. Refer to subsurface profile, Figure 7.
3) Critical section at approximately STA 17+30

Solution:

Bearing Soil Properties/Subsurface Information

Unit Weight of Bearing Soil (γ):	115	pcf	Estimated, Reference No. 2
Unit Weight of Soil Above Footing (γ):	125	pcf	Estimated
Cohesion of Bearing Soil (c):	0	psf	Estimated, Reference No. 2
Friction Angle of Bearing Soil (ϕ'):	33	degrees	Estimated, Reference No. 2

Soil Description: A minimum of 12 inches of compacted Gravel Borrow or Crushed Stone over proof-compacted existing embankment fill.

Footing Elevation:	145	ft, NAVD-88	Reference No. 3 and 4
Ground Surface (GS) Elevation:	149	ft, NAVD-88	Reference No. 3 and 4
Groundwater Elevation:	131	ft, NAVD-88	Estimated, Reference No. 2

Footing Geometry

Footing Embedment Depth (D_f):	4.0	ft	Calculated
Groundwater Depth Below GS (D_w):	18.0	ft	Calculated
Width (B):	7	ft	Reference No. 4
Length (L):	25.8	ft	Reference No. 5
Width Eccentricity (e_B):	1.17	ft	See Note 1
Length Eccentricity (e_L):	0	ft	Assumed
Effective Width (B'):	4.67	ft	Calculated
Effective Length (L'):	26	ft	Calculated

Notes:
1) Width eccentricity (e_B) is assumed to be B/6.
2) Bearing resistance calculation can be found on page 4.

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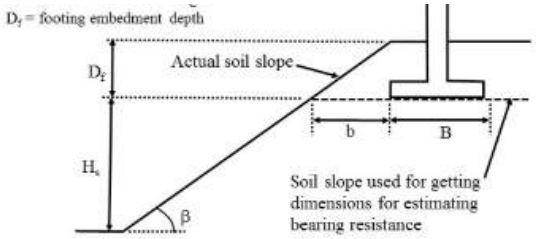
Bearing Resistance Calculations - Proposed Cantilever Wall #6 @ STA 17+30

Bottom of Wall @ El. 145

Friction Angle =	33	deg.	(phi)
Footing Width =	4.7	ft	(B')
Slope to footing distance =	10.4	ft	(b)
Slope Height =	8.3	ft	(H)
Slope Angle =	24	deg.	(Beta)



Interpolation

phi	B/H	b/B	Beta
33	0.5622	2.2286	24.0

Beta	b/B	B/H	phi
24.0	2.2286	0.56225	33
0.4	0.7829	0.1245	0.3
OK	OK	OK	OK

phi	B/H	b/B	Beta	Table				
30	0.5	1.25	20	0.72	0.612			
			30	0.45		0.8437		
		2.5	20	0.98	0.908			
			30	0.80			0.846	
	1	1.25	20	0.72	0.664			
			30	0.58		0.866		
		2.5	20	0.95	0.922			
			30	0.88				**0.800**
40	0.5	1.25	20	0.60	0.52			
			30	0.40		0.6813		
		2.5	20	0.81	0.726			
			30	0.60			0.692	
	1	1.25	20	0.64	0.604			
			30	0.55		0.768		
		2.5	20	0.85	0.814			
			30	0.76				

Reduction Factor = 0.800

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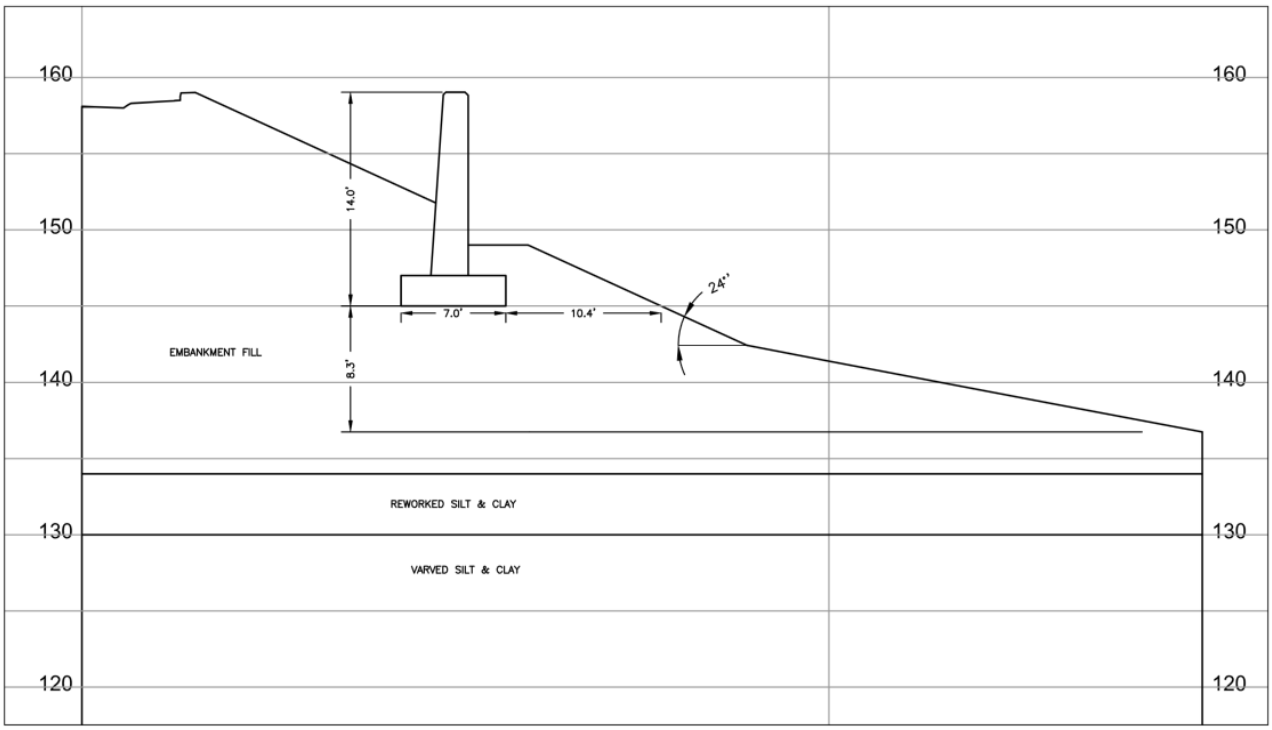
Bearing Resistance Calculations - Proposed Cantilever Wall #6 @ STA 17+30
Bottom of Wall @ El. 145



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Bearing Resistance Calculations - Proposed Cantilever Wall #6 @ STA 17+30

Bottom of Wall @ El. 145

Factored Bearing Resistance: $q_R = q_n * \phi_b$		Eq. 10.6.3.1.1-1
Resistance Factor (ϕ_b) =	0.55	Tb. 10.5.5.2.2-1 or 11.5.7-1
Nominal Resistance (q_n) =		
$q_{n\text{-sloping-ground}} = RC_{BN}*(c*N_{cm} + 0.5*\gamma*B'*N_{\gamma m}*C_{w\gamma})$		Eq. 10.6.3.1.2c-1
$N_{cm} = N_c*s_c*i_c$		Eq. 10.6.3.1.2a-2
Bearing Capacity Factor (N_c)	38.6	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_c)	1.00	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_c)	1.00	Assumed or Eq. 10.6.3.1.2a-5 or -6
N_{cm} =	38.60	
$N_{\gamma m} = N_\gamma*s_\gamma*i_\gamma$		Eq. 10.6.3.1.2a-4
Bearing Capacity Factor (N_γ or $N_{\gamma q}$)	35.2	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_γ)	0.93	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_γ)	1.00	Assumed or Eq. 10.6.3.1.2a-8 and -9
$N_{\gamma m}$=	32.66	
Groundwater Coefficients		
C_{wq} =	1.00	Tb. 10.6.3.1.2a-2
$C_{w\gamma}$ =	1.00	Tb. 10.6.3.1.2a-2
Nominal Bearing Resistance, q_n=	8.8 ksf	
Slope Reduction Coefficient, RC_{BC}=	0.800	Calculation and Tb. 10.6.3.1.2c-2
Nominal Bearing Resistance, $q_{n\text{-sloping-ground}}$=	7.0 ksf	q_n*RC_{BC}
Factored Geotechnical Bearing Resistance, q_R=	**3.9 ksf**	$\varphi_b * q_{n\text{-sloping ground}}$

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$$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma \quad BN_{\gamma m} C_{w\gamma} \qquad (10.6.3.1.2a\text{-}1)$$

$$N_{cm} = N_c s_c i_c \qquad (10.6.3.1.2a\text{-}2)$$

$$N_{qm} = N_q s_q d_q i_q \qquad (10.6.3.1.2a\text{-}3)$$

$$N_\gamma m = N_\gamma s_\gamma i_\gamma \qquad (10.6.3.1.2a\text{-}4)$$

c	=	cohesion, taken as undrained shear strength (ksf)
N_c	=	cohesion term (undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

N_q	=	surcharge (embedment) term (drained or undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)
N_γ	=	unit weight (footing width) term (drained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)
γ	=	total (moist) unit weight of soil above or below the bearing depth of the footing (kcf)
D_f	=	footing embedment depth (ft)
B	=	footing width (ft)
C_{wq},$C_{w\gamma}$	=	correction factors to account for the location of the groundwater table as specified in Table 10.6.3.1.2a-2 (dim)
s_c, s_γ,s_q	=	footing shape correction factors as specified in Table 10.6.3.1.2a-3 (dim)
d_q	=	correction factor to account for the shearing resistance along the failure surface passing through cohesionless material above the bearing elevation as specified in Table 10.6.3.1.2a-4 (dim)
i_c, i_γ, i_q	=	load inclination factors determined from Eqs. 10.6.3.1.2a-5 or 10.6.3.1.2a-6, and 10.6.3.1.2a-7 and 10.6.3.1.2a-8 (dim)

Table 10.6.3.1.2a-4—Depth Correction Factor d_q

Friction Angle, ϕ_f (degrees)	D_f/B	d_q
32	1	1.20
	2	1.30
	4	1.35
	8	1.40
37	1	1.20
	2	1.25
	4	1.30
	8	1.35
42	1	1.15
	2	1.20
	4	1.25
	8	1.30

For ϕ_f = 0:

$$i_c = 1 - (nH/cBLN_c) \qquad (10.6.3.1.2a\text{-}5)$$

For ϕ_f > 0:

$$i_c = i_q - [(1 - i_q)/(N_q - 1)] \qquad (10.6.3.1.2a\text{-}6)$$

in which:

$$i_q = \left[1 - \frac{H}{(V + cBL\cot\phi_f)}\right]^n \qquad (10.6.3.1.2a\text{-}7)$$

$$i_\gamma = \left[1 - \frac{H}{V + cBL\cot\phi_f)}\right]^{(n+1)} \qquad (10.6.3.1.2a\text{-}8)$$

Table 10.6.3.1.2a-3—Shape Correction Factors s_c, s_γ, s_q

Factor	Friction Angle	Cohesion Term (s_c)	Unit Weight Term (s_γ)	Surcharge Term (s_q)
Shape Factors s_c, s_γ, s_q	$\phi_f = 0$	$1 + \left(\frac{B}{5L}\right)$	1.0	1.0
	$\phi_f > 0$	$1 + \left(\frac{B}{L}\right)\left(\frac{N_q}{N_c}\right)$	$1 - 0.4\left(\frac{B}{L}\right)$	$1 + \left(\frac{B}{L}\tan\phi_f\right)$

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Table 10.6.3.1.2a-1—Bearing Capacity Factors N_c (Prandtl, 1921), N_q (Reissner, 1924), and N_γ (Vesic, 1975)

ϕ_f	N_c	N_q	N_γ	ϕ_f	N_c	N_q	N_γ
0	5.14	1.0	0.0	23	18.1	8.7	8.2
1	5.4	1.1	0.1	24	19.3	9.6	9.4
2	5.6	1.2	0.2	25	20.7	10.7	10.9
3	5.9	1.3	0.2	26	22.3	11.9	12.5
4	6.2	1.4	0.3	27	23.9	13.2	14.5
5	6.5	1.6	0.5	28	25.8	14.7	16.7
6	6.8	1.7	0.6	29	27.9	16.4	19.3
7	7.2	1.9	0.7	30	30.1	18.4	22.4
8	7.5	2.1	0.9	31	32.7	20.6	26.0
9	7.9	2.3	1.0	32	35.5	23.2	30.2
10	8.4	2.5	1.2	33	38.6	26.1	35.2
11	8.8	2.7	1.4	34	42.2	29.4	41.1
12	9.3	3.0	1.7	35	46.1	33.3	48.0
13	9.8	3.3	2.0	36	50.6	37.8	56.3
14	10.4	3.6	2.3	37	55.6	42.9	66.2
15	11.0	3.9	2.7	38	61.4	48.9	78.0
16	11.6	4.3	3.1	39	67.9	56.0	92.3
17	12.3	4.8	3.5	40	75.3	64.2	109.4
18	13.1	5.3	4.1	41	83.9	73.9	130.2
19	13.9	5.8	4.7	42	93.7	85.4	155.6
20	14.8	6.4	5.4	43	105.1	99.0	186.5
21	15.8	7.1	6.2	44	118.4	115.3	224.6
22	16.9	7.8	7.1	45	133.9	134.9	271.8

Table 10.6.3.1.2a-2—Coefficients C_{wq} and $C_{w\gamma}$ for Various Groundwater Depths

D_w	C_{wq}	$C_{w\gamma}$
0.0	0.5	0.5
D_f	1.0	0.5
$>1.5B + D_f$	1.0	1.0

Table 10.5.5.2.2-1—Resistance Factors for Geotechnical Resistance of Shallow Foundations at the Strength Limit State

Method/Soil/Condition			Resistance Factor
Bearing Resistance	φ_b	Theoretical method (Munfakh et al., 2001), in clay	0.50
		Theoretical method (Munfakh et al., 2001), in sand, using *CPT*	0.50
		Theoretical method (Munfakh et al., 2001), in sand, using *SPT*	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footings on rock	0.45
		Plate Load Test	0.55
Sliding	φ_τ	Precast concrete placed on sand	0.90
		Cast-in-Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on Clay	0.85
		Soil on soil	0.90
	φ_{ep}	Passive earth pressure component of sliding resistance	0.50

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Table 11.5.7-1—Strength Limit State Resistance Factors for Permanent Retaining Walls

Wall-Type and Condition		Resistance Factor
Nongravity Cantilevered and Anchored Walls		
Axial compressive resistance of vertical elements		Article 10.5 applies
Passive resistance of vertical elements		0.75
Pullout resistance of anchors [1]	• Cohesionless (granular) soils • Cohesive soils • Rock	0.65 [1] 0.70 [1] 0.50 [1]
Pullout resistance of anchors [2]	• Where proof tests are conducted	1.0 [2]
Tensile resistance of anchor tendon	• Mild steel (e.g., ASTM A615 bars) • High-strength steel (e.g., ASTM A722 bars)	0.90 [3] 0.80 [3]
Overall stability, soil failure		Article 11.6.3.7 applies
Flexural capacity of vertical elements		0.90
Mechanically Stabilized Earth Walls, Gravity Walls, and Semigravity Walls		
Bearing resistance	• Gravity and semigravity walls • MSE walls	0.55 0.65
Sliding		1.0
Tensile resistance of metallic reinforcement and connectors	Strip reinforcements [4] Grid reinforcements [4] [5]	0.75 0.65
Tensile resistance of geosynthetic reinforcement and connectors	• Geotextile and geogrid reinforcements • Geostrip reinforcements	0.80 0.55
Pullout resistance of metallic reinforcement	• Steel strip reinforcements • Steel grid reinforcements	0.90 0.90
Pullout resistance of geosynthetic reinforcement	• Geotextiles and geogrids • Geostrip reinforcements	0.70 0.70
Service Limit, for soil failure using stiffness method		1.0
Overall and compound stability, soil failure		Article 11.6.3.7 applies
Prefabricated Modular Walls		
Bearing		Article 10.5 applies
Sliding		Article 10.5 applies
Passive resistance		Article 10.5 applies
Overall stability, soil failure		Article 11.6.3.7 applies
Soil Nail Walls [6]		
Lateral sliding		1.00
Overall and Compound stability, soil failure		Article 11.6.3.7 applies
Tensile resistance of nail tendon	Mild steel bars (Grade 75) High resistance bars (Grades 95 and 150)	0.75 0.65
Pullout resistance of nail		0.65
Facing flexure	Initial and final facing	0.90
Facing punching shear	Initial and final facing	0.90
Tensile resistance of headed stud	A307 steel bolt [7] A325 steel bolt	0.70 0.80

(1) Apply to presumptive ultimate unit bond stresses for preliminary design only in Article C11.9.4.2.

10.6.3.1.2c—Considerations for Footings on Slopes

C10.6.3.1.2c

For footings constructed on or adjacent to slopes, the nominal bearing resistance shall be determined using a reduction coefficient (RC_{BC}) as presented in Tables 10.6.3.1.2c-1 and 10.6.3.1.2c-2. The reduction coefficient should be applied directly to the nominal bearing resistance calculated from Eq.10.6.3.1.2a-1 for footings on level ground and supported on the same foundation soil conditions.

The nominal resistance of footings on or adjacent to slopes shall be taken as:

$$q_{n-sloping\ ground} = RC_{BC} q_n = RC_{BC}\left(cN_c + 0.5\gamma BN_\gamma\right) \quad (10.6.3.1.2c\text{-}1)$$

where:

$q_{n\text{-}sloping\ ground}$ = the nominal footing bearing resistance considering the effect of sloping ground (ksf)

RC_{BC} = reduction coefficient for bearing resistance due to slope effects (dim)

and other variables are as defined in Article 10.6.3.1.2a and Figure 10.6.3.1.2c-1. The bearing capacity factors N_c and N_γ are obtained in accordance with Article 10.6.3.1.2a.

Reduction coefficients (RC_{BC}) should be determined using the definitions illustrated in Figure 10.6.3.1.2c-1

A rational approach for determining a modified bearing resistance for footings on or adjacent to a slope is presented in Leshchinsky (2015) and Leshchinsky and Xie (2016). These methods are considered valid and applicable to structure foundations in addition to the MSE retaining wall example presented in the reference papers. The reduction coefficients provided in Tables 10.6.3.1.2c-1 and 10.6.3.1.2c-2 are modified and reconfigured by the author of the cited papers to allow for more convenient use in practice. See the original papers for the complete tabulation of reduction coefficient values.

The reduction coefficients are applicable to purely cohesive, purely cohesionless and c-ϕ soils. The RC_{BC} factors are based on no footing embedment for footings either on or adjacent to slopes and may be conservative for deep footing embedment depths.

Limit analysis, or limit equilibrium analysis, should be considered to estimate the nominal bearing resistance of footings on or adjacent to slopes composed of soils and/or site conditions that are not consistent with the parameters and conditions described in the reference documents (i.e. embedment >0, layered soils, steeper slopes).

The schematic shown in Figure 10.6.3.1.2c-1 is provided only for illustrating and defining the terms used in the design equations and tables. This figure should not be used as the basis for locating footings on slopes regarding embedment depth and setback.

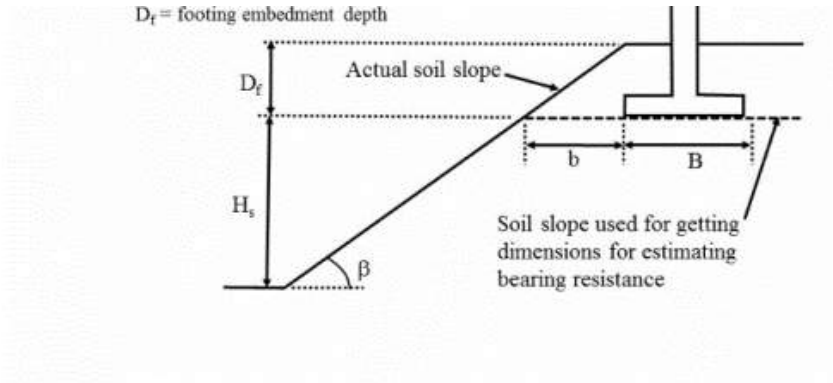

Figure 10.6.3.1.2c-1—Definition of Footing and Slope Geometric Parameters for Determination of RC_{BC}

Armory Street over Abandoned CSX Spur
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Calculated by: PCC Date: 11/23/2023
Checked by: SAK Date: 11/27/2023

Table 10.6.3.1.2c-2—Reduction Coefficients (RC_{BC}) for Footings Placed Adjacent to Slopes Composed of either Purely Cohesive Soils, ($\phi = 0$); Purely Cohesionless Soils ($c'=0$); or Soils with both Cohesive and Cohesionless Strength Components

			β=10°				β=20°				β=30°				β=40°			
			Ns				*Ns*				*Ns*				*Ns*			
ϕ (°)	***B/H***	***b/B***	**0**	**2**	**4**	***c'*=0**	**0**	**2**	**4**	***c'*=0**	**0**	**2**	**4**	***c'*=0**	**0**	**2**	**4**	***c'*=0**
0	0.2	0	0.89	0.88	0.88	0.00	0.89	0.87	0.86	0.00	0.82	0.81	0.78	0.00	0.76	0.73	0.69	0.00
		0.5	0.97	0.96	0.96	0.00	0.95	0.93	0.91	0.00	0.92	0.89	0.87	0.00	0.86	0.83	0.76	0.00
		1.25	1.00	0.99	0.98	0.00	1.00	0.98	0.96	0.00	1.00	0.97	0.95	0.00	0.95	0.91	0.81	0.00
		2.5	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	0.97	0.84	0.00
		5	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	0.89	0.00
		10	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
	0.5	0	0.92	0.91	0.88	0.00	0.85	0.82	0.76	0.00	0.77	0.73	0.63	0.00	0.71	0.65	0.52	0.00
		0.5	0.96	0.95	0.89	0.00	0.92	0.89	0.78	0.00	0.87	0.84	0.68	0.00	0.83	0.76	0.56	0.00
		1.25	0.98	0.97	0.90	0.00	0.96	0.94	0.80	0.00	0.94	0.92	0.71	0.00	0.90	0.83	0.58	0.00
		2.5	1.00	1.00	1.00	0.00	1.00	1.00	0.86	0.00	1.00	1.00	0.79	0.00	1.00	0.93	0.68	0.00
		5	1.00	1.00	1.00	0.00	1.00	1.00	0.95	0.00	1.00	1.00	0.93	0.00	1.00	1.00	0.88	0.00
		10	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
	1	0	0.87	0.84	0.75	0.00	0.87	0.79	0.56	0.00	0.80	0.66	0.42	0.00	0.73	0.56	0.33	0.00
		0.5	0.95	0.91	0.82	0.00	0.92	0.83	0.65	0.00	0.86	0.73	0.46	0.00	0.81	0.67	0.40	0.00
		1.25	0.97	0.94	0.83	0.00	0.95	0.87	0.67	0.00	0.92	0.81	0.50	0.00	0.89	0.76	0.46	0.00
		2.5	1.00	0.98	0.88	0.00	1.00	0.97	0.77	0.00	1.00	1.00	0.84	0.00	0.99	0.92	0.63	0.00
		5	1.00	1.00	0.95	0.00	1.00	1.00	0.90	0.00	1.00	1.00	0.84	0.00	1.00	1.00	0.83	0.00
		10	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
	2	0	0.87	0.79	0.57	0.00	0.87	0.71	0.44	0.00	0.81	0.62	0.35	0.00	0.75	0.56	0.29	0.00
		0.5	0.97	0.93	0.65	0.00	0.94	0.79	0.49	0.00	0.89	0.72	0.42	0.00	0.85	0.69	0.37	0.00
		1.25	0.99	0.98	0.73	0.00	0.99	0.91	0.57	0.00	0.98	0.86	0.51	0.00	0.96	0.83	0.47	0.00
		2.5	1.00	0.99	0.82	0.00	1.00	0.96	0.69	0.00	1.00	0.95	0.64	0.00	1.00	0.95	0.61	0.00
		5	1.00	1.00	0.96	0.00	1.00	1.00	0.87	0.00	1.00	1.00	0.84	0.00	1.00	1.00	0.81	0.00
		10	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
20	0.2	0	0.90	0.89	0.90	0.68	0.75	0.73	0.72	0.21	0.62	0.59	0.56	0.00	0.52	0.49	0.45	0.00
		0.5	0.78	0.87	0.86	0.70	0.74	0.76	0.74	0.40	0.63	0.65	0.63	0.00	0.52	0.56	0.52	0.00
		1.25	0.86	0.92	0.92	0.82	0.83	0.84	0.83	0.70	0.74	0.75	0.74	0.00	0.63	0.66	0.63	0.00
		2.5	0.96	0.98	0.99	0.83	0.95	0.94	0.95	0.84	0.90	0.89	0.90	0.00	0.78	0.81	0.78	0.00
		5	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	0.96	0.98	0.96	0.00
		10	1.00	1.00	1.00	0.84	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	0.99	0.99	1.00	0.00
	0.5	0	0.86	0.86	0.84	0.60	0.73	0.70	0.67	0.22	0.62	0.56	0.51	0.00	0.52	0.45	0.39	0.00
		0.5	0.84	0.91	0.92	0.71	0.80	0.80	0.79	0.40	0.70	0.68	0.67	0.00	0.62	0.59	0.56	0.00
		1.25	0.88	1.00	0.97	0.82	0.85	0.88	0.86	0.70	0.76	0.75	0.75	0.00	0.68	0.66	0.64	0.00
		2.5	0.97	1.00	1.00	0.81	0.95	0.97	0.98	0.84	0.90	0.94	0.96	0.00	0.84	0.86	0.87	0.00
		5	1.00	1.00	1.00	0.84	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
		10	1.00	1.00	1.00	0.84	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
	1	0	0.85	0.82	0.78	0.58	0.72	0.64	0.58	0.26	0.61	0.50	0.42	0.00	0.52	0.39	0.30	0.00
		0.5	0.84	0.91	0.91	0.71	0.81	0.80	0.79	0.46	0.70	0.69	0.67	0.00	0.64	0.62	0.60	0.00
		1.25	0.87	0.95	0.96	0.82	0.85	0.85	0.85	0.73	0.76	0.76	0.75	0.00	0.71	0.70	0.69	0.00
		2.5	0.97	1.00	1.00	0.82	0.95	0.97	0.98	0.83	0.90	0.94	0.97	0.00	0.86	0.89	0.91	0.00
		5	1.00	1.00	1.00	0.83	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
		10	1.00	1.00	1.00	0.83	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
	2	0	0.90	0.90	0.90	0.58	0.87	0.86	0.84	0.33	0.84	0.81	0.78	0.00	0.81	0.77	0.74	0.00
		0.5	0.90	0.93	0.93	0.70	0.88	0.88	0.87	0.54	0.84	0.83	0.81	0.00	0.84	0.82	0.81	0.00
		1.25	0.92	0.97	0.99	0.81	0.90	0.92	0.92	0.77	0.86	0.86	0.86	0.00	0.85	0.85	0.84	0.00
		2.5	0.98	1.00	1.00	0.81	0.97	0.98	1.00	0.81	0.93	0.97	1.00	0.00	0.92	0.96	0.99	0.00
		5	1.00	1.00	1.00	0.82	1.00	1.00	1.00	0.84	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
		10	1.00	1.00	1.00	0.82	1.00	1.00	1.00	0.84	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00

Table 10.6.3.1.2c-2 (cont.)

			β=10°				β=20°				β=30°				β=40°			
			Ns				*Ns*				*Ns*				*Ns*			
ϕ (°)	*B/H*	*b/B*	0	2	4	*c'*=0	0	2	4	*c'*=0	0	2	4	*c'*=0	0	2	4	*c'*=0
30	0.2	0	0.93	0.92	0.91	0.76	0.65	0.64	0.63	0.39	0.51	0.50	0.48	0.11	0.40	0.37	0.36	0.00
		0.5	0.74	0.81	0.80	0.75	0.70	0.66	0.65	0.50	0.57	0.52	0.49	0.21	0.47	0.42	0.39	0.00
		1.25	0.78	0.85	0.86	0.86	0.74	0.73	0.72	0.72	0.63	0.60	0.59	0.38	0.54	0.50	0.47	0.00
		2.5	0.84	0.92	0.93	0.99	0.81	0.82	0.83	0.94	0.72	0.73	0.74	0.74	0.64	0.62	0.61	0.00
		5	0.95	1.00	1.00	1.00	0.93	0.98	1.00	1.00	0.88	0.95	1.00	0.97	0.80	0.85	0.87	0.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
	0.5	0	0.79	0.79	0.78	0.70	0.63	0.59	0.55	0.36	0.50	0.43	0.39	0.13	0.39	0.32	0.27	0.00
		0.5	0.76	0.87	0.87	0.74	0.72	0.71	0.70	0.51	0.58	0.56	0.54	0.24	0.49	0.46	0.43	0.00
		1.25	0.79	0.85	0.92	0.87	0.75	0.73	0.76	0.72	0.63	0.62	0.61	0.45	0.54	0.52	0.50	0.00
		2.5	0.87	0.91	1.00	0.99	0.84	0.85	0.90	0.98	0.74	0.78	0.80	0.80	0.67	0.70	0.71	0.00
		5	0.97	1.00	1.00	1.00	0.95	1.00	1.00	1.00	0.90	1.00	1.00	1.00	0.85	0.94	0.98	0.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
	1	0	0.79	0.75	0.73	0.67	0.63	0.53	0.49	0.41	0.55	0.41	0.35	0.24	0.48	0.33	0.26	0.00
		0.5	0.78	0.87	0.89	0.74	0.75	0.74	0.74	0.51	0.64	0.62	0.60	0.35	0.59	0.56	0.54	0.00
		1.25	0.81	0.90	0.91	0.88	0.78	0.78	0.78	0.72	0.68	0.67	0.66	0.58	0.64	0.62	0.61	0.00
		2.5	0.88	0.99	1.00	0.96	0.85	0.90	0.92	0.95	0.78	0.81	0.84	0.88	0.75	0.78	0.80	0.00
		5	0.97	1.00	1.00	1.00	0.96	1.00	1.00	1.00	0.92	1.00	1.00	1.00	0.89	0.98	1.00	0.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
	2	0	0.88	0.88	0.87	0.65	0.87	0.85	0.83	0.48	0.85	0.82	0.80	0.38	0.83	0.80	0.76	0.00
		0.5	0.89	0.91	0.91	0.75	0.89	0.89	0.87	0.58	0.88	0.86	0.84	0.51	0.87	0.85	0.82	0.00
		1.25	0.90	0.92	0.93	0.88	0.90	0.90	0.90	0.75	0.89	0.87	0.87	0.70	0.89	0.87	0.86	0.00
		2.5	0.97	1.00	1.00	1.00	0.96	0.97	0.98	0.98	0.92	0.94	0.96	0.95	0.91	0.92	0.94	0.00
		5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
40	0.2	0	0.69	0.69	0.69	0.78	0.51	0.48	0.47	0.37	0.37	0.33	0.30	0.16	0.27	0.23	0.20	0.05
		0.5	0.65	0.73	0.71	0.74	0.60	0.55	0.53	0.38	0.64	0.38	0.35	0.25	0.34	0.29	0.25	0.13
		1.25	0.68	0.77	0.75	0.86	0.63	0.60	0.58	0.55	0.74	0.44	0.42	0.39	0.39	0.34	0.31	0.25
		2.5	0.72	0.83	0.84	1.00	0.68	0.68	0.68	0.76	0.87	0.53	0.53	0.62	0.45	0.43	0.41	0.48
		5	0.80	0.93	0.95	1.00	0.76	0.82	0.85	1.00	1.00	0.72	0.76	1.00	0.57	0.61	0.63	0.94
		10	0.94	1.00	1.00	1.00	0.91	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.76	0.93	1.00	1.00
	0.5	0	0.67	0.69	0.67	0.69	0.50	0.45	0.43	0.35	0.36	0.30	0.26	0.17	0.27	0.20	0.17	0.07
		0.5	0.68	0.81	0.81	0.73	0.63	0.62	0.61	0.46	0.47	0.44	0.41	0.25	0.39	0.35	0.32	0.09
		1.25	0.70	0.82	0.84	0.85	0.65	0.65	0.66	0.60	0.51	0.49	0.47	0.40	0.43	0.41	0.39	0.18
		2.5	0.76	0.92	0.96	1.00	0.72	0.77	0.80	0.81	0.59	0.62	0.63	0.60	0.54	0.56	0.56	0.37
		5	0.84	1.00	1.00	1.00	0.81	0.91	0.94	1.00	0.71	0.82	0.88	1.00	0.67	0.77	0.83	0.84
		10	0.96	1.00	1.00	1.00	0.94	1.00	1.00	1.00	0.89	1.00	1.00	1.00	0.86	1.00	1.00	1.00
	1	0	0.69	0.64	0.62	0.70	0.63	0.48	0.43	0.45	0.58	0.39	0.33	0.32	0.54	0.33	0.27	0.24
		0.5	0.77	0.81	0.82	0.74	0.75	0.73	0.72	0.49	0.71	0.66	0.62	0.38	0.68	0.62	0.57	0.30
		1.25	0.78	0.84	0.85	0.84	0.77	0.76	0.75	0.64	0.73	0.69	0.66	0.55	0.71	0.66	0.63	0.48
		2.5	0.83	0.92	0.95	1.00	0.81	0.85	0.87	0.85	0.76	0.78	0.79	0.76	0.75	0.76	0.77	0.72
		5	0.89	1.00	1.00	1.00	0.87	0.95	0.98	1.00	0.80	0.90	0.95	1.00	0.80	0.89	0.94	1.00
		10	0.98	1.00	1.00	1.00	0.97	1.00	1.00	1.00	0.94	1.00	1.00	1.00	0.93	1.00	1.00	1.00
	2	0	0.93	0.92	0.89	0.45	0.92	0.90	0.87	0.60	0.91	0.88	0.84	0.53	0.89	0.85	0.81	0.47
		0.5	0.93	0.95	0.93	0.76	0.93	0.92	0.90	0.65	0.92	0.89	0.87	0.64	0.92	0.89	0.86	0.60
		1.25	0.93	0.95	0.94	0.86	0.93	0.93	0.92	0.78	0.93	0.91	0.89	0.74	0.93	0.90	0.88	0.74
		2.5	0.94	0.99	1.00	1.00	0.94	0.98	0.98	0.92	0.94	0.97	0.97	0.87	0.94	0.96	0.96	0.88
		5	0.95	1.00	1.00	1.00	0.96	1.00	1.00	1.00	0.98	1.00	1.00	1.00	0.96	1.00	1.00	1.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00

Armory Street over Abandoned CSX Spur
(Bridge No. S-24-026)
Proposed Bridge Replacement and Roadway Widening
Springfield, Massachusetts

Discipline: Geotechnical Title: Settlement Analysis for Proposed Retaining Wall 4

MassDOT Project File No. 609409

Design Basis/Assumptions:

Purpose: Evaluate settlement and feasibility of a typical MassDOT cantilever retaining wall option for Retaining Wall 4 along the west side of Armory Street.

Assumptions:

1) Groundwater conditions the same or similar to those observed during the subsurface explorations by Nobis.
2) Critical section at approximately STA 16+00. Proposed roadway profile similar to the existing conditions.
3) Bottom of footing elevation at approximately El. 142.1. Refer to attached sketch on page 2 for the wall cross-section considered in analysis.
4) Maximum bearing pressure is approximately 4.9 ksf based on a total wall height of 17 feet.

Approach:

Use the computer settlement analysis software Settle3, by RocScience, Inc., to perform preliminary settlement analyses on the proposed Retaining Wall 4.

References:

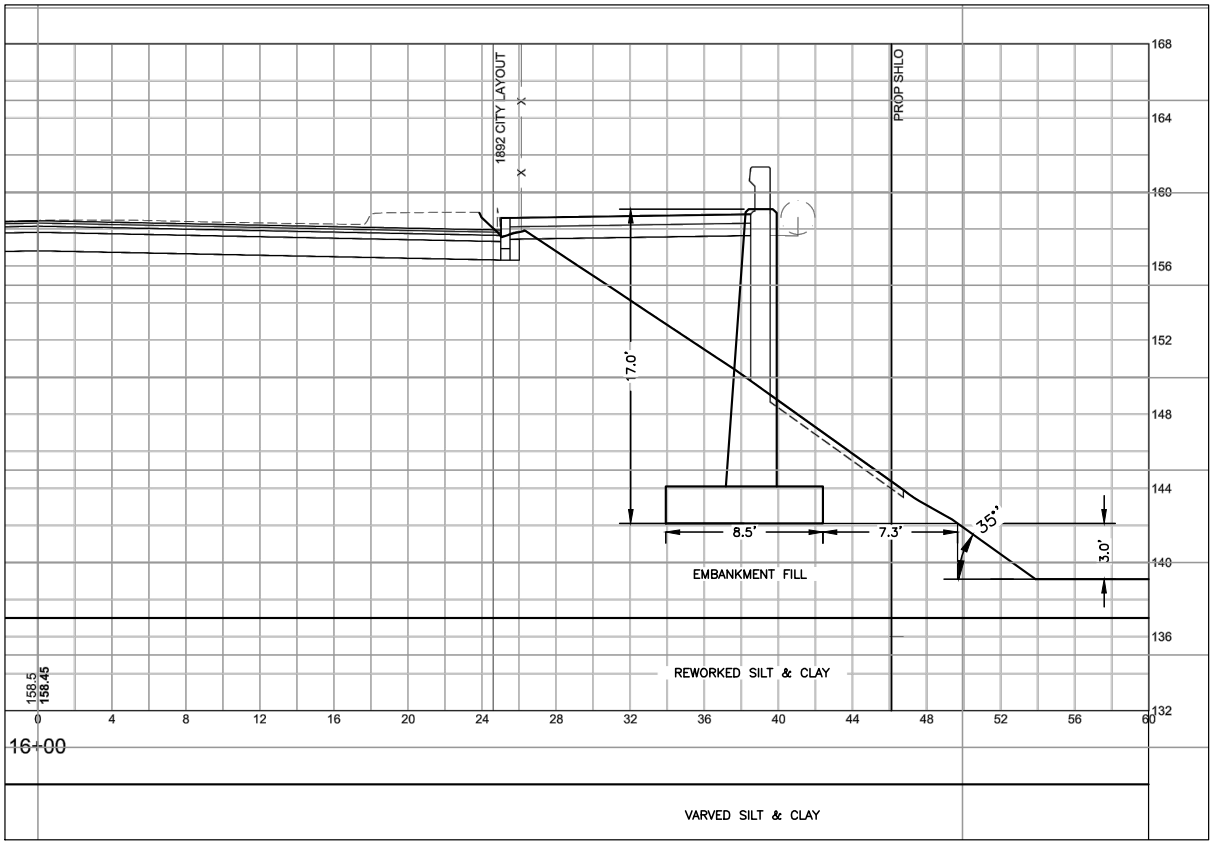
1) Grading Plans and Cross Sections provided by Tetra Tech in October 2023.
2) Subsurface explorations and laboratory tests performed by Nobis.
3) AASHTO LRFD Bridge Design Specifications, 9th Edition 2020.
4) MassDOT Standard Drawing E 305.3.0 - Cantilever Retaining Walls - Dense Foundation Soils, Level Backfill, Surcharge.

Remarks/Conclusions:

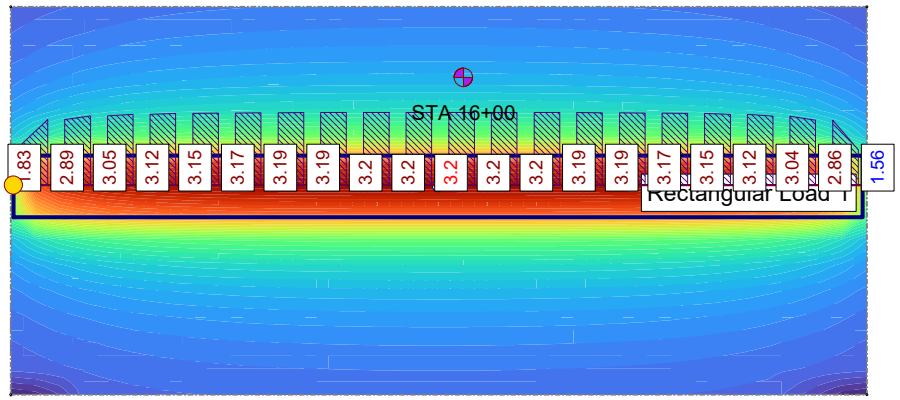
The total settlement (elastic, primary, and secondary consolidation settlements) due to the addition of Retaining Wall 4 as the cantilever option with a maximum bearing pressure of 4.9 ksf is on the order of 3.2 inches 50 years post-construction.

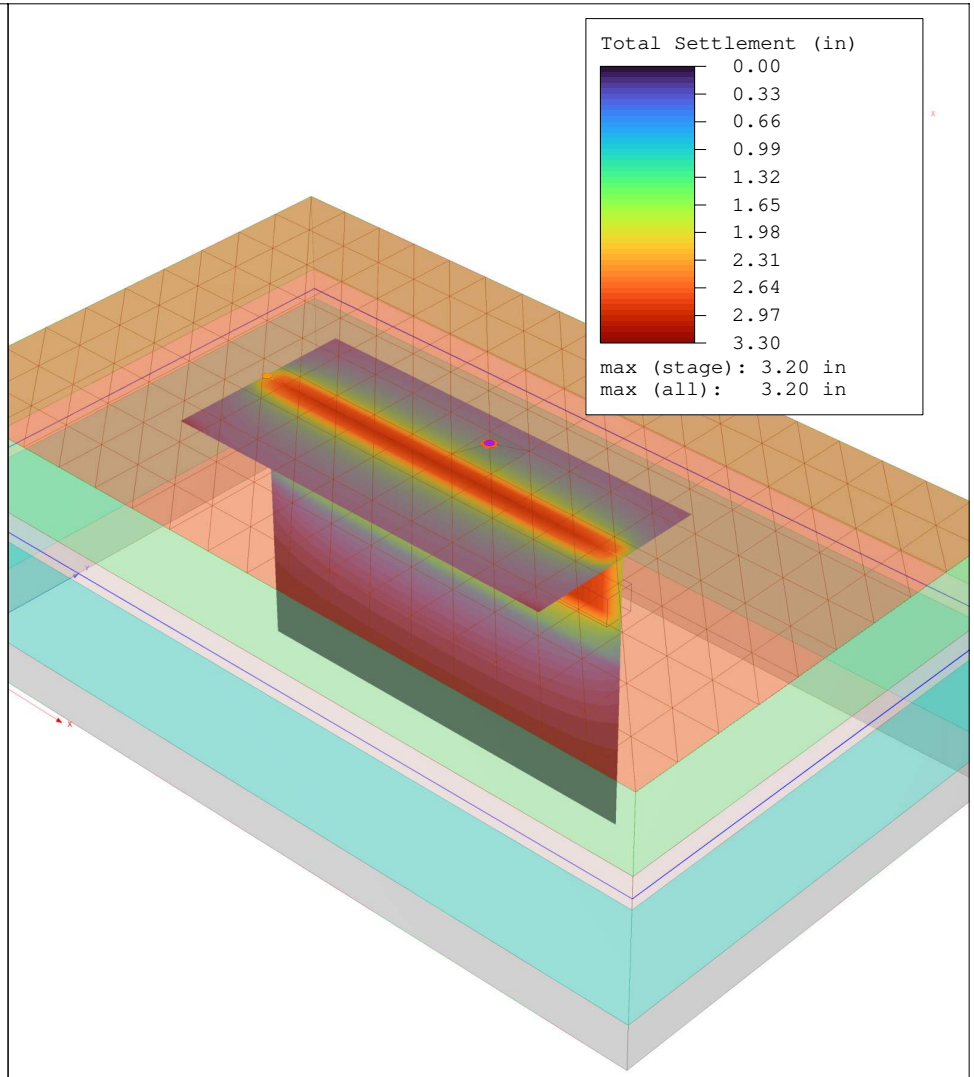
Originated By: Patrick Clarke, PE Date: 11/16/2023

Reviewed By: Sarah Kurtzer, EIT Date: 11/20/2023


1892 CITY LAYOUT
PROP SHLO
17.0'
8.5'
7.3'
3.5:1
3.0'
EMBANKMENT FILL
REWORKED SILT & CLAY
VARVED SILT & CLAY
158.5
158.45
16+00
168
164
160
156
152
148
144
140
136
132
0
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60

Material Name	Color	Unit Weight (kips/ft3)	Es (ksf)	Eur (ksf)	Cc/Cce	Cr/Cre	OCR	Cv (ft2/y)
Existing Fill		0.115	190	190	-	-	-	-
Varved Silt and Clay		0.12	-	-	0.1	0.025	4.5	173
Glacial Till		0.135	2819.53	2819.53	-	-	-	-
Reworked Silt and Clay		0.12	-	-	0.1	0.025	4.5	173





rocscience

SETTLE3 5.022

Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Settlement Analysis - Wall #4		
Drawn By	PCC Checked by: SAK	Company	Nobis Group
Date	11/16/2022	File Name	RW4.s3z

Settle3 Analysis Information

Armory Street Over Abandoned CSX Spur - Springfield, MA

Project Settings

Document Name	RW4
Project Title	Armory Street Over Abandoned CSX Spur - Springfield, MA
Analysis	Settlement Analysis - Wall #4
Author	PCC Checked by: SAK
Company	Nobis Group
Date Created	11/16/2022
Last saved with Settle3 version	5.022
Stress Computation Method	Boussinesq
Stress Units	Imperial, stress as ksf
Settlement Units	inches
Time-dependent Consolidation Analysis	
Time Units	years
Permeability Units	feet/year

Advanced Settings

Start of secondary consolidation (% of primary)	95
Min. stress for secondary consolidation (% of initial)	1
Reset time when load changes for secondary consolidation	No
Minimum settlement ratio for subgrade modulus	0.9
Use average poisson's ratio to calculate layered stresses	
Update Cv in each time step (improves consolidation accuracy)	
Ignore negative effective stresses in settlement calculations	
Add field points to load edges	

Soil Profile

Layer Option	Non-Horizontal Layers
Interpolation Method	TIN Triangulation
Use Non-Horizontal Ground Surface	Yes
Number of Surface Points	200
Vertical Axis	Elevation
Ground Elevation (ft)	159.1

Stage Settings

Stage #	Name	Time [years]
1	Stage 1	0
2	Present	85
3	Construction	91
4	2.5 Weeks Post Construction	91.05
5	3 Months Post Construction	91.25
6	9 Years Post Construction	100
7	50 Years Post Construction	141

Loads

1. Rectangular Load: "Rectangular Load 1"

Length	117 ft
Width	8.5 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	994.5 ft2
Load	4.9 ksf
Elevation	142.1 ft
Installation Stage	Construction = 91 y

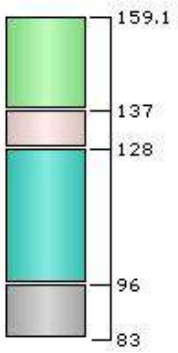
Coordinates

X [ft]	Y [ft]
-62	-19.25
55	-19.25
55	-10.75
-62	-10.75

Soil Layers

Ground Surface Drained: Yes

Layer #	Type	Thickness [ft]	Elevation [ft]	Drained at Bottom
1	Proposed Fill	0	159.1	Yes
2	Existing Fill	22.1	159.1	Yes
3	Reworked Silt and Clay	9	137	Yes
4	Varved Silt and Clay	32	128	No
5	Glacial Till	13	96	No
6	Weathered Bedrock	0	83	No
7	Bedrock	0	83	No
8	Existing Fill	0	83	No



Soil Properties

Property	Existing Fill	Varved Silt and Clay	Glacial Till	Weathered Bedrock
Color				
Unit Weight [kips/ft3]	0.115	0.12	0.135	0.15
Saturated Unit Weight [kips/ft3]	0.115	0.12	135	0.15
K0	1	1	1	1
Immediate Settlement	Enabled	Disabled	Enabled	Disabled
Es [ksf]	190	-	2819.53	-
Esur [ksf]	190	-	2819.53	-
Primary Consolidation	Disabled	Enabled	Disabled	Disabled
Material Type		Non-Linear		
Cce	-	0.1	-	-
Cre	-	0.025	-	-
e0	-	0.904	-	-
OCR	-	4.5	-	-
Cv [ft2/y]	-	173	-	-
Cvr [ft2/y]	-	173	-	-
B-bar	-	1	-	-
Secondary Consolidation	Disabled	Standard	Disabled	Disabled
Cae	-	0.0028	-	-
Care	-	0.0028	-	-
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8
Piezo Line ID	0	0	0	0

Property	Bedrock	Proposed Fill	Reworked Silt and Clay
Color			
Unit Weight [kips/ft3]	0.164	0.135	0.12
Saturated Unit Weight [kips/ft3]	0.164	0.135	0.12
K0	1	1	1
Immediate Settlement	Disabled	Enabled	Disabled
Es [ksf]	-	1305.34	-
Esur [ksf]	-	208.9	-
Primary Consolidation	Disabled	Disabled	Enabled
Material Type			Non-Linear
Cce	-	-	0.1
Cre	-	-	0.025

e0	-	-	1.1
OCR	-	-	4.5
Cv [ft2/y]	-	-	173
Cvr [ft2/y]	-	-	173
B-bar	-	-	1
Secondary Consolidation	Disabled	Disabled	Standard
Cae	-	-	0.0028
Care	-	-	0.0028
Undrained Su A [kips/ft2]	0	0	0
Undrained Su S	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8
Piezo Line ID	0	0	1

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft3

Piezometric Line Entities

ID	Elevation (ft)
1	131 ft

Armory Street over Abandoned CSX Spur
(Bridge No. S-24-026)
Proposed Bridge Replacement and Roadway Widening
Springfield, Massachusetts

Discipline: Geotechnical Title: Settlement Analysis for Proposed Retaining Wall 5

MassDOT Project File No. 609409

Design Basis/Assumptions:

Purpose: Evaluate settlement and feasibility of a typical MassDOT cantilever retaining wall option for Retaining Wall 5 along the east side of Armory Street.

Assumptions:

1) Groundwater conditions the same or similar to those observed during the subsurface explorations by Nobis.
2) Critical section at approximately STA 16+00. Proposed roadway profile similar to the existing conditions.
3) Bottom of footing elevation at approximately El. 145. Refer to attached sketch on page 2 for the wall cross-section considered in analysis.
4) Maximum bearing pressure is approximately 4.1 ksf based on a total wall height of 14 feet.

Approach:

Use the computer settlement analysis software Settle3, by RocScience, Inc., to perform preliminary settlement analyses on the proposed Retaining Wall 5.

References:

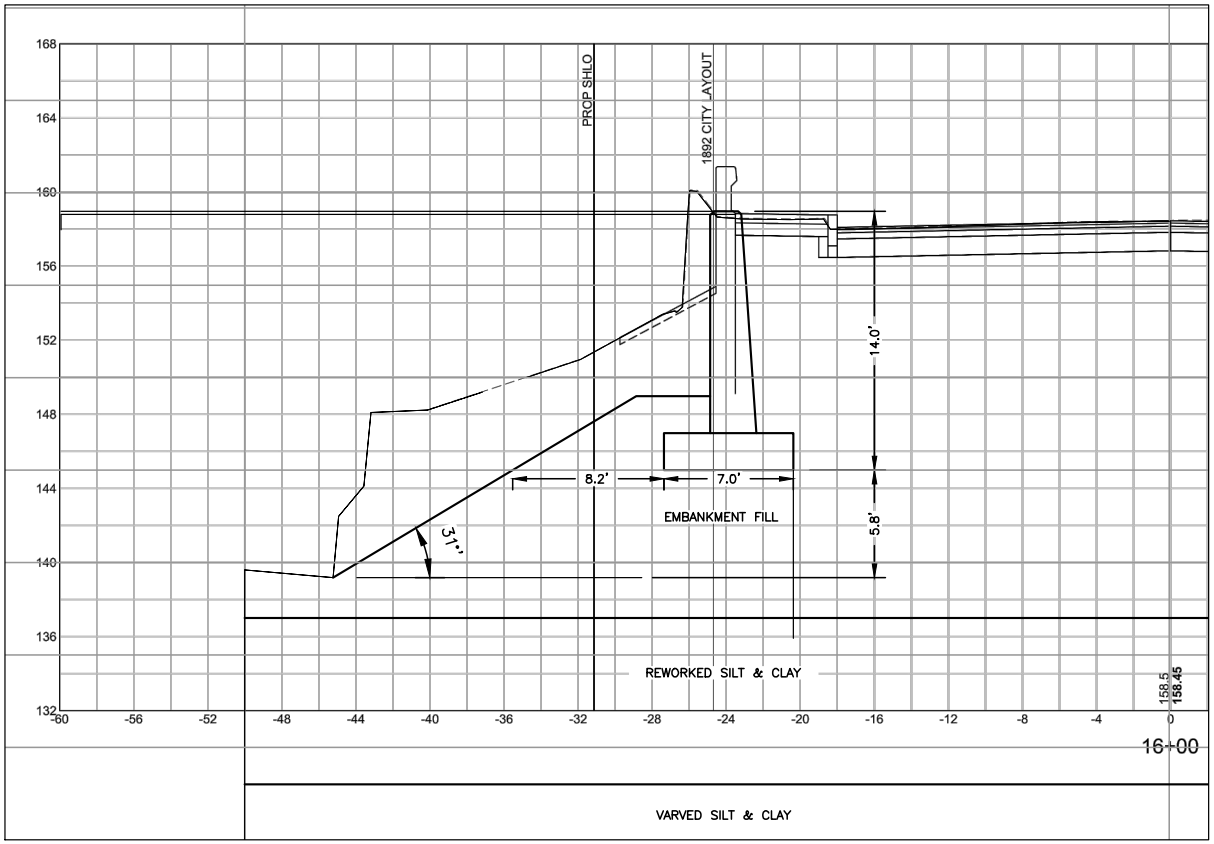
1) Grading Plans and Cross Sections provided by Tetra Tech in October 2023.
2) Subsurface explorations and laboratory tests performed by Nobis.
3) AASHTO LRFD Bridge Design Specifications, 9th Edition 2020.
4) MassDOT Standard Drawing E 305.3.0 - Cantilever Retaining Walls - Dense Foundation Soils, Level Backfill, Surcharge.

Remarks/Conclusions:

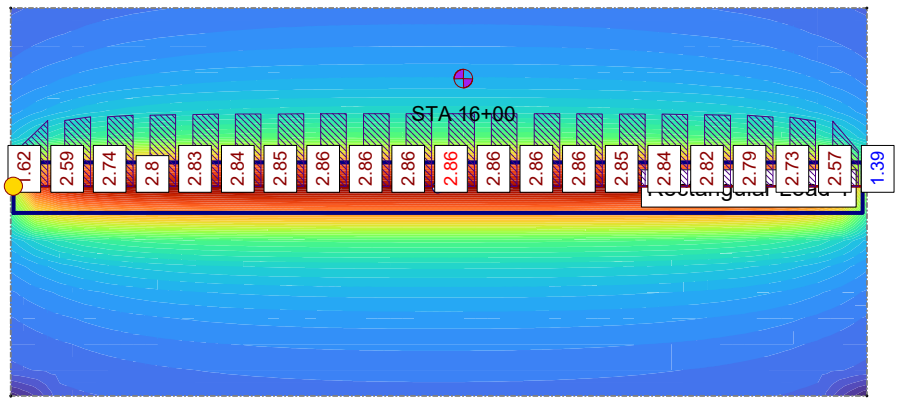
The total settlement (elastic, primary, and secondary consolidation settlements) due to the addition of Retaining Wall 5 as the cantilever option with a maximum bearing pressure of 4.1 ksf is on the order of 2.9 inches 50 years post-construction.

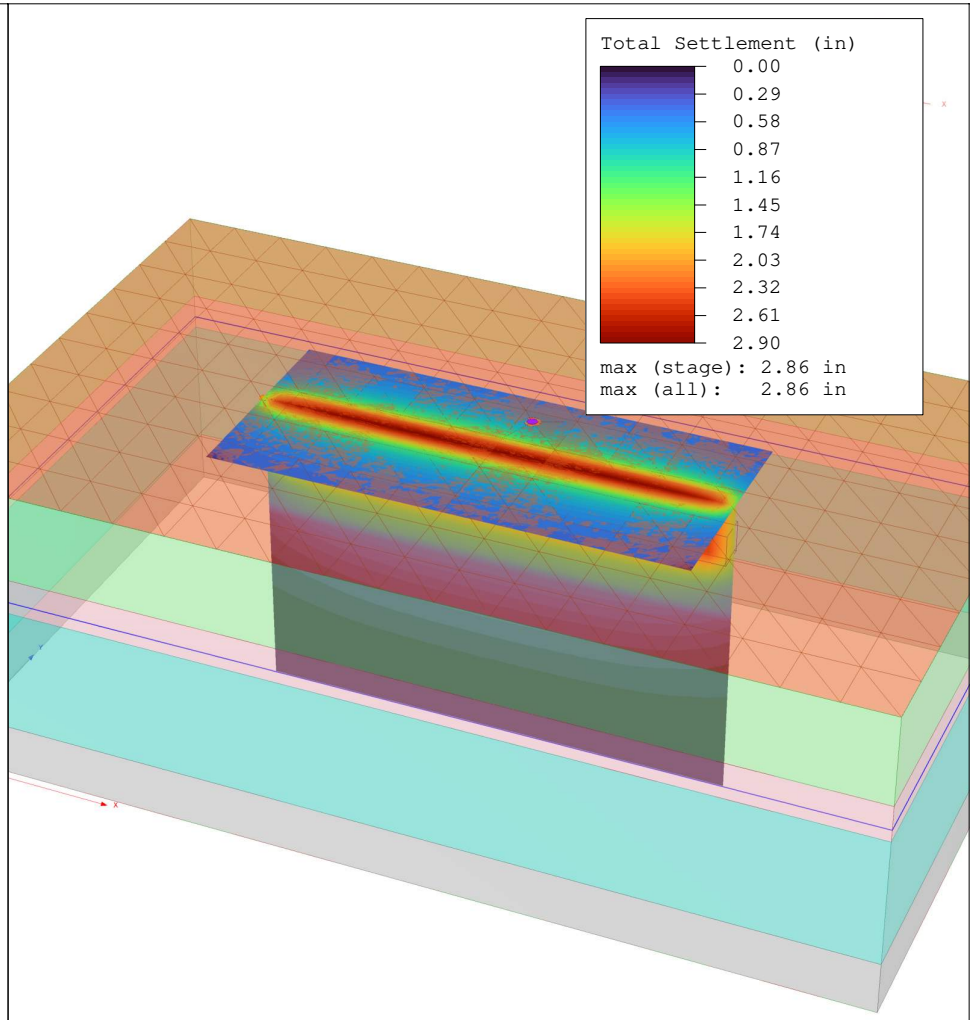
Originated By: Patrick Clarke, PE Date: 11/16/2023

Reviewed By: Sarah Kurtzer, EIT Date: 11/20/2023


PROP SHLO
1892 CITY LAYOUT
14.0'
8.2'
7.0'
EMBANKMENT FILL
5.8'
31°
REWORKED SILT & CLAY
158.5
158.45
16+00
VARVED SILT & CLAY
168
164
160
156
152
148
144
140
136
132
-60
-56
-52
-48
-44
-40
-36
-32
-28
-24
-20
-16
-12
-8
-4
0

Material Name	Color	Unit Weight (kips/ft3)	Es (ksf)	Eur (ksf)	Cc/Cce	Cr/Cre	OCR	Cv (ft2/y)
Existing Fill		0.115	190	190	-	-	-	-
Varved Silt and Clay		0.12	-	-	0.1	0.025	4.5	173
Glacial Till		0.135	2819.53	2819.53	-	-	-	-
Reworked Silt and Clay		0.12	-	-	0.1	0.025	4.5	173





rocscience	*Project*	Armory Street Over Abandoned CSX Spur - Springfield, MA	
	Analysis Description	Settlement Analysis - Wall #5	
	Drawn By PCC	Checked by: SAK	*Company* Nobis Group
SETTLE3 5.022	*Date* 11/16/2022		*File Name* RW5.s3z

Settle3 Analysis Information

Armory Street Over Abandoned CSX Spur - Springfield, MA

Project Settings

Document Name	RW5
Project Title	Armory Street Over Abandoned CSX Spur - Springfield, MA
Analysis	Settlement Analysis - Wall #5
Author	PCC Checked by: SAK
Company	Nobis Group
Date Created	11/16/2022
Last saved with Settle3 version	5.022
Stress Computation Method	Boussinesq
Stress Units	Imperial, stress as ksf
Settlement Units	inches
Time-dependent Consolidation Analysis	
Time Units	years
Permeability Units	feet/year

Advanced Settings

Start of secondary consolidation (% of primary)	95
Min. stress for secondary consolidation (% of initial)	1
Reset time when load changes for secondary consolidation	No
Minimum settlement ratio for subgrade modulus	0.9
Use average poisson's ratio to calculate layered stresses	
Update Cv in each time step (improves consolidation accuracy)	
Ignore negative effective stresses in settlement calculations	
Add field points to load edges	

Soil Profile

Layer Option	Non-Horizontal Layers
Interpolation Method	TIN Triangulation
Use Non-Horizontal Ground Surface	Yes
Number of Surface Points	200
Vertical Axis	Elevation
Ground Elevation (ft)	159

Stage Settings

Stage #	Name	Time [years]
1	Stage 1	0
2	Present	85
3	Construction	91
4	2.5 Weeks Post Construction	91.05
5	3 Months Post Construction	91.25
6	9 Years Post Construction	100
7	50 Years Post Construction	141

Loads

1. Rectangular Load: "Rectangular Load 1"

Length	117 ft
Width	7 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	819 ft2
Load	4.1 ksf
Elevation	145 ft
Installation Stage	Construction = 91 y

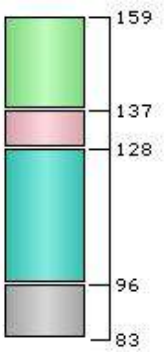
Coordinates

X [ft]	Y [ft]
-62	-18.5
55	-18.5
55	-11.5
-62	-11.5

Soil Layers

Ground Surface Drained: Yes

Layer #	Type	Thickness [ft]	Elevation [ft]	Drained at Bottom
1	Proposed Fill	0	159	Yes
2	Existing Fill	22	159	Yes
3	Reworked Silt and Clay	9	137	Yes
4	Varved Silt and Clay	32	128	No
5	Glacial Till	13	96	No
6	Weathered Bedrock	0	83	No
7	Bedrock	0	83	No
8	Existing Fill	0	83	No



Soil Properties

Property	Existing Fill	Varved Silt and Clay	Glacial Till	Weathered Bedrock
Color				
Unit Weight [kips/ft3]	0.115	0.12	0.135	0.15
Saturated Unit Weight [kips/ft3]	0.115	0.12	135	0.15
K0	1	1	1	1
Immediate Settlement	Enabled	Disabled	Enabled	Disabled
Es [ksf]	190	-	2819.53	-
Esur [ksf]	190	-	2819.53	-
Primary Consolidation	Disabled	Enabled	Disabled	Disabled
Material Type		Non-Linear		
Cce	-	0.1	-	-
Cre	-	0.025	-	-
e0	-	0.904	-	-
OCR	-	4.5	-	-
Cv [ft2/y]	-	173	-	-
Cvr [ft2/y]	-	173	-	-
B-bar	-	1	-	-
Secondary Consolidation	Disabled	Standard	Disabled	Disabled
Cae	-	0.0028	-	-
Care	-	0.0028	-	-
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8
Piezo Line ID	0	0	0	0

Property	Bedrock	Proposed Fill	Reworked Silt and Clay
Color			
Unit Weight [kips/ft3]	0.164	0.135	0.12
Saturated Unit Weight [kips/ft3]	0.164	0.135	0.12
K0	1	1	1
Immediate Settlement	Disabled	Enabled	Disabled
Es [ksf]	-	1305.34	-
Esur [ksf]	-	208.9	-
Primary Consolidation	Disabled	Disabled	Enabled
Material Type			Non-Linear
Cce	-	-	0.1
Cre	-	-	0.025

e0	-	-	1.1
OCR	-	-	4.5
Cv [ft2/y]	-	-	173
Cvr [ft2/y]	-	-	173
B-bar	-	-	1
Secondary Consolidation	Disabled	Disabled	Standard
Cae	-	-	0.0028
Care	-	-	0.0028
Undrained Su A [kips/ft2]	0	0	0
Undrained Su S	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8
Piezo Line ID	0	0	1

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft3

Piezometric Line Entities

ID	Elevation (ft)
1	131 ft

Armory Street over Abandoned CSX Spur
(Bridge No. S-24-026)
Proposed Bridge Replacement and Roadway Widening
Springfield, Massachusetts

Discipline: Geotechnical Title: Settlement Analysis for Proposed Retaining Wall 6

MassDOT Project File No. 609409

Design Basis/Assumptions:

Purpose: Evaluate settlement and feasibility of a typical MassDOT cantilever retaining wall option for Retaining Wall 6 along the west side of Armory Street.

Assumptions:

1) Groundwater conditions the same or similar to those observed during the subsurface explorations by Nobis.
2) Critical section at approximately STA 17+30. Proposed roadway profile similar to the existing conditions.
3) Bottom of footing elevation at approximately El. 145. Refer to attached sketch on page 2 for the wall cross-section considered in analysis.
4) Maximum bearing pressure is approximately 4.1 ksf based on a total wall height of 14 feet.

Approach:

Use the computer settlement analysis software Settle3, by RocScience, Inc., to perform preliminary settlement analyses on the proposed Retaining Wall 6.

References:

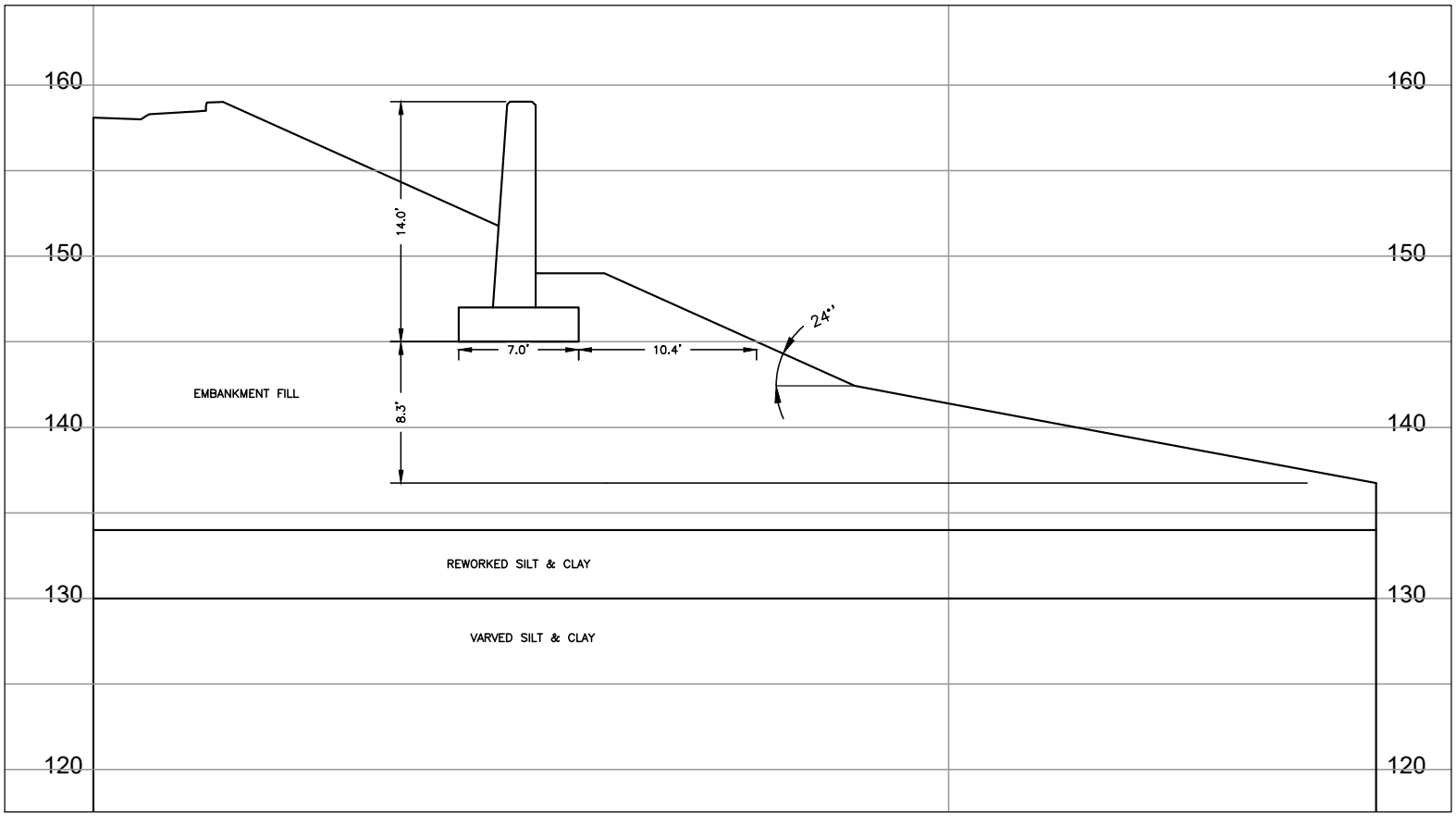
1) Grading Plans and Cross Sections provided by Tetra Tech in October 2023.
2) Subsurface explorations and laboratory tests performed by Nobis.
3) AASHTO LRFD Bridge Design Specifications, 9th Edition 2020.
4) MassDOT Standard Drawing E 305.3.0 - Cantilever Retaining Walls - Dense Foundation Soils, Level Backfill, Surcharge.

Remarks/Conclusions:

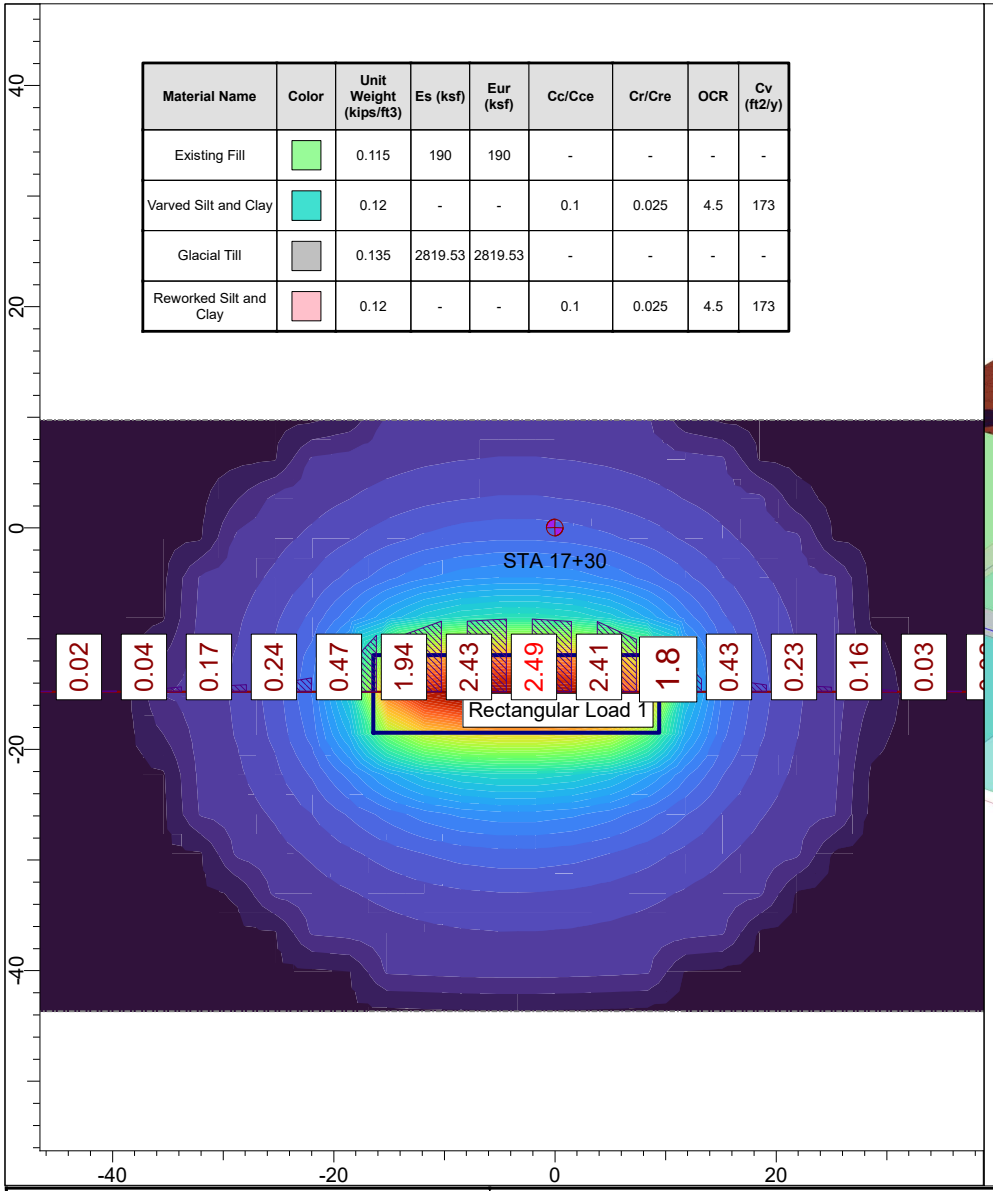
The total settlement (elastic, primary, and secondary consolidation settlements) due to the addition of Retaining Wall 6 as the cantilever option with a maximum bearing pressure of 4.1 ksf is on the order of 2.5 inches 50 years post-construction.

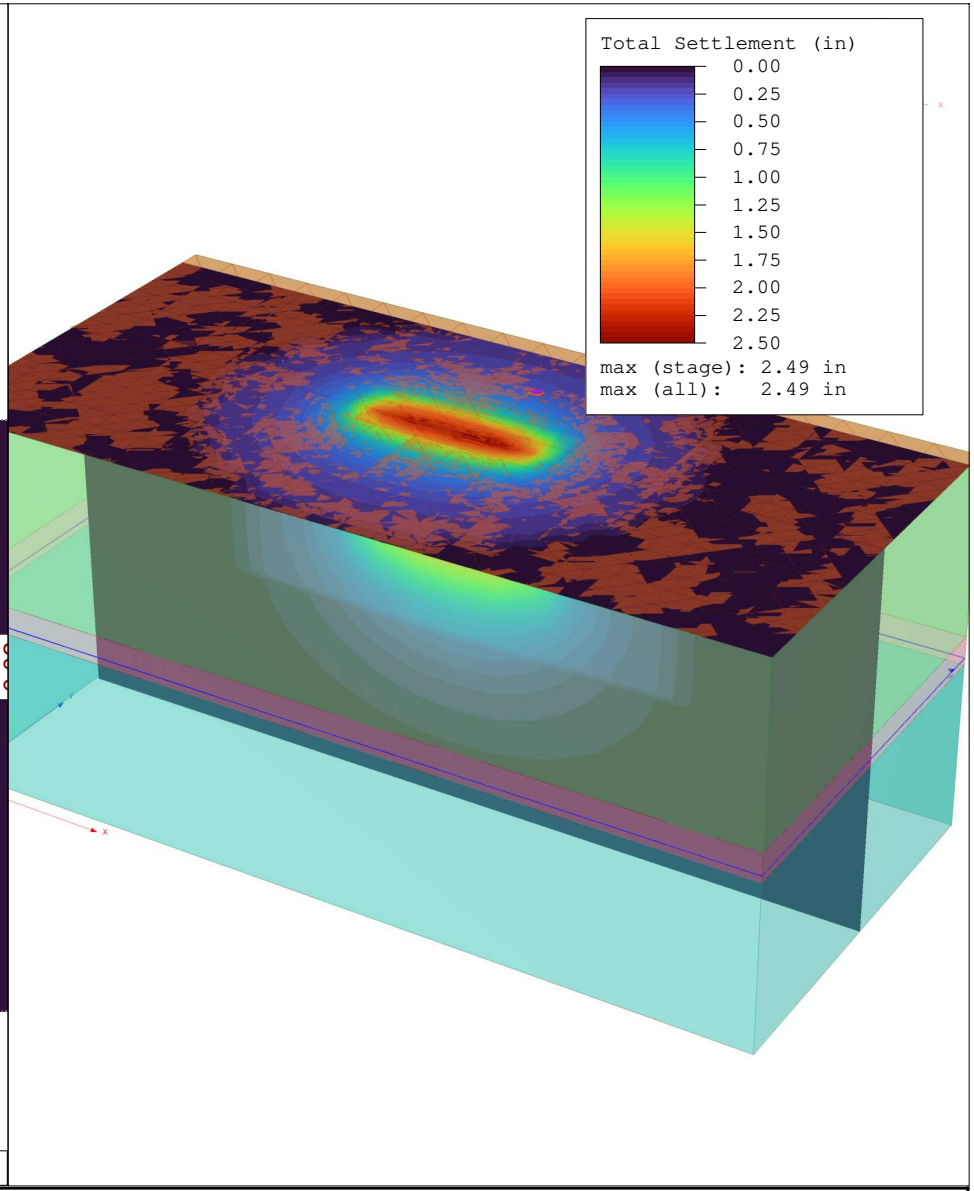
Originated By: Patrick Clarke, PE Date: 11/16/2023

Reviewed By: Sarah Kurtzer, EIT Date: 11/20/2023


160
150
140
130
120
14.0'
8.3'
7.0'
10.4'
24°
EMBANKMENT FILL
REWORKED SILT & CLAY
VARVED SILT & CLAY

Material Name	Color	Unit Weight (kips/ft3)	Es (ksf)	Eur (ksf)	Cc/Cce	Cr/Cre	OCR	Cv (ft2/y)
Existing Fill		0.115	190	190	-	-	-	-
Varved Silt and Clay		0.12	-	-	0.1	0.025	4.5	173
Glacial Till		0.135	2819.53	2819.53	-	-	-	-
Reworked Silt and Clay		0.12	-	-	0.1	0.025	4.5	173





rocscience

SETTLE3 5.022

Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Settlement Analysis - Wall #6		
Drawn By	PCC Checked by: SAK	*Company*	Nobis Group
Date	11/16/2022	*File Name*	RW6.s3z

Settle3 Analysis Information

Armory Street Over Abandoned CSX Spur - Springfield, MA

Project Settings

Document Name	RW6
Project Title	Armory Street Over Abandoned CSX Spur - Springfield, MA
Analysis	Settlement Analysis - Wall #6
Author	PCC Checked by: SAK
Company	Nobis Group
Date Created	11/16/2022
Last saved with Settle3 version	5.022
Stress Computation Method	Boussinesq
Stress Units	Imperial, stress as ksf
Settlement Units	inches
Time-dependent Consolidation Analysis	
Time Units	years
Permeability Units	feet/year

Advanced Settings

Start of secondary consolidation (% of primary)	95
Min. stress for secondary consolidation (% of initial)	1
Reset time when load changes for secondary consolidation	No
Minimum settlement ratio for subgrade modulus	0.9
Use average poisson's ratio to calculate layered stresses	
Update Cv in each time step (improves consolidation accuracy)	
Ignore negative effective stresses in settlement calculations	
Add field points to load edges	

Soil Profile

Layer Option	Non-Horizontal Layers
Interpolation Method	TIN Triangulation
Use Non-Horizontal Ground Surface	Yes
Number of Surface Points	200
Vertical Axis	Elevation
Ground Elevation (ft)	159

Stage Settings

Stage #	Name	Time [years]
1	Stage 1	0
2	Present	85
3	Construction	91
4	2.5 Weeks Post Construction	91.05
5	3 Months Post Construction	91.25
6	9 Years Post Construction	100
7	50 Years Post Construction	141

Loads

1. Rectangular Load: "Rectangular Load 1"

Length	25.83 ft
Width	7 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	180.81 ft2
Load	4.1 ksf
Elevation	145 ft
Installation Stage	Construction = 91 y

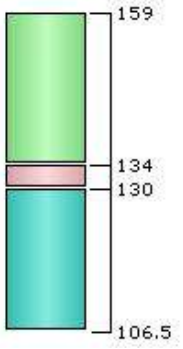
Coordinates

X [ft]	Y [ft]
-16.415	-18.5
9.415	-18.5
9.415	-11.5
-16.415	-11.5

Soil Layers

Ground Surface Drained: Yes

Layer #	Type	Thickness [ft]	Elevation [ft]	Drained at Bottom
1	Proposed Fill	0	159	Yes
2	Existing Fill	25	159	Yes
3	Reworked Silt and Clay	4	134	Yes
4	Varved Silt and Clay	23.5	130	No
5	Glacial Till	0	106.5	No
6	Weathered Bedrock	0	106.5	No
7	Bedrock	0	106.5	No
8	Existing Fill	0	106.5	No



Soil Properties

Property	Existing Fill	Varved Silt and Clay	Glacial Till	Weathered Bedrock
Color				
Unit Weight [kips/ft3]	0.115	0.12	0.135	0.15
Saturated Unit Weight [kips/ft3]	0.115	0.12	135	0.15
K0	1	1	1	1
Immediate Settlement	Enabled	Disabled	Enabled	Disabled
Es [ksf]	190	-	2819.53	-
Esur [ksf]	190	-	2819.53	-
Primary Consolidation	Disabled	Enabled	Disabled	Disabled
Material Type		Non-Linear		
Cce	-	0.1	-	-
Cre	-	0.025	-	-
e0	-	0.904	-	-
OCR	-	4.5	-	-
Cv [ft2/y]	-	173	-	-
Cvr [ft2/y]	-	173	-	-
B-bar	-	1	-	-
Secondary Consolidation	Disabled	Standard	Disabled	Disabled
Cae	-	0.0028	-	-
Care	-	0.0028	-	-
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8
Piezo Line ID	0	0	0	0

Property	Bedrock	Proposed Fill	Reworked Silt and Clay
Color			
Unit Weight [kips/ft3]	0.164	0.135	0.12
Saturated Unit Weight [kips/ft3]	0.164	0.135	0.12
K0	1	1	1
Immediate Settlement	Disabled	Enabled	Disabled
Es [ksf]	-	1305.34	-
Esur [ksf]	-	208.9	-
Primary Consolidation	Disabled	Disabled	Enabled
Material Type			Non-Linear
Cce	-	-	0.1
Cre	-	-	0.025

e0	-	-	1.1
OCR	-	-	4.5
Cv [ft2/y]	-	-	173
Cvr [ft2/y]	-	-	173
B-bar	-	-	1
Secondary Consolidation	Disabled	Disabled	Standard
Cae	-	-	0.0028
Care	-	-	0.0028
Undrained Su A [kips/ft2]	0	0	0
Undrained Su S	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8
Piezo Line ID	0	0	1

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft3

Piezometric Line Entities

ID	Elevation (ft)
1	131 ft

Armory Street Over Abandoned CSX Spur
Bridge No. S-24-026
Springfield, Massachusetts

Discipline: Geotechnical

Title: Global Stability Analysis for the Proposed Walls #4 through 6

MassDOT Contract No. 115769

MassDOT Project File No. 609409

Design Basis/Assumptions:

Purpose: Perform global stability analyses to evaluate the feasibility of designing Walls #4 through 6 as cantilever retaining walls on shallow foundations.

Assumptions:

1) Engineering properties for existing fill, varved silt and clay, glacial till, and bedrock encountered in the subsurface explorations (Reference 3).
2) Groundwater elevation is at approximately El. 131 at STA 16+00 and El. 135 at STA 17+30 based on measurements obtained from the subsurface explorations (Reference 3).
3) Surcharge loading of 250 psf (Reference 4).
4) Seismic loading 0.074g (A_s x 0.5 = 0.148 x 0.5) (Reference 5).

Approach:

Use the slope stability analysis software Slide2, by RocScience, Inc., to perform global stability analyses on the proposed retaining walls based on the results of the subsurface explorations performed by Nobis and information obtained from an AutoCAD drawing (Reference 1) and Cross Sections (Reference 2) provided by Tetra Tech.

References:

1) Drawings (AutoCAD) provided by Tetra Tech on November 15, 2023.
2) Cross Sections and Grading Plans (PDF) provided by Tetra Tech on October 4, 2023.
3) Standard Penetration Test (SPT) data and subsurface explorations observed by Nobis in 2019 and 2022.
4) AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
5) Seismic site classification and seismic parameters developed by Nobis.

Remarks/Conclusions:

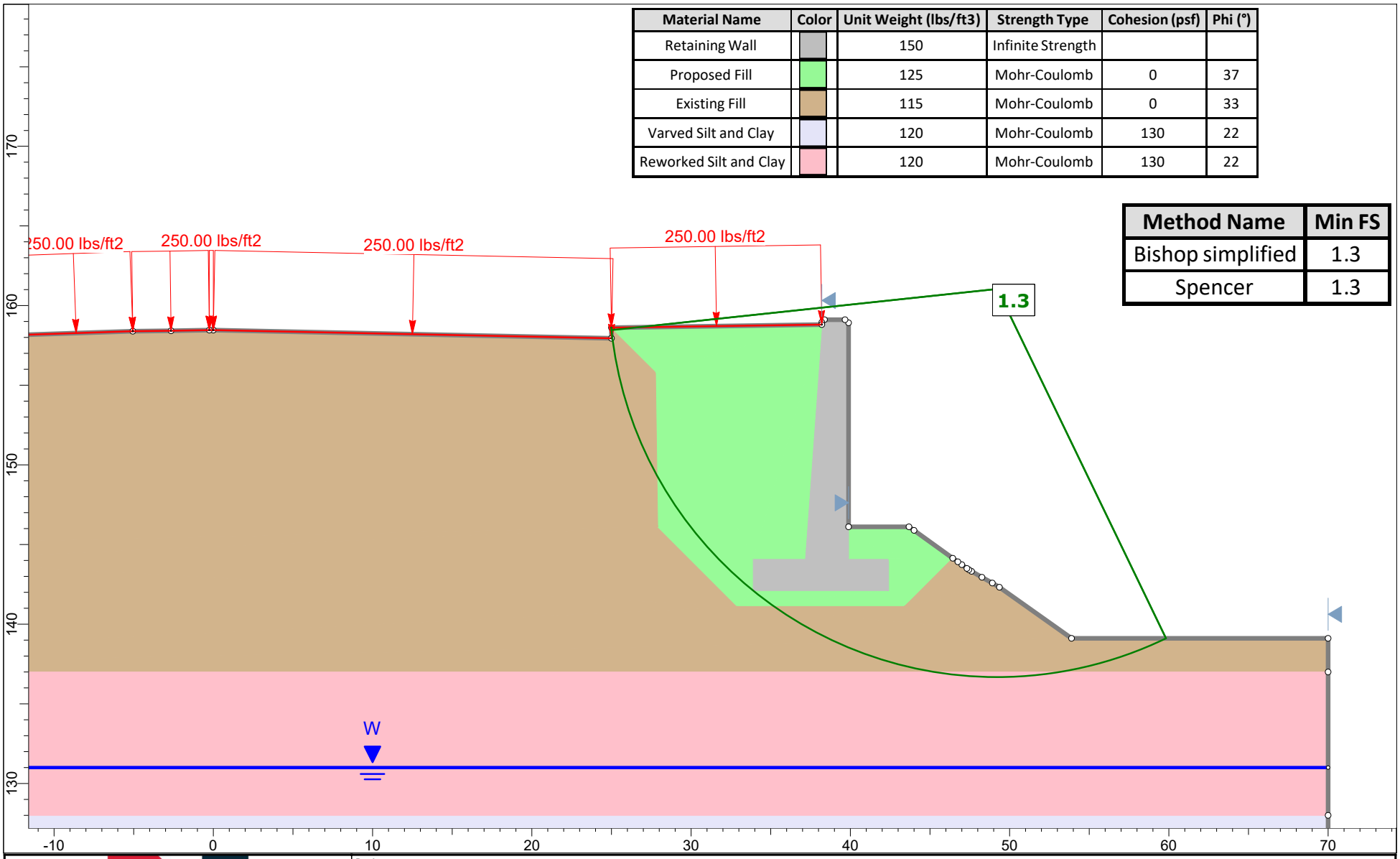
The minimum required FOS for global stability is at least 1.3 and 1.1 under static and seismic conditions, respectively, for the proposed retaining walls. Based on the Slide2 analysis, the minimum factor of safety (FOS) against global slope failure is 1.3 and 1.2 under static and seismic conditions, respectively, for the proposed Wall #4. The minimum factor of safety (FOS) is 1.3 and 1.1 under static and seismic conditions, respectively, for the proposed Wall #5. The minimum factor of safety (FOS) is 1.5 and 1.3 under static and seismic conditions, respectively, for the proposed Wall #6.

Originated By: Patrick Clarke, PE Date: 11/17/2023

Reviewed By: Sarah Kurtzer, EIT Date: 11/21/2023

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)
Retaining Wall		150	Infinite Strength		
Proposed Fill		125	Mohr-Coulomb	0	37
Existing Fill		115	Mohr-Coulomb	0	33
Varved Silt and Clay		120	Mohr-Coulomb	130	22
Reworked Silt and Clay		120	Mohr-Coulomb	130	22

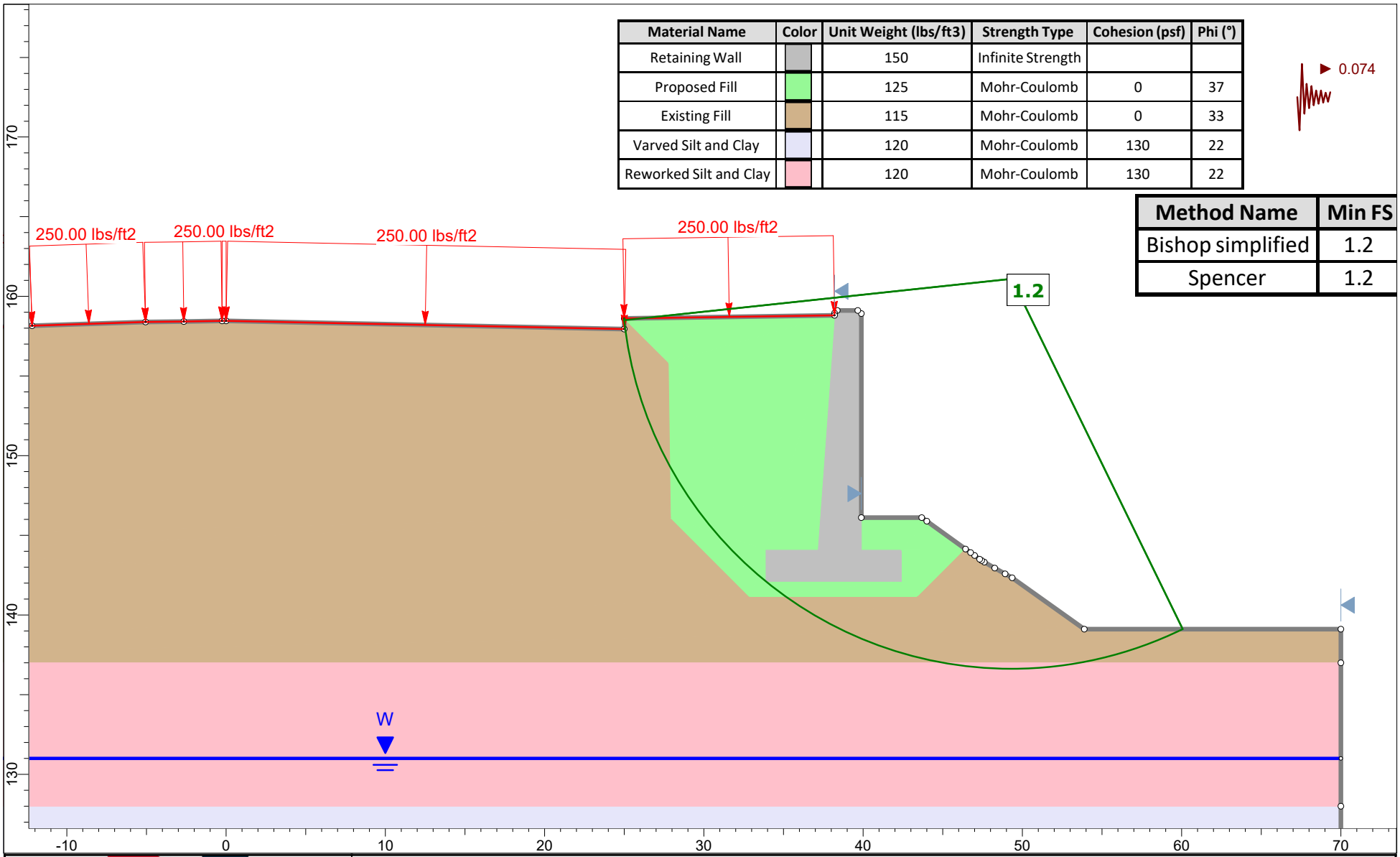
Method Name	Min FS
Bishop simplified	1.3
Spencer	1.3



Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Global Slope Stability - Wall 4 - Station # 16+00		
Drawn By	PCC	Scale 1:100	Company Nobis Group
Date	11/27/2023		File Name RW4 - STA 16+00.slmd

SLIDEINTERPRET 9.031

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)
Retaining Wall		150	Infinite Strength		
Proposed Fill		125	Mohr-Coulomb	0	37
Existing Fill		115	Mohr-Coulomb	0	33
Varved Silt and Clay		120	Mohr-Coulomb	130	22
Reworked Silt and Clay		120	Mohr-Coulomb	130	22



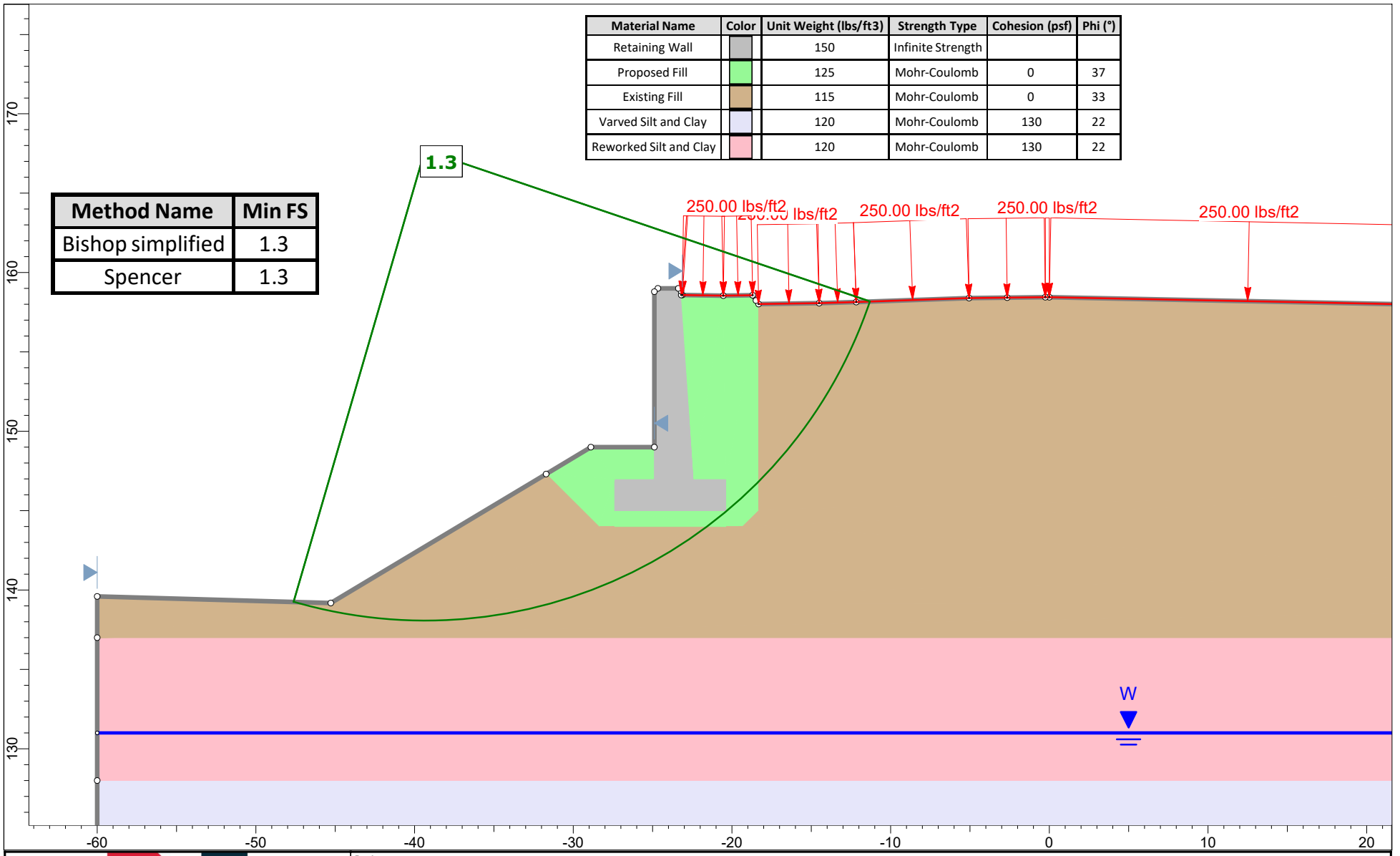
Method Name	Min FS
Bishop simplified	1.2
Spencer	1.2

Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Global Slope Stability - Wall 4 - Station # 16+00		
Drawn By	PCC	Scale 1:100	Company Nobis Group
Date	11/27/2023		File Name RW4 - STA 16+00.slmd

SLIDEINTERPRET 9.031

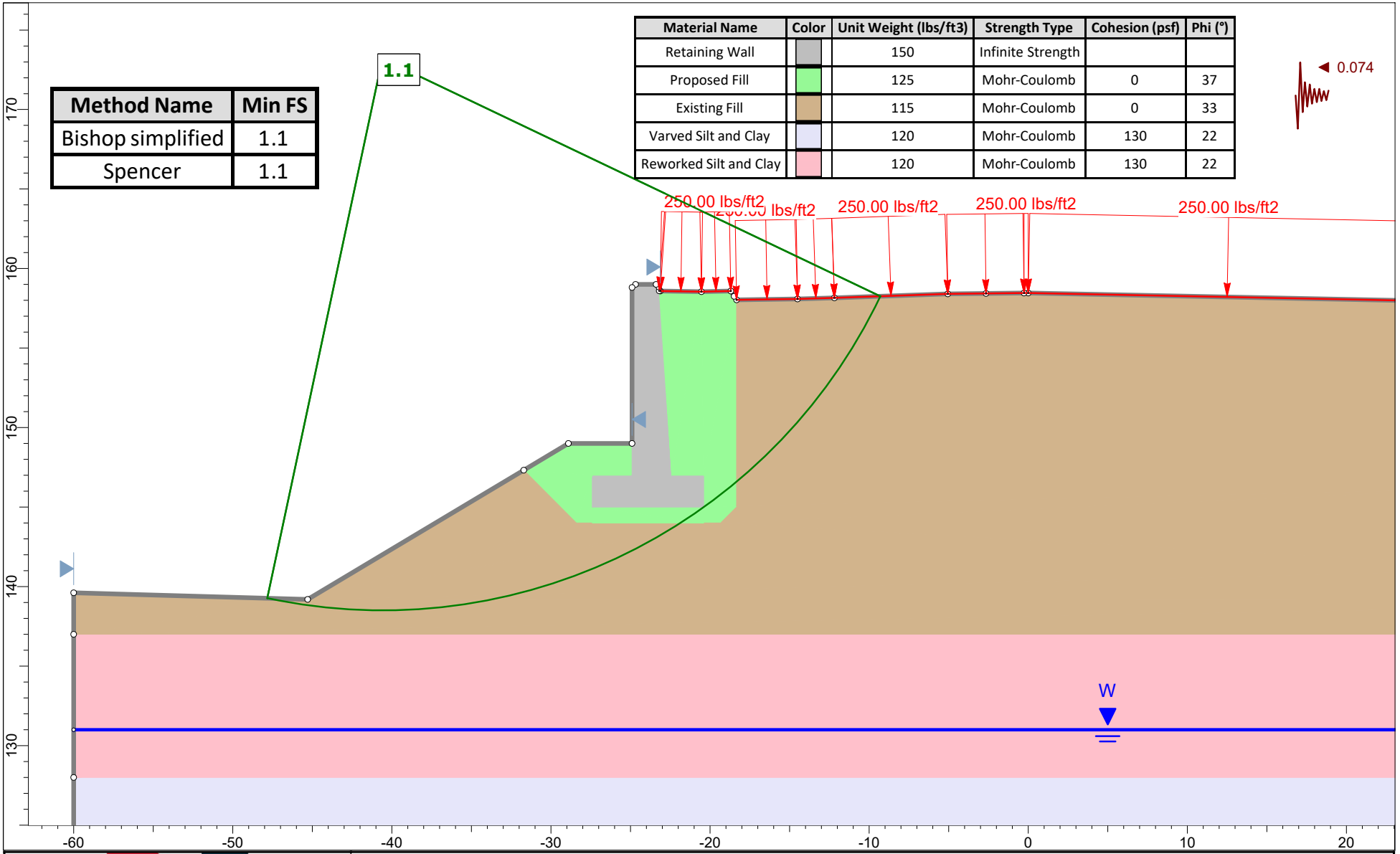
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)
Retaining Wall		150	Infinite Strength		
Proposed Fill		125	Mohr-Coulomb	0	37
Existing Fill		115	Mohr-Coulomb	0	33
Varved Silt and Clay		120	Mohr-Coulomb	130	22
Reworked Silt and Clay		120	Mohr-Coulomb	130	22

Method Name	Min FS
Bishop simplified	1.3
Spencer	1.3



Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Global Slope Stability - Wall 5 - Station # 16+00		
Drawn By	PCC	Scale 1:100	Company Nobis Group
Date	11/27/2023		File Name RW5 - STA 16+00.slmd

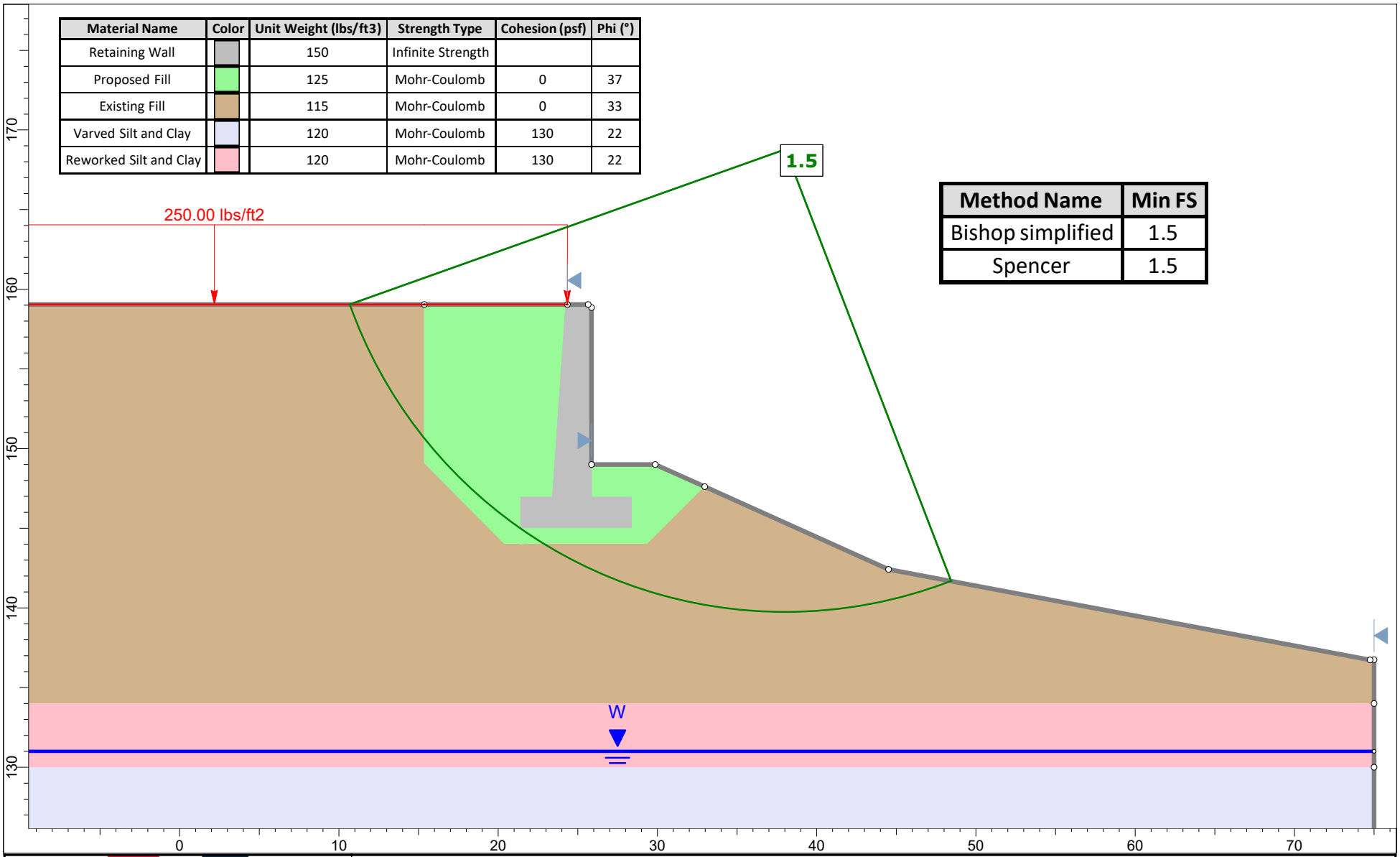
SLIDEINTERPRET 9.031



SLIDEINTERPRET 9.031

Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Global Slope Stability - Wall 5 - Station # 16+00		
Drawn By	PCC	Scale 1:100	Company Nobis Group
Date	11/27/2023		File Name RW5 - STA 16+00.slmd

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)
Retaining Wall		150	Infinite Strength		
Proposed Fill		125	Mohr-Coulomb	0	37
Existing Fill		115	Mohr-Coulomb	0	33
Varved Silt and Clay		120	Mohr-Coulomb	130	22
Reworked Silt and Clay		120	Mohr-Coulomb	130	22

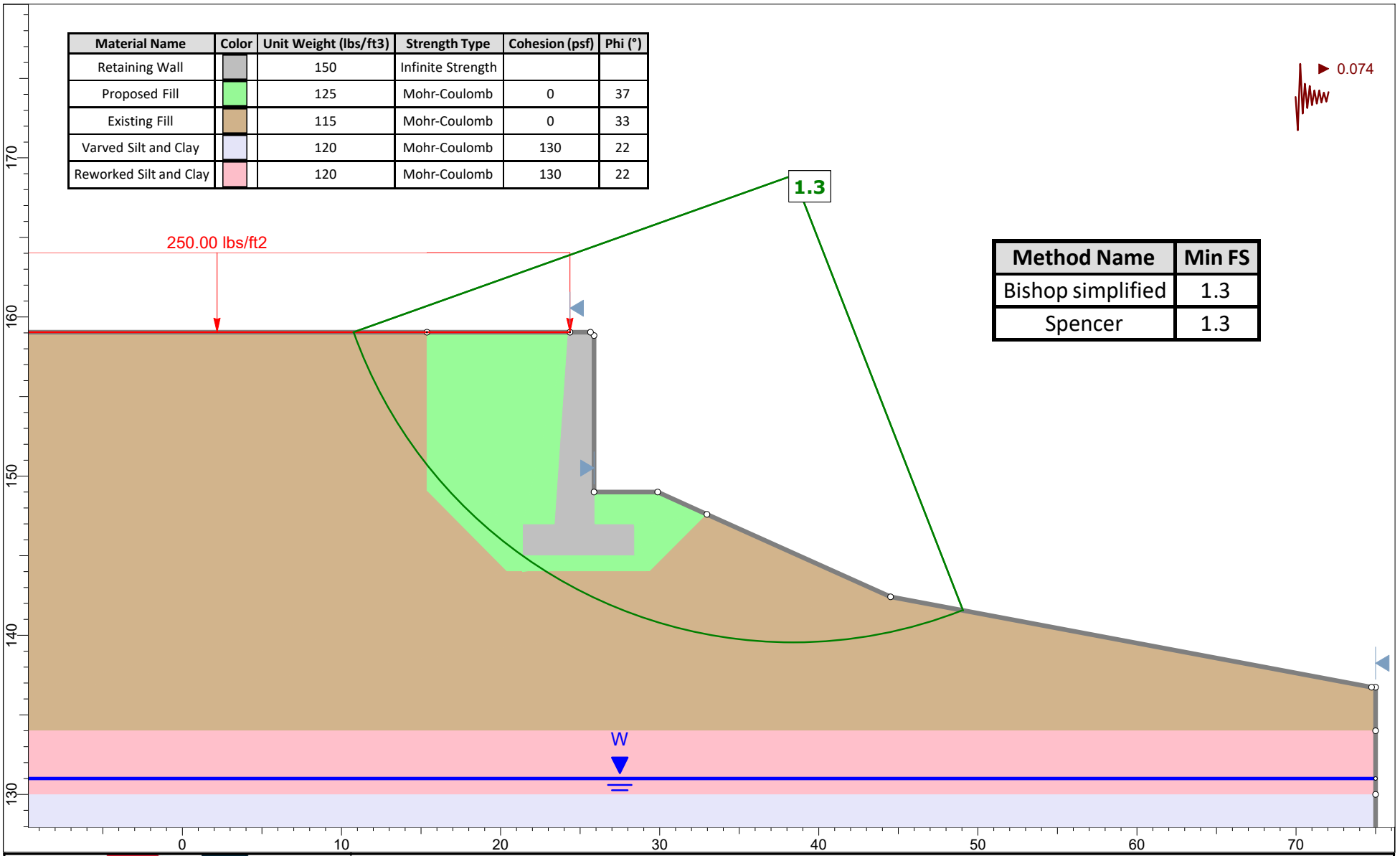


Method Name	Min FS
Bishop simplified	1.5
Spencer	1.5

SLIDEINTERPRET 9.031

Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Global Slope Stability - Wall 6 - Station # 17+30		
Drawn By	PCC	Scale 1:100	Company Nobis Group
Date	11/27/2023		File Name RW6 - STA 17+30.slmd

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)
Retaining Wall		150	Infinite Strength		
Proposed Fill		125	Mohr-Coulomb	0	37
Existing Fill		115	Mohr-Coulomb	0	33
Varved Silt and Clay		120	Mohr-Coulomb	130	22
Reworked Silt and Clay		120	Mohr-Coulomb	130	22



Method Name	Min FS
Bishop simplified	1.3
Spencer	1.3

SLIDEINTERPRET 9.031

Project	Armory Street Over Abandoned CSX Spur - Springfield, MA				
Analysis Description	Global Slope Stability - Wall 6 - Station # 17+30				
Drawn By	PCC	Scale	1:100	Company	Nobis Group
Date	11/27/2023			File Name	RW6 - STA 17+30.slmd

APPENDIX E.9 – Soldier Pile and Lagging Retaining Walls

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MassDOT Armory Street over Abandoned CSX Spur (No. S-24-026)
SPL Walls 4 through 6
Springfield, MA

Calculated by: PCC Date: 11/20/2023
Checked by: SAK Date: 11/28/2023

Rev. 3

Purpose: Complete evaluation of drilled soldier pile and lagging (SPL) for proposed Walls 4 through 6 for feasibility purposes. The actual SPL wall system will be designed later by a professional engineer registered in the Commonwealth of Massachusetts.

References: 1) Computer program Shoring Suite V8 by CivilTech Software.
2) AASHTO LRFD Bridge Design Specifications, 9th Edition (2020).
3) MassDOT LRFD Bridge Manual, (2020).
4) Cross-sections and proposed grading plans provided by Tetra Tech on October 31, November 3, and November 15, 2023.
5) Test borings observed by Nobis at the site in 2019 and 2022.

Assumption 1) Exposed heights of the SPL walls based on Reference 4 and attached sections.
2) Surcharge load of 250 psf applied along Armory Street and sidewalks up to 1.5 feet beyond nearest face of proposed walls.
3) Soil properties estimated using Reference 5. Fill properties were adjusted to account for backfilling of SPL wall and other earthwork activities with compacted structural fill.
4) Soils above approximately El. 148, 148.3, and 146 were not considered in the wall analyses for Wall 4 STA 15+50, 15+75, and 16+00, respectively, to accomodate the minimum 4-foot-wide benches in front of the walls. Soils above approximately El. 152.7 and 149 were not considered in the analyses for Walls 5 and 6, respectively.

Solution:

Step 1: Soil Properties and Profile

Nobis used subsurface information from Reference No. 5 to develop soil parameters in the table below. Soil unit weight (γ_{moist}), soil friction angle (ϕ), and cohesion were estimated based on N-values. Design groundwater level of El. 131 was considered in analyses.

Wall 4 - STA 15+50

Soil Layer	Depth (ft)	Elevation (ft)	γ_{moist} (pcf)	ϕ (°)	Cohesion (psf)
Fill	0 - 10.1	156.7 - 146.6	125	34	-
Reworked Silt & Clay	10.1 - 25.2	146.6 - 131.5	120	22	130
Varved Silt & Clay	25.2 - 66.2	131.5 - 90.5	120	22	130
Silt	66.2 - 74.1	90.5 - 82.6	120	26	-
Glacial Till	74.1 - 81.2	82.6 - 75.5	135	37	-

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Wall 4 - STA 15+75

Soil Layer	Depth (ft)	Elevation (ft)	γ_{moist} (pcf)	ϕ (°)	Cohesion (psf)
Fill	0 - 16	158 - 142	125	34	-
Reworked Silt & Clay	16 - 29	142 - 129	120	22	130
Varved Silt & Clay	29 - 65	129 - 93	120	22	130
Silt	65 - 76	93 - 82	120	26	-
Glacial Till	76 - 82	82 - 76	135	37	-

Wall 4 - STA 16+00

Soil Layer	Depth (ft)	Elevation (ft)	γ_{moist} (pcf)	ϕ (°)	Cohesion (psf)
Fill	0 - 2	159 - 157	125	34	-
Lightweight Fill	2 - 13.1[1]	157 - 145.9[1]	22.5	41	-
Fill	13.1[1] - 21.5	145.9[1] - 137.5	125	34	-
Reworked Silt & Clay	21.5 - 32.5	137.5 - 126.5	120	22	130
Varved Silt & Clay	32.5 - 63	126.5 - 96	120	22	130
Silt	63 - 76	96 - 83	120	26	-
Glacial Till	76 - 82	83 - 77	135	37	-

1) Lightweight fill in analysis considered placement at 45° between depth of exposed height of SPL wall and approximately 2 feet below finish grade. Refer to the attached Sketch 1 for the approximate extents of the modeled lightweight fill.

Wall 5 - STA 16+00

Soil Layer	Depth (ft)	Elevation (ft)	γ_{moist} (pcf)	ϕ (°)	Cohesion (psf)
Fill	0 - 21.5	159 - 137.5	125	34	-
Reworked Silt & Clay	21.5 - 32.5	137.5 - 126.5	120	22	130
Varved Silt & Clay	32.5 - 63	126.5 - 96	120	22	130
Silt	63 - 76	96 - 83	120	26	-
Glacial Till	76 - 82	83 - 77	135	37	-

Wall 6 - STA 17+30

Soil Layer	Depth (ft)	Elevation (ft)	γ_{moist} (pcf)	ϕ (°)	Cohesion (psf)
Fill	0 - 25	159 - 135	125	34	-
Reworked Silt & Clay	24 - 29	135 - 130	120	22	130
Varved Silt & Clay	29 - 52.5	130 - 106.5	120	22	130
Silt	52.5 - 65.5	106.5 - 93.5	120	26	-
Glacial Till	65.5 - 83.5	93.5 - 75.5	135	37	-

Step 2: Loads and Load Factors

Load and Resistance Factors (Reference 2)

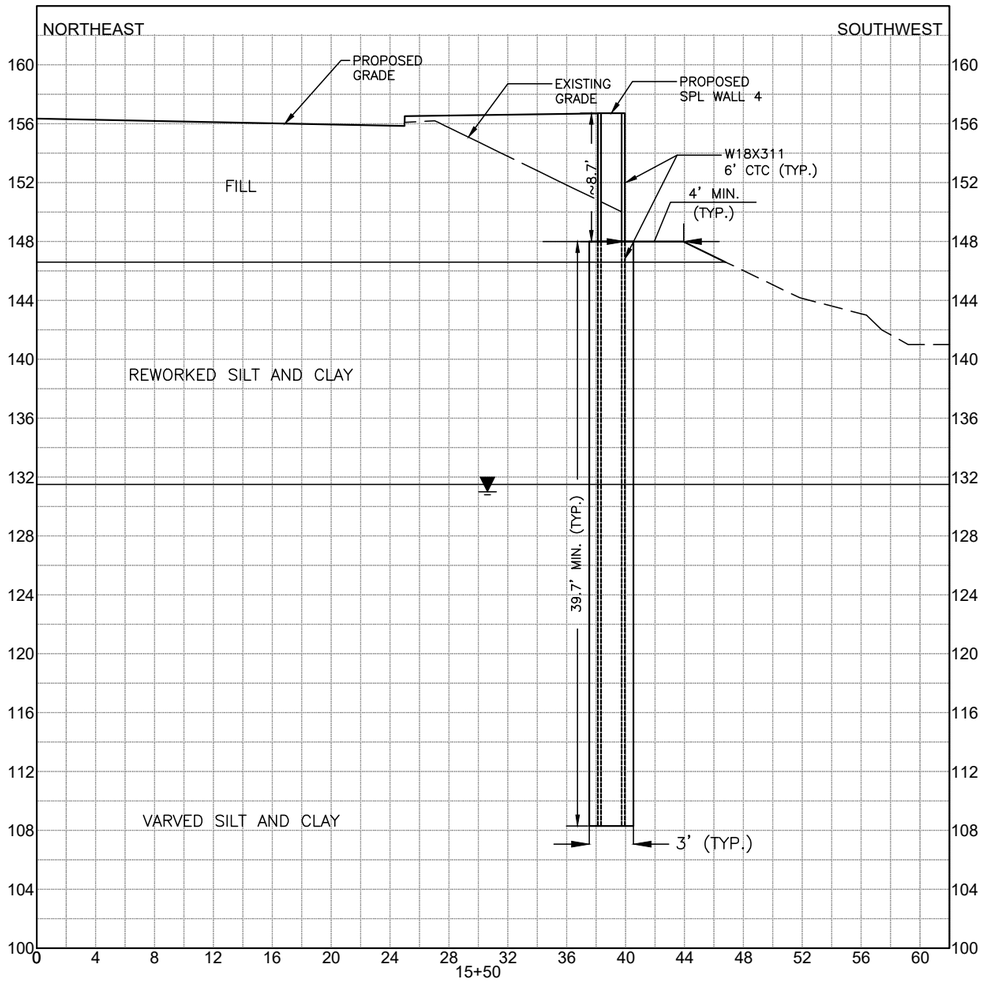
Active Pressure	1.5	(Table 3.4.1-2)
Passive Pressure	0.75	(Table 11.5.7-1, Passive Resistance of Vertical Elements)
Surcharge Load	1.75	(Table 3.4.1-1, Strength I, LL)

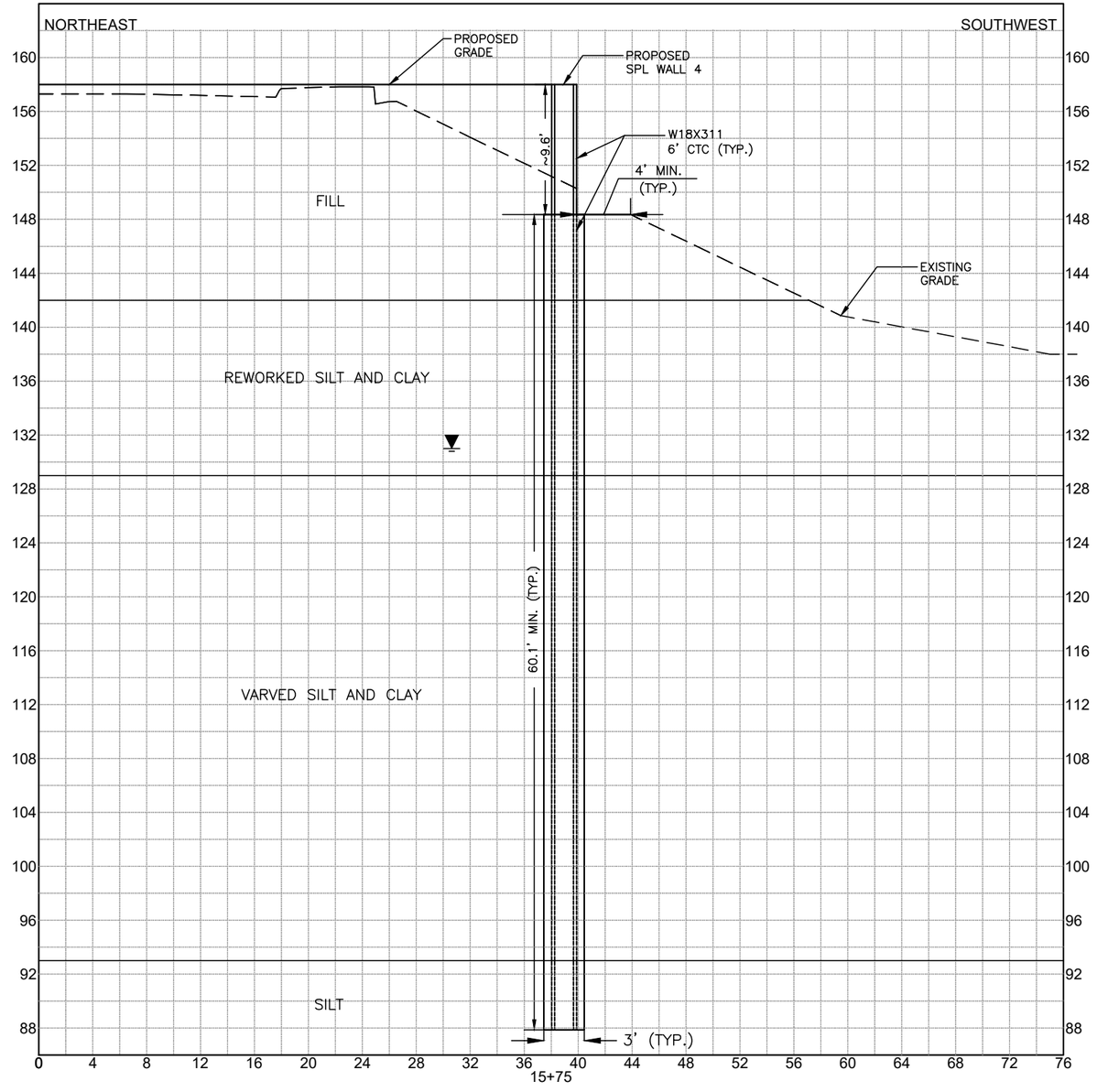
Results

Based on our evaluations, the pile type and spacing required is summarized in the following Table 1:

Table 1: Proposed SPL Retaining Walls

Steel Section	W18x311			W16x89	W18x283
Shaft Diameter (ft)	3				
Pile Spacing (ft c-t-c)	6				
Wall Designation	WALL 4			WALL 5	WALL 6
Approx. Station	15+19 to 15+50	15+50 to 15+75	15+75 to 16+18	14+72 to 16+18	17+30 to 17+49
Approx. Wall Length (ft)	31	25	43	174	27
Approx. No. Piles	5	4	7	30	5
Max. Pile Deflection (in)	0.7	2.0	2.0	0.9	1.7
Max. Shear Force (kips)	76.7	119.1	109.8	27.2	92.1
Max. Moment (kip-ft)	556.8	1052.4	901.1	213.5	690.9
Approx. Min. Pile Embedment (ft)	39.7	60.5	55.9	31.0	55.1
Approx. Pile Total Length (ft)	48.4	70.1	69.0	37.3	65.1





NOTES

1. SKETCHES WERE DEVELOPED USING DRAWINGS PROVIDED BY TETRA TECH ON OCTOBER 31, NOVEMBER 3, AND NOVEMBER 15, 2023.
2. LOCATIONS AND SITE FEATURES DEPICTED ARE APPROXIMATE AND GIVEN FOR ILLUSTRATIVE PURPOSES. SUBSURFACE CONDITIONS DEPICTED HEREON WERE DEVELOPED FROM SUBSURFACE EXPLORATIONS OBSERVED BY NOBIS AT THE SITE IN 2019, AND MAY NOT REPRESENT ACTUAL CONDITIONS.
3. ELEVATIONS ARE BASE ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

0 10' 20'
GRAPHIC SCALE

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Lowell, MA 01851
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www.nobis-group.com

SKETCH 1

PROPOSED SPL WALL 4
STATIONS 15+50 AND 15+75
ARMORY STREET OVER ABANDONED CSX SPUR
BRIDGE NO. S-24-026
SPRINGFIELD, MASSACHUSETTS

DRAWN BY: PC	CHECKED BY: KJ
PROJECT NO. 094184.100	DATE: NOVEMBER 2023

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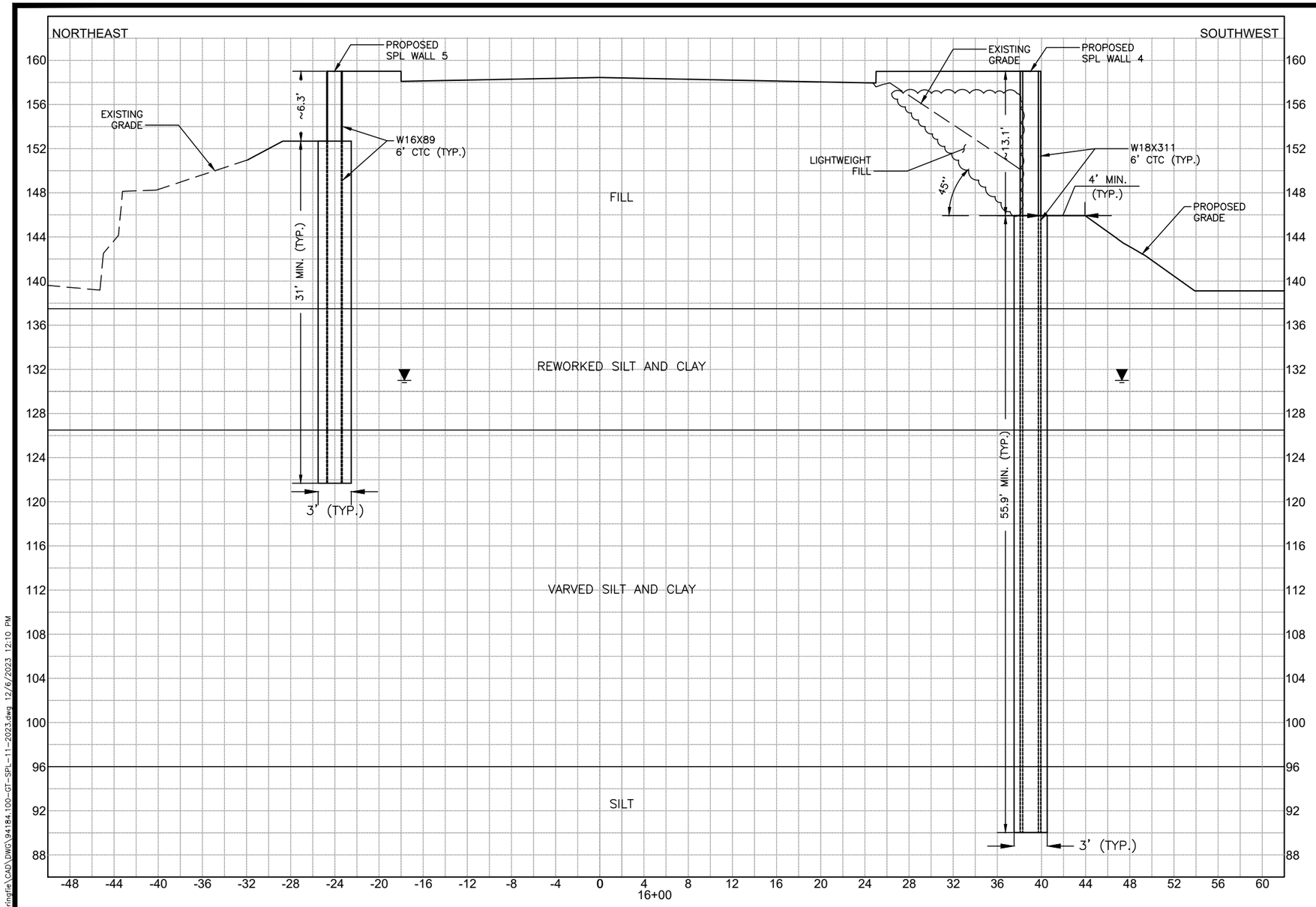

NOTES

1. SKETCHES WERE DEVELOPED USING DRAWINGS PROVIDED BY TETRA TECH ON OCTOBER 31, NOVEMBER 3, AND NOVEMBER 15, 2023.
2. LOCATIONS AND SITE FEATURES DEPICTED ARE APPROXIMATE AND GIVEN FOR ILLUSTRATIVE PURPOSES. SUBSURFACE CONDITIONS DEPICTED HEREON WERE DEVELOPED FROM SUBSURFACE EXPLORATIONS OBSERVED BY NOBIS AT THE SITE IN 2019, AND MAY NOT REPRESENT ACTUAL CONDITIONS.
3. ELEVATIONS ARE BASE ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

0 10' 20'
GRAPHIC SCALE

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SKETCH 2

PROPOSED SPL WALLS 4 AND 5
STATION 16+00
ARMORY STREET OVER ABANDONED CSX SPUR
BRIDGE NO. S-24-026
SPRINGFIELD, MASSACHUSETTS

DRAWN BY: PC	CHECKED BY: KJ
PROJECT NO. 094184.100	DATE: NOVEMBER 2023

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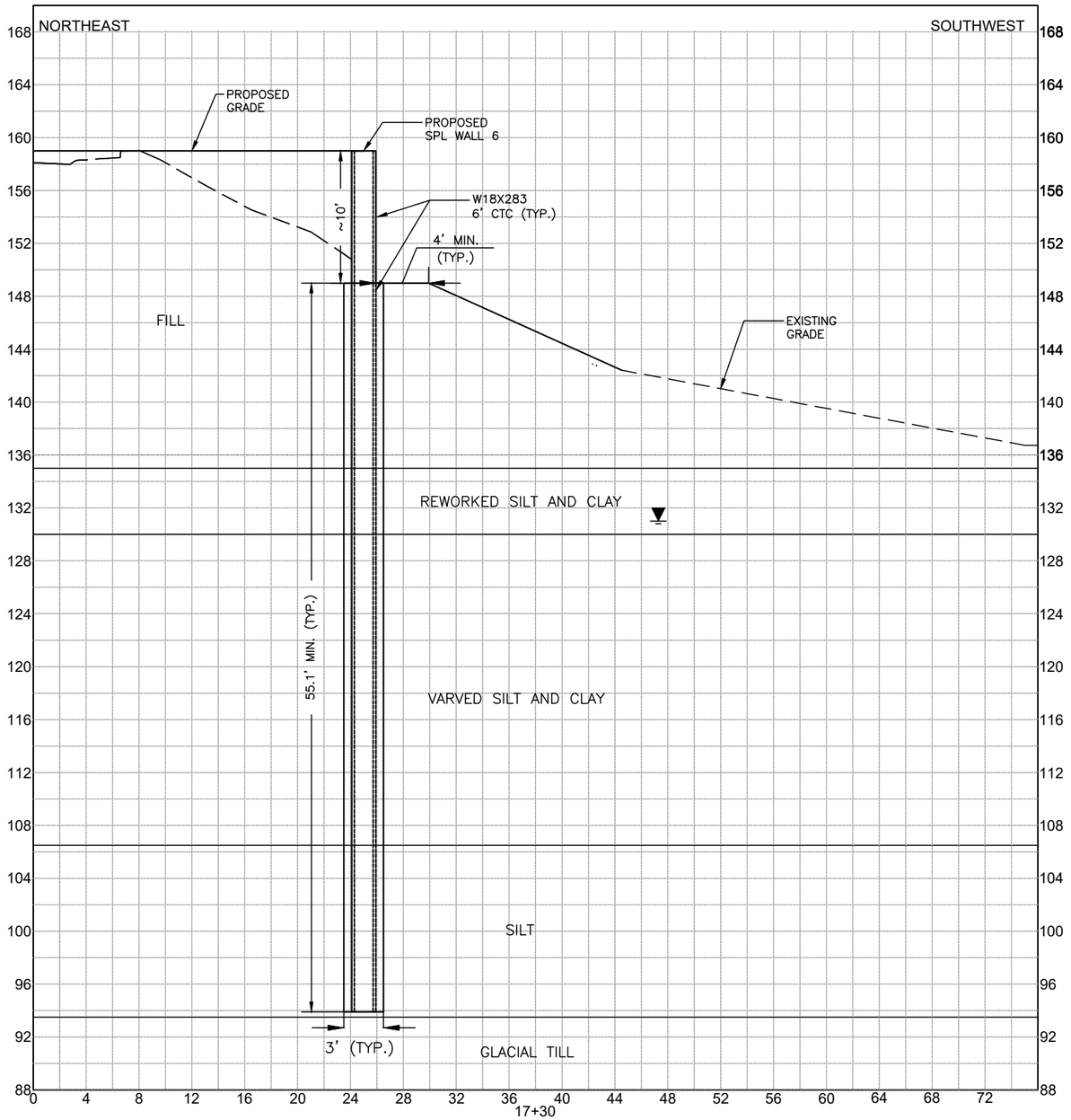

NOTES

1. SKETCHES WERE DEVELOPED USING DRAWINGS PROVIDED BY TETRA TECH ON OCTOBER 31, NOVEMBER 3, AND NOVEMBER 15, 2023.
2. LOCATIONS AND SITE FEATURES DEPICTED ARE APPROXIMATE AND GIVEN FOR ILLUSTRATIVE PURPOSES. SUBSURFACE CONDITIONS DEPICTED HEREON WERE DEVELOPED FROM SUBSURFACE EXPLORATIONS OBSERVED BY NOBIS AT THE SITE IN 2019, AND MAY NOT REPRESENT ACTUAL CONDITIONS.
3. ELEVATIONS ARE BASE ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

0 10' 20'
GRAPHIC SCALE

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SKETCH 3

PROPOSED SPL WALL 6
STATION 17+30
ARMORY STREET OVER ABANDONED CSX SPUR
BRIDGE NO. S-24-026
SPRINGFIELD, MASSACHUSETTS

DRAWN BY: PC	CHECKED BY: KJ
PROJECT NO. 094184.100	DATE: NOVEMBER 2023

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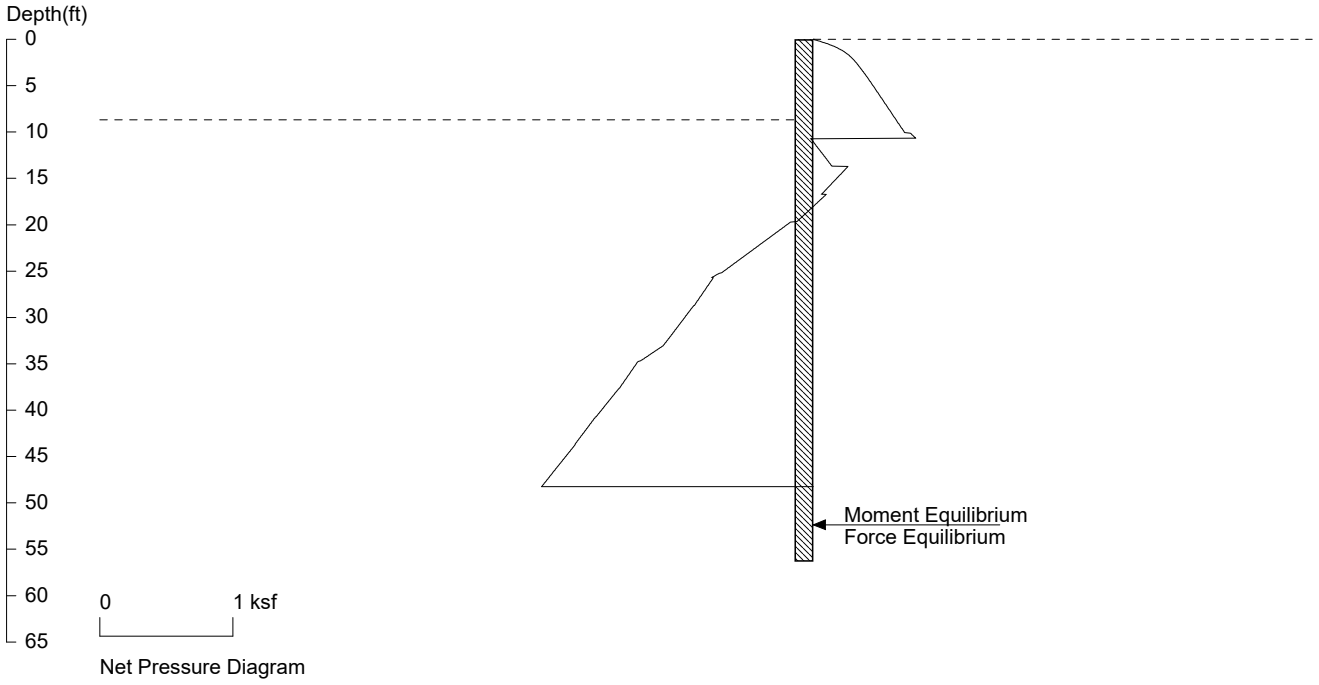
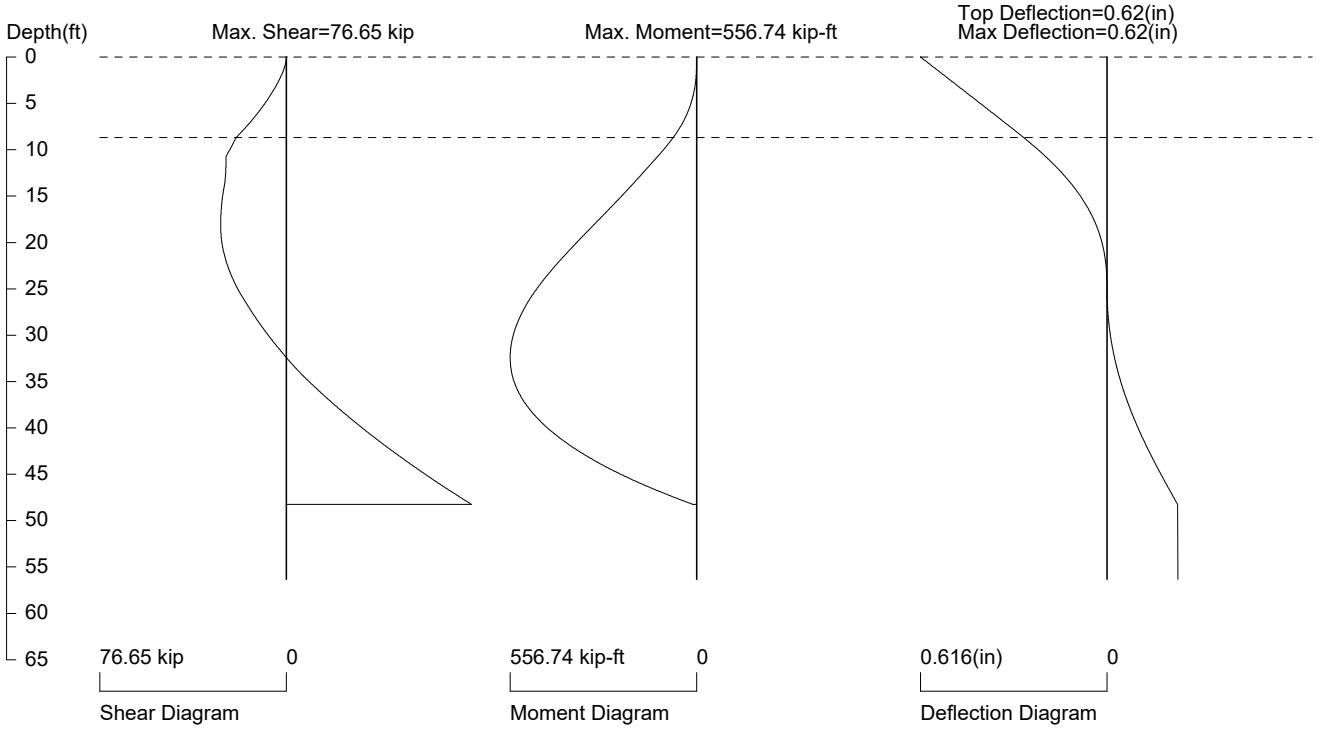
Drilled SPL Wall 4 - STA 15+50





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 6.0 foot or meter

User Input Pile, W18X311J: E (ksi)=29000.0, I (in4)/pile=6970.0

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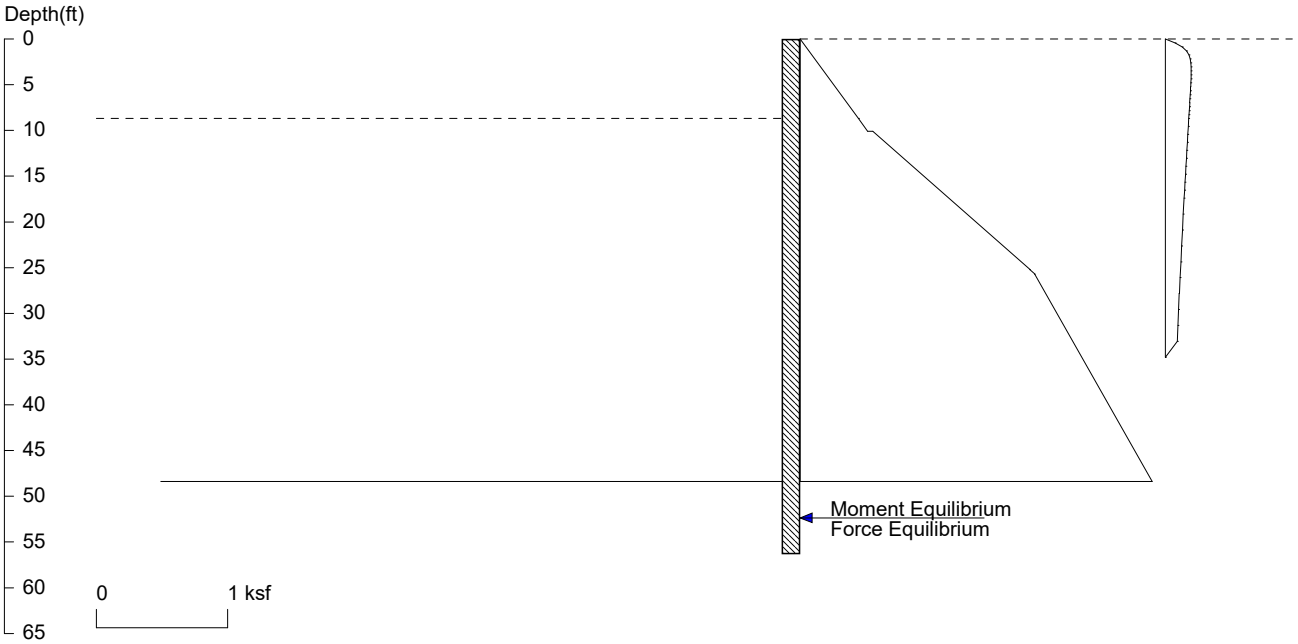
Drilled SPL Wall 4 - STA 15+50



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Licensed to 4324324234 3424343 Date: 12/6/2023

File: J:\094184.100-MassDOT Armory Street Bridges, Springfie\Calculations\Drilled SPL Walls\S-24-026\CivilTech\Drilled SP

Wall Height=8.7 Pile Diameter=3.0 Pile Spacing=6.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=39.69 Min. Pile Length=48.39
MOMENT IN PILE: Max. Moment=556.74 per Pile Spacing=6.0 at Depth=32.41

PILE SELECTION:
Request Min. Section Modulus = 202.5 in3/pile=3317.59 cm3/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=0.66
W18X311J has Section Modulus = 624.0 in3/pile=10225.49 cm3/pile. It is greater than Min. Requirements!
Top Deflection = 0.62(in) based on E (ksi)=29000.00 and I (in4)/pile=6970.0

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	8.700	0.443	0.050889
*	Below	Base		
8.700	0.443	10.10	0.514	0.050889
10.10	0.553	25.20	1.750	0.079321
25.20	1.748	25.70	1.787	0.078439
25.70	1.787	66.20	3.381	0.039345
*	Sur-	charg		
0.000	0.000	0.435	0.075	0.171471
0.435	0.075	0.870	0.130	0.126673
0.870	0.130	1.305	0.163	0.076020
1.305	0.163	1.740	0.181	0.041160
1.740	0.181	2.175	0.190	0.021262
2.175	0.190	2.610	0.194	0.010463
2.610	0.194	3.045	0.196	0.004549
3.045	0.196	3.480	0.197	0.001206
3.480	0.197	3.915	0.197	-0.00075
3.915	0.197	4.350	0.196	-0.00195

4.350	0.196	4.785	0.195	-0.00270
4.785	0.195	5.220	0.193	-0.00319
5.220	0.193	5.655	0.192	-0.00352
5.655	0.192	6.090	0.190	-0.00374
6.090	0.190	6.525	0.188	-0.00390
6.525	0.188	6.960	0.187	-0.00400
6.960	0.187	7.395	0.185	-0.00408
7.395	0.185	7.830	0.183	-0.00413
7.830	0.183	8.265	0.181	-0.00416
8.265	0.181	8.700	0.179	-0.00419
8.700	0.179	9.570	0.176	-0.00420
9.570	0.176	10.44	0.172	-0.00420
10.44	0.172	11.31	0.168	-0.00419
11.31	0.168	12.18	0.165	-0.00416
12.18	0.165	13.05	0.161	-0.00413
13.05	0.161	13.92	0.158	-0.00409
13.92	0.158	14.79	0.154	-0.00405
14.79	0.154	15.66	0.151	-0.00400
15.66	0.151	16.53	0.147	-0.00395
16.53	0.147	17.40	0.144	-0.00390
17.40	0.144	19.14	0.137	-0.00381
19.14	0.137	20.88	0.131	-0.00369
20.88	0.131	22.62	0.125	-0.00357
22.62	0.125	24.36	0.119	-0.00344
24.36	0.119	26.10	0.113	-0.00331
26.10	0.113	27.84	0.107	-0.00318
27.84	0.107	29.58	0.102	-0.00305
29.58	0.102	31.32	0.097	-0.00292
31.32	0.097	33.06	0.092	-0.00279
33.06	0.092	34.80	0.000	-0.05285

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
10.70	0.791	13.70	0.856	0.021683
13.70	0.736	16.70	1.160	0.141351
16.70	1.124	19.70	1.576	0.150540
19.70	1.619	25.20	2.558	0.170662
25.20	2.567	25.70	2.665	0.196399
25.70	2.652	28.70	2.903	0.083690
28.70	2.907	31.70	3.174	0.089171
31.70	3.174	34.70	3.446	0.090741
34.70	3.456	37.70	3.719	0.087627
37.70	3.722	40.70	4.009	0.095410
40.70	4.012	43.70	4.286	0.091402
43.70	4.283	46.70	4.568	0.095155
46.70	4.568	49.70	4.854	0.095155
49.70	4.854	52.70	5.139	0.095155
52.70	5.140	55.70	5.422	0.094047
55.70	5.416	58.70	5.701	0.095003

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	6.00
2	8.70	3.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	8.70	3.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

```
**************************************************************************

                        SHORING WALL CALCULATION SUMMARY
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ShoringSuite Software is developed by CivilTech Software, Bellevue, WA, USA.
The calculation method is based on the following references:
    1. FHWA 98-011, FHWA-RD-97-130, FHWA SA 96-069, FHWA-IF-99-015
    2. STEEL SHEET PILING DESIGN MANUAL by Pile Buck Inc., 1987
    3. DESIGN MANUAL DM-7 (NAVFAC), Department of the Navy, May 1982
    4. TRENCHING AND SHORING MANUAL Revision 12, California Department of
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    6. EARTH SUPPORT SYSTEM & RETAINING STRUCTURES, Pile Buck Inc. 2002
    5. DESIGN OF SHEET PILE WALLS, EM 1110-2-2504, U.S. Army Corps of Engineers, 31
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    7. EARTH RETENTION SYSTEMS HANDBOOK, Alan Macnab, McGraw-Hill. 2002
    8. Temporary Structures in Construction, Robert T. Ratay (Co-author of Chapter
7: John J. Peirce), McGraw-Hill. 2012
    9. AASHTO HB-17, American Association of State and Highway Transportation
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UNITS:   Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft,
Friction/Bearing/Pressure - ksf, Pres. Slope - kip/ft3, Deflection - in
--------------------------------------------------------------------------
Licensed to   4324324234     3424343
Date: 12/6/2023  File: J:\094184.100-MassDOT Armory Street Bridges,
Springfie\Calculations\Drilled SPL Walls\S-24-026\CivilTech\Drilled SPL Wall 4 - STA
15+50.sh8

Title: Drilled SPL Wall 4 - STA 15+50
Subtitle:

**********************************INPUT DATA**********************************
Wall Type: 2. Soldier Pile, Drilled
        Wall Height: 8.70
        Pile Diameter: 3.00
        Pile Spacing: 6.00
        Factor of Safety (F.S.): 1.00
Lateral Support Type (Braces): 1. No
        Top Brace Increase (Multi-Bracing): Add 15%*
Embedment Option: 1. Yes
        Friction at Pile Tip: No
Pile Properties:
        Steel Strength, Fy:  50 ksi = 345 MPa
        Allowable Fb/Fy: 0.66
        Elastic Module, E: 29000.00
        Moment of Inertia, I: 6970.0
```

User Input Pile: W18X311J

* DRIVING PRESSURE (ACTIVE, WATER, & SURCHARGE) *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Above	Base		
2	0.000	0.000	8.700	0.443	0.050889
3	*	Below	Base		
4	8.700	0.443	10.10	0.514	0.050889
5	10.10	0.553	25.20	1.750	0.079321
6	25.20	1.748	25.70	1.787	0.078439
7	25.70	1.787	66.20	3.381	0.039345
8	66.20	3.119	74.10	3.385	0.033663
9	74.10	2.054	78.30	2.162	0.025740
10	*	Sur-	charg		
11	0.000	0.000	0.435	0.075	0.171471
12	0.435	0.075	0.870	0.130	0.126673
13	0.870	0.130	1.305	0.163	0.076020
14	1.305	0.163	1.740	0.181	0.041160
15	1.740	0.181	2.175	0.190	0.021262
16	2.175	0.190	2.610	0.194	0.010463
17	2.610	0.194	3.045	0.196	0.004549
18	3.045	0.196	3.480	0.197	0.001206
19	3.480	0.197	3.915	0.197	-0.00075
20	3.915	0.197	4.350	0.196	-0.00195
21	4.350	0.196	4.785	0.195	-0.00270
22	4.785	0.195	5.220	0.193	-0.00319
23	5.220	0.193	5.655	0.192	-0.00352
24	5.655	0.192	6.090	0.190	-0.00374
25	6.090	0.190	6.525	0.188	-0.00390
26	6.525	0.188	6.960	0.187	-0.00400
27	6.960	0.187	7.395	0.185	-0.00408
28	7.395	0.185	7.830	0.183	-0.00413
29	7.830	0.183	8.265	0.181	-0.00416
30	8.265	0.181	8.700	0.179	-0.00419
31	8.700	0.179	9.570	0.176	-0.00420
32	9.570	0.176	10.44	0.172	-0.00420
33	10.44	0.172	11.31	0.168	-0.00419
34	11.31	0.168	12.18	0.165	-0.00416
35	12.18	0.165	13.05	0.161	-0.00413
36	13.05	0.161	13.92	0.158	-0.00409
37	13.92	0.158	14.79	0.154	-0.00405
38	14.79	0.154	15.66	0.151	-0.00400
39	15.66	0.151	16.53	0.147	-0.00395
40	16.53	0.147	17.40	0.144	-0.00390
41	17.40	0.144	19.14	0.137	-0.00381
42	19.14	0.137	20.88	0.131	-0.00369
43	20.88	0.131	22.62	0.125	-0.00357
44	22.62	0.125	24.36	0.119	-0.00344
45	24.36	0.119	26.10	0.113	-0.00331

46	26.10	0.113	27.84	0.107	-0.00318
47	27.84	0.107	29.58	0.102	-0.00305
48	29.58	0.102	31.32	0.097	-0.00292
49	31.32	0.097	33.06	0.092	-0.00279
50	33.06	0.092	34.80	0.000	-0.05285

* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Below	Base		
2	10.70	0.791	13.70	0.856	0.021683
3	13.70	0.736	16.70	1.160	0.141351
4	16.70	1.124	19.70	1.576	0.150540
5	19.70	1.619	25.20	2.558	0.170662
6	25.20	2.567	25.70	2.665	0.196399
7	25.70	2.652	28.70	2.903	0.083690
8	28.70	2.907	31.70	3.174	0.089171
9	31.70	3.174	34.70	3.446	0.090741
10	34.70	3.456	37.70	3.719	0.087627
11	37.70	3.722	40.70	4.009	0.095410
12	40.70	4.012	43.70	4.286	0.091402
13	43.70	4.283	46.70	4.568	0.095155
14	46.70	4.568	49.70	4.854	0.095155
15	49.70	4.854	52.70	5.139	0.095155
16	52.70	5.140	55.70	5.422	0.094047
17	55.70	5.416	58.70	5.701	0.095003
18	58.70	5.701	61.70	5.986	0.095003
19	61.70	5.986	66.20	6.413	0.095003
20	66.20	7.164	67.70	7.340	0.117057
21	67.70	7.346	70.70	7.669	0.107787
22	70.70	7.659	74.10	7.976	0.093179
23	74.10	11.24	76.70	11.93	0.268487
24	76.70	11.92	78.30	12.28	0.223059

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	6.00
2	8.70	3.00

* PASSIVE SPACE *

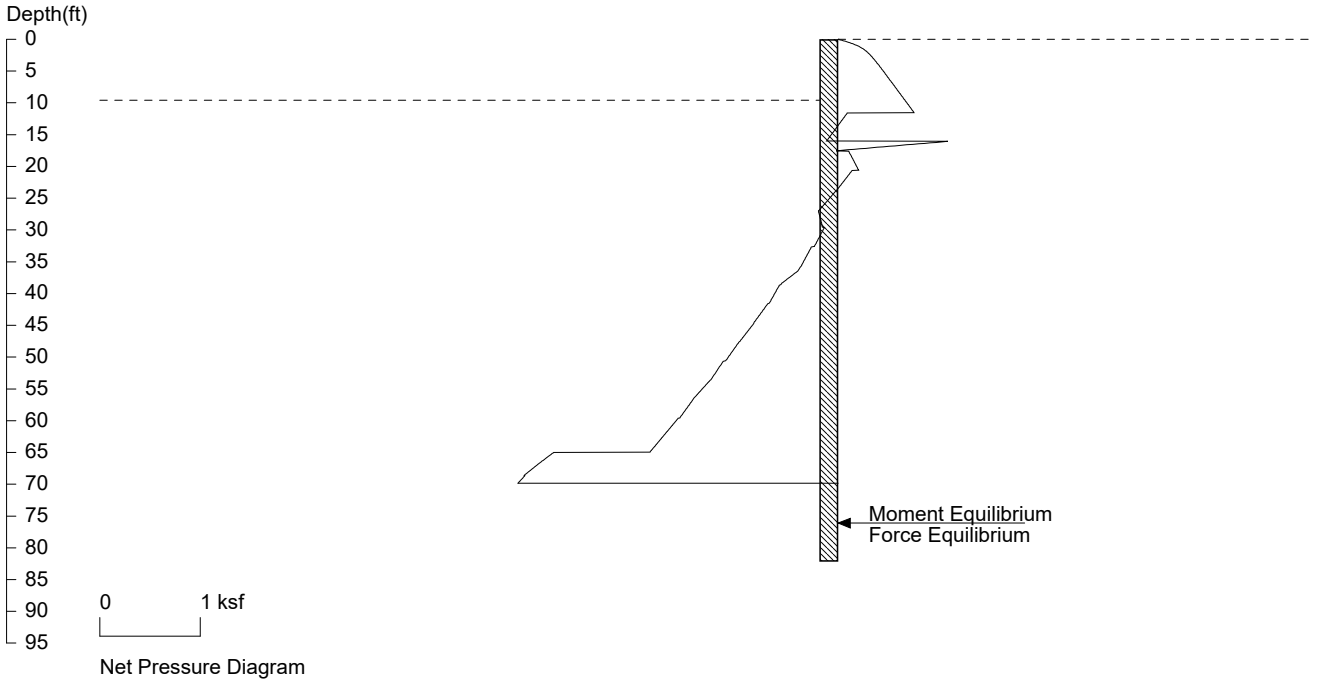
No.	Z depth	Spacing
1	8.70	3.00

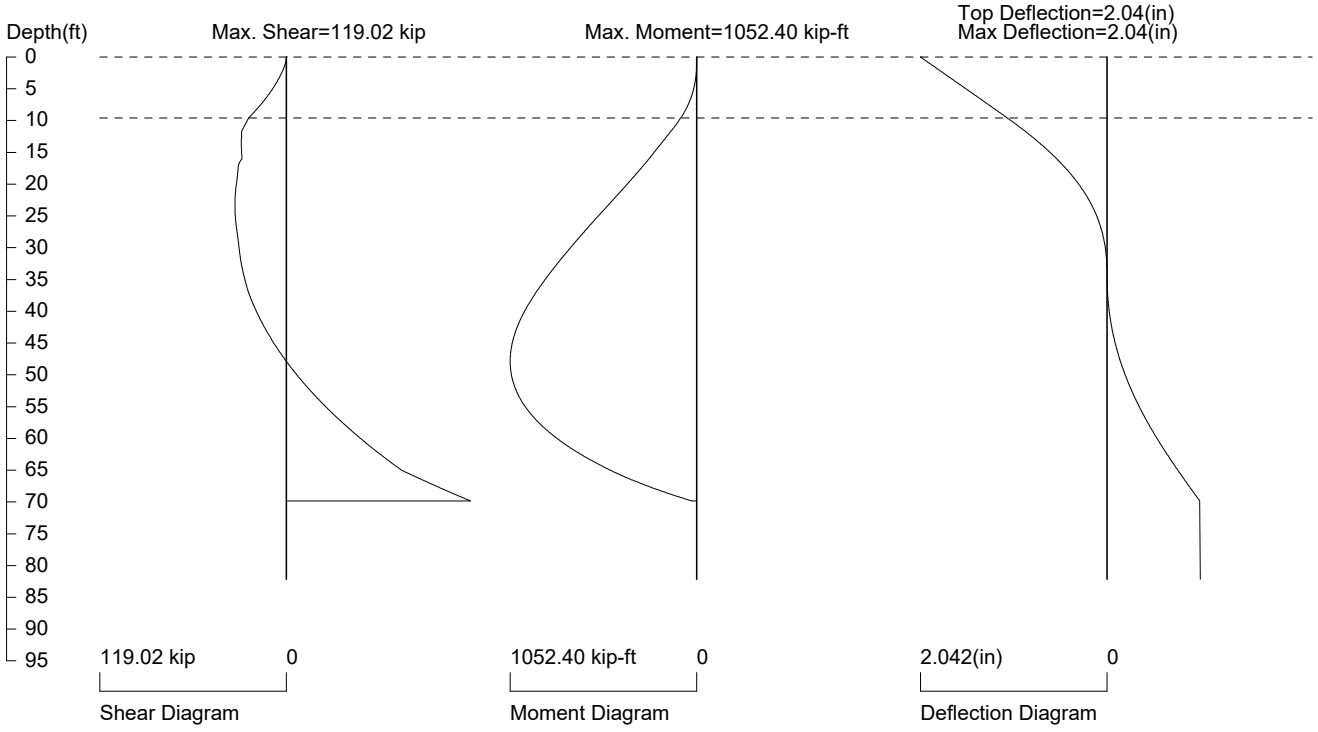
*For Tieback: Input1 = Diameter; Input2 = Bond Strength
*For Plate: Input1 = Diameter; Input2 = Allowable Pressure

```
*For Deadman:  Input1 = Horz. Width;  Input2 = Passive Pressure;
*For Sheet Pile Anchor:  Input1 = Horz. Width;  Input2 = Passive Slope;


*********************************CALCULATION*********************************

   The calculated moment and shear are per pile spacing.  Sheet piles are per one
foot or meter; Soldier piles are per pile.

   Top Pressures start at depth =  0.00


         |      D1=0.00
         |
         |
         |
      ==|==    D2=8.70
         |
         |
         |      D3=48.39

        D1 - TOP DEPTH
        D2 - EXCAVATION BASE
        D3 - PILE TIP

   MOMENT equilibrium   AT DEPTH=48.39  WITH EMBEDMENT OF 39.69
   FORCE equilibrium   AT DEPTH=48.39  WITH EMBEDMENT OF 39.69



*********************************RESULTS**************************************

* EMBEDMENT Notes *
The total desigh embedment is 39.69

Embedment Information:
If 20% increased, the total design embedment is 47.63
If 30% increased, the total design embedment is 51.60
If 40% increased, the total design embedment is 55.57
If 50% increased, the total design embedment is 59.53


* MOMENT IN PILE (per pile spacing)*
Pile Spacing:  sheet piles are one foot or one meter; soldier piles are one pile.
Overall Maximum Moment = 556.74 at 32.41
Maximum Shear = 76.65
Moment and Shear are per pile spacing: 6.0 foot or meter

* VERTICAL LOADING *
Vertical Loading from Braces = 0.00
```

```
Vertical Loading from External Load = 0.00
Total Vertical Loading = 0.00


*****************************SPECIFIED PILE **********************************

   Overall Maximum Moment = 556.74 at 32.41
   The pile selection is based on the magnitude of the moment only. Axial force is
neglected.

   Request Min. Section Modulus = 202.45 in3/pile = 3317.59 cm3/pile, Fy= 50 ksi =
345 MPa, Fb/Fy=0.66

   W18X311J has been found in Soldier Pile list!
   (English Units):
   Area= 91.6 in.  Depth= 22.3 in.  Width= 12 in.  Height= 18 in.
   Flange thickness= 2.74 in.   Web thickness= 1.52 in.
   Ix= 6970 in4/pile   Sx= 624 in3/pile   Iy= 795 in4/pile   Sy= 132 in3/pile
   (Metric Units):
   Ix= 2900.91 x100cm4/pile   Sx= 10225.49 cm3/pile   Iy= 330.88 x100cm4/pile   Sy=
2163.08 cm3/pile



   The pile selection is based on the magnitude of the moment only. Axial force is
neglected.

   W18X311J is capable to support the shoring!
   Top deflection = 0.616(in)
   Max. deflection = 0.616(in)

********************** LAGGING SIZE ESTIMATION **********************
Max. Pressure above base = 0.62
Piles are more rigid than timber lagging, due to arching, only portion of pressures
are acting to lagging, 30-50% loading is suggested.
     If 50% loading is used for lagging design, Design Pressure = 0.31
     Pile Spacing =6.0, Max. Moment in lagging = 1.40
     For 4"x12" Timber, Section Modules S=23.47 in3.  The request allowable bending
strength, fb=M/S=0.71
     For 6"x12" Timber, Section Modules S=57.98 in3.  The request allowable bending
strength, fb=M/S=0.29

     If 30% loading is used for lagging design, Design Pressure = 0.19
     Pile Spacing =6.0, Max. Moment in lagging = 0.84
     For 4"x12" Timber, Section Modules S=23.47 in3.  The request allowable bending
strength, fb=M/S=0.43
     For 6"x12" Timber, Section Modules S=57.98 in3.  The request allowable bending
strength, fb=M/S=0.17

Unit: Pressure: ksf,  Spacing: ft,  Moment: kip-ft, Bending Strength, fb: ksi
```

Drilled SPL Wall 4 - STA 15+75





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 6.0 foot or meter

User Input Pile, W18X311J: E (ksi)=29000.0, I (in4)/pile=6970.0

File: J:\094184.100-MassDOT Armory Street Bridges, Springfie\Calculations\Drilled SPL Walls\S-24-026\CivilTech\Drilled SPL Wall 4 - STA 15+75.sh8

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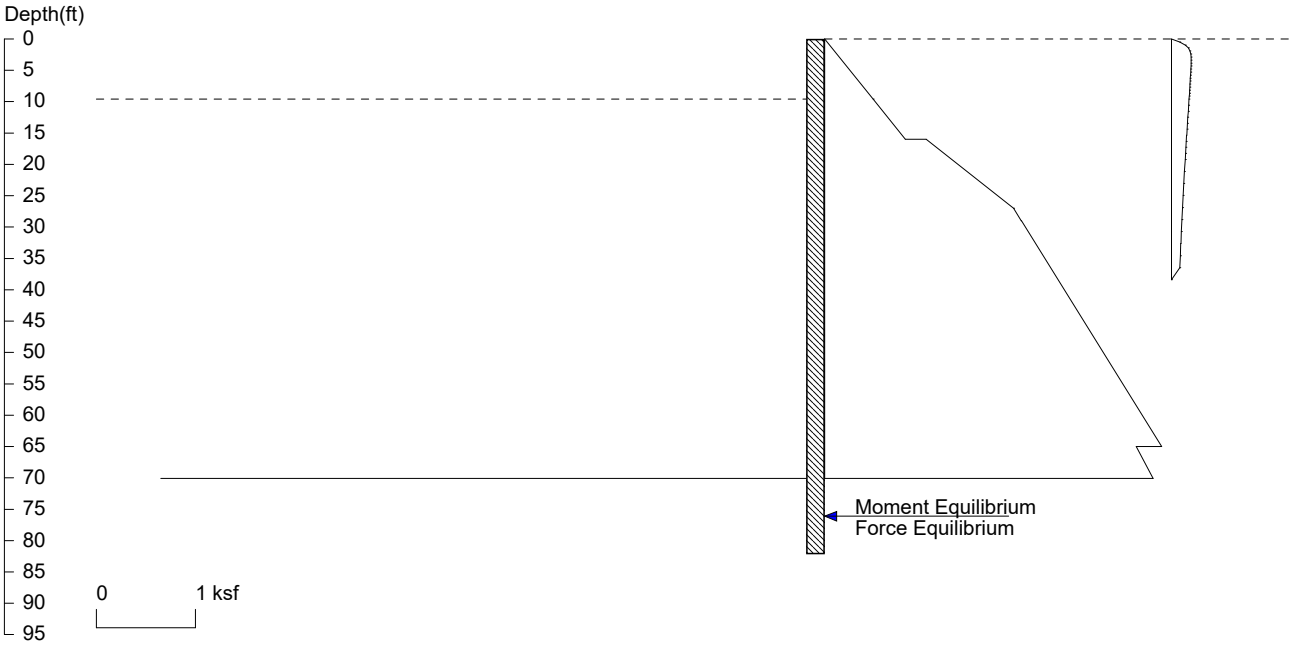

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File: J:\094184.100-MassDOT Armory Street Bridges, Springfie\Calculations\Drilled SPL Walls\S-24-026\CivilTech\Drilled SP

Wall Height=9.6 Pile Diameter=3.0 Pile Spacing=6.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=60.47 Min. Pile Length=70.07
MOMENT IN PILE: Max. Moment=1052.40 per Pile Spacing=6.0 at Depth=47.86

PILE SELECTION:
Request Min. Section Modulus = 382.7 in3/pile=6271.13 cm3/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=0.66
W18X311J has Section Modulus = 624.0 in3/pile=10225.49 cm3/pile. It is greater than Min. Requirements!
Top Deflection = 2.04(in) based on E (ksi)=29000.00 and I (in4)/pile=6970.0

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	9.600	0.489	0.050889
*	Below	Base		
9.600	0.489	16.000	0.814	0.050889
16.000	1.023	27.000	1.908	0.080428
27.000	1.905	29.000	1.984	0.039225
29.000	1.986	65.000	3.403	0.039347
65.000	3.145	76.000	3.516	0.033797
76.000	2.121	86.400	2.447	0.031364
*	Sur-	charge		
0.000	0.000	0.480	0.081	0.169541
0.480	0.081	0.960	0.138	0.118301
0.960	0.138	1.440	0.170	0.065463
1.440	0.170	1.920	0.185	0.032660
1.920	0.185	2.400	0.193	0.015472
2.400	0.193	2.880	0.196	0.006711
2.880	0.196	3.360	0.197	0.002121
3.360	0.197	3.840	0.197	-0.000392

3.840	0.197	4.320	0.196	-0.001834
4.320	0.196	4.800	0.195	-0.002696
4.800	0.195	5.280	0.193	-0.003231
5.280	0.193	5.760	0.191	-0.003574
5.760	0.191	6.240	0.189	-0.003798
6.240	0.189	6.720	0.188	-0.003948
6.720	0.188	7.200	0.186	-0.004048
7.200	0.186	7.680	0.184	-0.004115
7.680	0.184	8.160	0.182	-0.004159
8.160	0.182	8.640	0.180	-0.004187
8.640	0.180	9.120	0.178	-0.004203
9.120	0.178	9.600	0.176	-0.004209
9.600	0.176	10.560	0.172	-0.004207
10.560	0.172	11.520	0.168	-0.004189
11.520	0.168	12.480	0.164	-0.004158
12.480	0.164	13.440	0.160	-0.004119
13.440	0.160	14.400	0.156	-0.004073
14.400	0.156	15.360	0.152	-0.004023
15.360	0.152	16.320	0.148	-0.003968
16.320	0.148	17.280	0.144	-0.003910
17.280	0.144	18.240	0.141	-0.003849
18.240	0.141	19.200	0.137	-0.003786
19.200	0.137	21.120	0.130	-0.003687
21.120	0.130	23.040	0.123	-0.003550
23.040	0.123	24.960	0.117	-0.003408
24.960	0.117	26.880	0.110	-0.003263
26.880	0.110	28.800	0.104	-0.003118
28.800	0.104	30.720	0.099	-0.002972
30.720	0.099	32.640	0.093	-0.002828
32.640	0.093	34.560	0.088	-0.002685
34.560	0.088	36.480	0.083	-0.002546
36.480	0.083	38.400	0.000	-0.043271

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
11.600	0.669	16.000	1.080	0.093336
16.000	0.037	17.600	1.360	0.827144
17.600	1.191	20.600	1.322	0.043637
20.600	1.385	23.600	1.763	0.126235
23.600	1.765	27.000	2.214	0.132116
27.000	2.213	29.000	2.252	0.019526
29.000	2.255	29.600	2.270	0.024915
29.600	2.249	32.600	2.460	0.070308
32.600	2.486	35.600	2.698	0.070691
35.600	2.698	38.600	2.937	0.079580
38.600	2.947	41.600	3.172	0.075034
41.600	3.184	44.600	3.440	0.085587
44.600	3.436	47.600	3.702	0.088805
47.600	3.706	50.600	3.958	0.084104
50.600	3.980	53.600	4.225	0.081447
53.600	4.228	56.600	4.519	0.096827
56.600	4.515	59.600	4.771	0.085391
59.600	4.784	65.000	5.282	0.092140
65.000	5.980	65.600	6.051	0.118528
65.600	6.054	68.600	6.397	0.114605
68.600	6.386	71.600	6.660	0.091334
71.600	6.660	76.000	7.052	0.088930
76.000	10.434	77.600	10.874	0.275309

77.600	10.915	80.600	11.603	0.229135
80.600	11.584	83.600	12.142	0.185984

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	6.00
2	9.60	3.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	9.60	3.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
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7: John J. Peirce), McGraw-Hill. 2012
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Friction/Bearing/Pressure - ksf, Pres. Slope - kip/ft3, Deflection - in
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15+75.sh8

Title: Drilled SPL Wall 4 - STA 15+75
Subtitle:

**********************************INPUT DATA**********************************
Wall Type: 2. Soldier Pile, Drilled
        Wall Height: 9.60
        Pile Diameter: 3.00
        Pile Spacing: 6.00
        Factor of Safety (F.S.): 1.00
Lateral Support Type (Braces): 1. No
        Top Brace Increase (Multi-Bracing): Add 15%*
Embedment Option: 1. Yes
        Friction at Pile Tip: No
Pile Properties:
        Steel Strength, Fy:  50 ksi = 345 MPa
        Allowable Fb/Fy: 0.66
        Elastic Module, E: 29000.00
        Moment of Inertia, I: 6970.00
```

User Input Pile: W18X311J

* DRIVING PRESSURE (ACTIVE, WATER, & SURCHARGE) *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Above	Base		
2	0.000	0.000	9.600	0.489	0.050889
3	*	Below	Base		
4	9.600	0.489	16.000	0.814	0.050889
5	16.000	1.023	27.000	1.908	0.080428
6	27.000	1.905	29.000	1.984	0.039225
7	29.000	1.986	65.000	3.403	0.039347
8	65.000	3.145	76.000	3.516	0.033797
9	76.000	2.121	86.400	2.447	0.031364
10	*	Sur-	charge		
11	0.000	0.000	0.480	0.081	0.169541
12	0.480	0.081	0.960	0.138	0.118301
13	0.960	0.138	1.440	0.170	0.065463
14	1.440	0.170	1.920	0.185	0.032660
15	1.920	0.185	2.400	0.193	0.015472
16	2.400	0.193	2.880	0.196	0.006711
17	2.880	0.196	3.360	0.197	0.002121
18	3.360	0.197	3.840	0.197	-0.000392
19	3.840	0.197	4.320	0.196	-0.001834
20	4.320	0.196	4.800	0.195	-0.002696
21	4.800	0.195	5.280	0.193	-0.003231
22	5.280	0.193	5.760	0.191	-0.003574
23	5.760	0.191	6.240	0.189	-0.003798
24	6.240	0.189	6.720	0.188	-0.003948
25	6.720	0.188	7.200	0.186	-0.004048
26	7.200	0.186	7.680	0.184	-0.004115
27	7.680	0.184	8.160	0.182	-0.004159
28	8.160	0.182	8.640	0.180	-0.004187
29	8.640	0.180	9.120	0.178	-0.004203
30	9.120	0.178	9.600	0.176	-0.004209
31	9.600	0.176	10.560	0.172	-0.004207
32	10.560	0.172	11.520	0.168	-0.004189
33	11.520	0.168	12.480	0.164	-0.004158
34	12.480	0.164	13.440	0.160	-0.004119
35	13.440	0.160	14.400	0.156	-0.004073
36	14.400	0.156	15.360	0.152	-0.004023
37	15.360	0.152	16.320	0.148	-0.003968
38	16.320	0.148	17.280	0.144	-0.003910
39	17.280	0.144	18.240	0.141	-0.003849
40	18.240	0.141	19.200	0.137	-0.003786
41	19.200	0.137	21.120	0.130	-0.003687
42	21.120	0.130	23.040	0.123	-0.003550
43	23.040	0.123	24.960	0.117	-0.003408
44	24.960	0.117	26.880	0.110	-0.003263
45	26.880	0.110	28.800	0.104	-0.003118

46	28.800	0.104	30.720	0.099	-0.002972
47	30.720	0.099	32.640	0.093	-0.002828
48	32.640	0.093	34.560	0.088	-0.002685
49	34.560	0.088	36.480	0.083	-0.002546
50	36.480	0.083	38.400	0.000	-0.043271

* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Below	Base		
2	11.600	0.669	16.000	1.080	0.093336
3	16.000	0.037	17.600	1.360	0.827144
4	17.600	1.191	20.600	1.322	0.043637
5	20.600	1.385	23.600	1.763	0.126235
6	23.600	1.765	27.000	2.214	0.132116
7	27.000	2.213	29.000	2.252	0.019526
8	29.000	2.255	29.600	2.270	0.024915
9	29.600	2.249	32.600	2.460	0.070308
10	32.600	2.486	35.600	2.698	0.070691
11	35.600	2.698	38.600	2.937	0.079580
12	38.600	2.947	41.600	3.172	0.075034
13	41.600	3.184	44.600	3.440	0.085587
14	44.600	3.436	47.600	3.702	0.088805
15	47.600	3.706	50.600	3.958	0.084104
16	50.600	3.980	53.600	4.225	0.081447
17	53.600	4.228	56.600	4.519	0.096827
18	56.600	4.515	59.600	4.771	0.085391
19	59.600	4.784	65.000	5.282	0.092140
20	65.000	5.980	65.600	6.051	0.118528
21	65.600	6.054	68.600	6.397	0.114605
22	68.600	6.386	71.600	6.660	0.091334
23	71.600	6.660	76.000	7.052	0.088930
24	76.000	10.434	77.600	10.874	0.275309
25	77.600	10.915	80.600	11.603	0.229135
26	80.600	11.584	83.600	12.142	0.185984
27	83.600	12.140	86.400	12.617	0.170312

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	6.00
2	9.60	3.00

* PASSIVE SPACE *

No.	Z depth	Spacing
1	9.60	3.00

```
---------------------------------------------------------------------------
*For Tieback:  Input1 = Diameter;  Input2 = Bond Strength
*For Plate:  Input1 = Diameter;  Input2 = Allowable Pressure
*For Deadman:  Input1 = Horz. Width;  Input2 = Passive Pressure;
*For Sheet Pile Anchor:  Input1 = Horz. Width;  Input2 = Passive Slope;


*******************************CALCULATION*********************************

   The calculated moment and shear are per pile spacing.  Sheet piles are per one
foot or meter; Soldier piles are per pile.

   Top Pressures start at depth =  0.00


         |      D1=0.00
         |
         |
         |
      ==|==    D2=9.60
         |
         |
         |      D3=70.07

        D1 - TOP DEPTH
        D2 - EXCAVATION BASE
        D3 - PILE TIP

   MOMENT equilibrium   AT DEPTH=70.07  WITH EMBEDMENT OF 60.47
   FORCE equilibrium   AT DEPTH=70.07  WITH EMBEDMENT OF 60.47



*******************************RESULTS***************************************

* EMBEDMENT Notes *
The total desigh embedment is 60.47

Embedment Information:
If 20% increased, the total design embedment is 72.56
If 30% increased, the total design embedment is 78.61
If 40% increased, the total design embedment is 84.66
If 50% increased, the total design embedment is 90.71


* MOMENT IN PILE (per pile spacing)*
Pile Spacing:  sheet piles are one foot or one meter; soldier piles are one pile.
Overall Maximum Moment = 1052.40 at 47.86
Maximum Shear = 119.02
Moment and Shear are per pile spacing: 6.0 foot or meter
```

```
* VERTICAL LOADING *
Vertical Loading from Braces = 0.00
Vertical Loading from External Load = 0.00
Total Vertical Loading = 0.00


*****************************SPECIFIED PILE **********************************

   Overall Maximum Moment = 1052.40 at 47.86
   The pile selection is based on the magnitude of the moment only. Axial force is
neglected.

   Request Min. Section Modulus = 382.69 in3/pile = 6271.13 cm3/pile, Fy= 50 ksi =
345 MPa, Fb/Fy=0.66

   W18X311J has been found in Soldier Pile list!
   (English Units):
   Area= 91.6 in.  Depth= 22.3 in.  Width= 12 in.  Height= 18 in.
   Flange thickness= 2.74 in.   Web thickness= 1.52 in.
   Ix= 6970 in4/pile   Sx= 624 in3/pile   Iy= 795 in4/pile   Sy= 132 in3/pile
   (Metric Units):
   Ix= 2900.91 x100cm4/pile   Sx= 10225.49 cm3/pile   Iy= 330.88 x100cm4/pile   Sy=
2163.08 cm3/pile



   The pile selection is based on the magnitude of the moment only. Axial force is
neglected.

   W18X311J is capable to support the shoring!
   Top deflection = 2.042(in)
   Max. deflection = 2.042(in)

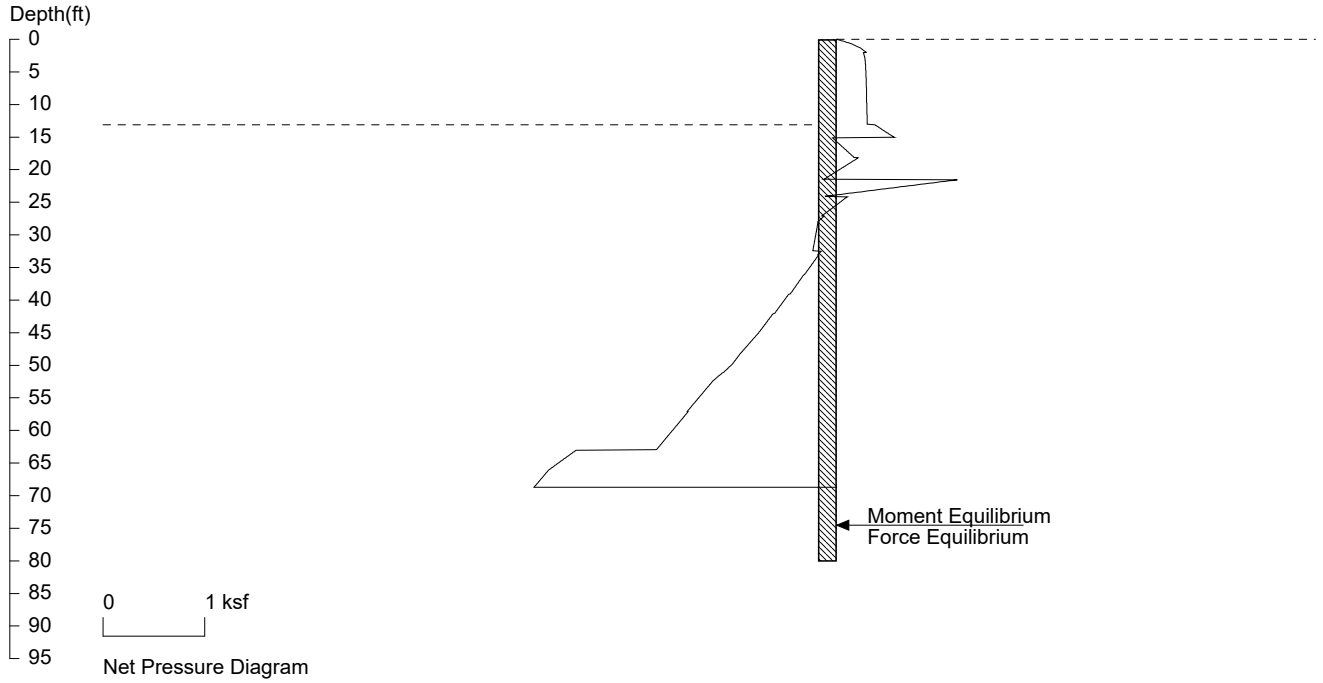
********************** LAGGING SIZE ESTIMATION **********************
Max. Pressure above base = 0.66
Piles are more rigid than timber lagging, due to arching, only portion of pressures
are acting to lagging, 30-50% loading is suggested.
     If 50% loading is used for lagging design, Design Pressure = 0.33
     Pile Spacing =6.0, Max. Moment in lagging = 1.49
     For 4"x12" Timber, Section Modules S=23.47 in3.  The request allowable bending
strength, fb=M/S=0.76
     For 6"x12" Timber, Section Modules S=57.98 in3.  The request allowable bending
strength, fb=M/S=0.31

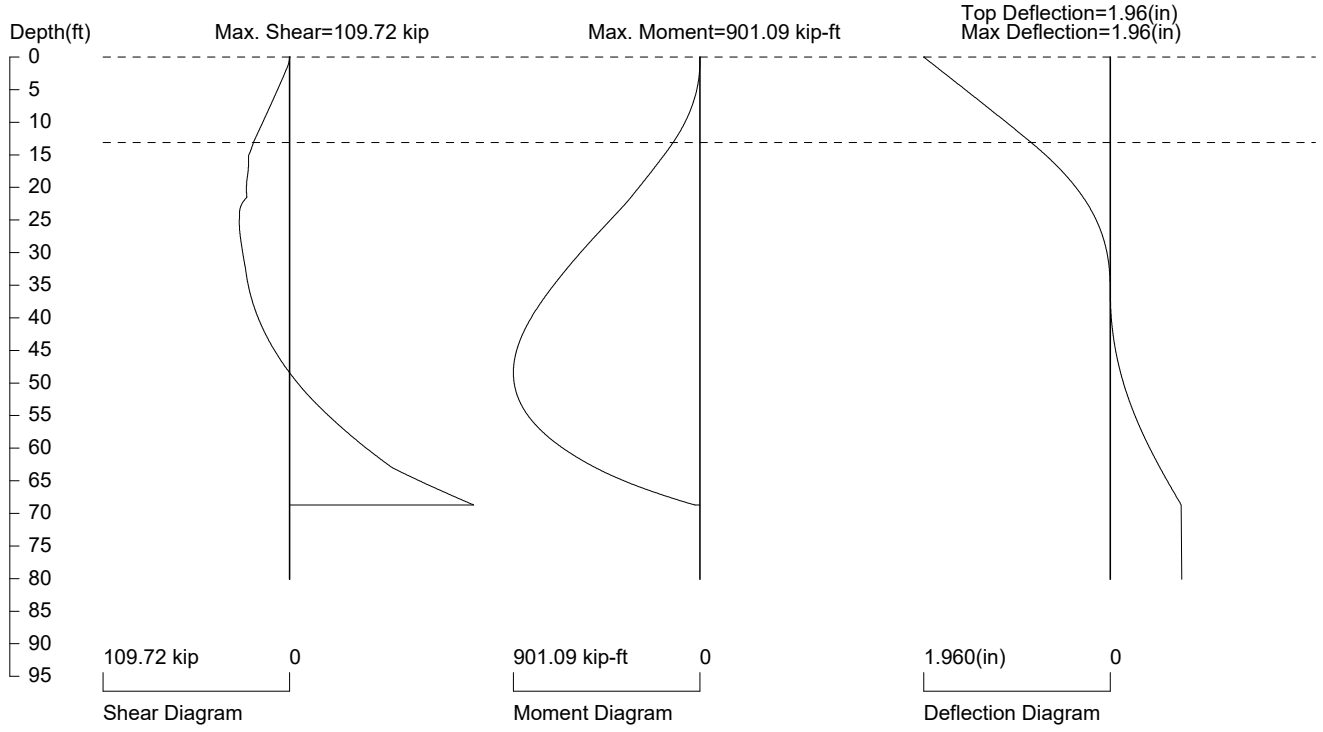
     If 30% loading is used for lagging design, Design Pressure = 0.20
     Pile Spacing =6.0, Max. Moment in lagging = 0.90
     For 4"x12" Timber, Section Modules S=23.47 in3.  The request allowable bending
strength, fb=M/S=0.46
     For 6"x12" Timber, Section Modules S=57.98 in3.  The request allowable bending
```

strength, fb=M/S=0.19

Unit: Pressure: ksf, Spacing: ft, Moment: kip-ft, Bending Strength, fb: ksi

Drilled SPL Wall 4 - STA 16+00





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 6.0 foot or meter

User Input Pile, W18X311J: E (ksi)=29000.0, I (in4)/pile=6970.0

File: J:\094184.100-MassDOT Armory Street Bridges, Springfie\Calculations\Drilled SPL Walls\S-24-026\CivilTech\Drilled SPL Wall 4 - STA 16+00 LW Fill.sh8

<ShoringSuite> CIVILTECH SOFTWARE USA www.civiltech.com

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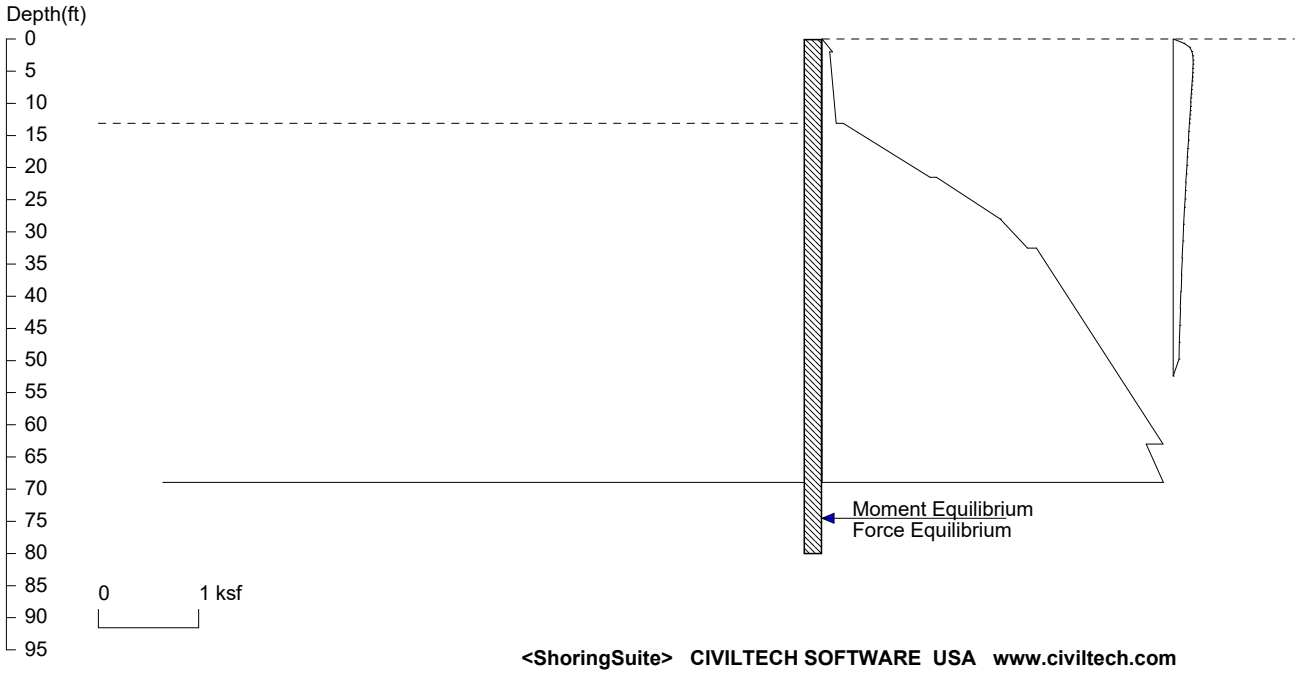
Drilled SPL Wall 4 - STA 16+00



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File: J:\094184.100-MassDOT Armory Street Bridges, Springfie\Calculations\Drilled SPL Walls\S-24-026\CivilTech\Drilled SP

Wall Height=13.1 Pile Diameter=3.0 Pile Spacing=6.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=55.84 Min. Pile Length=68.94
MOMENT IN PILE: Max. Moment=901.09 per Pile Spacing=6.0 at Depth=48.39

PILE SELECTION:
Request Min. Section Modulus = 327.7 in3/pile=5369.51 cm3/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=0.66
W18X311J has Section Modulus = 624.0 in3/pile=10225.49 cm3/pile. It is greater than Min. Requirements!
Top Deflection = 1.96(in) based on E (ksi)=29000.00 and I (in4)/pile=6970.0

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	2.000	0.102	0.050889
2.000	0.074	13.100	0.139	0.005791
*	Below	Base		
13.100	0.211	21.500	1.075	0.102936
21.500	1.138	28.000	1.772	0.097609
28.000	1.775	32.500	2.045	0.060174
32.500	2.134	63.000	3.397	0.041400
63.000	3.229	76.000	3.600	0.028538
76.000	2.351	117.900	3.305	0.022762
*	Sur-	charge		
0.000	0.000	0.655	0.105	0.160979
0.655	0.105	1.310	0.163	0.087935
1.310	0.163	1.965	0.186	0.035401
1.965	0.186	2.620	0.195	0.012685
2.620	0.195	3.275	0.197	0.003545
3.275	0.197	3.930	0.197	-0.000365
3.930	0.197	4.585	0.195	-0.002187

4.585	0.195	5.240	0.193	-0.003104
5.240	0.193	5.895	0.191	-0.003596
5.895	0.191	6.550	0.188	-0.003873
6.550	0.188	7.205	0.186	-0.004032
7.205	0.186	7.860	0.183	-0.004124
7.860	0.183	8.515	0.180	-0.004176
8.515	0.180	9.170	0.177	-0.004201
9.170	0.177	9.825	0.175	-0.004210
9.825	0.175	10.480	0.172	-0.004207
10.480	0.172	11.135	0.169	-0.004195
11.135	0.169	11.790	0.166	-0.004177
11.790	0.166	12.445	0.164	-0.004154
12.445	0.164	13.100	0.161	-0.004128
13.100	0.161	14.410	0.156	-0.004082
14.410	0.156	15.720	0.150	-0.004012
15.720	0.150	17.030	0.145	-0.003936
17.030	0.145	18.340	0.140	-0.003854
18.340	0.140	19.650	0.135	-0.003767
19.650	0.135	20.960	0.130	-0.003677
20.960	0.130	22.270	0.126	-0.003583
22.270	0.126	23.580	0.121	-0.003488
23.580	0.121	24.890	0.117	-0.003390
24.890	0.117	26.200	0.112	-0.003292
26.200	0.112	28.820	0.104	-0.003143
28.820	0.104	31.440	0.096	-0.002944
31.440	0.096	34.060	0.089	-0.002748
34.060	0.089	36.680	0.083	-0.002557
36.680	0.083	39.300	0.076	-0.002373
39.300	0.076	41.920	0.071	-0.002196
41.920	0.071	44.540	0.065	-0.002029
44.540	0.065	47.160	0.060	-0.001871
47.160	0.060	49.780	0.056	-0.001723
49.780	0.056	52.400	0.000	-0.021329

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
15.100	0.613	18.100	0.698	0.028482
18.100	0.648	21.500	1.334	0.201518
21.500	0.057	24.100	1.637	0.607517
24.100	1.404	27.100	1.943	0.179544
27.100	1.917	28.000	2.066	0.165830
28.000	2.066	32.500	2.376	0.068795
32.500	2.381	33.100	2.441	0.099351
33.100	2.430	36.100	2.685	0.084941
36.100	2.692	39.100	2.944	0.083976
39.100	2.957	42.100	3.216	0.086209
42.100	3.230	45.100	3.491	0.087163
45.100	3.493	48.100	3.781	0.095772
48.100	3.782	51.100	4.046	0.087915
51.100	4.052	54.100	4.338	0.095411
54.100	4.338	57.100	4.624	0.095411
57.100	4.613	63.000	5.172	0.094838
63.000	5.789	63.100	5.800	0.118013
63.100	5.801	66.100	6.153	0.117350
66.100	6.152	69.100	6.401	0.082840
69.100	6.400	72.100	6.641	0.080247
72.100	6.634	76.000	7.072	0.112347
76.000	10.271	78.100	10.878	0.288965

78.100	10.944	81.100	11.505	0.187249

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	6.00
2	13.10	3.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	13.10	3.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

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**************************************************************************

                        SHORING WALL CALCULATION SUMMARY
                  The leading shoring design and calculation software
                        Software Copyright by CivilTech Software
                              www.civiltech.com

**************************************************************************
ShoringSuite Software is developed by CivilTech Software, Bellevue, WA, USA.
The calculation method is based on the following references:
    1. FHWA 98-011, FHWA-RD-97-130, FHWA SA 96-069, FHWA-IF-99-015
    2. STEEL SHEET PILING DESIGN MANUAL by Pile Buck Inc., 1987
    3. DESIGN MANUAL DM-7 (NAVFAC), Department of the Navy, May 1982
    4. TRENCHING AND SHORING MANUAL Revision 12, California Department of
       Transportation, January 2000
    6. EARTH SUPPORT SYSTEM & RETAINING STRUCTURES, Pile Buck Inc. 2002
    5. DESIGN OF SHEET PILE WALLS, EM 1110-2-2504, U.S. Army Corps of Engineers, 31
March 1994
    7. EARTH RETENTION SYSTEMS HANDBOOK, Alan Macnab, McGraw-Hill. 2002
    8. Temporary Structures in Construction, Robert T. Ratay (Co-author of Chapter
7: John J. Peirce), McGraw-Hill. 2012
    9. AASHTO HB-17, American Association of State and Highway Transportation
Officials, 2 September 2002

UNITS:   Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft,
Friction/Bearing/Pressure - ksf, Pres. Slope - kip/ft3, Deflection - in
--------------------------------------------------------------------------
Licensed to   4324324234     3424343
Date: 12/1/2023  File: J:\094184.100-MassDOT Armory Street Bridges,
Springfie\Calculations\Drilled SPL Walls\S-24-026\CivilTech\Drilled SPL Wall 4 - STA
16+00 LW Fill.sh8

Title: Drilled SPL Wall 4 - STA 16+00
Subtitle:

**********************************INPUT DATA**********************************
Wall Type: 2. Soldier Pile, Drilled
        Wall Height: 13.10
        Pile Diameter: 3.00
        Pile Spacing: 6.00
        Factor of Safety (F.S.): 1.00
Lateral Support Type (Braces): 1. No
        Top Brace Increase (Multi-Bracing): Add 15%*
Embedment Option: 1. Yes
        Friction at Pile Tip: No
Pile Properties:
        Steel Strength, Fy:  50 ksi = 345 MPa
        Allowable Fb/Fy: 0.66
        Elastic Module, E: 29000.00
        Moment of Inertia, I: 6970.00
```

User Input Pile: W18X311J

* DRIVING PRESSURE (ACTIVE, WATER, & SURCHARGE) *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Above	Base		
2	0.000	0.000	2.000	0.102	0.050889
3	2.000	0.074	13.100	0.139	0.005791
4	*	Below	Base		
5	13.100	0.211	21.500	1.075	0.102936
6	21.500	1.138	28.000	1.772	0.097609
7	28.000	1.775	32.500	2.045	0.060174
8	32.500	2.134	63.000	3.397	0.041400
9	63.000	3.229	76.000	3.600	0.028538
10	76.000	2.351	117.900	3.305	0.022762
11	*	Sur-	charge		
12	0.000	0.000	0.655	0.105	0.160979
13	0.655	0.105	1.310	0.163	0.087935
14	1.310	0.163	1.965	0.186	0.035401
15	1.965	0.186	2.620	0.195	0.012685
16	2.620	0.195	3.275	0.197	0.003545
17	3.275	0.197	3.930	0.197	-0.000365
18	3.930	0.197	4.585	0.195	-0.002187
19	4.585	0.195	5.240	0.193	-0.003104
20	5.240	0.193	5.895	0.191	-0.003596
21	5.895	0.191	6.550	0.188	-0.003873
22	6.550	0.188	7.205	0.186	-0.004032
23	7.205	0.186	7.860	0.183	-0.004124
24	7.860	0.183	8.515	0.180	-0.004176
25	8.515	0.180	9.170	0.177	-0.004201
26	9.170	0.177	9.825	0.175	-0.004210
27	9.825	0.175	10.480	0.172	-0.004207
28	10.480	0.172	11.135	0.169	-0.004195
29	11.135	0.169	11.790	0.166	-0.004177
30	11.790	0.166	12.445	0.164	-0.004154
31	12.445	0.164	13.100	0.161	-0.004128
32	13.100	0.161	14.410	0.156	-0.004082
33	14.410	0.156	15.720	0.150	-0.004012
34	15.720	0.150	17.030	0.145	-0.003936
35	17.030	0.145	18.340	0.140	-0.003854
36	18.340	0.140	19.650	0.135	-0.003767
37	19.650	0.135	20.960	0.130	-0.003677
38	20.960	0.130	22.270	0.126	-0.003583
39	22.270	0.126	23.580	0.121	-0.003488
40	23.580	0.121	24.890	0.117	-0.003390
41	24.890	0.117	26.200	0.112	-0.003292
42	26.200	0.112	28.820	0.104	-0.003143
43	28.820	0.104	31.440	0.096	-0.002944
44	31.440	0.096	34.060	0.089	-0.002748
45	34.060	0.089	36.680	0.083	-0.002557

46	36.680	0.083	39.300	0.076	-0.002373
47	39.300	0.076	41.920	0.071	-0.002196
48	41.920	0.071	44.540	0.065	-0.002029
49	44.540	0.065	47.160	0.060	-0.001871
50	47.160	0.060	49.780	0.056	-0.001723
51	49.780	0.056	52.400	0.000	-0.021329

* PASSIVE PRESSURE *

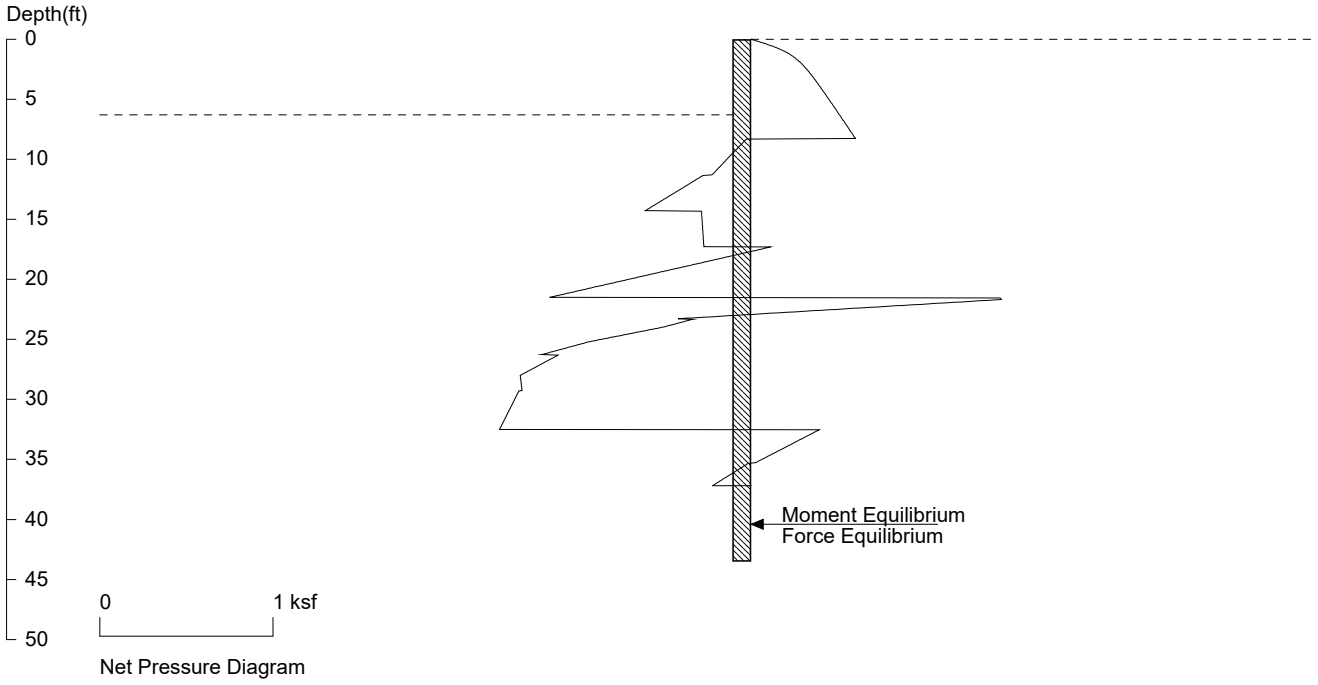
No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Below	Base		
2	15.100	0.613	18.100	0.698	0.028482
3	18.100	0.648	21.500	1.334	0.201518
4	21.500	0.057	24.100	1.637	0.607517
5	24.100	1.404	27.100	1.943	0.179544
6	27.100	1.917	28.000	2.066	0.165830
7	28.000	2.066	32.500	2.376	0.068795
8	32.500	2.381	33.100	2.441	0.099351
9	33.100	2.430	36.100	2.685	0.084941
10	36.100	2.692	39.100	2.944	0.083976
11	39.100	2.957	42.100	3.216	0.086209
12	42.100	3.230	45.100	3.491	0.087163
13	45.100	3.493	48.100	3.781	0.095772
14	48.100	3.782	51.100	4.046	0.087915
15	51.100	4.052	54.100	4.338	0.095411
16	54.100	4.338	57.100	4.624	0.095411
17	57.100	4.613	63.000	5.172	0.094838
18	63.000	5.789	63.100	5.800	0.118013
19	63.100	5.801	66.100	6.153	0.117350
20	66.100	6.152	69.100	6.401	0.082840
21	69.100	6.400	72.100	6.641	0.080247
22	72.100	6.634	76.000	7.072	0.112347
23	76.000	10.271	78.100	10.878	0.288965
24	78.100	10.944	81.100	11.505	0.187249
25	81.100	11.473	84.100	11.937	0.154759
26	84.100	11.878	87.100	12.587	0.236368
27	87.100	12.612	90.100	13.327	0.238296
28	90.100	13.317	93.100	14.062	0.248283
29	93.100	14.062	96.100	14.802	0.246649
30	96.100	14.802	99.100	15.537	0.245026
31	99.100	15.537	102.100	16.267	0.243444
32	102.100	16.274	105.100	16.973	0.232833
33	105.100	16.933	108.100	17.647	0.237782
34	108.100	17.647	111.100	18.356	0.236469
35	111.100	18.356	114.100	19.062	0.235247
36	114.100	19.062	117.100	19.764	0.234113
37	117.100	19.764	117.900	19.951	0.233439

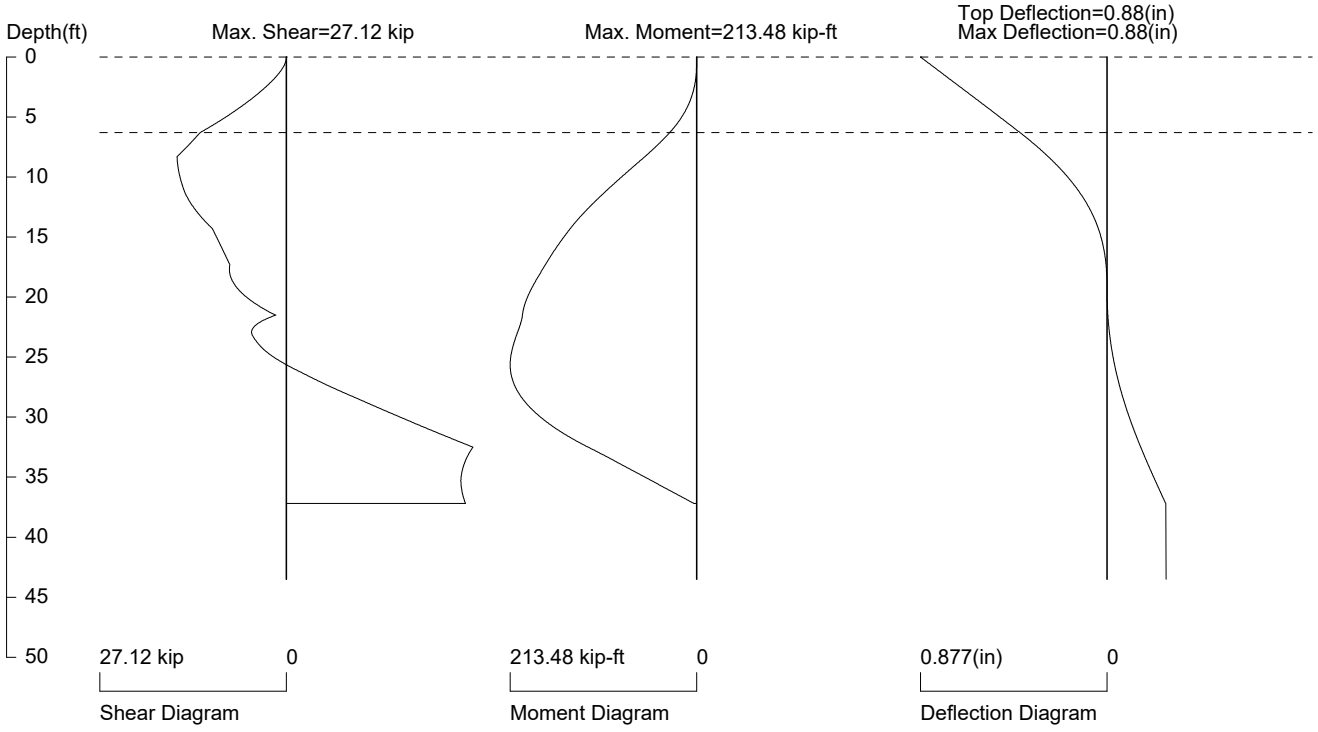
```
* ACTIVE SPACE *
 No.    Z depth         Spacing
-------------------------------------------------------------------------
 1      0.00            6.00
 2      13.10           3.00
-------------------------------------------------------------------------

* PASSIVE SPACE *
 No.    Z depth         Spacing
-------------------------------------------------------------------------
 1      13.10           3.00
-------------------------------------------------------------------------
*For Tieback:  Input1 = Diameter;  Input2 = Bond Strength
*For Plate:  Input1 = Diameter;  Input2 = Allowable Pressure
*For Deadman:  Input1 = Horz. Width;  Input2 = Passive Pressure;
*For Sheet Pile Anchor:  Input1 = Horz. Width;  Input2 = Passive Slope;


*******************************CALCULATION*********************************

   The calculated moment and shear are per pile spacing.  Sheet piles are per one
foot or meter; Soldier piles are per pile.

   Top Pressures start at depth =  0.00


        |      D1=0.00
        |
        |
        |
      ==|==    D2=13.10
        |
        |
        |      D3=68.94

        D1 - TOP DEPTH
        D2 - EXCAVATION BASE
        D3 - PILE TIP

   MOMENT equilibrium   AT DEPTH=68.94  WITH EMBEDMENT OF 55.84
   FORCE equilibrium   AT DEPTH=68.94  WITH EMBEDMENT OF 55.84



*********************************RESULTS***********************************

* EMBEDMENT Notes *
The total desigh embedment is 55.84

Embedment Information:
```

```
If 20% increased, the total design embedment is 67.01
If 30% increased, the total design embedment is 72.60
If 40% increased, the total design embedment is 78.18
If 50% increased, the total design embedment is 83.76


* MOMENT IN PILE (per pile spacing)*
Pile Spacing:  sheet piles are one foot or one meter; soldier piles are one pile.
Overall Maximum Moment = 901.09 at 48.39
Maximum Shear = 109.72
Moment and Shear are per pile spacing: 6.0 foot or meter

* VERTICAL LOADING *
Vertical Loading from Braces = 0.00
Vertical Loading from External Load = 0.00
Total Vertical Loading = 0.00


*****************************SPECIFIED PILE **********************************

   Overall Maximum Moment = 901.09 at 48.39
   The pile selection is based on the magnitude of the moment only. Axial force is
neglected.

   Request Min. Section Modulus = 327.67 in3/pile = 5369.51 cm3/pile, Fy= 50 ksi =
345 MPa, Fb/Fy=0.66

   W18X311J has been found in Soldier Pile list!
   (English Units):
   Area= 91.6 in.  Depth= 22.3 in.  Width= 12 in.  Height= 18 in.
   Flange thickness= 2.74 in.   Web thickness= 1.52 in.
   Ix= 6970 in4/pile   Sx= 624 in3/pile   Iy= 795 in4/pile   Sy= 132 in3/pile
   (Metric Units):
   Ix= 2900.91 x100cm4/pile   Sx= 10225.49 cm3/pile   Iy= 330.88 x100cm4/pile   Sy=
2163.08 cm3/pile



   The pile selection is based on the magnitude of the moment only. Axial force is
neglected.

   W18X311J is capable to support the shoring!
   Top deflection = 1.960(in)
   Max. deflection = 1.960(in)

********************** LAGGING SIZE ESTIMATION **********************
Max. Pressure above base = 0.30
Piles are more rigid than timber lagging, due to arching, only portion of pressures
are acting to lagging, 30-50% loading is suggested.
     If 50% loading is used for lagging design, Design Pressure = 0.15
```

```
     Pile Spacing =6.0, Max. Moment in lagging = 0.67
     For 4"x12" Timber, Section Modules S=23.47 in3.  The request allowable bending
strength, fb=M/S=0.34
     For 6"x12" Timber, Section Modules S=57.98 in3.  The request allowable bending
strength, fb=M/S=0.14

     If 30% loading is used for lagging design, Design Pressure = 0.09
     Pile Spacing =6.0, Max. Moment in lagging = 0.40
     For 4"x12" Timber, Section Modules S=23.47 in3.  The request allowable bending
strength, fb=M/S=0.21
     For 6"x12" Timber, Section Modules S=57.98 in3.  The request allowable bending
strength, fb=M/S=0.08

Unit: Pressure: ksf,  Spacing: ft,  Moment: kip-ft, Bending Strength, fb: ksi
```

Drilled SPL Wall 5 - STA 16+00





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 6.0 foot or meter

User Input Pile, W16X89: E (ksi)=29000.0, I (in4)/pile=1300.0

File: J:\094184.100-MassDOT Armory Street Bridges, Springfie\Calculations\Drilled SPL Walls\S-24-026\CivilTech\Drilled SPL Wall 5 - STA 16+00.sh8

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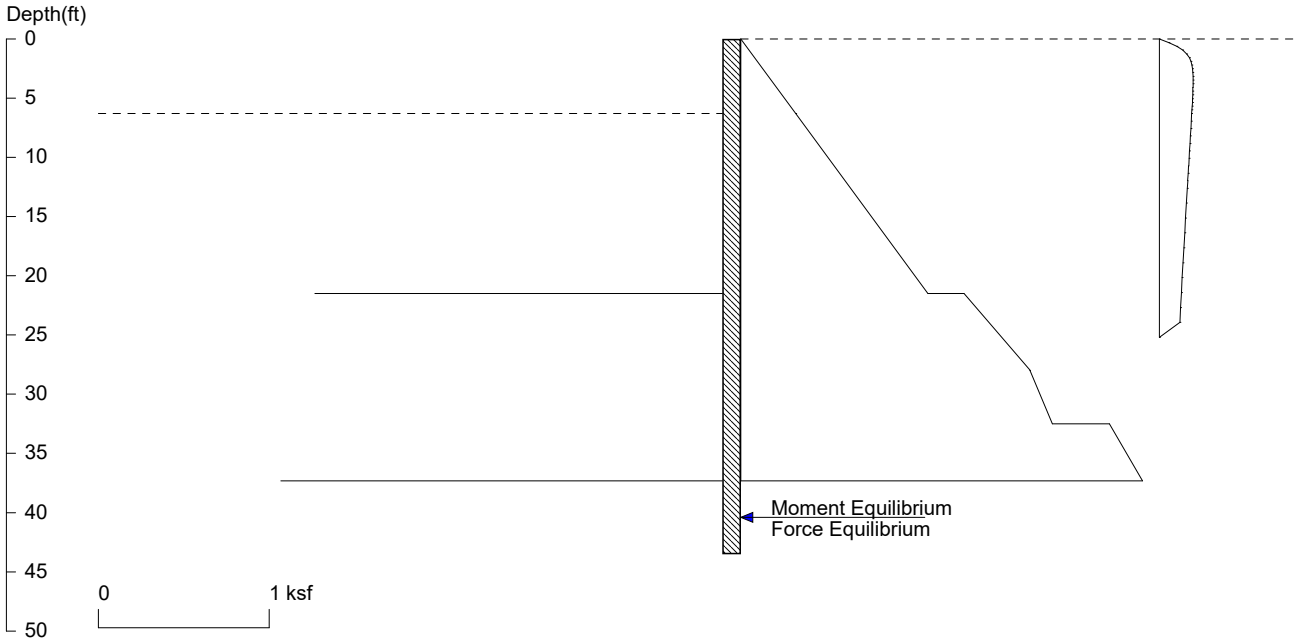
Drilled SPL Wall 5 - STA 16+00



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File: J:\094184.100-MassDOT Armory Street Bridges, Springfie\Calculations\Drilled SPL Walls\S-24-026\CivilTech\Drilled SP

Wall Height=6.3 Pile Diameter=3.0 Pile Spacing=6.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=31.01 Min. Pile Length=37.31
MOMENT IN PILE: Max. Moment=213.48 per Pile Spacing=6.0 at Depth=25.65

PILE SELECTION:
Request Min. Section Modulus = 77.6 in3/pile=1272.08 cm3/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=0.66
W16X89 has Section Modulus = 155.0 in3/pile=2539.99 cm3/pile. It is greater than Min. Requirements!
Top Deflection = 0.88(in) based on E (ksi)=29000.00 and I (in4)/pile=1300.0

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	6.300	0.321	0.050889
*	Below	Base		
6.300	0.321	21.500	1.094	0.050889
21.500	1.307	28.000	1.695	0.059607
28.000	1.693	32.500	1.825	0.029302
32.500	2.158	56.700	3.132	0.040251
*	Sur-	charge		
0.000	0.000	0.315	0.055	0.175901
0.315	0.055	0.630	0.102	0.148670
0.630	0.102	0.945	0.137	0.109771
0.945	0.137	1.260	0.160	0.074154
1.260	0.160	1.575	0.175	0.047658
1.575	0.175	1.890	0.185	0.029824
1.890	0.185	2.205	0.190	0.018300
2.205	0.190	2.520	0.194	0.010918
2.520	0.194	2.835	0.196	0.006150
2.835	0.196	3.150	0.197	0.003022

3.150	0.197	3.465	0.197	0.000928
3.465	0.197	3.780	0.197	-0.000502
3.780	0.197	4.095	0.196	-0.001498
4.095	0.196	4.410	0.196	-0.002204
4.410	0.196	4.725	0.195	-0.002714
4.725	0.195	5.040	0.194	-0.003087
5.040	0.194	5.355	0.193	-0.003364
5.355	0.193	5.670	0.192	-0.003572
5.670	0.192	5.985	0.190	-0.003730
5.985	0.190	6.300	0.189	-0.003851
6.300	0.189	6.930	0.187	-0.003979
6.930	0.187	7.560	0.184	-0.004090
7.560	0.184	8.190	0.182	-0.004155
8.190	0.182	8.820	0.179	-0.004191
8.820	0.179	9.450	0.176	-0.004207
9.450	0.176	10.080	0.174	-0.004210
10.080	0.174	10.710	0.171	-0.004203
10.710	0.171	11.340	0.168	-0.004190
11.340	0.168	11.970	0.166	-0.004171
11.970	0.166	12.600	0.163	-0.004148
12.600	0.163	13.860	0.158	-0.004107
13.860	0.158	15.120	0.153	-0.004044
15.120	0.153	16.380	0.148	-0.003973
16.380	0.148	17.640	0.143	-0.003897
17.640	0.143	18.900	0.138	-0.003816
18.900	0.138	20.160	0.133	-0.003731
20.160	0.133	21.420	0.129	-0.003642
21.420	0.129	22.680	0.124	-0.003552
22.680	0.124	23.940	0.120	-0.003459
23.940	0.120	25.200	0.000	-0.095202

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
8.300	0.632	11.300	0.971	0.113077
11.300	1.018	14.300	1.499	0.160261
14.300	1.172	17.300	1.299	0.042323
17.300	0.913	21.500	2.388	0.351130
21.678	0.000	23.300	1.977	1.218958
23.300	1.868	26.300	2.812	0.314616
26.300	2.708	28.000	3.031	0.189732
28.000	3.028	29.300	3.056	0.020907
29.300	3.074	32.500	3.279	0.064155
32.500	1.761	35.300	2.250	0.174587
35.300	2.285	38.300	2.738	0.151066
38.300	2.633	41.300	3.341	0.235896
41.300	3.432	44.300	3.688	0.085507

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	6.00
2	6.30	3.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	6.30	3.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

```
**************************************************************************

                        SHORING WALL CALCULATION SUMMARY
                The leading shoring design and calculation software
                      Software Copyright by CivilTech Software
                            www.civiltech.com

**************************************************************************
ShoringSuite Software is developed by CivilTech Software, Bellevue, WA, USA.
The calculation method is based on the following references:
    1. FHWA 98-011, FHWA-RD-97-130, FHWA SA 96-069, FHWA-IF-99-015
    2. STEEL SHEET PILING DESIGN MANUAL by Pile Buck Inc., 1987
    3. DESIGN MANUAL DM-7 (NAVFAC), Department of the Navy, May 1982
    4. TRENCHING AND SHORING MANUAL Revision 12, California Department of
       Transportation, January 2000
    6. EARTH SUPPORT SYSTEM & RETAINING STRUCTURES, Pile Buck Inc. 2002
    5. DESIGN OF SHEET PILE WALLS, EM 1110-2-2504, U.S. Army Corps of Engineers, 31
March 1994
    7. EARTH RETENTION SYSTEMS HANDBOOK, Alan Macnab, McGraw-Hill. 2002
    8. Temporary Structures in Construction, Robert T. Ratay (Co-author of Chapter
7: John J. Peirce), McGraw-Hill. 2012
    9. AASHTO HB-17, American Association of State and Highway Transportation
Officials, 2 September 2002

UNITS:   Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft,
Friction/Bearing/Pressure - ksf, Pres. Slope - kip/ft3, Deflection - in
--------------------------------------------------------------------------
Licensed to   4324324234     3424343
Date: 11/30/2023  File: J:\094184.100-MassDOT Armory Street Bridges,
Springfie\Calculations\Drilled SPL Walls\S-24-026\CivilTech\Drilled SPL Wall 5 - STA
16+00.sh8

Title: Drilled SPL Wall 5 - STA 16+00
Subtitle:

**********************************INPUT DATA**********************************
Wall Type: 2. Soldier Pile, Drilled
        Wall Height: 6.30
        Pile Diameter: 3.00
        Pile Spacing: 6.00
        Factor of Safety (F.S.): 1.00
Lateral Support Type (Braces): 1. No
        Top Brace Increase (Multi-Bracing): Add 15%*
Embedment Option: 1. Yes
        Friction at Pile Tip: No
Pile Properties:
        Steel Strength, Fy:  50 ksi = 345 MPa
        Allowable Fb/Fy: 0.66
        Elastic Module, E: 29000.00
        Moment of Inertia, I: 1300.00
```

User Input Pile: W16X89

* DRIVING PRESSURE (ACTIVE, WATER, & SURCHARGE) *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Above	Base		
2	0.000	0.000	6.300	0.321	0.050889
3	*	Below	Base		
4	6.300	0.321	21.500	1.094	0.050889
5	21.500	1.307	28.000	1.695	0.059607
6	28.000	1.693	32.500	1.825	0.029302
7	32.500	2.158	56.700	3.132	0.040251
8	*	Sur-	charge		
9	0.000	0.000	0.315	0.055	0.175901
10	0.315	0.055	0.630	0.102	0.148670
11	0.630	0.102	0.945	0.137	0.109771
12	0.945	0.137	1.260	0.160	0.074154
13	1.260	0.160	1.575	0.175	0.047658
14	1.575	0.175	1.890	0.185	0.029824
15	1.890	0.185	2.205	0.190	0.018300
16	2.205	0.190	2.520	0.194	0.010918
17	2.520	0.194	2.835	0.196	0.006150
18	2.835	0.196	3.150	0.197	0.003022
19	3.150	0.197	3.465	0.197	0.000928
20	3.465	0.197	3.780	0.197	-0.000502
21	3.780	0.197	4.095	0.196	-0.001498
22	4.095	0.196	4.410	0.196	-0.002204
23	4.410	0.196	4.725	0.195	-0.002714
24	4.725	0.195	5.040	0.194	-0.003087
25	5.040	0.194	5.355	0.193	-0.003364
26	5.355	0.193	5.670	0.192	-0.003572
27	5.670	0.192	5.985	0.190	-0.003730
28	5.985	0.190	6.300	0.189	-0.003851
29	6.300	0.189	6.930	0.187	-0.003979
30	6.930	0.187	7.560	0.184	-0.004090
31	7.560	0.184	8.190	0.182	-0.004155
32	8.190	0.182	8.820	0.179	-0.004191
33	8.820	0.179	9.450	0.176	-0.004207
34	9.450	0.176	10.080	0.174	-0.004210
35	10.080	0.174	10.710	0.171	-0.004203
36	10.710	0.171	11.340	0.168	-0.004190
37	11.340	0.168	11.970	0.166	-0.004171
38	11.970	0.166	12.600	0.163	-0.004148
39	12.600	0.163	13.860	0.158	-0.004107
40	13.860	0.158	15.120	0.153	-0.004044
41	15.120	0.153	16.380	0.148	-0.003973
42	16.380	0.148	17.640	0.143	-0.003897
43	17.640	0.143	18.900	0.138	-0.003816
44	18.900	0.138	20.160	0.133	-0.003731
45	20.160	0.133	21.420	0.129	-0.003642

46	21.420	0.129	22.680	0.124	-0.003552
47	22.680	0.124	23.940	0.120	-0.003459
48	23.940	0.120	25.200	0.000	-0.095202

* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Below	Base		
2	8.300	0.632	11.300	0.971	0.113077
3	11.300	1.018	14.300	1.499	0.160261
4	14.300	1.172	17.300	1.299	0.042323
5	17.300	0.913	21.500	2.388	0.351130
6	21.678	0.000	23.300	1.977	1.218958
7	23.300	1.868	26.300	2.812	0.314616
8	26.300	2.708	28.000	3.031	0.189732
9	28.000	3.028	29.300	3.056	0.020907
10	29.300	3.074	32.500	3.279	0.064155
11	32.500	1.761	35.300	2.250	0.174587
12	35.300	2.285	38.300	2.738	0.151066
13	38.300	2.633	41.300	3.341	0.235896
14	41.300	3.432	44.300	3.688	0.085507
15	44.300	3.690	47.300	3.935	0.081461
16	47.300	3.954	50.300	4.188	0.078178
17	50.300	4.219	53.300	4.454	0.078578
18	53.300	4.459	56.300	4.752	0.097773
19	56.300	4.752	56.700	4.792	0.097744

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	6.00
2	6.30	3.00

* PASSIVE SPACE *

No.	Z depth	Spacing
1	6.30	3.00

*For Tieback: Input1 = Diameter; Input2 = Bond Strength
*For Plate: Input1 = Diameter; Input2 = Allowable Pressure
*For Deadman: Input1 = Horz. Width; Input2 = Passive Pressure;
*For Sheet Pile Anchor: Input1 = Horz. Width; Input2 = Passive Slope;

**********CALCULATION**********

The calculated moment and shear are per pile spacing. Sheet piles are per one

```
foot or meter; Soldier piles are per pile.

   Top Pressures start at depth =  0.00


         |      D1=0.00
         |
         |
         |
      ==|==    D2=6.30
         |
         |
         |      D3=37.31

        D1 - TOP DEPTH
        D2 - EXCAVATION BASE
        D3 - PILE TIP

   MOMENT equilibrium   AT DEPTH=37.31  WITH EMBEDMENT OF 31.01
   FORCE equilibrium   AT DEPTH=37.31  WITH EMBEDMENT OF 31.01



**********RESULTS**********

* EMBEDMENT Notes *
The total desigh embedment is 31.01

Embedment Information:
If 20% increased, the total design embedment is 37.21
If 30% increased, the total design embedment is 40.31
If 40% increased, the total design embedment is 43.41
If 50% increased, the total design embedment is 46.51


* MOMENT IN PILE (per pile spacing)*
Pile Spacing:  sheet piles are one foot or one meter; soldier piles are one pile.
Overall Maximum Moment = 213.48 at 25.65
Maximum Shear = 27.12
Moment and Shear are per pile spacing: 6.0 foot or meter

* VERTICAL LOADING *
Vertical Loading from Braces = 0.00
Vertical Loading from External Load = 0.00
Total Vertical Loading = 0.00


**********SPECIFIED PILE **********

   Overall Maximum Moment = 213.48 at 25.65
```

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

Request Min. Section Modulus = 77.63 in3/pile = 1272.08 cm3/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=0.66

W16X89 has been found in Soldier Pile list!
(English Units):
Area= 26.2 in. Depth= 16.8 in. Width= 10.4 in. Height= 16 in.
Flange thickness= 0.875 in. Web thickness= 0.525 in.
Ix= 1300 in4/pile Sx= 155 in3/pile Iy= 163 in4/pile Sy= 31.4 in3/pile
(Metric Units):
Ix= 541.06 x100cm4/pile Sx= 2539.99 cm3/pile Iy= 67.84 x100cm4/pile Sy= 514.55 cm3/pile

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

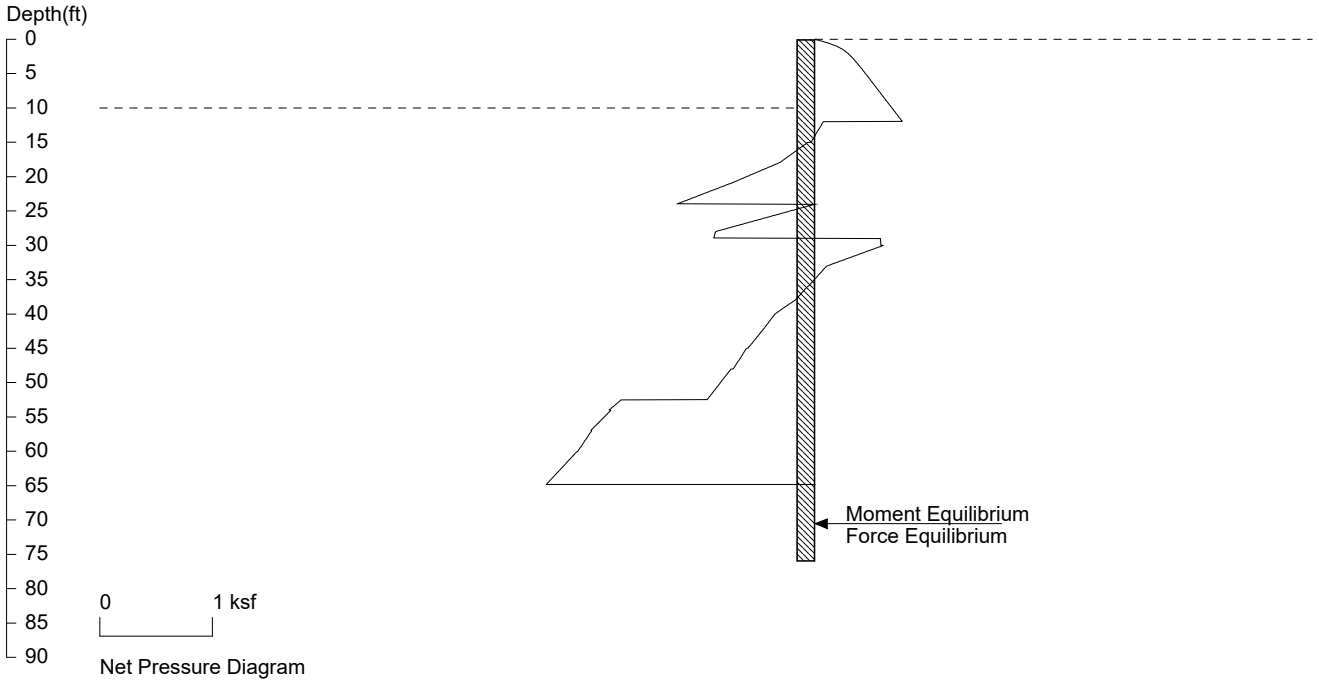
W16X89 is capable to support the shoring!
Top deflection = 0.877(in)
Max. deflection = 0.877(in)

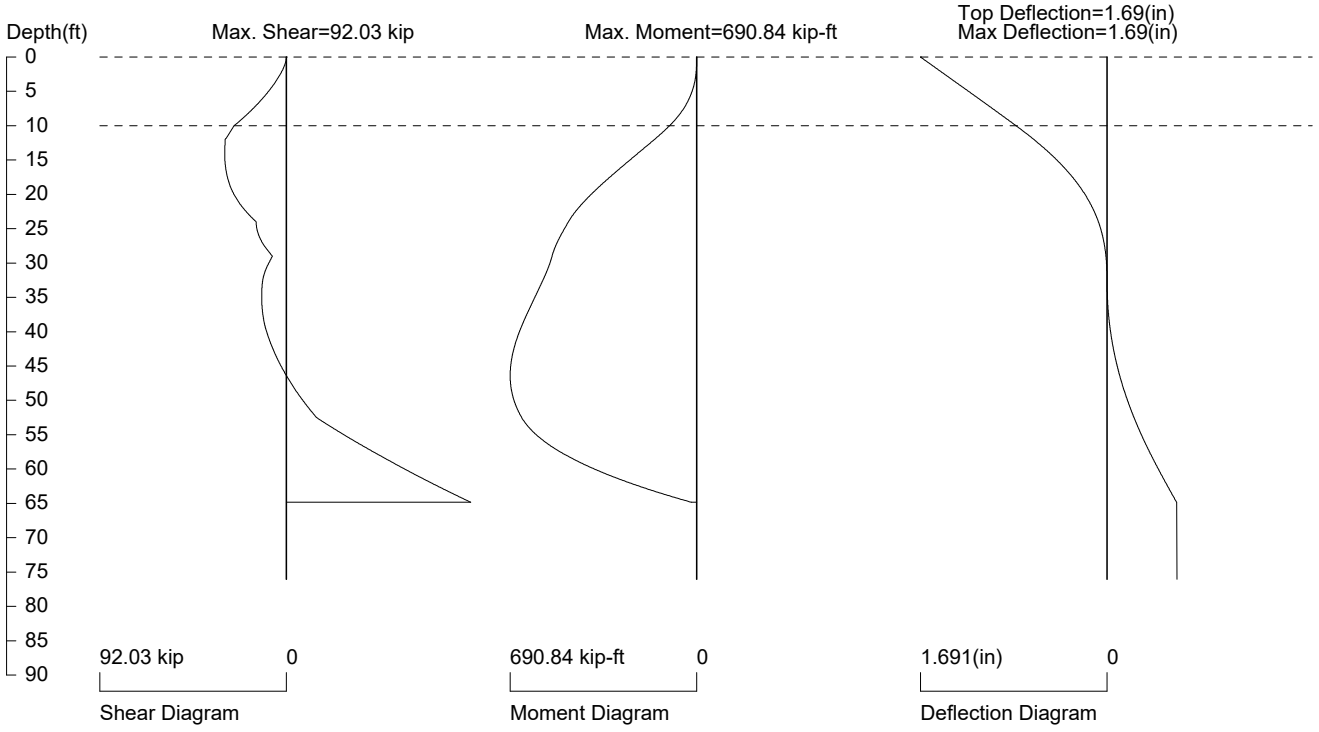
********** LAGGING SIZE ESTIMATION **********
Max. Pressure above base = 0.51
Piles are more rigid than timber lagging, due to arching, only portion of pressures are acting to lagging, 30-50% loading is suggested.
If 50% loading is used for lagging design, Design Pressure = 0.25
Pile Spacing =6.0, Max. Moment in lagging = 1.14
For 4"x12" Timber, Section Modules S=23.47 in3. The request allowable bending strength, fb=M/S=0.58
For 6"x12" Timber, Section Modules S=57.98 in3. The request allowable bending strength, fb=M/S=0.24

If 30% loading is used for lagging design, Design Pressure = 0.15
Pile Spacing =6.0, Max. Moment in lagging = 0.69
For 4"x12" Timber, Section Modules S=23.47 in3. The request allowable bending strength, fb=M/S=0.35
For 6"x12" Timber, Section Modules S=57.98 in3. The request allowable bending strength, fb=M/S=0.14

Unit: Pressure: ksf, Spacing: ft, Moment: kip-ft, Bending Strength, fb: ksi

Drilled SPL Wall 6 - STA 17+30





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 6.0 foot or meter

User Input Pile, W18X283J: E (ksi)=29000.0, I (in4)/pile=6170.0

File: J:\094184.100-MassDOT Armory Street Bridges, Springfie\Calculations\Drilled SPL Walls\S-24-026\CivilTech\Drilled SPL Wall 6 - STA 17+30.sh8

<ShoringSuite> CIVILTECH SOFTWARE USA www.civiltech.com

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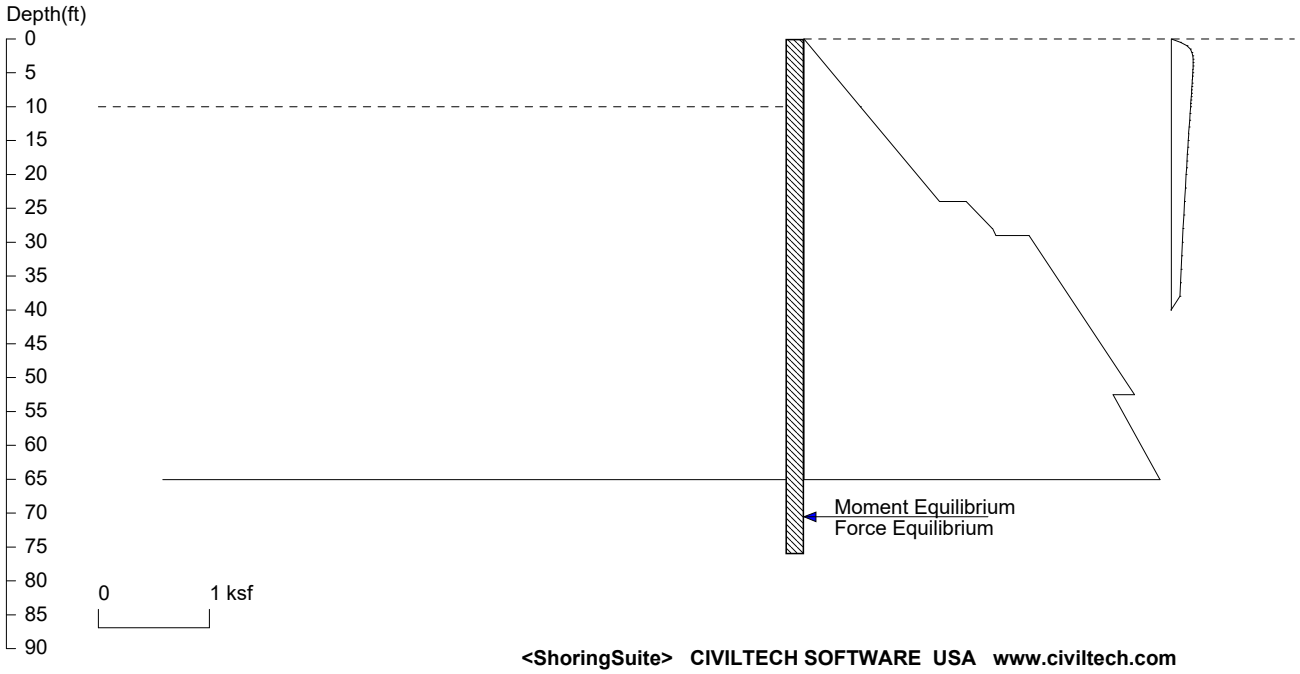
Drilled SPL Wall 6 - STA 17+30



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Wall Height=10.0 Pile Diameter=3.0 Pile Spacing=6.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=55.05 Min. Pile Length=65.05
MOMENT IN PILE: Max. Moment=690.84 per Pile Spacing=6.0 at Depth=46.38

PILE SELECTION:
Request Min. Section Modulus = 251.2 in3/pile=4116.64 cm3/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=0.66
W18X283J has Section Modulus = 565.0 in3/pile=9258.66 cm3/pile. It is greater than Min. Requirements!
Top Deflection = 1.69(in) based on E (ksi)=29000.00 and I (in4)/pile=6170.0

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	10.000	0.509	0.050889
*	Below	Base		
10.000	0.509	24.000	1.221	0.050889
24.000	1.460	28.000	1.697	0.059067
28.000	1.699	29.000	1.728	0.029302
29.000	2.026	52.500	2.976	0.040424
52.500	2.783	65.500	3.221	0.033736
65.500	1.980	90.000	2.688	0.028912
*	Sur-	charge		
0.000	0.000	0.500	0.084	0.168642
0.500	0.084	1.000	0.142	0.114621
1.000	0.142	1.500	0.172	0.061166
1.500	0.172	2.000	0.187	0.029429
2.000	0.187	2.500	0.194	0.013381
2.500	0.194	3.000	0.196	0.005403
3.000	0.196	3.500	0.197	0.001297
3.500	0.197	4.000	0.197	-0.000925

4.000	0.197	4.500	0.195	-0.002187
4.500	0.195	5.000	0.194	-0.002937
5.000	0.194	5.500	0.192	-0.003399
5.500	0.192	6.000	0.190	-0.003693
6.000	0.190	6.500	0.188	-0.003883
6.500	0.188	7.000	0.186	-0.004009
7.000	0.186	7.500	0.184	-0.004091
7.500	0.184	8.000	0.182	-0.004145
8.000	0.182	8.500	0.180	-0.004179
8.500	0.180	9.000	0.178	-0.004199
9.000	0.178	9.500	0.176	-0.004208
9.500	0.176	10.000	0.174	-0.004210
10.000	0.174	11.000	0.170	-0.004201
11.000	0.170	12.000	0.166	-0.004176
12.000	0.166	13.000	0.161	-0.004139
13.000	0.161	14.000	0.157	-0.004094
14.000	0.157	15.000	0.153	-0.004043
15.000	0.153	16.000	0.149	-0.003988
16.000	0.149	17.000	0.145	-0.003928
17.000	0.145	18.000	0.142	-0.003866
18.000	0.142	19.000	0.138	-0.003800
19.000	0.138	20.000	0.134	-0.003733
20.000	0.134	22.000	0.127	-0.003627
22.000	0.127	24.000	0.120	-0.003482
24.000	0.120	26.000	0.113	-0.003333
26.000	0.113	28.000	0.107	-0.003182
28.000	0.107	30.000	0.101	-0.003030
30.000	0.101	32.000	0.095	-0.002879
32.000	0.095	34.000	0.089	-0.002730
34.000	0.089	36.000	0.084	-0.002583
36.000	0.084	38.000	0.079	-0.002441
38.000	0.079	40.000	0.000	-0.039698

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
12.000	0.703	15.000	0.951	0.082768
15.000	0.979	18.000	1.374	0.131740
18.000	1.379	21.000	1.950	0.190120
21.000	1.953	24.000	2.569	0.205322
24.000	1.578	28.000	2.687	0.277137
28.000	2.689	29.000	2.733	0.043768
29.000	1.549	30.000	1.584	0.034882
30.000	1.559	33.000	2.172	0.204094
33.000	2.176	36.000	2.454	0.092555
36.000	2.460	39.000	2.740	0.093158
39.000	2.739	42.000	3.000	0.086895
42.000	2.999	45.000	3.269	0.089930
45.000	3.280	48.000	3.521	0.080103
48.000	3.539	52.500	3.935	0.087971
52.500	4.504	54.000	4.661	0.104816
54.000	4.644	57.000	4.928	0.094744
57.000	4.918	60.000	5.141	0.074523
60.000	5.148	65.500	5.646	0.090419
65.500	8.787	66.000	8.930	0.285553
66.000	8.945	69.000	9.736	0.263420
69.000	9.696	72.000	10.230	0.177868
72.000	10.229	75.000	10.696	0.155583
75.000	10.674	78.000	11.256	0.193750

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	6.00
2	10.00	3.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	10.00	3.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

```
*************************************************************************

                        SHORING WALL CALCULATION SUMMARY
                  The leading shoring design and calculation software
                        Software Copyright by CivilTech Software
                              www.civiltech.com

*************************************************************************
ShoringSuite Software is developed by CivilTech Software, Bellevue, WA, USA.
The calculation method is based on the following references:
    1. FHWA 98-011, FHWA-RD-97-130, FHWA SA 96-069, FHWA-IF-99-015
    2. STEEL SHEET PILING DESIGN MANUAL by Pile Buck Inc., 1987
    3. DESIGN MANUAL DM-7 (NAVFAC), Department of the Navy, May 1982
    4. TRENCHING AND SHORING MANUAL Revision 12, California Department of
       Transportation, January 2000
    6. EARTH SUPPORT SYSTEM & RETAINING STRUCTURES, Pile Buck Inc. 2002
    5. DESIGN OF SHEET PILE WALLS, EM 1110-2-2504, U.S. Army Corps of Engineers, 31
March 1994
    7. EARTH RETENTION SYSTEMS HANDBOOK, Alan Macnab, McGraw-Hill. 2002
    8. Temporary Structures in Construction, Robert T. Ratay (Co-author of Chapter
7: John J. Peirce), McGraw-Hill. 2012
    9. AASHTO HB-17, American Association of State and Highway Transportation
Officials, 2 September 2002

UNITS:   Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft,
Friction/Bearing/Pressure - ksf, Pres. Slope - kip/ft3, Deflection - in
-------------------------------------------------------------------------
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Date: 11/30/2023  File: J:\094184.100-MassDOT Armory Street Bridges,
Springfie\Calculations\Drilled SPL Walls\S-24-026\CivilTech\Drilled SPL Wall 6 - STA
17+30.sh8

Title: Drilled SPL Wall 6 - STA 17+30
Subtitle:

*********************************INPUT DATA*********************************
Wall Type: 2. Soldier Pile, Drilled
        Wall Height: 10.00
        Pile Diameter: 3.00
        Pile Spacing: 6.00
        Factor of Safety (F.S.): 1.00
Lateral Support Type (Braces): 1. No
        Top Brace Increase (Multi-Bracing): Add 15%*
Embedment Option: 1. Yes
        Friction at Pile Tip: No
Pile Properties:
        Steel Strength, Fy:  50 ksi = 345 MPa
        Allowable Fb/Fy: 0.66
        Elastic Module, E: 29000.00
        Moment of Inertia, I: 6170.00
```

User Input Pile: W18X283J

* DRIVING PRESSURE (ACTIVE, WATER, & SURCHARGE) *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Above	Base		
2	0.000	0.000	10.000	0.509	0.050889
3	*	Below	Base		
4	10.000	0.509	24.000	1.221	0.050889
5	24.000	1.460	28.000	1.697	0.059067
6	28.000	1.699	29.000	1.728	0.029302
7	29.000	2.026	52.500	2.976	0.040424
8	52.500	2.783	65.500	3.221	0.033736
9	65.500	1.980	90.000	2.688	0.028912
10	*	Sur-	charge		
11	0.000	0.000	0.500	0.084	0.168642
12	0.500	0.084	1.000	0.142	0.114621
13	1.000	0.142	1.500	0.172	0.061166
14	1.500	0.172	2.000	0.187	0.029429
15	2.000	0.187	2.500	0.194	0.013381
16	2.500	0.194	3.000	0.196	0.005403
17	3.000	0.196	3.500	0.197	0.001297
18	3.500	0.197	4.000	0.197	-0.000925
19	4.000	0.197	4.500	0.195	-0.002187
20	4.500	0.195	5.000	0.194	-0.002937
21	5.000	0.194	5.500	0.192	-0.003399
22	5.500	0.192	6.000	0.190	-0.003693
23	6.000	0.190	6.500	0.188	-0.003883
24	6.500	0.188	7.000	0.186	-0.004009
25	7.000	0.186	7.500	0.184	-0.004091
26	7.500	0.184	8.000	0.182	-0.004145
27	8.000	0.182	8.500	0.180	-0.004179
28	8.500	0.180	9.000	0.178	-0.004199
29	9.000	0.178	9.500	0.176	-0.004208
30	9.500	0.176	10.000	0.174	-0.004210
31	10.000	0.174	11.000	0.170	-0.004201
32	11.000	0.170	12.000	0.166	-0.004176
33	12.000	0.166	13.000	0.161	-0.004139
34	13.000	0.161	14.000	0.157	-0.004094
35	14.000	0.157	15.000	0.153	-0.004043
36	15.000	0.153	16.000	0.149	-0.003988
37	16.000	0.149	17.000	0.145	-0.003928
38	17.000	0.145	18.000	0.142	-0.003866
39	18.000	0.142	19.000	0.138	-0.003800
40	19.000	0.138	20.000	0.134	-0.003733
41	20.000	0.134	22.000	0.127	-0.003627
42	22.000	0.127	24.000	0.120	-0.003482
43	24.000	0.120	26.000	0.113	-0.003333
44	26.000	0.113	28.000	0.107	-0.003182
45	28.000	0.107	30.000	0.101	-0.003030

46	30.000	0.101	32.000	0.095	-0.002879
47	32.000	0.095	34.000	0.089	-0.002730
48	34.000	0.089	36.000	0.084	-0.002583
49	36.000	0.084	38.000	0.079	-0.002441
50	38.000	0.079	40.000	0.000	-0.039698

* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Below	Base		
2	12.000	0.703	15.000	0.951	0.082768
3	15.000	0.979	18.000	1.374	0.131740
4	18.000	1.379	21.000	1.950	0.190120
5	21.000	1.953	24.000	2.569	0.205322
6	24.000	1.578	28.000	2.687	0.277137
7	28.000	2.689	29.000	2.733	0.043768
8	29.000	1.549	30.000	1.584	0.034882
9	30.000	1.559	33.000	2.172	0.204094
10	33.000	2.176	36.000	2.454	0.092555
11	36.000	2.460	39.000	2.740	0.093158
12	39.000	2.739	42.000	3.000	0.086895
13	42.000	2.999	45.000	3.269	0.089930
14	45.000	3.280	48.000	3.521	0.080103
15	48.000	3.539	52.500	3.935	0.087971
16	52.500	4.504	54.000	4.661	0.104816
17	54.000	4.644	57.000	4.928	0.094744
18	57.000	4.918	60.000	5.141	0.074523
19	60.000	5.148	65.500	5.646	0.090419
20	65.500	8.787	66.000	8.930	0.285553
21	66.000	8.945	69.000	9.736	0.263420
22	69.000	9.696	72.000	10.230	0.177868
23	72.000	10.229	75.000	10.696	0.155583
24	75.000	10.674	78.000	11.256	0.193750
25	78.000	11.257	81.000	11.865	0.202670
26	81.000	11.865	84.000	12.453	0.196009
27	84.000	12.453	87.000	13.024	0.190234
28	87.000	13.023	90.000	13.579	0.185305

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	6.00
2	10.00	3.00

* PASSIVE SPACE *

No.	Z depth	Spacing

```
 1      10.00           3.00
--------------------------------------------------------------------------------
*For Tieback:  Input1 = Diameter;  Input2 = Bond Strength
*For Plate:  Input1 = Diameter;  Input2 = Allowable Pressure
*For Deadman:  Input1 = Horz. Width;  Input2 = Passive Pressure;
*For Sheet Pile Anchor:  Input1 = Horz. Width;  Input2 = Passive Slope;


*******************************CALCULATION*********************************

   The calculated moment and shear are per pile spacing.  Sheet piles are per one
foot or meter; Soldier piles are per pile.

   Top Pressures start at depth =  0.00


         |      D1=0.00
         |
         |
         |
      ==|==    D2=10.00
         |
         |
         |      D3=65.05

        D1 - TOP DEPTH
        D2 - EXCAVATION BASE
        D3 - PILE TIP

   MOMENT equilibrium   AT DEPTH=65.05  WITH EMBEDMENT OF 55.05
   FORCE equilibrium   AT DEPTH=65.05  WITH EMBEDMENT OF 55.05



********************************RESULTS***************************************

* EMBEDMENT Notes *
The total desigh embedment is 55.05

Embedment Information:
If 20% increased, the total design embedment is 66.06
If 30% increased, the total design embedment is 71.56
If 40% increased, the total design embedment is 77.06
If 50% increased, the total design embedment is 82.57


* MOMENT IN PILE (per pile spacing)*
Pile Spacing:  sheet piles are one foot or one meter; soldier piles are one pile.
Overall Maximum Moment = 690.84 at 46.38
Maximum Shear = 92.03
```

Moment and Shear are per pile spacing: 6.0 foot or meter

* VERTICAL LOADING *
Vertical Loading from Braces = 0.00
Vertical Loading from External Load = 0.00
Total Vertical Loading = 0.00

**********SPECIFIED PILE **********

Overall Maximum Moment = 690.84 at 46.38
The pile selection is based on the magnitude of the moment only. Axial force is neglected.

Request Min. Section Modulus = 251.21 in3/pile = 4116.64 cm3/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=0.66

W18X283J has been found in Soldier Pile list!
(English Units):
Area= 83.3 in. Depth= 21.9 in. Width= 11.9 in. Height= 18 in.
Flange thickness= 2.5 in. Web thickness= 1.4 in.
Ix= 6170 in4/pile Sx= 565 in3/pile Iy= 704 in4/pile Sy= 118 in3/pile
(Metric Units):
Ix= 2567.95 x100cm4/pile Sx= 9258.66 cm3/pile Iy= 293.00 x100cm4/pile Sy= 1933.67 cm3/pile

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

W18X283J is capable to support the shoring!
Top deflection = 1.691(in)
Max. deflection = 1.691(in)

********** LAGGING SIZE ESTIMATION **********
Max. Pressure above base = 0.68
Piles are more rigid than timber lagging, due to arching, only portion of pressures are acting to lagging, 30-50% loading is suggested.
If 50% loading is used for lagging design, Design Pressure = 0.34
Pile Spacing =6.0, Max. Moment in lagging = 1.53
For 4"x12" Timber, Section Modules S=23.47 in3. The request allowable bending strength, fb=M/S=0.78
For 6"x12" Timber, Section Modules S=57.98 in3. The request allowable bending strength, fb=M/S=0.32

If 30% loading is used for lagging design, Design Pressure = 0.20
Pile Spacing =6.0, Max. Moment in lagging = 0.92
For 4"x12" Timber, Section Modules S=23.47 in3. The request allowable bending strength, fb=M/S=0.47

For 6"x12" Timber, Section Modules S=57.98 in3. The request allowable bending strength, fb=M/S=0.19

Unit: Pressure: ksf, Spacing: ft, Moment: kip-ft, Bending Strength, fb: ksi

APPENDIX E.10 – Earth Pressure for Retaining Walls

MassDOT Armory Street over CSX Spur (No. S-24-026)
SPL Walls 4 through 7
Springfield, MA

Calculated by: PCC Date: 2/24/21
Checked by: SAK Date: 2/24/21

Objective: Calculate lateral earth pressure coefficients for proposed Walls 4, 5, 6, and 7.

Approach: Use Coulomb's method to determine active earth pressure and Rankine's method to determine at-rest and passive earth pressure coefficients in accordance with MassDOT LRFD Bridge Manual.

References:
1. MassDOT LRFD Bridge Manual, Section 3.1.6, 2013.
2. Principles of Foundation Engineering, Second Edition, Das.
3. AASHTO Bridge Design Specifications, 9th Edition, 2020.

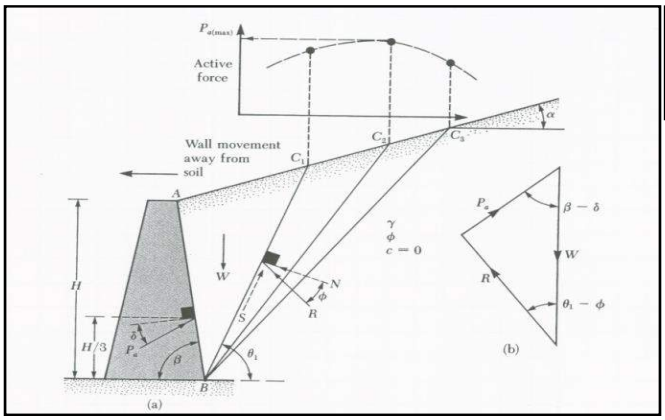
Assumptions:
1. Retained soil is granular with an effective friction angle of 34°.

At-Rest Earth Pressure using Rankine's Method (Principles of Foundation Engineering, Second Edition, Das)

$K_o = 1 - \sin(\phi)$

K_o = 0.44 Effective friction angle of soil: ϕ = 34° **(Use for proposed walls)**

Active Earth Pressure using Coulomb's Method (Principles of Foundation Engineering, Second Edition, Das)



$$K_a = \text{Coulomb's active earth pressure coefficient} = \frac{\sin^2(\beta+\phi)}{\sin^2\beta \cdot \sin(\beta-\delta)\left[1+\sqrt{\frac{\sin(\phi+\delta)\cdot\sin(\phi-\alpha)}{\sin(\beta-\delta)\cdot\sin(\alpha+\beta)}}\right]^2}$$

α = backslope angle
β = wall batter angle
ϕ = soil friction angle
δ = soil/wall friction angle (= ϕ(2/3))

Proposed Wall

α	β	ϕ	δ
0	90	34	23

β (and active earth pressure) will vary with height and wall type selected.

K_a = 0.25

Passive Earth Pressure using Rankine's Method (Principles of Foundation Engineering, Second Edition, Das)

$K_p = (1 + \sin(\phi))/(K_o)$

K_p = 3.5

APPENDIX E.11 – Settlement Analyses for the Proposed Roadway Widening Along the West Side of Armory Street

Armory Street over Abandoned CSX Spur
(Bridge No. S-24-026)
Proposed Bridge Replacement and Roadway Widening
Springfield, Massachusetts

Discipline: Geotechnical

Title: Settlement Analysis for Proposed Roadway Widening along West Side of Armory Street

MassDOT Project File No. 609409

Design Basis/Assumptions:

Purpose: Evaluate settlement due to the addition of fill for the proposed roadway widening along the west side of Armory Street.

Assumptions:

1) Groundwater conditions the same or similar to those observed during the subsurface explorations by Nobis.
2) Proposed roadway profile and bridge abutment heights will be similar to the existing conditions.

Approach:

Use the computer settlement analysis software Settle3, by RocScience, Inc., to perform settlement analyses on the proposed placement of fill due to widening Armory Street.

References:

1) Grading Plans and Cross Sections drawings provided by Tetra Tech in October and November 2023.
2) Subsurface explorations and laboratory tests performed by Nobis.
3) AASHTO LRFD Bridge Design Specifications, 9th Edition 2020.

Remarks/Conclusions:

The total settlement (elastic, primary, and secondary consolidation settlements) due to the widening of Armory Street 20 feet to the west is estimated to be on the order of 1.1-inches.

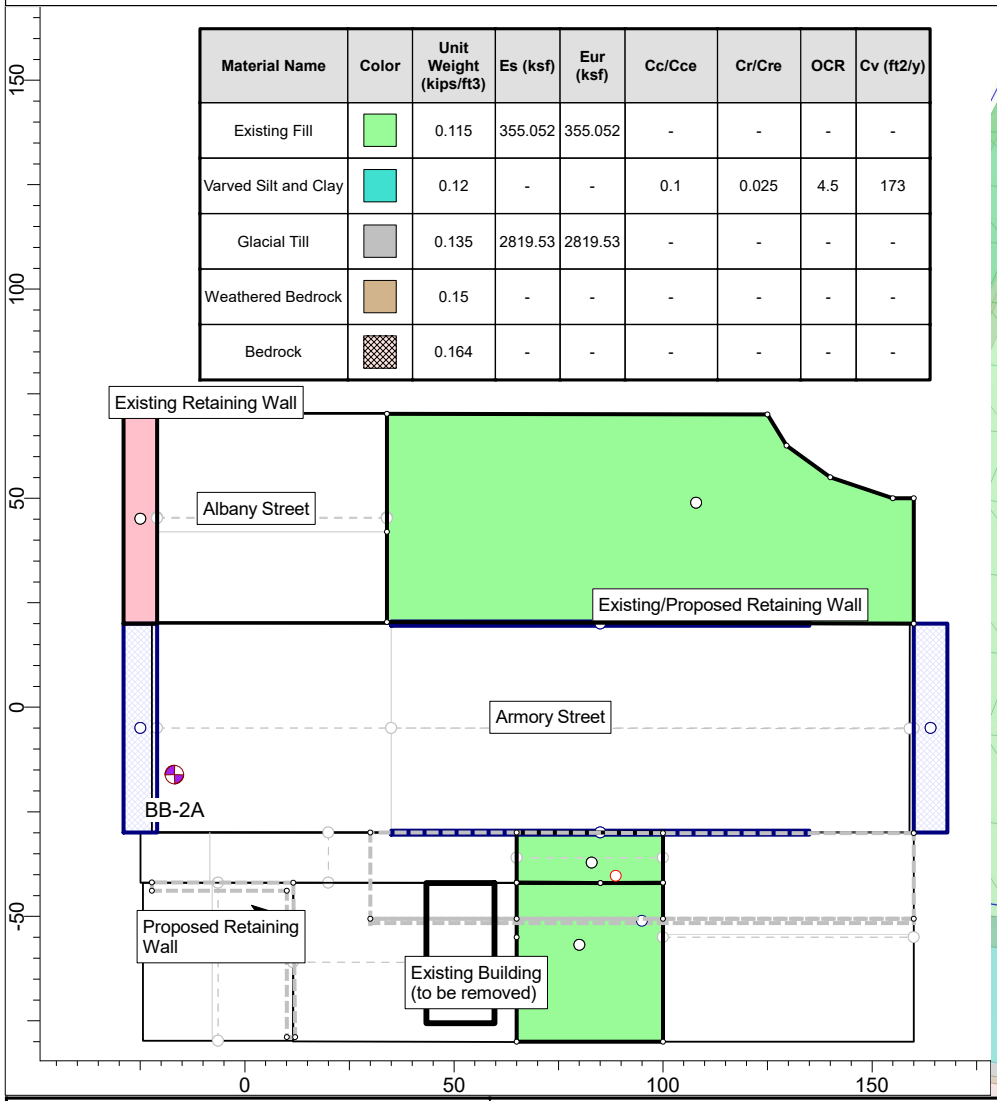
Originated By: Sarah A. Kurtzer Date: 02/12/2021

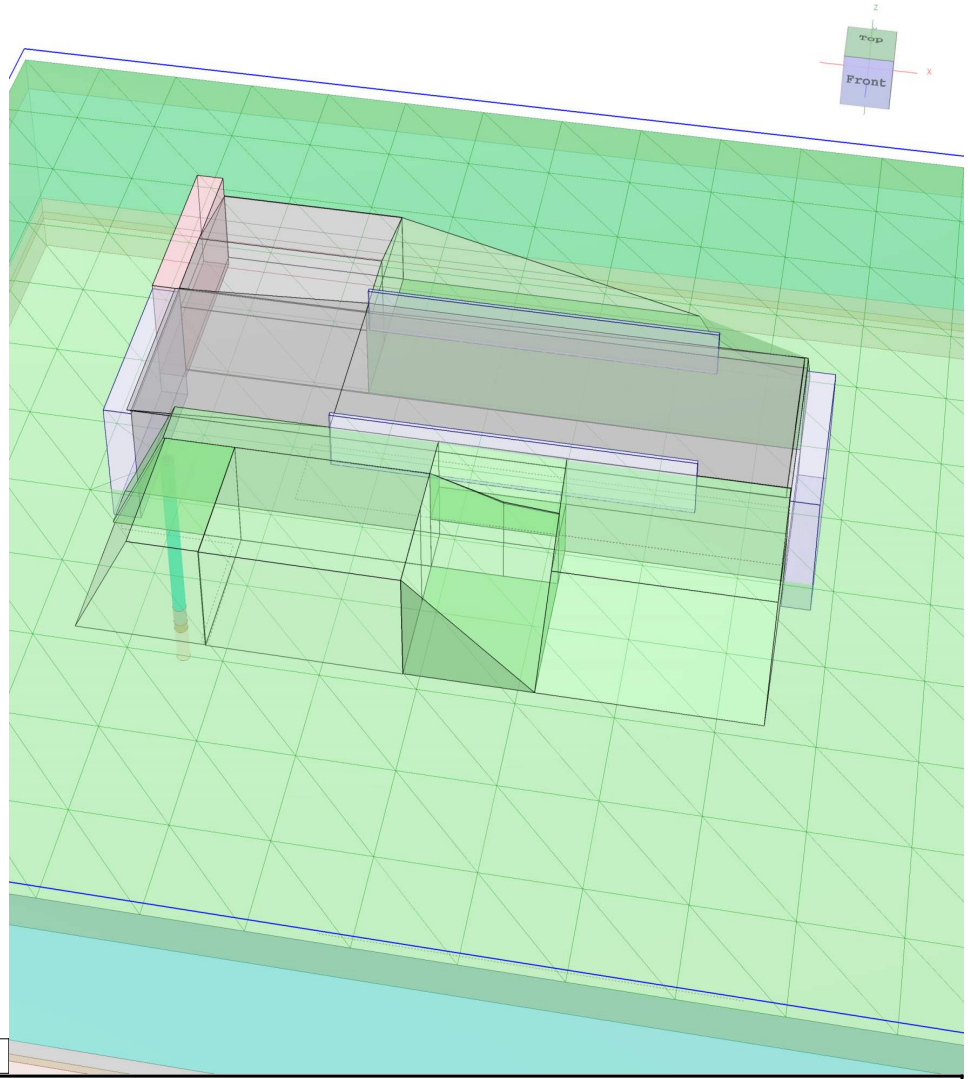
Revised By: Sarah A. Kurtzer Date: 11/06/2023

Reviewed By: Kurt Jelinek, PE Date: 11/27/2023

[R] Present Day = 85 y

Material Name	Color	Unit Weight (kips/ft3)	Es (ksf)	Eur (ksf)	Cc/Cce	Cr/Cre	OCR	Cv (ft2/y)
Existing Fill		0.115	355.052	355.052	-	-	-	-
Varved Silt and Clay		0.12	-	-	0.1	0.025	4.5	173
Glacial Till		0.135	2819.53	2819.53	-	-	-	-
Weathered Bedrock		0.15	-	-	-	-	-	-
Bedrock		0.164	-	-	-	-	-	-





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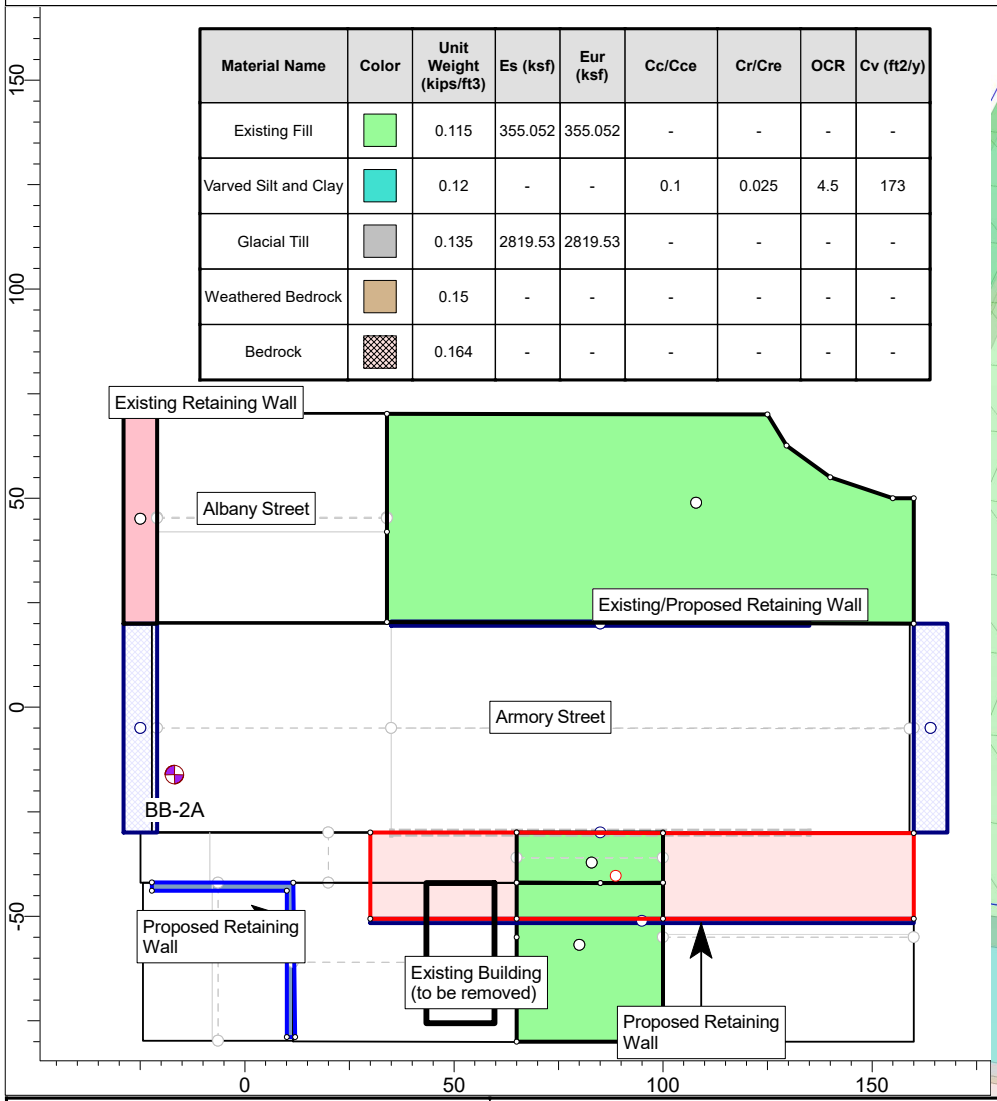
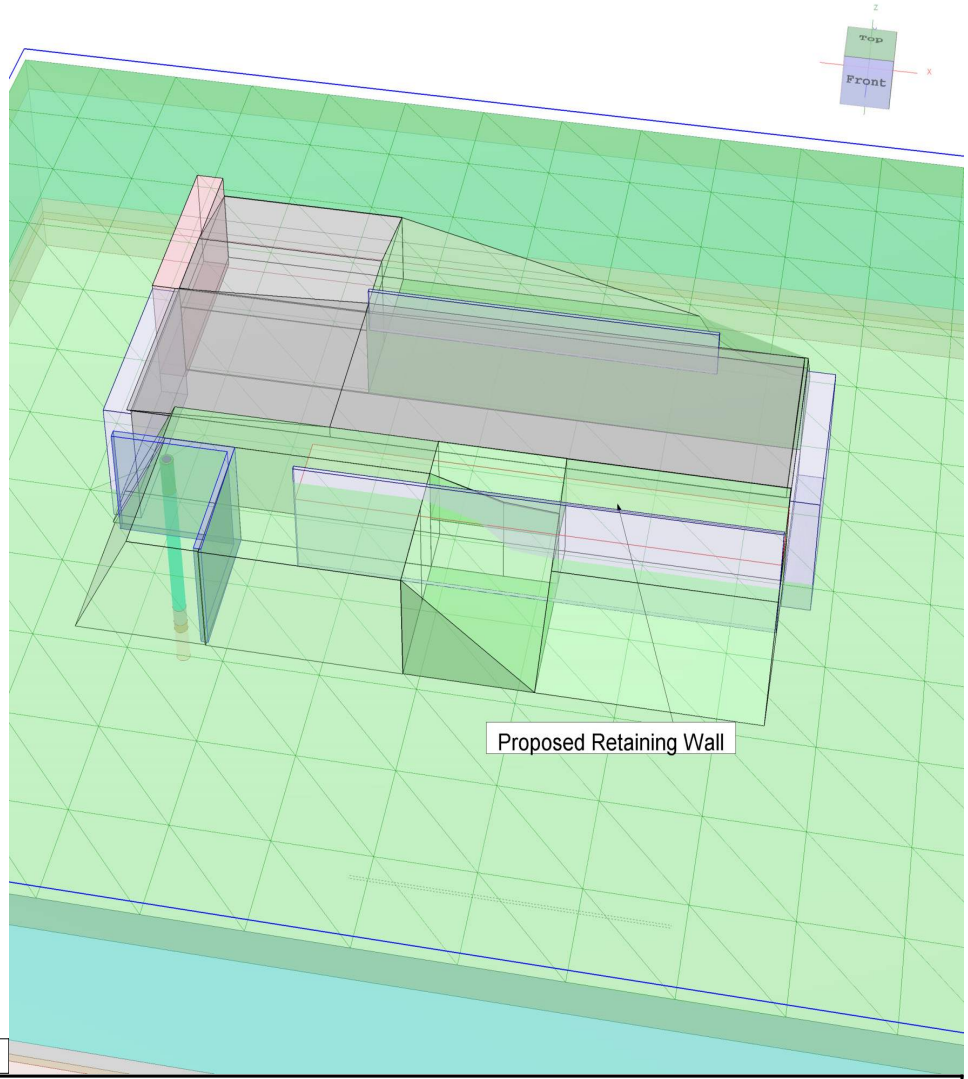
SETTLE3 5.022

Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Settlement Analysis - Armory Street Widening		
Drawn By	SAK Checked by: KJ	Company	Nobis Group
Date	11/10/2023	File Name	armory st widening - 026.s3z

Construction = 91 y

Material Name	Color	Unit Weight (kips/ft3)	Es (ksf)	Eur (ksf)	Cc/Cce	Cr/Cre	OCR	Cv (ft2/y)
Existing Fill		0.115	355.052	355.052	-	-	-	-
Varved Silt and Clay		0.12	-	-	0.1	0.025	4.5	173
Glacial Till		0.135	2819.53	2819.53	-	-	-	-
Weathered Bedrock		0.15	-	-	-	-	-	-
Bedrock		0.164	-	-	-	-	-	-





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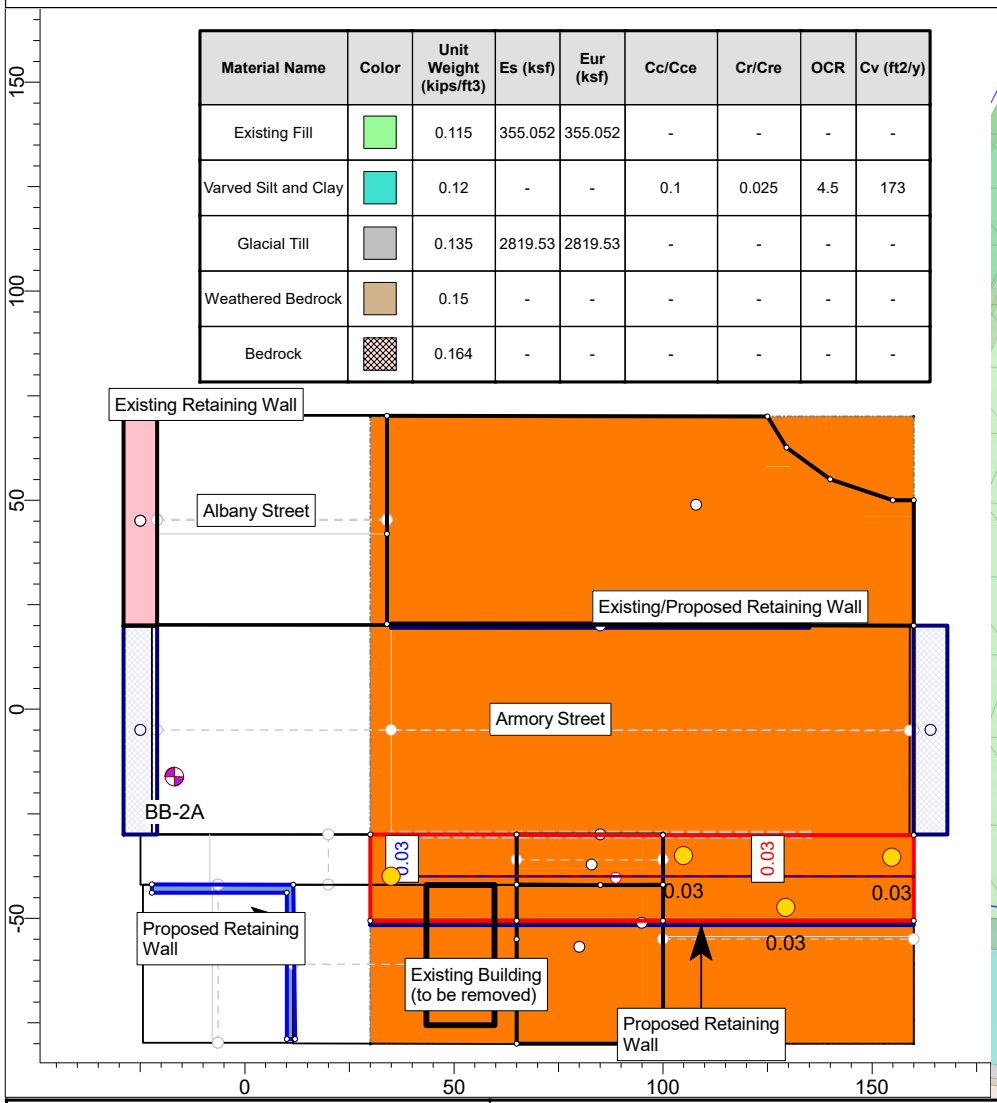
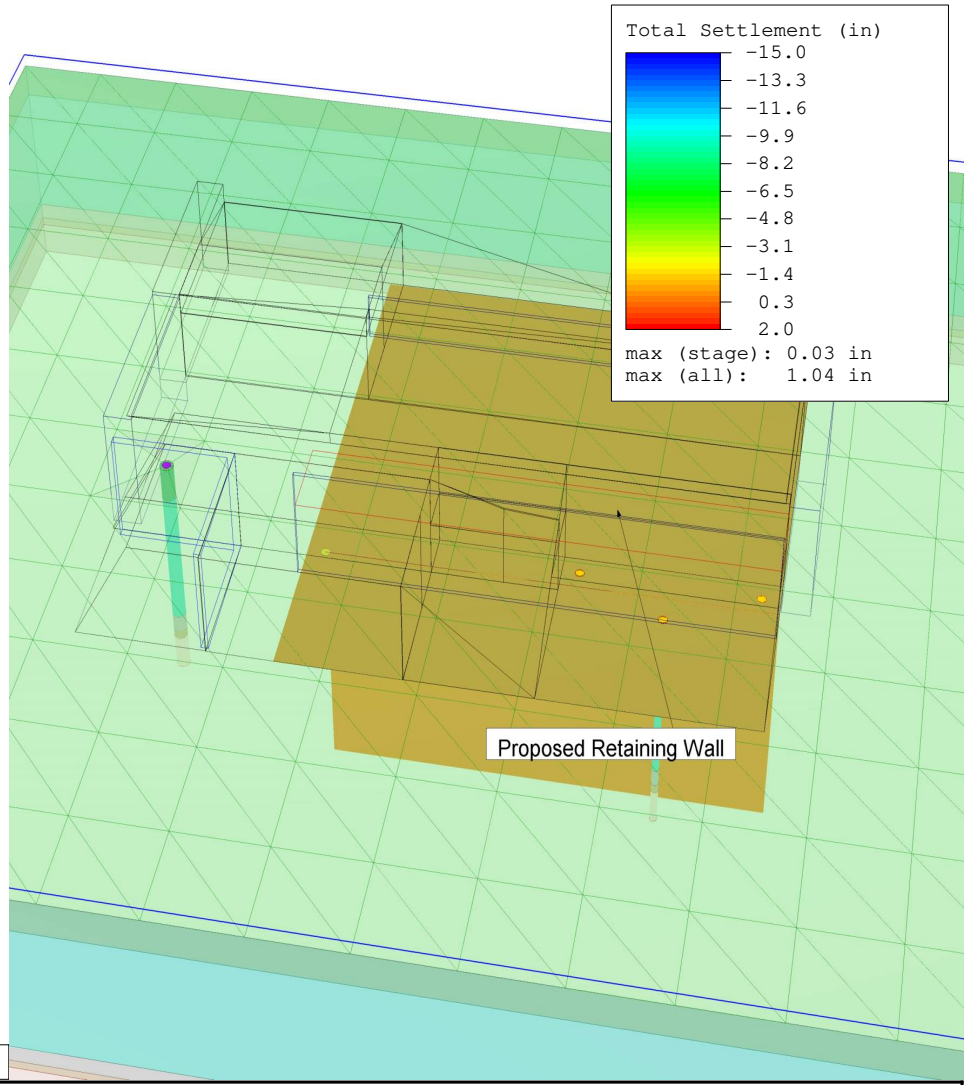
SETTLE3 5.022

Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Settlement Analysis - Armory Street Widening		
Drawn By	SAK Checked by: KJ	Company	Nobis Group
Date	11/10/2023	File Name	armory st widening - 026.s3z

Construction = 91 y

Material Name	Color	Unit Weight (kips/ft3)	Es (ksf)	Eur (ksf)	Cc/Cce	Cr/Cre	OCR	Cv (ft2/y)
Existing Fill		0.115	355.052	355.052	-	-	-	-
Varved Silt and Clay		0.12	-	-	0.1	0.025	4.5	173
Glacial Till		0.135	2819.53	2819.53	-	-	-	-
Weathered Bedrock		0.15	-	-	-	-	-	-
Bedrock		0.164	-	-	-	-	-	-





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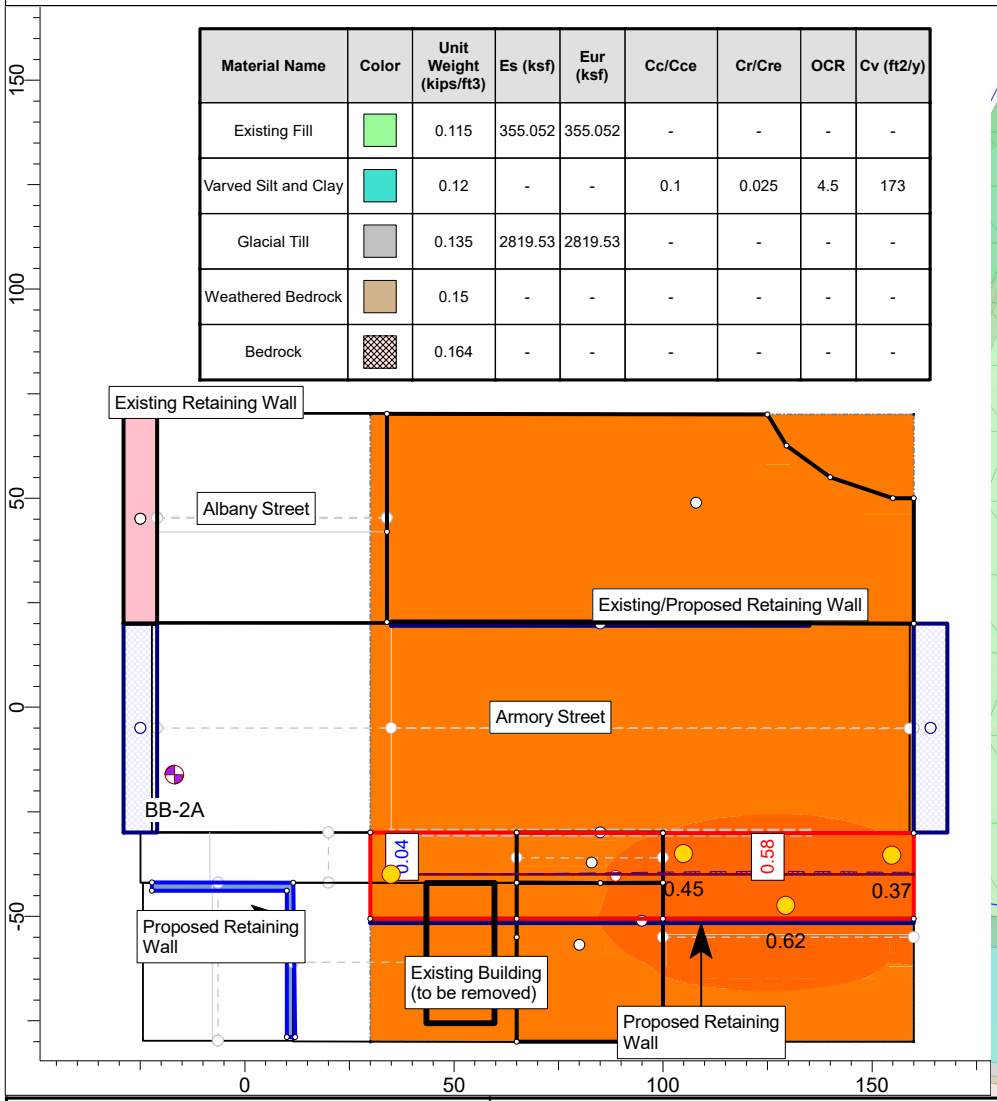
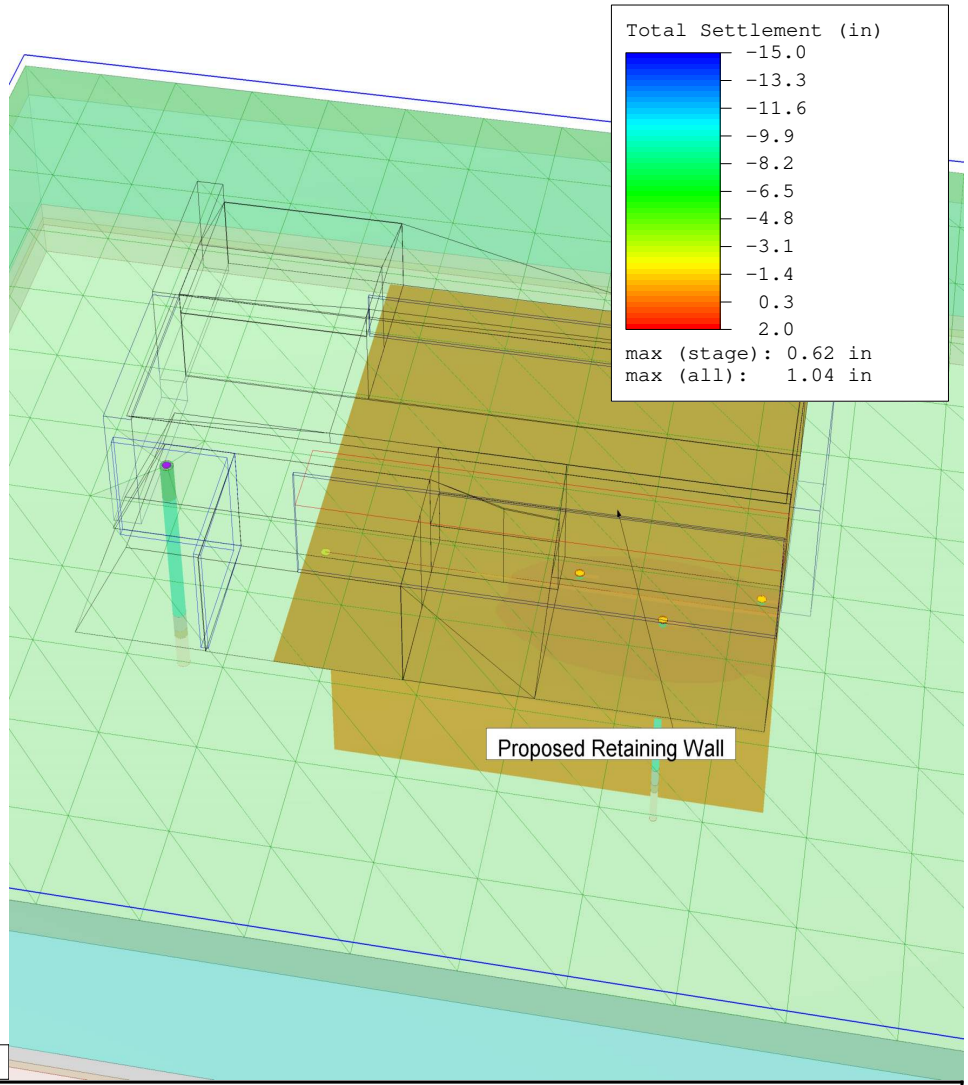
SETTLE3 5.022

Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Settlement Analysis - Armory Street Widening		
Drawn By	SAK Checked by: KJ	Company	Nobis Group
Date	11/10/2023	File Name	armory st widening - 026.s3z

3 Months Post Construction = 91.25 y

Material Name	Color	Unit Weight (kips/ft3)	Es (ksf)	Eur (ksf)	Cc/Cce	Cr/Cre	OCR	Cv (ft2/y)
Existing Fill		0.115	355.052	355.052	-	-	-	-
Varved Silt and Clay		0.12	-	-	0.1	0.025	4.5	173
Glacial Till		0.135	2819.53	2819.53	-	-	-	-
Weathered Bedrock		0.15	-	-	-	-	-	-
Bedrock		0.164	-	-	-	-	-	-





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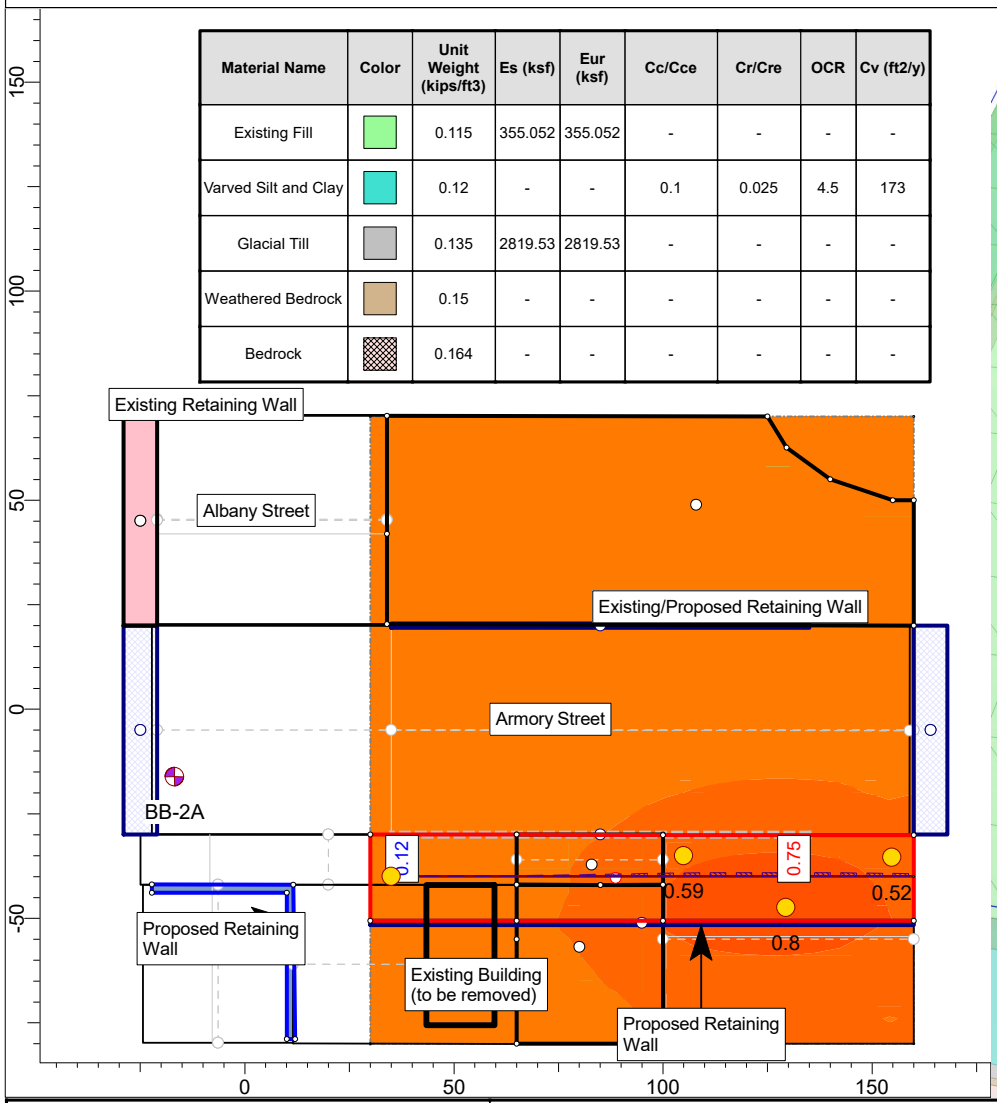
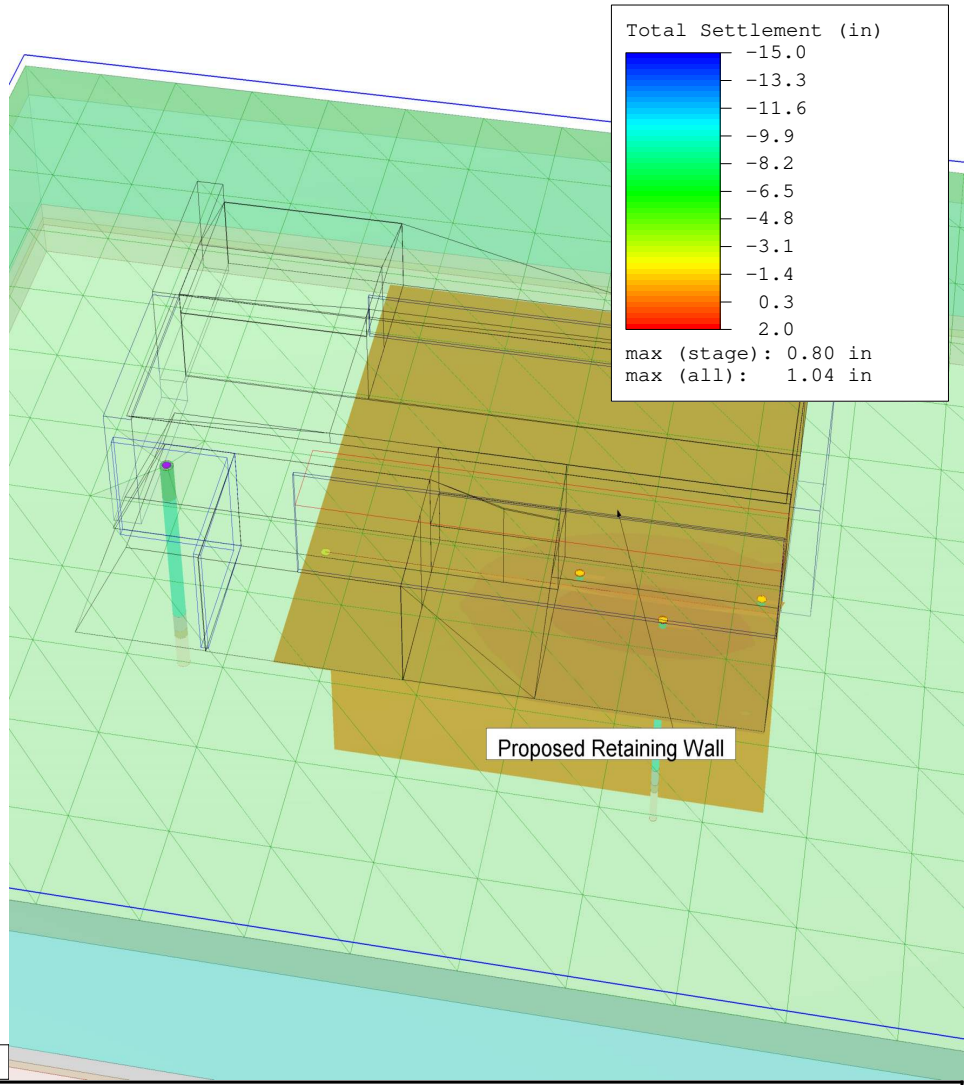
SETTLE3 5.022

Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Settlement Analysis - Armory Street Widening		
Drawn By	SAK Checked by: KJ	Company	Nobis Group
Date	11/10/2023	File Name	armory st widening - 026.s3z

9 Years Post Constructions = 100 y

Material Name	Color	Unit Weight (kips/ft3)	Es (ksf)	Eur (ksf)	Cc/Cce	Cr/Cre	OCR	Cv (ft2/y)
Existing Fill		0.115	355.052	355.052	-	-	-	-
Varved Silt and Clay		0.12	-	-	0.1	0.025	4.5	173
Glacial Till		0.135	2819.53	2819.53	-	-	-	-
Weathered Bedrock		0.15	-	-	-	-	-	-
Bedrock		0.164	-	-	-	-	-	-





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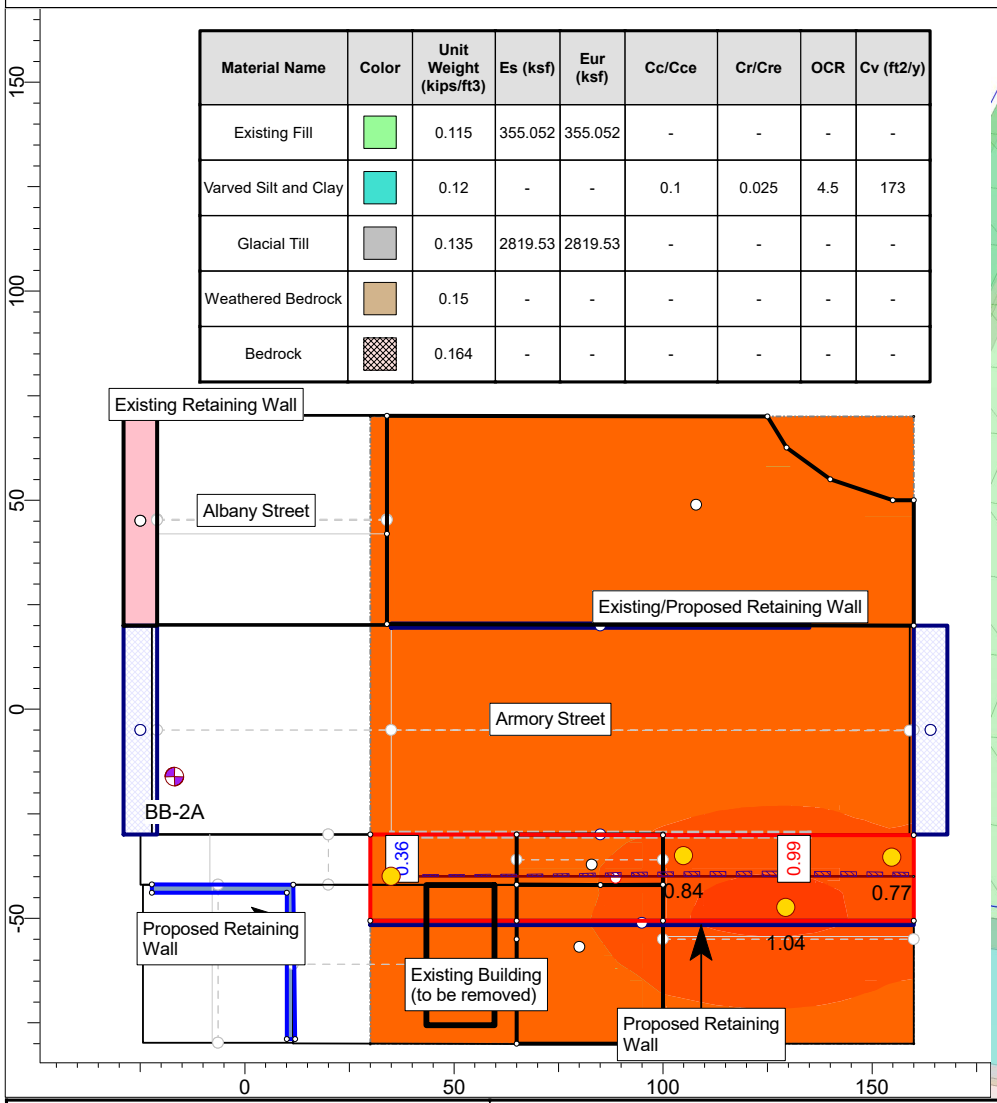
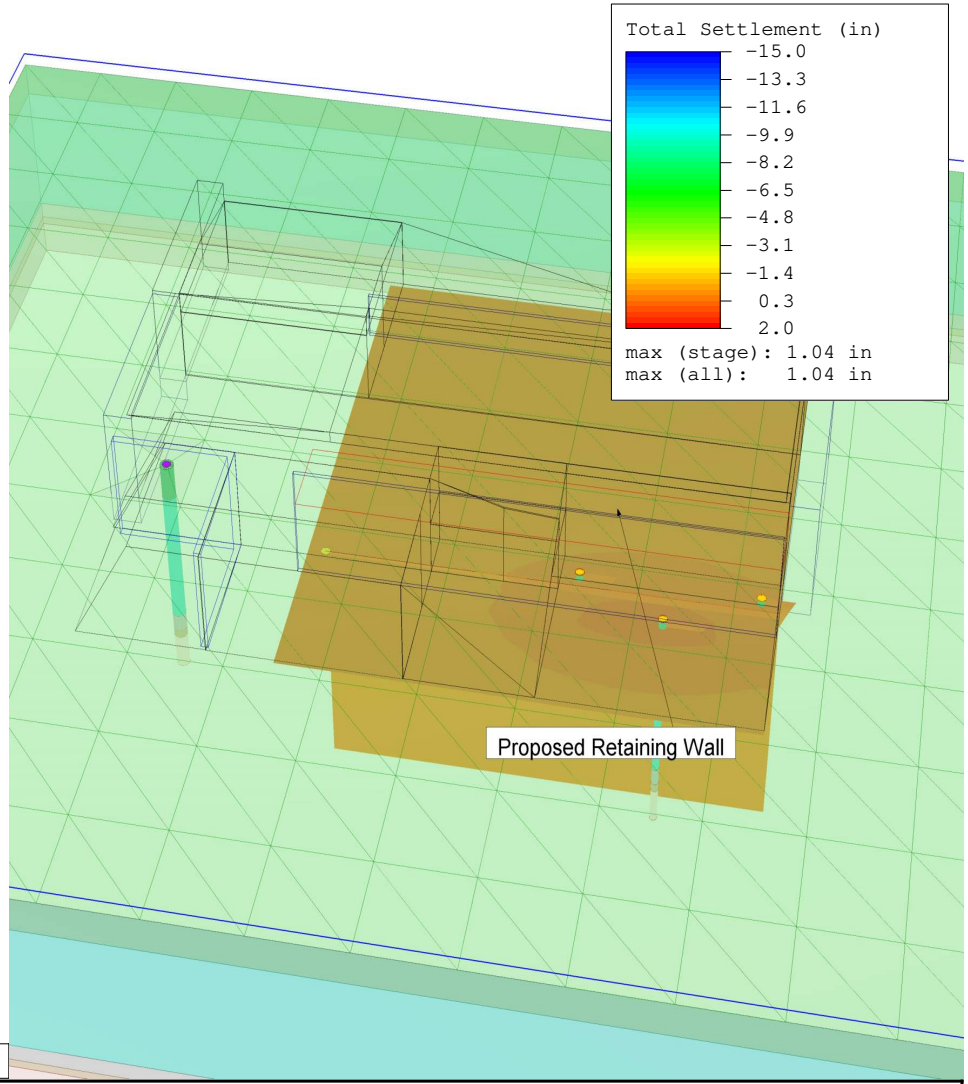
SETTLE3 5.022

Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Settlement Analysis - Armory Street Widening		
Drawn By	SAK Checked by: KJ	*Company*	Nobis Group
Date	11/10/2023	*File Name*	armory st widening - 026.s3z

50 Years Post Construction = 141 y

Material Name	Color	Unit Weight (kips/ft3)	Es (ksf)	Eur (ksf)	Cc/Cce	Cr/Cre	OCR	Cv (ft2/y)
Existing Fill		0.115	355.052	355.052	-	-	-	-
Varved Silt and Clay		0.12	-	-	0.1	0.025	4.5	173
Glacial Till		0.135	2819.53	2819.53	-	-	-	-
Weathered Bedrock		0.15	-	-	-	-	-	-
Bedrock		0.164	-	-	-	-	-	-





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SETTLE3 5.022

Project	Armory Street Over Abandoned CSX Spur - Springfield, MA		
Analysis Description	Settlement Analysis - Armory Street Widening		
Drawn By	SAK Checked by: KJ	Company	Nobis Group
Date	11/10/2023	File Name	armory st widening - 026.s3z

Settle3 Analysis Information

Armory Street Over Abandoned CSX Spur - Springfield, MA

Project Settings

Document Name	armory st widening - 026.s3z
Project Title	Armory Street Over Abandoned CSX Spur - Springfield, MA
Analysis	Settlement Analysis - Armory Street Widening
Author	SAK Checked by: KJ
Company	Nobis Group
Date Created	11/10/2023
Last saved with Settle3 version	5.009
Stress Computation Method	Boussinesq
Stress Units	Imperial, stress as ksf
Settlement Units	inches
Time-dependent Consolidation Analysis	
Time Units	years
Permeability Units	feet/year

Advanced Settings

Start of secondary consolidation (% of primary)	95
Min. stress for secondary consolidation (% of initial)	1
Reset time when load changes for secondary consolidation	No
Minimum settlement ratio for subgrade modulus	0.9
Use average poisson's ratio to calculate layered stresses	
Update Cv in each time step (improves consolidation accuracy)	
Ignore negative effective stresses in settlement calculations	
Add field points to load edges	

Soil Profile

Layer Option	Non-Horizontal Layers
Interpolation Method	TIN Triangulation
Use Non-Horizontal Ground Surface	Yes
Number of Surface Points	200
Vertical Axis	Elevation
Ground Elevation (ft)	127.2

Stage Settings

Stage #	Name	Time [years]
1	Stage 1	0
2	Present Day	85
3	Construction	91
4	2.5 weeks Post Construction	91.05
5	3 Months Post Construction	91.25
6	1 Year Post Construction	92
7	9 Years Post Constructions	100
8	50 Years Post Construction	141

Results (relative to Stage: Present Day = 85 y)

Time taken to compute: 15.9497 seconds

Stage: Stage 1 = 0 y

Data Type	Minimum	Maximum
Total Settlement [in]	-14.1189	0
Total Consolidation Settlement [in]	-14.1189	0
Virgin Consolidation Settlement [in]	-7.05103	0
Recompression Consolidation Settlement [in]	-7.17431	0
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	0
Loading Stress XX [ksf]	0	0
Loading Stress YY [ksf]	0	0
Effective Stress ZZ [ksf]	-3.56323	-0.00158356
Effective Stress XX [ksf]	-3.56323	-0.00158356
Effective Stress YY [ksf]	-3.56323	-0.00158356
Total Stress ZZ [ksf]	-0.263458	6.82121e-13
Total Stress XX [ksf]	-6.82121e-13	6.82121e-13
Total Stress YY [ksf]	-6.82121e-13	6.82121e-13
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	1373.06
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	-3.51937	0
Total Strain	-0.230185	0
Pore Water Pressure [ksf]	0.00158356	3.56323
Excess Pore Water Pressure [ksf]	0.00158356	3.56323
Degree of Consolidation [%]	-100	0
Pre-consolidation Stress [ksf]	-3.54012	0
Over-consolidation Ratio	-4.44089e-16	3.5
Void Ratio	0	0.483389
Permeability [ft/y]	-74.5294	0
Coefficient of Consolidation [ft^2/y]	0	0
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	-100	0
Undrained Shear Strength	-0.21782	0

Stage: Present Day = 85 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	0
Total Consolidation Settlement [in]	0	0
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	0
Loading Stress XX [ksf]	0	0
Loading Stress YY [ksf]	0	0
Effective Stress ZZ [ksf]	0	0
Effective Stress XX [ksf]	0	0
Effective Stress YY [ksf]	0	0
Total Stress ZZ [ksf]	0	0
Total Stress XX [ksf]	0	0
Total Stress YY [ksf]	0	0
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0	0
Pore Water Pressure [ksf]	0	0
Excess Pore Water Pressure [ksf]	0	0
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	0	0
Over-consolidation Ratio	0	0
Void Ratio	0	0
Permeability [ft/y]	0	0
Coefficient of Consolidation [ft^2/y]	0	0
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	0

Stage: Construction = 91 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.0335632
Total Consolidation Settlement [in]	-1.65975e-05	5.87939e-05
Virgin Consolidation Settlement [in]	0	6.47294e-05
Recompression Consolidation Settlement [in]	-1.65975e-05	1.90812e-05
Immediate Settlement [in]	0	0.00127584
Secondary Settlement [in]	0	0.0322724
Loading Stress ZZ [ksf]	-0.00295041	0.291513
Loading Stress XX [ksf]	-0.355064	0.671596
Loading Stress YY [ksf]	-0.793728	0.862986
Effective Stress ZZ [ksf]	-0.00450514	0.00460168
Effective Stress XX [ksf]	-0.355064	0.671596
Effective Stress YY [ksf]	-0.793728	0.862986
Total Stress ZZ [ksf]	-0.00295041	0.291513
Total Stress XX [ksf]	-0.302548	0.93577
Total Stress YY [ksf]	-0.708432	1.13239
Modulus of Subgrade Reaction (Total) [ksf/ft]	-0.773284	0.369201
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	-79.6647	415.112
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	-0.00257738	0.371672
Total Strain	0	8.18171e-05
Pore Water Pressure [ksf]	-0.003643	0.291513
Excess Pore Water Pressure [ksf]	-0.003643	0.291513
Degree of Consolidation [%]	-16.6554	0
Pre-consolidation Stress [ksf]	0	0.00191676
Over-consolidation Ratio	-0.000769663	0.000603349
Void Ratio	-0.00015578	0
Permeability [ft/y]	0	0
Coefficient of Consolidation [ft^2/y]	0	0
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	-33.8373	3.62299e-07
Undrained Shear Strength	-5.11585e-05	0.000152226

Stage: 2.5 weeks Post Construction = 91.05 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.470473
Total Consolidation Settlement [in]	-0.00155895	0.436856
Virgin Consolidation Settlement [in]	0	0.404756
Recompression Consolidation Settlement [in]	-0.00155895	0.127017
Immediate Settlement [in]	0	0.00127584
Secondary Settlement [in]	0	0.0326668
Loading Stress ZZ [ksf]	-0.00295041	0.291513
Loading Stress XX [ksf]	-0.355064	0.671596
Loading Stress YY [ksf]	-0.793728	0.862986
Effective Stress ZZ [ksf]	-0.0251683	0.291513
Effective Stress XX [ksf]	-0.344857	0.93577
Effective Stress YY [ksf]	-0.780848	1.13239
Total Stress ZZ [ksf]	-0.00295041	0.291513
Total Stress XX [ksf]	-0.302548	0.93577
Total Stress YY [ksf]	-0.708432	1.13239
Modulus of Subgrade Reaction (Total) [ksf/ft]	-0.773284	0.354186
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	-79.6647	415.112
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	-0.77843	0.356463
Total Strain	0	0.0237913
Pore Water Pressure [ksf]	-0.00219021	0.132432
Excess Pore Water Pressure [ksf]	-0.00219021	0.132432
Degree of Consolidation [%]	-8.62883	0
Pre-consolidation Stress [ksf]	0	0.2893
Over-consolidation Ratio	-0.648913	0.00368218
Void Ratio	-0.0499617	0
Permeability [ft/y]	0	1.35809
Coefficient of Consolidation [ft^2/y]	0	0
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	-9.58467	3.68713e-07
Undrained Shear Strength	-3.34571e-05	0.215499

Stage: 3 Months Post Construction = 91.25 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.62057
Total Consolidation Settlement [in]	-0.00379055	0.586375
Virgin Consolidation Settlement [in]	0	0.518223
Recompression Consolidation Settlement [in]	-0.00379055	0.170184
Immediate Settlement [in]	0	0.00127584
Secondary Settlement [in]	0	0.034242
Loading Stress ZZ [ksf]	-0.00295041	0.291513
Loading Stress XX [ksf]	-0.355064	0.671596
Loading Stress YY [ksf]	-0.793728	0.862986
Effective Stress ZZ [ksf]	-0.0341095	0.291513
Effective Stress XX [ksf]	-0.34862	0.93577
Effective Stress YY [ksf]	-0.771805	1.13239
Total Stress ZZ [ksf]	-0.00295041	0.291513
Total Stress XX [ksf]	-0.302548	0.93577
Total Stress YY [ksf]	-0.708432	1.13239
Modulus of Subgrade Reaction (Total) [ksf/ft]	-0.773284	0.386897
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	-79.6647	415.112
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	-0.77843	0.389639
Total Strain	0	0.0237969
Pore Water Pressure [ksf]	-0.00225785	0.10182
Excess Pore Water Pressure [ksf]	-0.00225785	0.10182
Degree of Consolidation [%]	-7.50889	0
Pre-consolidation Stress [ksf]	0	0.289419
Over-consolidation Ratio	-0.6542	0.00993787
Void Ratio	-0.0499734	0
Permeability [ft/y]	0	1.35809
Coefficient of Consolidation [ft^2/y]	0	0
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	-7.91415	3.68713e-07
Undrained Shear Strength	-3.34009e-05	0.21565

Stage: 1 Year Post Construction = 92 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.668284
Total Consolidation Settlement [in]	-0.00226291	0.630704
Virgin Consolidation Settlement [in]	0	0.519536
Recompression Consolidation Settlement [in]	-0.00226291	0.19831
Immediate Settlement [in]	0	0.00127584
Secondary Settlement [in]	0	0.0401188
Loading Stress ZZ [ksf]	-0.00295041	0.291513
Loading Stress XX [ksf]	-0.355064	0.671596
Loading Stress YY [ksf]	-0.793728	0.862986
Effective Stress ZZ [ksf]	-0.0369797	0.291513
Effective Stress XX [ksf]	-0.346043	0.93577
Effective Stress YY [ksf]	-0.76853	1.13239
Total Stress ZZ [ksf]	-0.00295041	0.291513
Total Stress XX [ksf]	-0.302548	0.93577
Total Stress YY [ksf]	-0.708432	1.13239
Modulus of Subgrade Reaction (Total) [ksf/ft]	-0.773284	0.385112
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	-79.6647	415.112
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	-0.77843	0.388058
Total Strain	0	0.0238069
Pore Water Pressure [ksf]	-0.00228865	0.0806348
Excess Pore Water Pressure [ksf]	-0.00228865	0.0806348
Degree of Consolidation [%]	-5.7926	0
Pre-consolidation Stress [ksf]	0	0.28942
Over-consolidation Ratio	-0.654258	0.0124121
Void Ratio	-0.0499944	0
Permeability [ft/y]	0	1.35809
Coefficient of Consolidation [ft^2/y]	0	0
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	-5.10345	3.55046e-06
Undrained Shear Strength	-3.33833e-05	0.215678

Stage: 9 Years Post Constructions = 100 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.795642
Total Consolidation Settlement [in]	0	0.698523
Virgin Consolidation Settlement [in]	0	0.519543
Recompression Consolidation Settlement [in]	0	0.242346
Immediate Settlement [in]	0	0.00127584
Secondary Settlement [in]	0	0.0999818
Loading Stress ZZ [ksf]	-0.00295041	0.291513
Loading Stress XX [ksf]	-0.355064	0.671596
Loading Stress YY [ksf]	-0.793728	0.862986
Effective Stress ZZ [ksf]	-0.00295041	0.291513
Effective Stress XX [ksf]	-0.303527	0.93577
Effective Stress YY [ksf]	-0.709389	1.13239
Total Stress ZZ [ksf]	-0.00295041	0.291513
Total Stress XX [ksf]	-0.302548	0.93577
Total Stress YY [ksf]	-0.708432	1.13239
Modulus of Subgrade Reaction (Total) [ksf/ft]	-0.773284	2.74846
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	-79.6647	415.112
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	-0.77843	0.385677
Total Strain	0	0.0239083
Pore Water Pressure [ksf]	-0.00230082	0.0022529
Excess Pore Water Pressure [ksf]	-0.00230082	0.0022529
Degree of Consolidation [%]	-0.150091	9.77696e-05
Pre-consolidation Stress [ksf]	0	0.28942
Over-consolidation Ratio	-0.654258	0.0013718
Void Ratio	-0.0502073	0
Permeability [ft/y]	0	1.35809
Coefficient of Consolidation [ft^2/y]	0	0
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	-0.124074	3.5508e-06
Undrained Shear Strength	-3.33633e-05	0.215688

Stage: 50 Years Post Construction = 141 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	1.04393
Total Consolidation Settlement [in]	0	0.700194
Virgin Consolidation Settlement [in]	0	0.519543
Recompression Consolidation Settlement [in]	0	0.243427
Immediate Settlement [in]	0	0.00127584
Secondary Settlement [in]	0	0.346659
Loading Stress ZZ [ksf]	-0.00295041	0.291513
Loading Stress XX [ksf]	-0.355064	0.671596
Loading Stress YY [ksf]	-0.793728	0.862986
Effective Stress ZZ [ksf]	-0.00295041	0.291513
Effective Stress XX [ksf]	-0.302548	0.93577
Effective Stress YY [ksf]	-0.708432	1.13239
Total Stress ZZ [ksf]	-0.00295041	0.291513
Total Stress XX [ksf]	-0.302548	0.93577
Total Stress YY [ksf]	-0.708432	1.13239
Modulus of Subgrade Reaction (Total) [ksf/ft]	-0.773284	3.18058
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	-79.6647	415.112
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	-0.77843	0.385619
Total Strain	0	0.0243261
Pore Water Pressure [ksf]	-0.00230101	0.00225273
Excess Pore Water Pressure [ksf]	-0.00230101	0.00225273
Degree of Consolidation [%]	-6.82719e-07	0.000582706
Pre-consolidation Stress [ksf]	0	0.28942
Over-consolidation Ratio	-0.654258	0.0013718
Void Ratio	-0.0510847	0
Permeability [ft/y]	0	1.35809
Coefficient of Consolidation [ft^2/y]	0	0
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	-0.000158387	0.000351958
Undrained Shear Strength	-3.33628e-05	0.215688

Loads

1. Rectangular Load: "Abutment"

Length	8 ft
Width	50 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	400 ft2
Load	3.5 ksf
Elevation	119 ft
Installation Stage	Stage 1 = 0 y

Coordinates

X [ft]	Y [ft]
-29	-30
-21	-30
-21	20
-29	20

2. Rectangular Load: " "

Length	8 ft
Width	50 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	400 ft2
Load	0.0001 ksf
Elevation	125 ft
Installation Stage	Stage 1 = 0 y

Coordinates

X [ft]	Y [ft]
-29	20
-21	20
-21	70
-29	70

3. Rectangular Load: "Abutment"

Length	8 ft
Width	50 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	400 ft2
Load	3.5 ksf
Elevation	119 ft
Installation Stage	Stage 1 = 0 y

Coordinates

X [ft]	Y [ft]
160	-29.9824
168	-29.9824
168	20.0176
160	20.0176

4. Rectangular Load: " "

Length	100 ft
Width	1 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	100 ft2
Load	0.2 ksf
Elevation	148 ft
Installation Stage	Stage 1 = 0 y

Coordinates

X [ft]	Y [ft]
35	19.5
135	19.5
135	20.5
35	20.5

5. Rectangular Load: " "

Length	100 ft
Width	1 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	100 ft2
Load	0.2 ksf

Advanced Staging

Stage	Load Factor	Bottom Elevation [ft]
Stage 1 = 0 y	1	145
Present Day = 85 y	1	145
Construction = 91 y	0	0
2.5 weeks Post Construction = 91.05 y	0	0
3 Months Post Construction = 91.25 y	0	0
1 Year Post Construction = 92 y	0	0
9 Years Post Constructions = 100 y	0	0
50 Years Post Construction = 141 y	0	0

Coordinates

X [ft]	Y [ft]
35	-30.5
135	-30.5
135	-29.5
35	-29.5

6. Polygonal Load: " "

Label	
Load Type	Flexible
Area of Load	421.65 ft2
Elevation	142 ft
Installation Stage	Stage 1 = 0 y

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
65	-30	1.61
65	-42	1.61
85	-42.066	0.96
100	-42.066	0.822
100	-30	1.61

7. Polygonal Load: " "

Label	
Load Type	Flexible
Area of Load	1328.84 ft2
Elevation	127.2 ft
Installation Stage	Stage 1 = 0 y

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
85	-42.066	2.622
65	-42	3.312
65	-55	3.312
65	-80	3.312
100	-80	0
100	-42	2.484

8. Polygonal Load: " "

Label	
Load Type	Flexible
Area of Load	130.606 ft2
Load	0.001 ksf
Elevation	127.2 ft
Installation Stage	Construction = 91 y

Coordinates

X [ft]	Y [ft]
-22.2706	-41.9377
-22.2706	-43.9377
10	-43.9377
10	-78.9377
12.014	-78.9377
11.5912	-41.9746

9. Fill Load: " "

Label	
Load Type	Flexible
Area of Load	5788.15 ft2
Elevation	127.2 ft
Installation Stage	Stage 1 = 0 y

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
160	20	3.312
160	50	0
155	50	0
140	55	0
129.571	62.544	0
125	70	0
34	70.1878	2.3
34	41.96	2.99
34	20.3771	2.99

10. Rectangular Load: " (Copy)"

Length	130 ft
Width	1 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	130 ft2
Load	0.2 ksf

Advanced Staging

Stage	Load Factor	Bottom Elevation [ft]
Stage 1 = 0 y	0	0
Present Day = 85 y	0	0
Construction = 91 y	1	130
2.5 weeks Post Construction = 91.05 y	1	130
3 Months Post Construction = 91.25 y	1	130
1 Year Post Construction = 92 y	1	130
9 Years Post Constructions = 100 y	1	130
50 Years Post Construction = 141 y	1	130

Coordinates

X [ft]	Y [ft]
30	-51.607
160	-51.607
160	-50.607
30	-50.607

11. Polygonal Load: "Polygonal Load 9"

Label	Polygonal Load 9
Load Type	Flexible
Area of Load	2669.62 ft2
Elevation	150 ft
Installation Stage	Construction = 91 y

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
160	-50.607	1.125
160	-30.1169	0
100	-30.1169	0
65	-30	0
30	-30.0129	0
30	-50.607	0
65	-50.607	0
100	-50.607	1.125

Embankments

1. Embankment: "Embankment Fill"

Label	Embankment Fill
Center Line	(-21, -5) to (160, -5)
Near End Angle	90 degrees
Far End Angle	90 degrees
Number of Layers	1
Base Width	50

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft3)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 1 = 0 y	0	90	25.8	0.115	90	0

2. Embankment: "Embankment Load 2"

Label	Embankment Load 2
Center Line	(35, -5) to (159, -5.13487)
Near End Angle	3 degrees
Far End Angle	90 degrees
Number of Layers	1
Base Width	50

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft3)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 1 = 0 y	0	90	3	0.115	90	0

3. Embankment: "Embankment Load 3"

Label	Embankment Load 3
Center Line	(-6.40881, -79.8121) to (-6.40881, -41.9746)
Near End Angle	90 degrees
Far End Angle	90 degrees
Number of Layers	1
Base Width	36

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft3)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 1 = 0 y	0	60	28.8	0.115	90	0

4. Embankment: "Embankment Load 5"

Label	Embankment Load 5
Center Line	(-21, 45.3771) to (34, 45.3771)
Near End Angle	90 degrees
Far End Angle	90 degrees
Number of Layers	1
Base Width	50

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft3)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 1 = 0 y	0	90	20	0.115	90	0

5. Embankment: "Embankment Load 6"

Label	Embankment Load 6
Center Line	(-21, 45.1878) to (34, 45.1878)
Near End Angle	90 degrees
Far End Angle	90 degrees
Number of Layers	1
Base Width	50

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft3)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 1 = 0 y	0	12	6	0.115	90	0

6. Embankment: "Embankment Load 7"

Label	Embankment Load 7
Center Line	(100, -55) to (160, -55)
Near End Angle	90 degrees
Far End Angle	90 degrees
Number of Layers	2
Base Width	50

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft3)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 1 = 0 y	0	90	14.8	0.115	30	0
2	Stage 1 = 0 y	0	90	14	0.115	30	0

7. Embankment: "Embankment Load 8"

Label	Embankment Load 8
Center Line	(65, -36) to (100, -36)
Near End Angle	90 degrees
Far End Angle	90 degrees
Number of Layers	1
Base Width	12

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft3)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 1 = 0 y	0	90	14.8	0.115	90	0

8. Embankment: "Embankment Load 4"

Label	Embankment Load 4
Center Line	(20, -30.0129) to (20, -42)
Near End Angle	90 degrees
Far End Angle	90 degrees
Number of Layers	1
Base Width	90

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft3)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 1 = 0 y	0	90	28.8	0.115	60	0

9. Embankment: "Embankment Load 12"

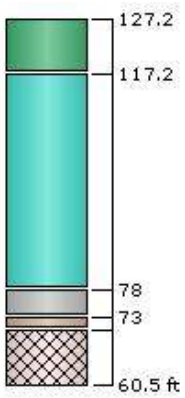
Label	Embankment Load 12
Center Line	(11.5205, -60.9745) to (64.9663, -61.0659)
Near End Angle	90 degrees
Far End Angle	90 degrees
Number of Layers	1
Base Width	38

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft3)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 1 = 0 y	0	90	28.8	0.115	90	0

Soil Layers

Ground Surface Drained: Yes

Layer #	Type	Thickness [ft]	Elevation [ft]	Drained at Bottom
1	Existing Fill	0	127.2	No
2	Reworked Silt and Clay	10	127.2	Yes
3	Varved Silt and Clay	39.2	117.2	No
4	Glacial Till	5	78	No
5	Weathered Bedrock	2.5	73	No
6	Bedrock	10	70.5	No



Soil Properties

Property	Existing Fill	Varved Silt and Clay	Glacial Till	Weathered Bedrock
Color				
Unit Weight [kips/ft3]	0.115	0.12	0.135	0.15
Saturated Unit Weight [kips/ft3]	0.115	0.12	135	0.15
K0	1	1	1	1
Immediate Settlement	Enabled	Disabled	Enabled	Disabled
Es [ksf]	355.052	-	2819.53	-
Esur [ksf]	355.052	-	2819.53	-
Primary Consolidation	Disabled	Enabled	Disabled	Disabled
Material Type		Non-Linear		
Cce	-	0.1	-	-
Cre	-	0.025	-	-
e0	-	0.904	-	-
OCR	-	4.5	-	-
Cv [ft2/y]	-	173	-	-
Cvr [ft2/y]	-	173	-	-
B-bar	-	1	-	-
Secondary Consolidation	Disabled	Standard	Disabled	Disabled
Cae	-	0.0028	-	-
Care	-	0.0028	-	-
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8
Piezo Line ID	1	1	1	1

Property	Bedrock	Reworked Silt and Clay
Color		
Unit Weight [kips/ft3]	0.164	0.12
Saturated Unit Weight [kips/ft3]	0.164	0.12
K0	1	1
Primary Consolidation	Disabled	Enabled
Material Type		Non-Linear
Cce	-	0.1
Cre	-	0.025
e0	-	1.1
OCR	-	4.5
Cv [ft2/y]	-	173
Cvr [ft2/y]	-	173
B-bar	-	1
Secondary Consolidation	Disabled	Standard

Cae	-	0.0028
Care	-	0.0028
Undrained Su A [kips/ft2]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8
Piezo Line ID	1	1

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft3

Piezometric Line Entities

ID	Elevation (ft)
1	131 ft

Query

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Query Point 1	154.735, -35.4031	Auto: 51
2	Query Point 2	104.928, -35.062	Auto: 51
4	Query Point 4	129.413, -47.4785	Auto: 51

Query Lines

Line #	Query Line Name	Start Location	End Location	Horizontal Divisions	Vertical Divisions
1	Query Line 1	35, -40	160, -40	20	Auto: 51

Field Point Grid

Number of points	833
Expansion Factor	1

Grid Coordinates

X [ft]	Y [ft]
251.919	154.297
251.919	-163.985
-112.919	-163.985
-112.919	154.297

⑤ Addendum No. 5, April 1, 2026

Project # 609409	Contract # 133236			
Location : SPRINGFIELD				
Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
120.1	1,300	UNCLASSIFIED EXCAVATION AT _____ PER CUBIC YARD		
127.	120	CONCRETE EXCAVATION AT _____ PER CUBIC YARD		
127.1	500	REINFORCED CONCRETE EXCAVATION AT _____ PER CUBIC YARD		
⑤ 140.	2,881	BRIDGE EXCAVATION AT _____ PER CUBIC YARD		
141.1	50	TEST PIT FOR EXPLORATION AT _____ PER CUBIC YARD		
142.	178	CLASS B TRENCH EXCAVATION AT _____ PER CUBIC YARD		
144.	306	CLASS B ROCK EXCAVATION AT _____ PER CUBIC YARD		
146.	3	DRAINAGE STRUCTURE REMOVED AT _____ EACH		
149.2	1	PUBLIC OUTREACH AT _____ LUMP SUM		

⑤ Addendum No. 5, April 1, 2026

Project # 609409	Contract # 133236			
Location : SPRINGFIELD				
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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
201.	4	CATCH BASIN AT _____ EACH		
202.	5	MANHOLE AT _____ EACH		
210.1	2	SANITARY SEWER MANHOLE MUNICIPAL STANDARD AT _____ EACH		
210.11	1	SANITARY SEWER MANHOLE MUNICIPAL STANDARD - DOGHOUSE AT _____ EACH		
212.	1	TEMPORARY SANITARY SEWER BYPASS AT _____ LUMP SUM		
⑤ 213.	1	FLOW BYPASS FOR SEWER PIPE AT _____ LUMP SUM		
220.	20	DRAINAGE STRUCTURE ADJUSTED AT _____ EACH		
220.7	8	SANITARY STRUCTURE ADJUSTED AT _____ EACH		
220.9	1	SANITARY STRUCTURE ABANDONED AT _____ EACH		

Addendum No. 5, April 1, 2026

Project # 609409	Contract # 133236			
Location : SPRINGFIELD				
Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
221.	4	FRAME AND COVER AT _____ EACH		
222.1	3	FRAME AND GRATE - MASSDOT CASCADE TYPE AT _____ EACH		
223.2	3	FRAME AND GRATE (OR COVER) REMOVED AND DISCARDED AT _____ EACH		
227.3	10	REMOVAL OF DRAINAGE STRUCTURE SEDIMENT AT _____ PER CUBIC YARD		
227.31	300	REMOVAL OF DRAINAGE PIPE SEDIMENT AT _____ PER FOOT		
241.12	200	12 INCH REINFORCED CONCRETE PIPE AT _____ PER FOOT		
250.15	50	15 INCH POLYVINYLCHLORIDE SANITARY SEWER PIPE AT _____ PER FOOT		
258.	10	STONE FOR PIPE ENDS AT _____ PER SQUARE YARD		
302.122	440	12 INCH DUCTILE IRON WATER PIPE CLASS 56 AT _____ PER FOOT		

Addendum No. 5, April 1, 2026
④ Addendum No. 4, March 26, 2026

Project # 609409 **Contract # 133236**

Location : SPRINGFIELD

Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX

ITEM #	QUANTITY	ITEM WITH UNIT BID PRICE WRITTEN IN WORDS	UNIT PRICE	AMOUNT
303.06	30	6 INCH DUCTILE IRON WATER PIPE (MECHANICAL JOINT) AT _____ PER FOOT		
303.08	160	8 INCH DUCTILE IRON WATER PIPE (MECHANICAL JOINT) AT _____ PER FOOT		
303.12	320	12 INCH DUCTILE IRON WATER PIPE (MECHANICAL JOINT) AT _____ PER FOOT		
④ 309.	4,500	DUCTILE IRON FITTINGS FOR WATER PIPE AT _____ PER POUND		
325.18	410	18 INCH STEEL PIPE CASING FOR WATER PIPE AT _____ PER FOOT		
347.2	40	2 INCH COPPER TUBING TYPE K AT _____ PER FOOT		
348.1	40	1 INCH COPPER PIPE TYPE L AT _____ PER FOOT		
348.2	40	2 INCH COPPER PIPE TYPE L AT _____ PER FOOT		
350.06	1	6 INCH GATE AND GATE BOX AT _____ EACH		

Addendum No. 5, April 1, 2026
④ Addendum No. 4, March 26, 2026

Project # 609409	Contract # 133236			
Location : SPRINGFIELD				
Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
350.08	3	8 INCH GATE AND GATE BOX AT _____ EACH		
350.12	3	12 INCH GATE AND GATE BOX AT _____ EACH		
357.12	1	12 INCH GATE BOX AT _____ EACH		
358.	22	GATE BOX ADJUSTED AT _____ EACH		
363.1	2	1 INCH CORPORATION COCK AT _____ EACH		
363.2	5	2 INCH CORPORATION COCK AT _____ EACH		
④ 371.06	2	6 INCH COUPLING AT _____ EACH		
④ 371.08	2	8 INCH COUPLING AT _____ EACH		
④ 371.12	4	12 INCH COUPLING AT _____ EACH		

Addendum No. 5, April 1, 2026
④ Addendum No. 4, March 26, 2026

Project # 609409	Contract # 133236			
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Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
373.12	320	12 INCH WATER PIPE INSULATION AT _____ PER FOOT		
373.18	440	18 INCH WATER PIPE INSULATION AT _____ PER FOOT		
④ 377.12	2	12 INCH WATER MAIN EXPANSION JOINT AT _____ EACH		
379.2	2	2 INCH AIR RELEASE VALVE ASSEMBLY AT _____ EACH		
381.01	1	SERVICE BOX (MUNICIPAL STANDARD) AT _____ EACH		
381.3	3	SERVICE BOX ADJUSTED AT _____ EACH		
384.	1	CURB STOP AT _____ EACH		
402.	200	DENSE GRADED CRUSHED STONE FOR SUB-BASE AT _____ PER CUBIC YARD		
415.2	1,700	PAVEMENT FINE MILLING AT _____ PER SQUARE YARD		

Addendum No. 5, April 1, 2026
Addendum No. 4, March 26, 2026

Project # 609409	Contract # 133236			
Location : SPRINGFIELD				
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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
431.	60	HIGH EARLY STRENGTH CEMENT CONCRETE BASE COURSE AT _____ PER SQUARE YARD		
443.	11	WATER FOR ROADWAY DUST CONTROL AT _____ PER 1000 GALLONS		
450.231	280	SUPERPAVE SURFACE COURSE - 12.5 POLYMER (SSC - 12.5 - P) AT _____ PER TON		
450.311	190	SUPERPAVE INTERMEDIATE COURSE - 12.5 POLYMER (SIC -12.5 - P) AT _____ PER TON		
450.42	370	SUPERPAVE BASE COURSE - 37.5 (SBC - 37.5) AT _____ PER TON		
450.611	80	SUPERPAVE BRIDGE SURFACE COURSE - 12.5 POLYMER (SSC-B - 12.5 - P) AT _____ PER TON		
450.711	106	SUPERPAVE BRIDGE PROTECTIVE COURSE - 12.5POLYMER (SPC-B - 12.5 - P) AT _____ PER TON		
451.	80	HMA FOR PATCHING AT _____ PER TON		
452.	590	ASPHALT EMULSION FOR TACK COAT AT _____ PER GALLON		

Addendum No. 5, April 1, 2026
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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
453.	1,720	HMA JOINT ADHESIVE AT _____ PER FOOT		
458.7	2,223	LIGHTWEIGHT AGGREGATE AT _____ PER CUBIC YARD		
472.	60	TEMPORARY ASPHALT PATCHING AT _____ PER TON		
482.5	150	SAWCUTTING ASPHALT PAVEMENT FOR BOX WIDENING AT _____ PER FOOT		
506.1	110	GRANITE CURB TYPE VB - CURVED AT _____ PER FOOT		
509.	90	GRANITE TRANSITION CURB FOR PEDESTRIAN CURB RAMPS - STRAIGHT AT _____ PER FOOT		
509.1	30	GRANITE TRANSITION CURB FOR PEDESTRIAN CURB RAMPS - CURVED AT _____ PER FOOT		
580.	190	CURB REMOVED AND RESET AT _____ PER FOOT		
582.	4	CURB CORNER REMOVED AND RESET AT _____ EACH		

Addendum No. 5, April 1, 2026
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Project # 609409	Contract # 133236			
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Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
590.	325	CURB REMOVED AND STACKED AT _____ PER FOOT		
594.	364	CURB REMOVED AND DISCARDED AT _____ PER FOOT		
620.13	20	GUARDRAIL, TL-3 (SINGLE FACED) AT _____ PER FOOT		
620.33	50	GUARDRAIL - CURVED, TL-3 (SINGLE FACED) AT _____ PER FOOT		
627.2	1	GUARDRAIL ROUNDED END UNIT AT _____ EACH		
628.24	2	TRANSITION TO BRIDGE RAIL AT _____ EACH		
628.25	1	TRANSITION TO THRIE BEAM AT _____ EACH		
628.314	2	TEMPORARY IMPACT ATTENUATOR, REDIRECTIVE, TL-2 AT _____ EACH		
628.4	2	TEMPORARY IMPACT ATTENUATOR, REMOVED AND RESET AT _____ EACH		

Addendum No. 5, April 1, 2026
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Project # 609409	Contract # 133236			
Location : SPRINGFIELD				
Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
630.2	135	HIGHWAY GUARD REMOVED AND DISCARDED AT _____ PER FOOT		
645.172	90	72 INCH CHAIN LINK FENCE (PIPE TOP RAIL) VINYL COATED (LINE POST OPTION) AT _____ PER FOOT		
647.084	14	84 INCH CHAIN LINK FENCE (PIPE TOP RAIL) W/BARB (LINE POST OPTION) AT _____ PER FOOT		
651.096	28	96 INCH CHAIN LINK GATE WITH GATE POSTS AND BARBED WIRE AT _____ PER FOOT		
652.072	4	72 INCH CHAIN LINK FENCE END POST AT _____ EACH		
652.084	1	84 INCH CHAIN LINK FENCE END POST AT _____ EACH		
652.096	3	96 INCH CHAIN LINK FENCE END POST AT _____ EACH		
653.072	3	72 INCH CHAIN LINK FENCE CORNER OR INTERMEDIATE BRACE POST AT _____ EACH		
654.096	15	96 INCH CHAIN LINK FENCE FABRIC AT _____ PER FOOT		

Addendum No. 5, April 1, 2026
Addendum No. 4, March 26, 2026

Project # 609409	Contract # 133236			
Location : SPRINGFIELD				
Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
657.	400	TEMPORARY FENCE AT _____ PER FOOT		
657.5	400	TEMPORARY FENCE REMOVED AND RESET AT _____ PER FOOT		
665.	360	CHAIN LINK FENCE REMOVED AND STACKED AT _____ PER FOOT		
666.	20	CHAIN LINK FENCE REMOVED AND RESET AT _____ PER FOOT		
671.	1	FENCE GATE AND GATE POSTS REMOVED AND STACKED AT _____ EACH		
697.1	6	SILT SACK AT _____ EACH		
698.3	10	GEOTEXTILE FABRIC FOR SEPARATION AT _____ PER SQUARE YARD		
701.	190	CEMENT CONCRETE SIDEWALK AT _____ PER SQUARE YARD		
701.1	90	CEMENT CONCRETE SIDEWALK AT DRIVEWAYS AT _____ PER SQUARE YARD		

Addendum No. 5, April 1, 2026
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Project # 609409	Contract # 133236			
Location : SPRINGFIELD				
Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
701.2	110	CEMENT CONCRETE PEDESTRIAN CURB RAMP AT _____ PER SQUARE YARD		
702.	30	HOT MIX ASPHALT SIDEWALK OR DRIVEWAY AT _____ PER TON		
710.3	6	BOUND - LETTERED GRANITE AT _____ EACH		
710.4	13	BOUND - PLAIN GRANITE AT _____ EACH		
722.1	1	SCHEDULE OF OPERATIONS (TYPE A) - FIXED PRICE $200,000 AT Two Hundred Thousand Dollars LUMP SUM	$200,000.00	$200,000.00
740.	73	ENGINEER'S FIELD OFFICE AND EQUIPMENT (TYPE A) AT _____ PER MONTH		
748.	1	MOBILIZATION AT _____ LUMP SUM		
751.1	50	LOAM FOR LAWNS AT _____ PER CUBIC YARD		
751.7	80	COMPOST BLANKET AT _____ PER CUBIC YARD		

Addendum No. 5, April 1, 2026
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Project # 609409	Contract # 133236			
Location : SPRINGFIELD				
Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
756.	1	NPDES STORMWATER POLLUTION PREVENTION PLAN AT _____ LUMP SUM		
765.	400	SEEDING AT _____ PER SQUARE YARD		
765.2	1,220	SEEDING FOR SHORT TERM EROSION CONTROL AT _____ PER SQUARE YARD		
765.21	10	ANNUAL COVER CROP FOR NATIVE SEEDING AT _____ PER POUND		
765.453	10	WOODLAND EDGE SHADE MIX AT _____ PER POUND		
765.635	820	NATIVE SEEDING AND ESTABLISHMENT AT _____ PER SQUARE YARD		
767.121	760	SEDIMENT CONTROL BARRIER AT _____ PER FOOT		
769.	90	PAVEMENT MILLING MULCH UNDER GUARD RAIL AT _____ PER FOOT		
804.2	80	2 INCH ELECTRICAL CONDUIT TYPE NM - PLASTIC (UL) AT _____ PER FOOT		

Addendum No. 5, April 1, 2026
④ Addendum No. 4, March 26, 2026

Project # 609409 **Contract # 133236**

Location : SPRINGFIELD

Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX

ITEM #	QUANTITY	ITEM WITH UNIT BID PRICE WRITTEN IN WORDS	UNIT PRICE	AMOUNT
804.3	480	3 INCH ELECTRICAL CONDUIT TYPE NM - PLASTIC -(UL) AT _____ PER FOOT		
804.4	2,520	4 INCH ELECTRICAL CONDUIT TYPE NM - PLASTIC -(UL) AT _____ PER FOOT		
804.5	370	5 INCH ELECTRICAL CONDUIT TYPE NM-PLASTIC (UL) AT _____ PER FOOT		
④ 805.4	1,150	FRE CONDUIT INSTALLATION AT _____ PER FOOT		
806.3	210	3 INCH ELECTRICAL CONDUIT TYPE RM - GALVANIZED STEEL AT _____ PER FOOT		
809.41	2,730	TEMPORARY 4 INCH ELECTRICAL CONDUIT AT _____ PER FOOT		
809.42	430	TEMPORARY CONDUIT CASING PIPE AT _____ PER FOOT		
810.2	350	4-4 INCH AND 2-5 INCH DUCT BANK AT _____ PER FOOT		
810.6	300	6-4 INCH DUCT BANK AT _____ PER FOOT		

Addendum No. 5, April 1, 2026
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Project # 609409	Contract # 133236			
Location : SPRINGFIELD				
Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
811.31	14	PULL BOX 12 X 12 INCHES - SD2.031 AT _____ EACH		
811.35	5	PULL BOX ADJUSTED AT _____ EACH		
816.01	1	TRAFFIC SIGNAL RECONSTRUCTION LOCATION NO. 1 AT _____ LUMP SUM		
816.02	1	TRAFFIC SIGNAL RECONSTRUCTION LOCATION NO. 2 AT _____ LUMP SUM		
816.03	1	TRAFFIC SIGNAL RECONSTRUCTION LOCATION NO. 3 AT _____ LUMP SUM		
816.1	64	FIELD ADJUSTMENT OF EXISTING TRAFFIC SIGNAL TIMING AT _____ PER HOUR		
816.2	50	TRAFFIC MONITORING AND ENGINEERING AT _____ PER HOUR		
816.82	1	TEMPORARY TRAFFIC CONTROL SIGNAL LOCATION NO.2 AT _____ LUMP SUM		
816.83	1	TEMPORARY TRAFFIC CONTROL SIGNAL LOCATION NO.3 AT _____ LUMP SUM		

Project # 609409 Contract # 133236				
Location : SPRINGFIELD				
Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
816.84	1	TEMPORARY TRAFFIC CONTROL SIGNAL LOCATION NO.4 AT _____ LUMP SUM		
816.85	1	TEMPORARY TRAFFIC CONTROL SIGNAL LOCATION NO.5 AT _____ LUMP SUM		
823.70	3	HIGHWAY LIGHTING POLE AND LUMINAIRE REMOVED AND RESET AT _____ EACH		
832.	80	WARNING-REGULATORY AND ROUTE MARKER - ALUMINUM PANEL (TYPE A) AT _____ PER SQUARE FOOT		
833.7	1	DELINEATION FOR GUARD RAIL TERMINI AT _____ EACH		
847.1	12	SIGN SUP (N/GUIDE)+RTE MKR W/1 BRKWAY POST ASSEMBLY - STEEL AT _____ EACH		
850.41	1,250	ROADWAY FLAGGER AT _____ PER HOUR		
851.1	60	TRAFFIC CONES FOR TRAFFIC MANAGEMENT AT _____ PER DAY		
852.	830	SAFETY SIGNING FOR TRAFFIC MANAGEMENT AT _____ PER SQUARE FOOT		

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Project # 609409	Contract # 133236			
Location : SPRINGFIELD				
Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
852.11	550	TEMPORARY PEDESTRIAN BARRICADE AT _____ PER FOOT		
852.12	12	TEMPORARY PEDESTRIAN CURB RAMP AT _____ EACH		
853.1	15	PORTABLE BREAKAWAY BARRICADE TYPE III AT _____ EACH		
853.2	50	TEMPORARY BARRIER (TL-2) AT _____ PER FOOT		
853.21	380	TEMPORARY BARRIER REMOVED AND RESET AT _____ PER FOOT		
853.33	763	TEMPORARY BARRIER - LIMITED DEFLECTION (TL-3) AT _____ PER FOOT		
853.8	70	TEMPORARY ILLUMINATION FOR WORK ZONE AT _____ PER DAY		
854.016	3,120	TEMPORARY PAVING MARKINGS - 6 INCH (PAINTED) AT _____ PER FOOT		
854.036	210	TEMPORARY PAVING MARKINGS - 6 INCH (TAPE) AT _____ PER FOOT		

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Project # 609409	Contract # 133236			
Location : SPRINGFIELD				
Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
854.1	550	PAVEMENT MARKING REMOVAL AT _____ PER SQUARE FOOT		
856.12	4,510	PORTABLE CHANGEABLE MESSAGE SIGN AT _____ PER DAY		
859.	8,100	REFLECTORIZED DRUM AT _____ PER DAY		
859.1	20	REFLECTORIZED DRUMS WITH SEQUENTIAL FLASHING WARNING LIGHTS AT _____ PER DAY		
864.04	180	PAVEMENT ARROWS AND LEGENDS REFLECTORIZED WHITE (THERMOPLASTIC) AT _____ PER SQUARE FOOT		
864.41	400	GREEN COLORIZED PAVEMENT MARKINGS AT _____ PER SQUARE FOOT		
866.106	2,140	6 INCH REFLECTORIZED WHITE LINE (THERMOPLASTIC) AT _____ PER FOOT		
866.112	2,110	12 INCH REFLECTORIZED WHITE LINE (THERMOPLASTIC) AT _____ PER FOOT		
867.106	1,700	6 INCH REFLECTORIZED YELLOW LINE (THERMOPLASTIC) AT _____ PER FOOT		

⑤ Addendum No. 5, April 1, 2026
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Project # 609409	Contract # 133236			
Location : SPRINGFIELD				
Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
867.112	40	12 INCH REFLECTORIZED YELLOW LINE (THERMOPLASTIC) AT _____ PER FOOT		
874.	2	STREET NAME SIGN AT _____ EACH		
874.41	22	TRAFFIC SIGN REMOVED AND DISCARDED AT _____ EACH		
901.3	10	4000 PSI, 1.5 INCH, 565 CEMENT CONCRETE FOR POST FOUNDATION AT _____ PER CUBIC YARD		
903.	10	3000 PSI, 1.5 INCH, 470 CEMENT CONCRETE AT _____ PER CUBIC YARD		
904.	1	4000 PSI, 3/4 INCH, 610 CEMENT CONCRETE AT _____ PER CUBIC YARD		
904.3	1,179	5000 PSI, 3/4 INCH, 685 HP CEMENT CONCRETE AT _____ PER CUBIC YARD		
⑤ 904.33	3,600	PRECAST CONCRETE PANELS AT _____ PER SQUARE FOOT		
909.5	20	RAPID HARDENING CEMENTITIOUS PRODUCTS FOR CONCRETE REPAIRS AT _____ PER CUBIC YARD		

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Project # 609409	Contract # 133236			
Location : SPRINGFIELD				
Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
910.2	121,772	STEEL REINFORCEMENT FOR STRUCTURES - COATED AT _____ PER POUND		
912.4	14	DRILLED AND GROUTED #4 DOWELS AT _____ EACH		
912.5	104	DRILLED AND GROUTED #5 DOWELS AT _____ EACH		
942.102	128	STEEL PILE HP 10 X 57 AT _____ PER FOOT		
942.283	1,474	STEEL PILE W18X283 AT _____ PER FOOT		
942.311	1,006	STEEL PILE W18X311 AT _____ PER FOOT		
942.89	1,119	STEEL PILE W16X89 AT _____ PER FOOT		
945.10	19,658	DRILLED MICROPILES AT _____ PER FOOT		
945.101	2,940	DRILLED SHAFT EXCAVATION 3.0 FOOT DIAMETER AT _____ PER FOOT		

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Project # 609409	Contract # 133236			
Location : SPRINGFIELD				
Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
945.301	45	OBSTRUCTION EXCAVATION 3.0 FOOT DIAMETER AT _____ PER FOOT		
945.501	2,940	DRILLED SHAFT 3.0 FOOT DIAMETER AT _____ PER FOOT		
948.60	4	MICROPILE VERIFICATION LOAD TEST AT _____ EACH		
948.61	16	MICROPILE PROOF LOAD TEST AT _____ EACH		
951.1	720	GRANITE CORING AT _____ PER FOOT		
951.2	720	STEEL SLEEVE/ CONCRETE CORING AT _____ PER FOOT		
953.31	1	TEMPORARY EXCAVATION SUPPORT SYSTEM AT _____ LUMP SUM		
970.	8,153	DAMP-PROOFING AT _____ PER SQUARE FOOT		
975.4	368	PROTECTIVE SCREEN TYPE II AT _____ PER FOOT		

⑤ Addendum No. 5, April 1, 2026
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Project # 609409	Contract # 133236			
Location : SPRINGFIELD				
Description : Bridge Replacement, S-24-016, Armory Street over CSX Mainline & S-24-026, Armory Street over Abandoned CSX				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
975.5	150	ALUMINUM HANDRAIL AT _____ PER FOOT		
992.33	1	TEMPORARY SUPPORT FOR UTILITIES - SYSTEM 1 AT _____ LUMP SUM		
992.34	1	TEMPORARY SUPPORT FOR UTILITIES - SYSTEM 2 AT _____ LUMP SUM		
992.35	1	TEMPORARY SUPPORT FOR UTILITIES - SYSTEM 3 AT _____ LUMP SUM		
992.36	1	TEMPORARY SUPPORT FOR UTILITIES - SYSTEM 4 AT _____ LUMP SUM		
994.1	6,930	TEMPORARY PROTECTIVE SHIELDING AT _____ PER SQUARE FOOT		
995.01	1	BRIDGE STRUCTURE, BRIDGE NO. S-24-016 AT _____ LUMP SUM		
995.02	1	BRIDGE STRUCTURE, BRIDGE NO. S-24-026 AT _____ LUMP SUM		
Total Qty:	334,627.25			

⑤④

GENERAL NOTES

DESIGN:
IN ACCORDANCE WITH THE 2020 AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS LRFD BRIDGE DESIGN SPECIFICATIONS 9th EDITION, FOR HL-93 LOADING.

MASSDOT BENCH MARK:
ELEVATIONS ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988.

DATE:
TO BE PLACED ON THE INSIDE FACE OF THE NORTHEAST HIGHWAY GUARDRAIL TRANSITION. A SHEET SHOWING SIZE AND CHARACTER OF NUMERALS WILL BE FURNISHED. THE DATE USED SHALL BE THE LATEST YEAR OF CONTRACT COMPLETION AS OF THE DATE THE FIRST HIGHWAY GUARDRAIL TRANSITION IS CONSTRUCTED. BOTH HIGHWAY GUARDRAIL TRANSITIONS SHALL FEATURE THE SAME DATE.

MASSDOT SURVEY NOTEBOOKS:
ELECTRONIC SURVEY PERFORMED BY GREEN INTERNATIONAL WAS USED IN THE PREPARATION OF THESE CONSTRUCTION DRAWINGS. FILES CAN BE OBTAINED AT THE SURVEY OFFICE, MASSDOT – HIGHWAY DIVISION, 10 PARK PLAZA, BOSTON, MASSACHUSETTS.

SCALES:
SCALES NOTED ON THE PLANS ARE NOT APPLICABLE TO REDUCED SIZE PRINTS. DIVIDE SCALES BY 2 FOR HALF-SIZE PRINTS (A3).

FOUNDATIONS:
FOUNDATIONS MAY BE ALTERED, IF NECESSARY, TO SUIT CONDITIONS ENCOUNTERED DURING CONSTRUCTION, WITH THE APPROVAL OF THE ENGINEER.

UNSUITABLE MATERIAL:
ALL UNSUITABLE MATERIAL SHALL BE REMOVED WITHIN THE LIMITS OF THE FOUNDATIONS OF THE STRUCTURE, AS DIRECTED BY THE ENGINEER.

ANCHOR BOLTS:
ALL ANCHOR BOLTS SHALL BE SET BY TEMPLATE BEFORE THE CONCRETE IS PLACED.

CONCRETE:
UNLESS OTHERWISE SPECIFIED, ALL CONCRETE SHALL BE 5000 HP CONCRETE. ALL CONCRETE POURS SHOWN ON THESE CONSTRUCTION DRAWINGS WHERE ALL VOLUMETRIC DIMENSIONS ARE 4 FEET OR GREATER SHALL BE CONSIDERED TO BE MASS CONCRETE PLACEMENTS AND SHALL REQUIRE A HEAT OF HYDRATION ANALYSIS AND THERMAL CONTROL PLAN, AS SPECIFIED IN THE MASSDOT STANDARD SPECIFICATIONS.

CONCRETE MIX:
UNLESS OTHERWISE NOTED, CONCRETE SHALL BE AS FOLLOWS:

(1)	(2)	(3)	
5000	3/4"	685 HP	CP-PL2 BARRIER, SIDEWALKS, SHARED USE PATHS, MOMENT SLABS, HIGHWAY GUARD TRANSITIONS, DECK SLAB, APPROACH SLABS, ABUTMENTS, PILE CAPS, PRECAST WALL PANELS BACKWALLS, CURTAIN WALLS & KEEPER BLOCKS

REINFORCEMENT:
(1) 28 DAY COMPRESSIVE STRENGTH (PSI)
(2) MAXIMUM AGGREGATE SIZE (INCH)
(3) CEMENTITIOUS CONTENT (POUNDS/CY) CEMENT SHALL CONFORM TO AASHTO M85

REINFORCING STEEL SHALL CONFORM TO THE REQUIREMENTS OF AASHTO M31 GRADE 60. UNLESS OTHERWISE NOTED ON THE CONSTRUCTION DRAWINGS, ALL BARS SHALL BE LAPPED AS FOLLOWS:

MODIFICATION CONDITION	#4 BARS	#5 BARS	#6 BARS	#7 BARS	#8 BARS	#9 BARS
1. NONE	16"	17"	21"	23"	26"	32"
2. 12" OF CONCRETE BELOW BAR	18"	22"	27"	30"	34"	42"
3. EPOXY COATED BARS, COVER < 3db, OR CLEAR SPACING < 6db	21"	26"	31"	36"	41"	46"
4. COATED BARS, ALL OTHER CASES	17"	21"	25"	28"	31"	35"
5. CONDITION 2. AND 3.	23"	29"	35"	42"	55"	70"
6. CONDITION 2. AND 4.	21"	27"	32"	36"	41"	46"

ALL OTHER BARS SHALL BE LAPPED AS SHOWN ON THE CONSTRUCTION DRAWINGS.

ABBREVIATIONS:
GB GRAVITY BLOCK
LFGA LIGHTWEIGHT FOAMED GLASS AGGREGATE

MEMBRANE WATERPROOFING:
ALL MEMBRANE WATERPROOFING USED ON BRIDGE DECKS SHALL BE MEMBRANE WATERPROOFING FOR BRIDGE DECKS SPRAY APPLIED.

RAILROAD REQUIREMENTS:
NO WORK OVER AND ADJACENT TO RAILROAD PROPERTY MAY BE IN PROGRESS DURING THE PASSAGE OF TRAINS, AND ALL WORK ADJACENT TO AND OVER RAILROAD PROPERTY SHALL BE PERFORMED UNDER THE PROTECTION OF A RAILROAD FLAGMAN. RAILROAD PROPERTY SHALL BE KEPT CLEAR OF ALL PROJECT-GENERATED DEBRIS. ALL TEMPORARY STRUCTURES SHALL BE COMPLETELY REMOVED AND THE AREAS RESTORED AT THE COMPLETION OF WORK.

STRUCTURAL STEEL & WELDING:
ALL STRUCTURAL STEEL SHALL BE AASHTO M270 GRADE 50W UNCOATED WEATHERING STEEL UNO.

PAINT ALL SUPERSTRUCTURE STEEL WITHIN A DISTANCE OF 1 1/2 TIMES THE DEPTH OF GIRDER FROM BRIDGE JOINTS. WHEN WEATHERING STEEL IS PAINTED, THE FINISH COAT COLOR SHALL CONFORM TO FEDERAL STANDARD 595B, "COLOR USED IN GOVERNMENT PROCUREMENT, COLOR CHIP NO. 30045.

ALL WELDING, WELDING MATERIAL, PREPARATION AND ASSEMBLY OF MATERIAL FOR WELDING SHALL CONFORM TO THE MASSDOT STANDARD SPECIFICATION FOR HIGHWAY AND BRIDGES, THE AASHTO LRFD BRIDGE DESIGN SPECIFICATION, THE AASHTO/AWS BRIDGE WELDING CODE (ASI/AASHTO/AWS D1.5), AND ALL INTERIM REVISIONS PUBLISHED BY AASHTO AS OF THE BID OPENING DATE. ALL SUPPORT ANGLES AND MECHANICAL REINFORCING BAR SPLICERS AND COUPLERS SHALL BE IN ACCORDANCE WITH THE BRIDGE WELDING CODE; ANSI/AASHTO/AWS D1.5; AND IN ACCORDANCE WITH INTERIM PUBLISHED BY AASHTO AS OF THE BID OPENING DATE.

UTILITIES:
THE CONTRACTOR SHALL LOCATE AND PROTECT FROM DAMAGE OR RELOCATE, AS NECESSARY, ANY EXISTING UTILITIES/POLES. THE CONTRACTOR SHALL COORDINATE AND COOPERATE WITH THE RESPECTIVE UTILITY OWNERS FOR ALL UTILITIES THAT ARE TO BE TEMPORARILY OR PERMANENTLY RELOCATED FOR BRIDGE REPLACEMENT WORK.

TRAFFIC:
CONSTRUCTION SHALL TAKE PLACE IN SEVERAL STAGES AND THE BRIDGE WILL BE OPEN TO THRU-TRAFFIC IN ONE DIRECTION AND DETOURED IN THE OTHER DIRECTION. REFER TO THE STAGE CONSTRUCTION PLANS AND SECTIONS, THE TRAFFIC MANAGEMENT AND/OR DETOUR PLANS FOR TRAFFIC CONTROL DURING DEMOLITION AND CONSTRUCTION.

ESTIMATED QUANTITIES (NOT GUARANTEED)

ITEM NO	DESCRIPTION	QTY	UNIT
100.91	PRECONSTRUCTION SURVEY AND MONITORING OF EXISTING STRUCTURES	1	LS
114.1	DEMOLITION OF SUPERSTRUCTURE OF BRIDGE NO S-24-016	1	LS
127.1	REINFORCED CONCRETE EXCAVATION	320	CY
140	BRIDGE EXCAVATION	1254	CY
144	CLASS B ROCK EXCAVATION	124	CY
151.2	GRAVEL BORROW FOR BACKFILLING STRUCTURES AND PIPES	505	CY
156	CRUSHED STONE	125	TON
450.611	SUPERPAVE BRIDGE SURFACE COURSE - 12.5 POLYMER (SSC-B - 12.5 - P)	45	TON
450.711	SUPERPAVE BRIDGE PROTECTIVE COURSE – 12.5P POLYMER (SPC-B - 12.5 - P)	59	TON
458.7	LIGHTWEIGHT AGGREGATE	1175	CY
853.33	TEMPORARY BARRIER - LIMITED DEFLECTION (TL-3)	127	FT
904.3	5000 PSI 3/4IN 685 HP CEMENT CONCRETE	559	CY
904.33	PRECAST CONCRETE PANELS (5 1105)	2142	SF
909.50	RAPID HARDENING CEMENTITIOUS PRODUCTS	12	CY
910.2	STEEL REINFORCEMENT FOR STRUCTURES - COATED	59682	LB
912.40	DRILLED AND GROUTED #4 DOWELS	14	EA
912.50	DRILLED AND GROUTED #5 DOWELS	57	EA
942.102	STEEL PILE HP 10 X 57	128	FT
942.283	STEEL PILE W18X283	1148	FT
945.10	DRILLED MICROPILES	7697	FT
945.101	DRILLED SHAFT EXCAVATION 3.0 FOOT DIAMETER	901	FT
945.301	OBSTRUCTION EXCAVATION 3.0 FOOT DIAMETER	20	FT
945.501	DRILLED SHAFT 3.0 FOOT DIAMETER	901	FT
948.60	MICROPILE VERIFICATION LOAD TEST	2	EA
948.61	MICROPILE PROOF LOAD TEST	9	EA
951.1	GRANITE CORING	600	FT
951.2	STEEL SLEEVE / CONCRETE CORING	360	FT
953.31	TEMPORARY EXCAVATION SUPPORT SYSTEM	1	LS
970	DAMP-PROOFING	3988	SF
975.4	PROTECTIVE SCREEN TYPE II	200	FT
992.33	TEMPORARY SUPPORTS FOR UTILITIES -SYSTEM 1	1	LS
992.34	TEMPORARY SUPPORTS FOR UTILITIES -SYSTEM 2	1	LS
992.36	TEMPORARY SUPPORTS FOR UTILITIES -SYSTEM 4	1	LS
994.1	TEMPORARY PROTECTIVE SHIELDING	6930	SF
995.01	BRIDGE STRUCTURE, BRIDGE NO. S-24-016	1	LS

SPRINGFIELD
ARMORY STREET/RR CSX MAINLINE

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-0035(924)	62	204
PROJECT FILE NO. 609409			

GENERAL NOTES & QTY'S

PROJECT INFORMATION

PROJECT FILE NO.: 609409	
PROJECT DESCRIPTION: BRIDGE REPLACEMENT BRIDGE NO. S-24-016	
BRIDGE DESIGN LOADING: HL-93	
SURVEY: SURVEY BY GREEN INTERNATIONAL AFFILIATES, INC.	
ELEVATION REFERENCE: NAVD OF 1988	
BENCH MARK 3:	BENCH MARK 5:
N: 2868946.498'	N: 2868991.460'
E: 362701.562'	E: 362604.965'
EL: 154.041'	EL: 151.827'
MDHL [3]	MDHL [5]

TRAFFIC DATA

	ROADWAY OVER	ROADWAY UNDER
DESIGN YEAR	2024	
AVERAGE DAILY TRAFFIC-PRESENT	15800	
AVERAGE DAILY TRAFFIC-DESIGN YEAR	16200	
DESIGN HOURLY VOLUME (2019)	1280	
DIRECTIONAL DISTRIBUTION	55%	
TRUCK PERCENTAGE-AVERAGE DAY	3.5%	
TRUCK PERCENTAGE-PEAK HOUR	7.5%	
DESIGN SPEED	30 mph	
DIRECTIONAL DESIGN HOURLY VOLUME (2019)	920	

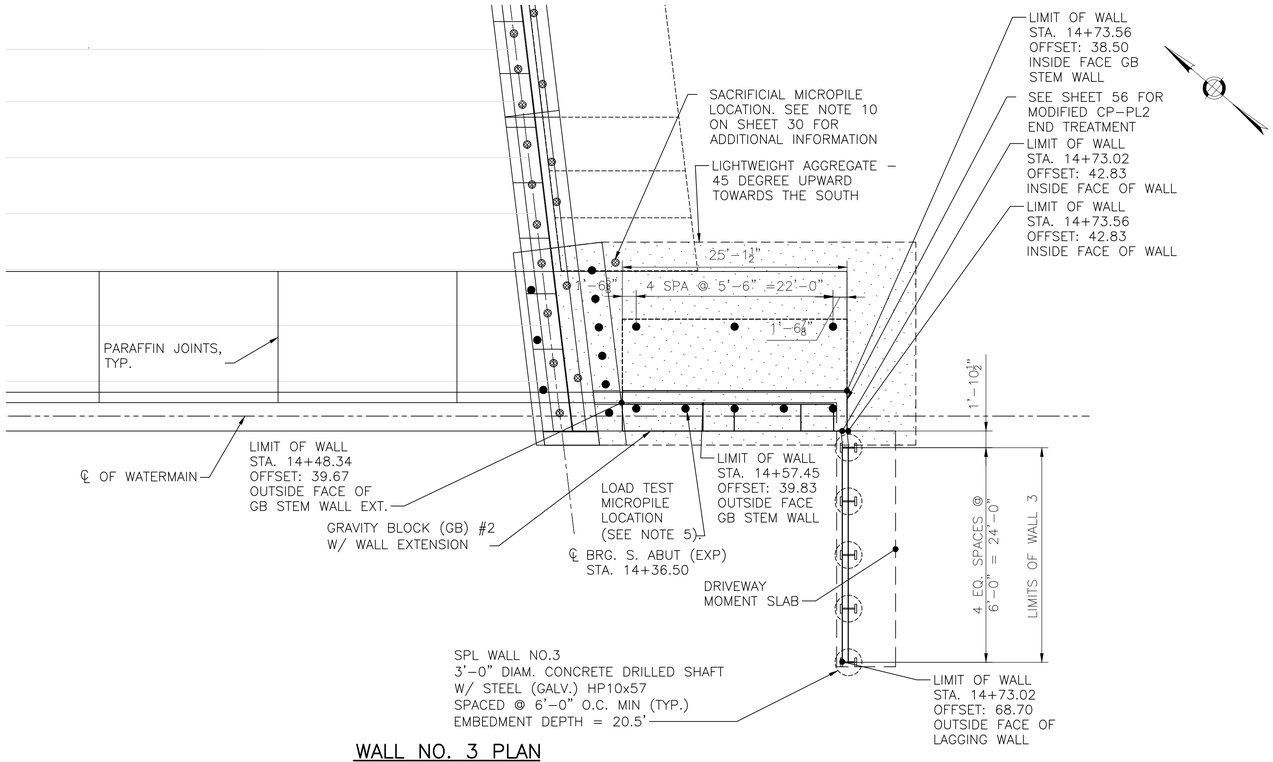
SEISMIC DESIGN CRITERIA

DESIGN RETURN PERIOD:	1000-YEAR
DESIGN SPECTRA	
As	0.148
SDs	0.325
SD1	0.133
SITE CLASS	E
SEISMIC DESIGN CATEGORY (SDC)	A

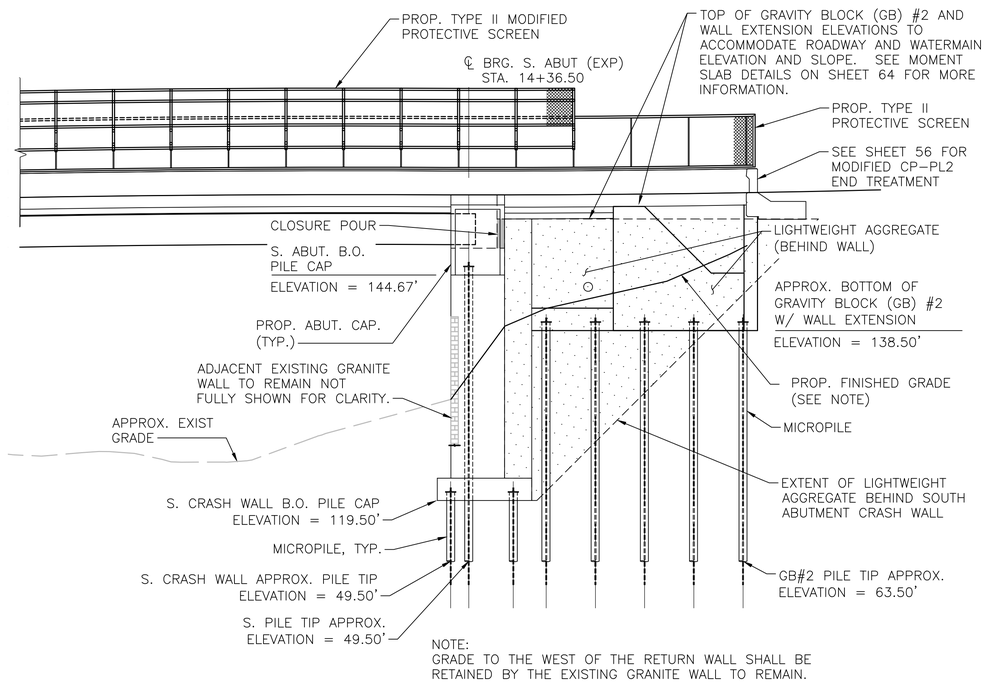
DATE	DESCRIPTION
DEC 20, 2025	ISSUED FOR CONSTRUCTION

THIS SHEET IS APPROVED FOR CONSTRUCTION BY MASSDOT
AUTHORIZED SIGNATORY: _____ STATE BRIDGE ENGINEER
USE ONLY PRINTS OF LATEST DATE

S-24-016 (GENERAL NOTES & QTY'S).DWG Plotted on 27-Mar-2026 10:10 AM
Xxxxx Structural Submittal (S#) DD-Month-YYYY
S-24-016 (General Notes & Qty's).dwg

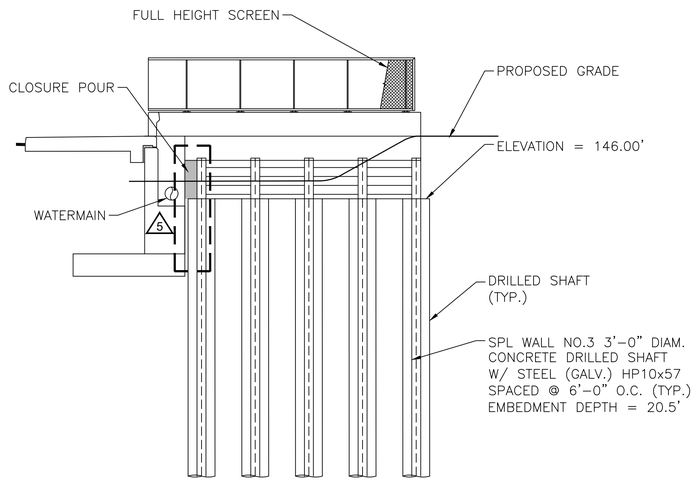


WALL NO. 3 PLAN
SCALE: 1/8" = 1'-0"



NOTE:
GRADE TO THE WEST OF THE RETURN WALL SHALL BE RETAINED BY THE EXISTING GRANITE WALL TO REMAIN.

GRAVITY BLOCK NO. 2 W/ WALL EXTENSION
SCALE: 1/8" = 1'-0"



WALL NO. 3 ELEVATION
1/8" = 1'-0"

SPRINGFIELD
ARMORY STREET/RR CSX MAINLINE

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-003S(924)	85	204
PROJECT FILE NO. 609409			

PROPOSED RETAINING WALLS, SOLDIER PILE AND LAGGING WALL NO. 3

NOTES:

1. SEE SHEETS 26 TO 29 FOR WALL SECTIONS AND DETAILS.
2. SEE SHEETS 34 AND 35 FOR SOLDIER PILE AND LAGGING WALL DETAILS AND ADDITIONAL INFORMATION.
3. SEE SHEETS 30 AND 31 FOR MICROPILE DETAILS AND ADDITIONAL INFORMATION.
4. REFER TO HIGHWAY PLANS FOR ROADWAY GRADES TO DETERMINE WALL ELEVATIONS.
5. SUGGESTED LOCATION(S) OF PRODUCTION MICROPILE FOR PROOF LOAD TEST (ITEM 948.61). CONTRACTOR TO SELECT THE PROOF LOAD TEST LOCATION(S) WITH THE APPROVAL OF THE ENGINEER.

DEC 20, 2025	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION

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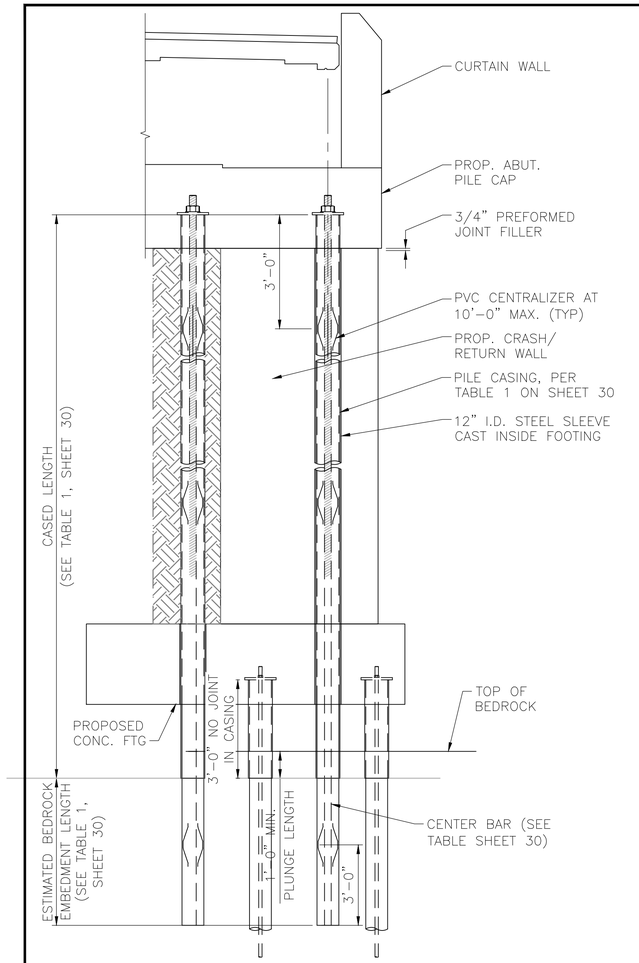
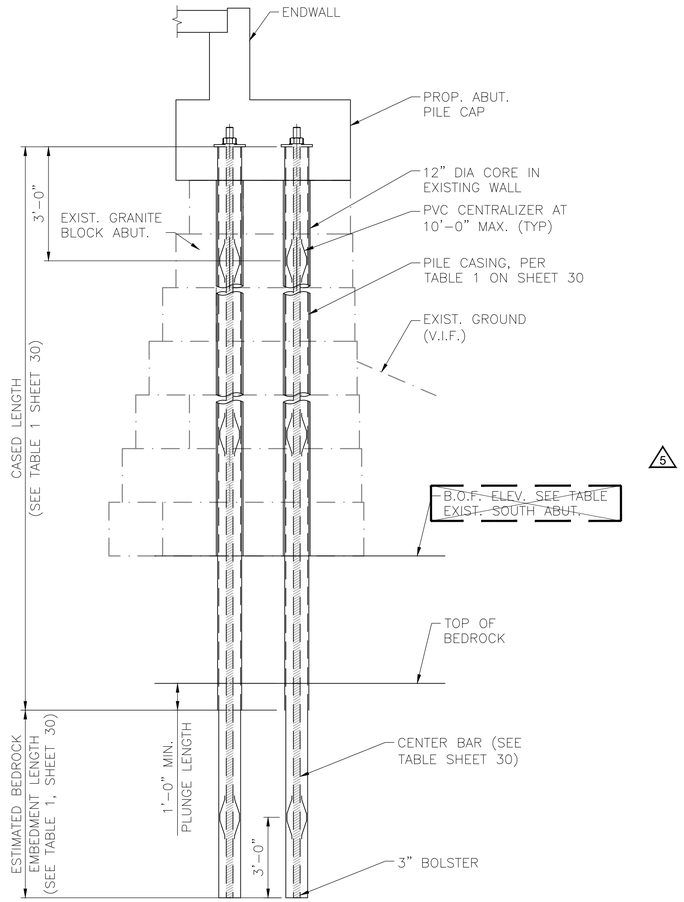
USE ONLY PRINTS OF LATEST DATE

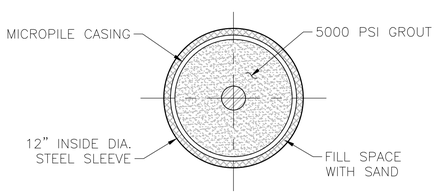
S-24-016 (PROPOSED RETAINING WALLS NO 1-3).DWG Plotted on 27-Mar-2026 10:16 AM
Xxxxx Structural Submittal (S#) DD-Month-YYYY



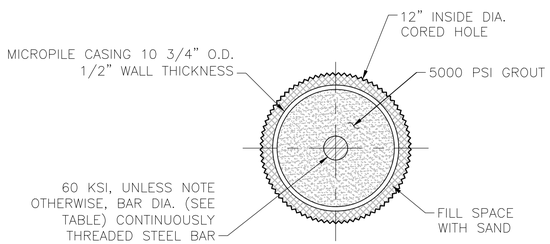
MICROPILE SLEEVE SECTION
@ NORTH RETURN WALL AND SOUTH CRASHWALL
SCALE: 3/8"= 1'-0"



MICROPILE CORED SECTION
@ SOUTH ABUTMENT
SCALE: 3/8"= 1'-0"



MICROPILE AT
SLEEVE ZONE



MICROPILE AT
CORED ZONE

SPRINGFIELD
ARMORY STREET/RR CSX MAINLINE

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-003S(924)	91	204
PROJECT FILE NO. 609409			

MICROPILE DETAILS

NOTES:

1. SEE TABLE ON SHEET 30 FOR FACTORED AXIAL DESIGN LOAD PER MICROPILE.
2. STEEL SLEEVE SHALL BE PRIME STEEL AND MEET THE REQUIREMENTS OF API 5L PSL1 GRADE 52 WITH SR 15 SUPPLEMENTAL REQUIREMENTS. NO CASING JOINT SHALL BE IN THE TOP THREE FEET OF THE PILE BELOW THE PILE CAP AND PROPOSED CONCRETE FOOTING.
3. THE PROPOSED MICROPILES AT THE SOUTH ABUTMENT WILL BE INSTALLED THROUGH THE EXISTING SOUTH ABUTMENT OR THE PROPOSED ABUTMENT EXTENSION (PILE CAP WITH A CONCRETE CRASH WALL BELOW).
4. THE PROPOSED MICROPILES AT THE SOUTH ABUTMENT WILL BE INSTALLED THROUGH THE EXISTING SOUTH ABUTMENT OR THE PROPOSED ABUTMENT EXTENTION (PILE CAP WITH A CONCRETE CRASH WALL BELOW).

PRE-DRILLING NOTES:

1. PRIOR TO INSTALLING THE MICROPILES THROUGH THE EXISTING ABUTMENT, AN APPROXIMATELY 12-INCH DIAMETER HOLE NEEDS TO BE CORED THROUGH THE ENTIRE HEIGHT OF THE EXISTING ABUTMENT. AFTER THE MICROPILE DRILLING AND INSTALLATION, THE ANNULUS OF THE MICROPILE CASING AND THE CORED HOLES IN THE EXISTING ABUTMENT OR PREVIOUSLY EMBEDDED OPENING THROUGH THE ABUTMENT EXTENSION SHALL BE FILLED WITH SAND AFTER THE MICROPILES ARE INSTALLED.

MICROPILE STEEL SLEEVE NOTES:

1. STEEL SLEEVES SHALL HAVE AN INSIDE DIA. OF 12" MIN. AND EXTEND FROM THE BOTTOM OF THE BRIDGE PILE CAP TO THE APPROX. PILE TIP.

DEC 20, 2025	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION

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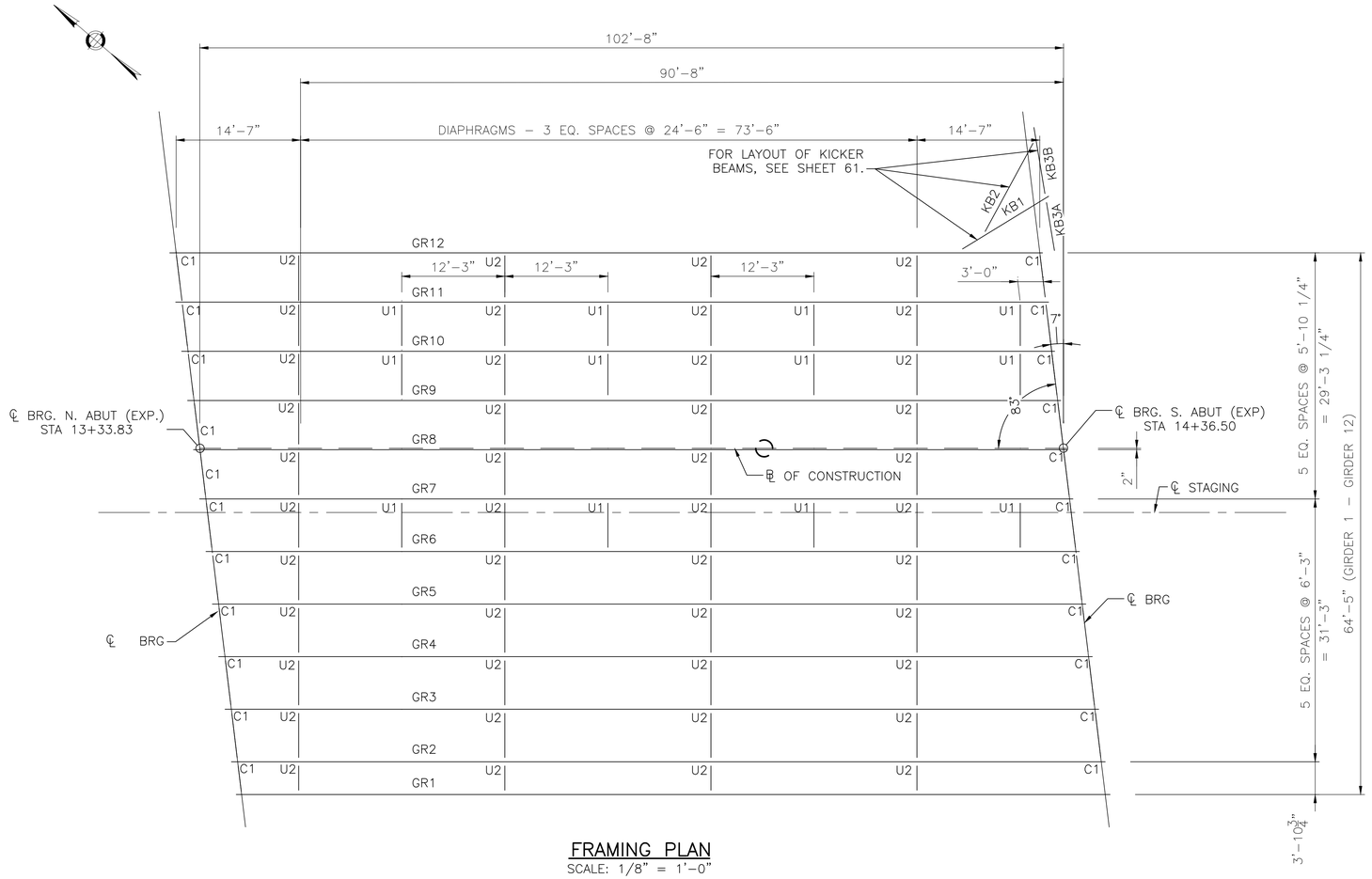
AUTHORIZED SIGNATORY: _____ STATE BRIDGE ENGINEER
USE ONLY PRINTS OF LATEST DATE

S-24-016 (MICROPILE DETAILS).DWG Plotted on 27-Mar-2026 10:23 AM
Xxxxxx Structural Submittal (S#) DD-Month-YYYY
S-24-016 (Micropile Details).dwg

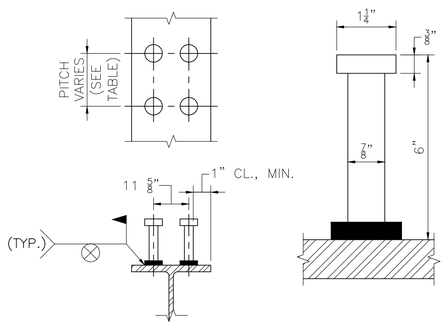
SPRINGFIELD
ARMORY STREET/RR CSX MAINLINE

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-003S(924)	109	204
PROJECT FILE NO. 609409			

FRAMING PLAN



FRAMING PLAN
SCALE: 1/8" = 1'-0"



STUD SHEAR CONNECTORS
NOT TO SCALE

GIRDER	STUDS/ROW	PITCH (in)	TOTAL SHEAR STUDS
1	2	22.00	116
2	2	6.00	414
3	2	6.00	414
4	2	6.00	414
5	2	6.00	414
6	2	6.00	414
7	2	6.00	414
8	2	6.00	414
9	2	6.00	414
10	2	6.00	414
11	2	6.00	414
12	2	14.00	180
KB#1	2	24	14
KB#2	2	20	16

5

NOTES:

1. C1 = C15x33.9 (TYPICAL END DIAPHRAGM)
   U1 = UTILITY SUPPORT BETWEEN DIAPHRAGMS
   U2 = UTILITY SUPPORT AT INTERMEDIATE DIAPHRAGMS
2. SEE SHEETS 52 TO 53 FOR DIAPHRAGM AND UTILITY SUPPORT DETAILS.
3. THE MAIN LOAD CARRYING MEMBERS ARE GIRDERS 1 THROUGH 12.
4. ALL STRUCTURAL STEEL SHAPES SHALL CONFORM TO AASHTO M270 GRADE 50W UNLESS NOTED OTHERWISE.

DEC 20, 2025	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION

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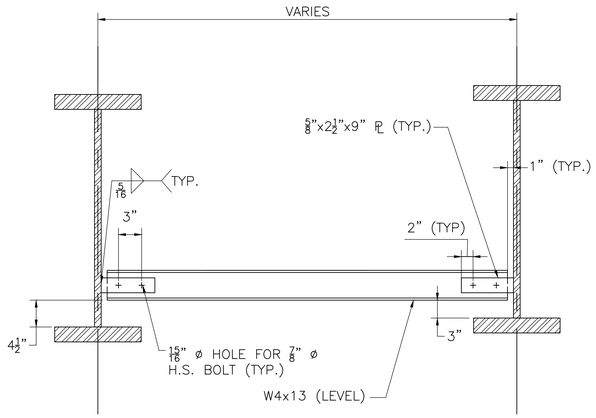
AUTHORIZED SIGNATORY: _____ STATE BRIDGE ENGINEER
USE ONLY PRINTS OF LATEST DATE

S-24-016 (Framing Plan).dwg
S-24-016 (FRAMING PLAN).DWG Plotted on 27-Mar-2026 10:30 AM
Xxxxx Structural Submittal (S#) DD-Month-YYYY

SPRINGFIELD
ARMORY STREET/RR CSX MAINLINE

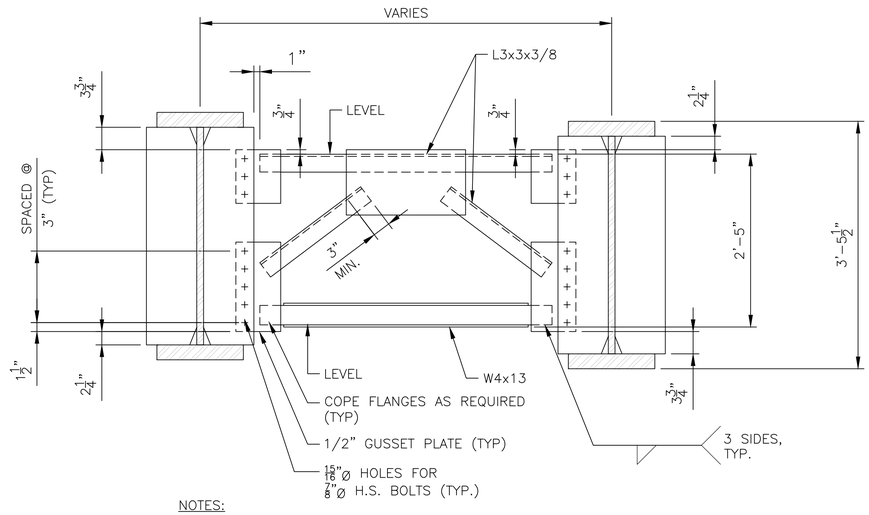
STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-0035(924)	112	204
PROJECT FILE NO. 609409			

UTILITY SUPPORT DETAILS



UTILITY SUPPORT DETAIL BETWEEN DIAPHRAGMS (TYPE U1)

SCALE: 1" = 1'-0"

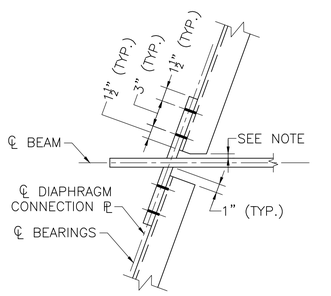


NOTES:

1. SEE CLIP DETAIL ON SHEET 50.
2. TERMINATE FILLET WELDS 1/2" SHORT OF ALL PLATE EDGES.

TYPICAL INTERMEDIATE DIAPHRAGM/UTILITY SUPPORT FRAME DETAIL (U2)

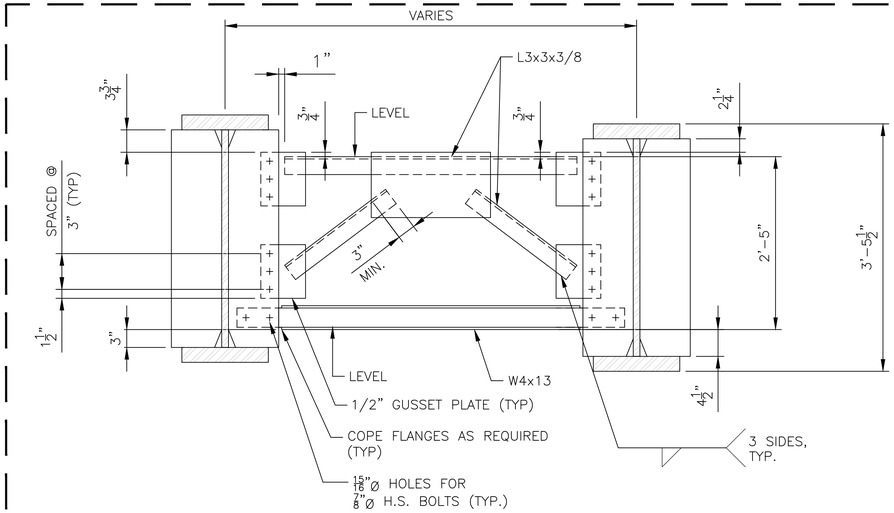
SCALE: 3/4" = 1'-0"



NOTE:
FLANGE OF CHANNEL MAY BE CLIPPED TO AVOID INTERFERENCE WITH WEB.

END DIAPHRAGM CONNECTION DETAIL

SCALE: 1 1/2" = 1'-0"



NOTES:

1. SEE CLIP DETAIL ON SHEET 50.
2. TERMINATE FILLET WELDS 1/2" SHORT OF ALL PLATE EDGES.
3. FOR USE AS REQUIRED BY CONTRACTOR.

ALTERNATE INTERMEDIATE DIAPHRAGM/UTILITY SUPPORT FRAME DETAIL (U2)

SCALE: 3/4" = 1'-0"

DEC 20, 2025	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION

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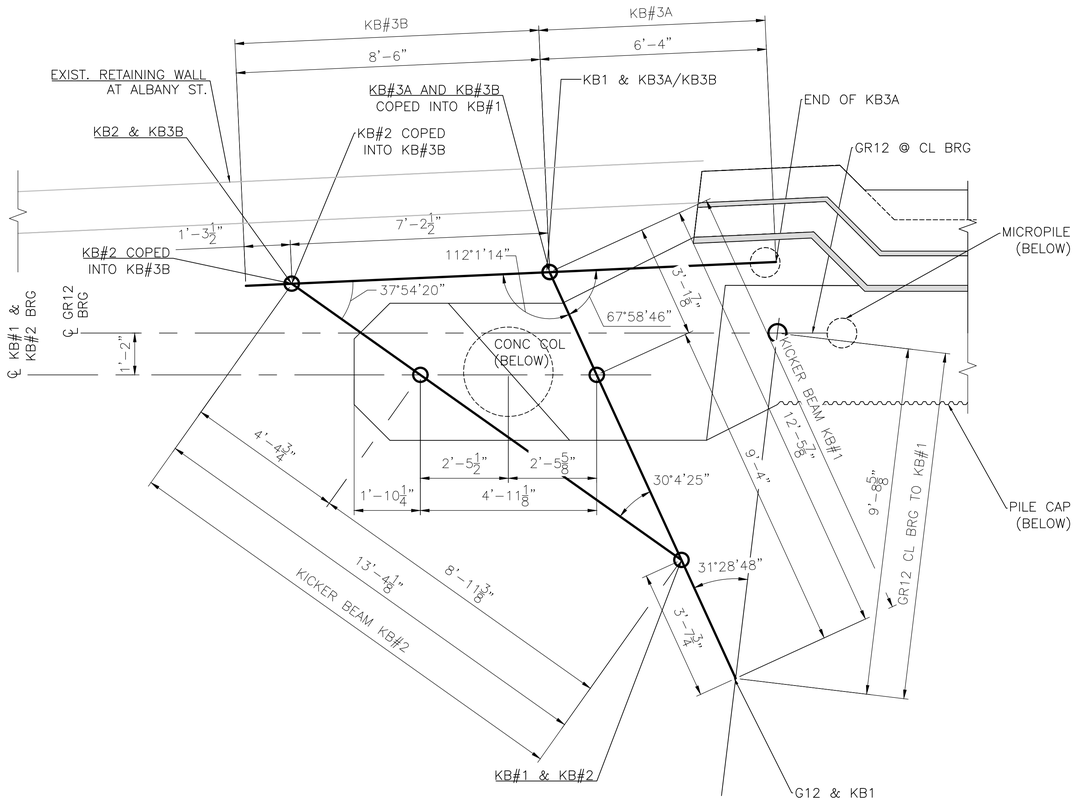
AUTHORIZED SIGNATORY: _____ STATE BRIDGE ENGINEER
USE ONLY PRINTS OF LATEST DATE

S-24-016 (Utility Support Details).dwg
Plotted on 27-Mar-2026 10:33 AM
S:24-016 (UTILITY SUPPORT DETAILS).DWG
Xxxxx Structural Submittal (S#) DD-Month-YYYY

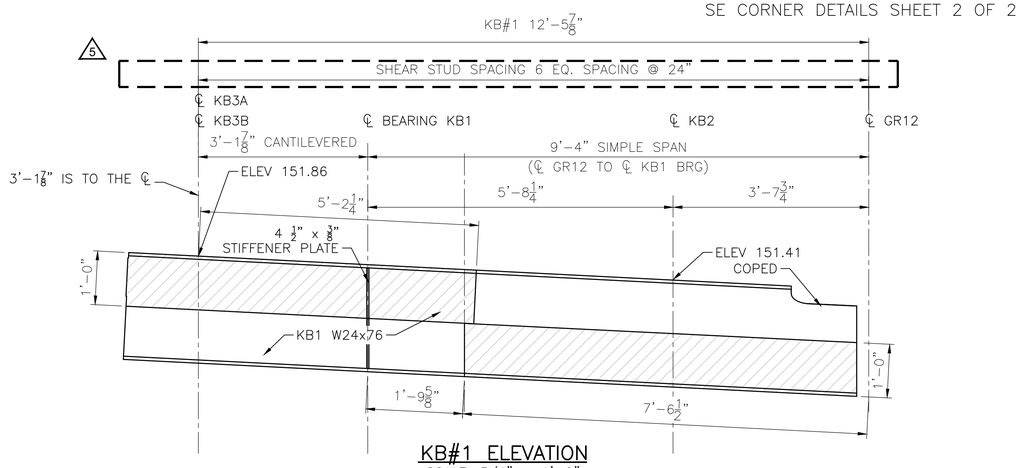
SPRINGFIELD
ARMORY STREET/RR CSX MAINLINE

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-003S(924)	121	204
PROJECT FILE NO. 609409			

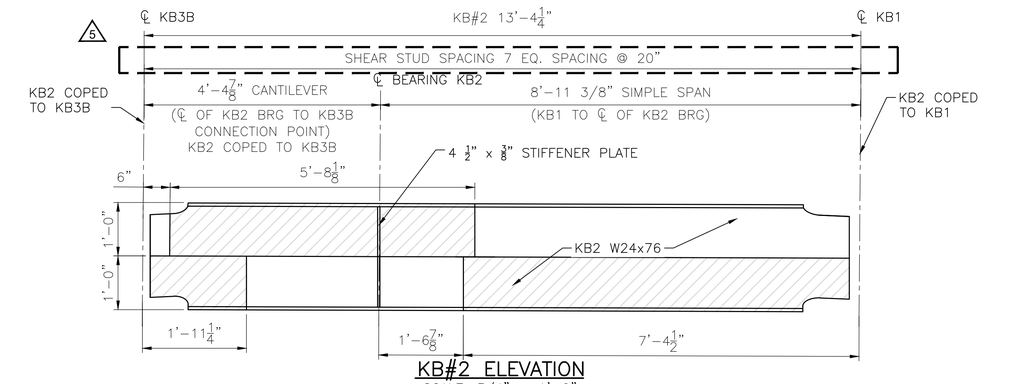
SE CORNER DETAILS SHEET 2 OF 2



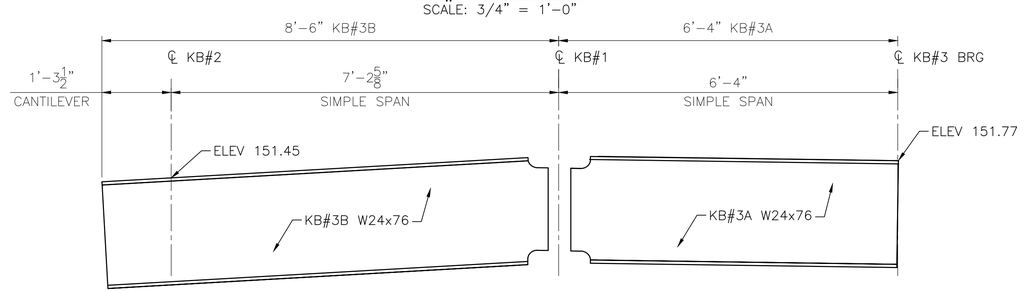
ENLARGED PLAN OF SOUTHEAST
FRAMING AND BEARING LOCATIONS
SCALE" 1/2" = 1'-0"



KB#1 ELEVATION
SCALE: 3/4" = 1'-0"



KB#2 ELEVATION
SCALE: 3/4" = 1'-0"



DENOTES LIMITS OF NET TENSILE STRESS
UNDER STRENGTH 1 LOADING COMBINATION

KB#3 ELEVATION
SCALE: 3/4" = 1'-0"

DEC 20, 2025	ISSUED FOR CONSTRUCTION
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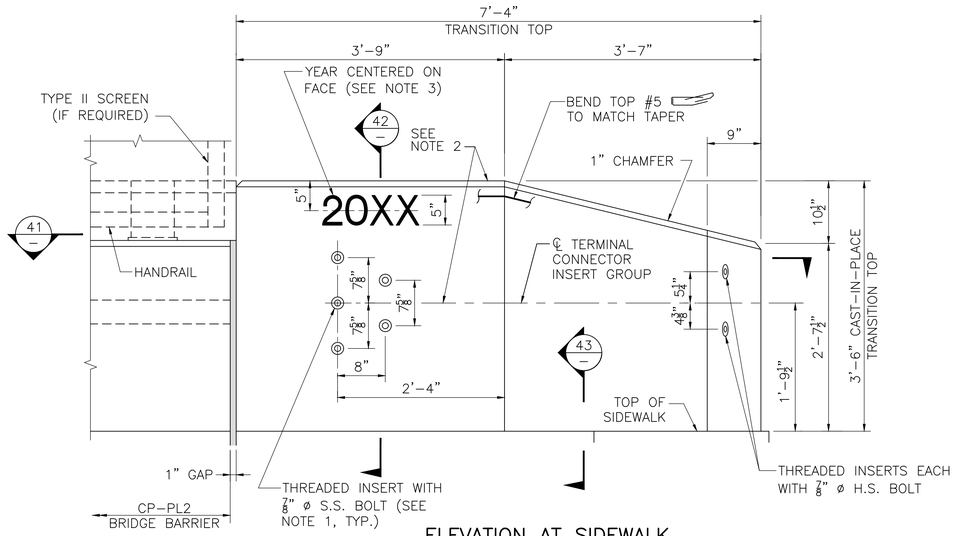
USE ONLY PRINTS OF LATEST DATE

S-24-016 (Southeast Corner Details).dwg
S-24-016 (SOUTHEAST CORNER DETAILS).DWG Plotted on 27-Mar-2026 10:34 AM
Xxxxxx Structural Submittal (S#) DD-Month-YYYY

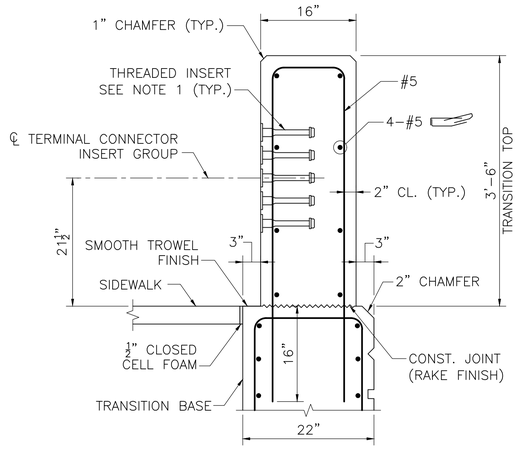
SPRINGFIELD
ARMORY STREET/RR CSX MAINLINE

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-0035(924)	130	204
PROJECT FILE NO. 609409			

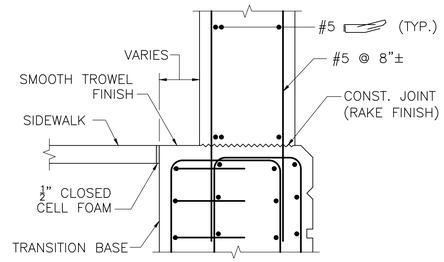
HIGHWAY GUARDRAIL TRANSITION
(MASSDOT STANDARD SHEETS)



ELEVATION AT SIDEWALK
SCALE: 1" = 1'-0"



SECTION 42 AT SIDEWALK
SCALE: 1" = 1'-0"

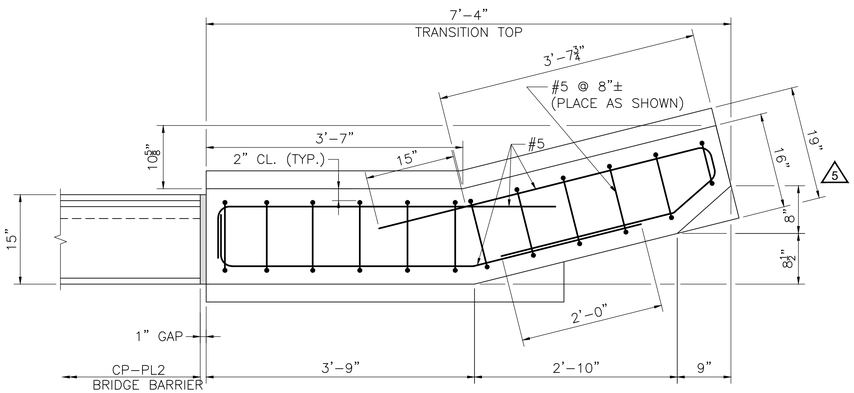


SECTION 43 AT SIDEWALK
SCALE: 1" = 1'-0"

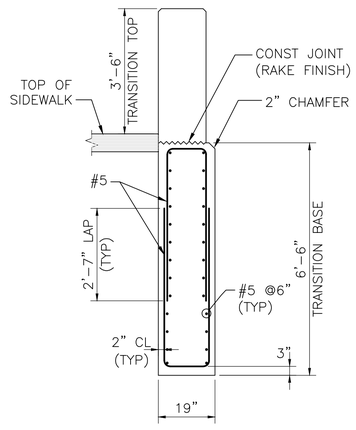
NOTES:

1. THREADED INSERTS SHALL BE PREQUALIFIED BY THE MANUFACTURER AS BEING CAPABLE OF DEVELOPING A NOMINAL SHEAR RESISTANCE OF 20 KIPS PER ⅞" ø S.S. BOLT. S.S. BOLTS SHALL BE ⅞" ø x 1½" LONG FULLY THREADED AISI TYPE 304N STAINLESS STEEL. INSERTS FOR ⅞" S.S. BOLTS SHALL BE GALVANIZED AND CAST INTO THE TRANSITION.
2. FOR AN APPROACH GRADE UP TO 3%, THE TRANSITION MAY BE CAST SQUARE AND SET PLUMB WITH THE MINIMUM EMBEDMENT DEPTH SHOWN. THE TERMINAL CONNECTOR INSERT GROUP SHALL BE SQUARE TO THE POST.

   FOR AN APPROACH GRADE IN EXCESS OF 3%, THE TRANSITION TOP AND THE TOP OF THE BRIDGE BARRIERS SHALL FOLLOW THE APPROACH GRADE. THE HEIGHT OF THE TRANSITION TOP SHALL VARY PROVIDED THAT THE MINIMUM DIMENSIONS SHOWN ON THE CONSTRUCTION DRAWINGS ARE MET. THE BOTTOM OF THE TRANSITION BASE SHALL BE SET LEVEL WITH THE MINIMUM EMBEDMENT DEPTH SHOWN. THE TERMINAL CONNECTOR INSERT GROUP SHALL BE SLOPED TO FOLLOW THE APPROACH GRADE.
3. USE LATEST CONTRACT COMPLETION YEAR IN EFFECT WHEN THE FIRST GUARDRAIL TRANSITION IS CAST. USE THIS YEAR FOR ALL GUARDRAIL TRANSITIONS.
4. ALL CONCRETE FOR THE PRECAST 5 HIGHWAY GUARDRAIL TRANSITION SHALL BE 5000 PSI, ¾", 685 HP CEMENT CONCRETE.
5. LIFTING DEVICES (NOT SHOWN), INCLUDING THEIR NUMBER AND LOCATION, SHALL BE DESIGNED AND DETAILED BY THE PRECASTER. THEY SHALL BE GALVANIZED AND SHALL BE PLACED AND RECESSED IN POCKETS TO PROVIDE 1½" CLEAR COVER TO THE FACE OF THE TRANSITION CONCRETE. THESE DEVICES SHALL BE CLEARLY SHOWN ON THE SHOP DRAWINGS ALONG WITH ALL SUPPORTING CALCULATIONS AND/OR CATALOG CUTS. ONCE THE PRECAST TRANSITION IS SET IN PLACE, THE LIFTING DEVICE POCKETS SHALL BE FILLED WITH A NON-SHRINK GROUT THAT MATCHES THE COLOR OF THE TRANSITION CONCRETE WHEN CURED AND THE FILLED POCKETS SHALL BE RUBBED WITH A CORUNDUM STONE TO BLEND OUT THE JOINTS.

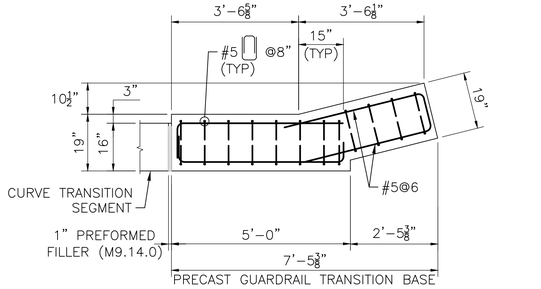


SECTION 41
SCALE: 1" = 1'-0"



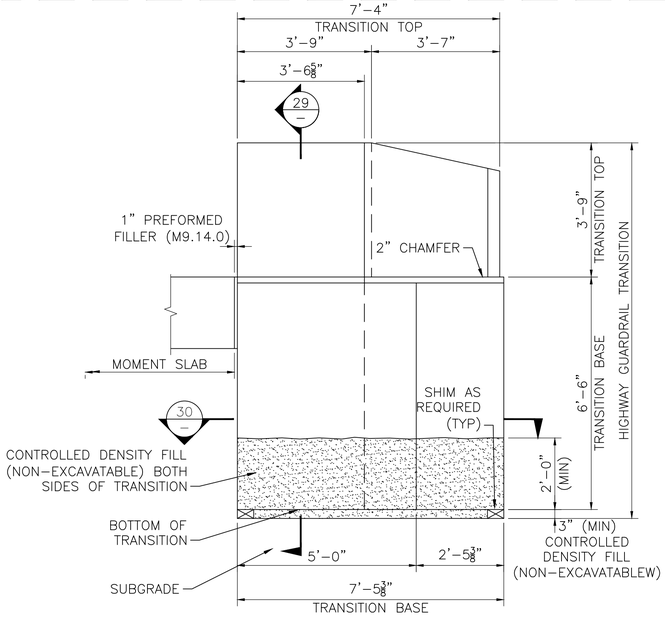
NOTE:
REINFORCEMENT OF THE TRANSITION TOP NOT SHOWN FOR CLARITY

SECTION 29
SCALE: 1/2" = 1'-0"



NOTE:
MOMENT SLAB REINFORCEMENT NOT SHOWN FOR CLARITY

SECTION 30
SCALE: 1/2" = 1'-0"



CIP GUARDRAIL TRANSITION ELEVATION
SCALE: 1/2" = 1'-0"

DEC 20, 2025	ISSUED FOR CONSTRUCTION
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AUTHORIZED SIGNATORY: _____ STATE BRIDGE ENGINEER
USE ONLY PRINTS OF LATEST DATE

S-24-016 (MassDot Standard Sheets).dwg
S-24-016 (MASSDOT STANDARD SHEETS).DWG Plotted on 27-Mar-2026 10:36 AM
Xxxxxx Structural Submittal (S#) DD-Month-YYYY

GENERAL NOTES

DESIGN:
IN ACCORDANCE WITH THE 2020 AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS LRFD BRIDGE DESIGN SPECIFICATIONS 9th EDITION, FOR HL-93 LOADING.

MASSDOT BENCH MARK:
ELEVATIONS ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988.

DATE:
TO BE PLACED ON THE INSIDE FACE OF THE SOUTHEAST AND NORTHWEST HIGHWAY GUARDRAIL TRANSITIONS. A SHEET SHOWING SIZE AND CHARACTER OF NUMERALS WILL BE FURNISHED. THE DATE USED SHALL BE THE LATEST YEAR OF CONTRACT COMPLETION AS OF THE DATE THE FIRST HIGHWAY GUARDRAIL TRANSITION IS CONSTRUCTED. BOTH HIGHWAY GUARDRAIL TRANSITIONS SHALL FEATURE THE SAME DATE.

MASSDOT SURVEY NOTEBOOKS:
ELECTRONIC SURVEY PERFORMED BY GREEN INTERNATIONAL WAS USED IN THE PREPARATION OF THESE CONSTRUCTION DRAWINGS. FILES CAN BE OBTAINED AT THE SURVEY OFFICE, MASSDOT – HIGHWAY DIVISION, 10 PARK PLAZA, MASSACHUSETTS.

SCALES:
SCALES NOTED ON THE PLANS ARE NOT APPLICABLE TO REDUCED SIZE PRINTS. DIVIDE SCALES BY 2 FOR HALF-SIZE PRINTS (A3).

FOUNDATIONS:
FOUNDATIONS MAY BE ALTERED, IF NECESSARY, TO SUIT CONDITIONS ENCOUNTERED DURING CONSTRUCTION, WITH THE APPROVAL OF THE ENGINEER.

UNSUITABLE MATERIAL:
ALL UNSUITABLE MATERIAL SHALL BE REMOVED WITHIN THE LIMITS OF THE FOUNDATIONS OF THE STRUCTURE, AS DIRECTED BY THE ENGINEER.

ANCHOR BOLTS:
ALL ANCHOR BOLTS SHALL BE SET BY TEMPLATE BEFORE THE CONCRETE IS PLACED.

CONCRETE:
ALL CONCRETE SHALL BE 5000 HP CONCRETE, EXCEPT AS NOTED BELOW.

CONCRETE MIX:
UNLESS OTHERWISE NOTED, CONCRETE SHALL BE AS FOLLOWS

(1)	(2)	(3)
5000	3/4"	685 HP

(1) 28 DAY COMPRESSIVE STRENGTH (PSI)
(2) MAXIMUM AGGREGATE SIZE (INCH)
(3) CEMENTITIOUS CONTENT (POUNDS/CY) CEMENT SHALL CONFORM TO AASHTO M85

REINFORCEMENT:
REINFORCING STEEL SHALL CONFORM TO THE REQUIREMENTS OF AASHTO M31 GRADE 60. UNLESS OTHERWISE NOTED ON THE CONSTRUCTION DRAWINGS, ALL BARS SHALL BE LAPPED AS FOLLOWS:

MODIFICATION CONDITION	#4 BARS	#5 BARS	#6 BARS	#7 BARS
1. NONE	16"	17"	21"	23"
2. 12" OF CONCRETE BELOW BAR	18"	22"	27"	30"
3. EPOXY COATED BARS, COVER < 3db, OR CLEAR SPACING < 6db	21"	26"	31"	36"
4. COATED BARS, ALL OTHER CASES	17"	21"	25"	28"
5. CONDITION 2. AND 3.	23"	29"	35"	42"
6. CONDITION 2. AND 4.	21"	27"	32"	36"

ALL OTHER BARS SHALL BE LAPPED AS SHOWN ON THE CONSTRUCTION DRAWINGS.

ABBREVIATIONS:
GB GRAVITY BLOCK
UF-LGA LIGHTWEIGHT FOAMED GLASS AGGREGATE

MEMBRANE WATERPROOFING:
ALL MEMBRANE WATERPROOFING USED ON BRIDGE DECKS SHALL BE MEMBRANE WATERPROOFING FOR BRIDGE DECKS SPRAY APPLIED.

RAILROAD REQUIREMENTS:
NO WORK OVER ADJACENT TO RAILROAD PROPERTY MAY BE IN PROGRESS DURING THE PASSAGE OF TRAINS, AND ALL WORK ADJACENT TO AND OVER RAILROAD PROPERTY SHALL BE PERFORMED UNDER THE PROTECTION OF A RAILROAD FLAGMAN. RAILROAD PROPERTY SHALL BE KEPT CLEAR OF ALL PROJECT-GENERATED DEBRIS. ALL TEMPORARY STRUCTURES SHALL BE COMPLETELY REMOVED AND THE AREAS RESTORED AT THE COMPLETION OF WORK.

STRUCTURAL STEEL & WELDING:
ALL STRUCTURAL STEEL SHALL BE AASHTO M270 GRADE 50W UNCOATED WEATHERING STEEL UNO.

PAINT ALL SUPERSTRUCTURE STEEL WITHIN A DISTANCE OF 1 1/2 TIMES THE DEPTH OF GIRDER FROM BRIDGE JOINTS. WHEN WEATHERING STEEL IS PAINTED, THE FINISH COAT COLOR SHALL CONFORM TO FEDERAL STANDARD 595B, "COLOR USED IN GOVERNMENT PROCUREMENT, COLOR CHIP NO. 30045.

ALL WELDING, WELDING MATERIAL, PREPARATION AND ASSEMBLY OF MATERIAL FOR WELDING SHALL CONFORM TO THE MASSDOT STANDARD SPECIFICATION FOR HIGHWAY AND BRIDGES, THE AASHTO LRFD BRIDGE DESIGN SPECIFICATION, THE AASHTO/AWS BRIDGE WELDING CODE (ASI/AASHTO/AWS D1.5), AND ALL INTERIM REVISIONS PUBLISHED BY AASHTO AS OF THE BID OPENING DATE. ALL SUPPORT ANGLES AND MECHANICAL REINFORCING BAR SPLICERS AND COUPLERS SHALL BE IN ACCORDANCE WITH THE BRIDGE WELDING CODE; ANSI/AASHTO/AWS D1.5; AND IN ACCORDANCE WITH INTERIM PUBLISHED BY AASHTO AS OF THE BID OPENING DATE.

UTILITIES:
THE CONTRACTOR SHALL LOCATE AND PROTECT FROM DAMAGE OR RELOCATE, AS NECESSARY, ANY EXISTING UTILITIES/POLES. THE CONTRACTOR SHALL COORDINATE AND COOPERATE WITH THE RESPECTIVE UTILITY OWNERS FOR ALL UTILITIES THAT ARE TO BE TEMPORARILY OR PERMANENTLY RELOCATED FOR BRIDGE REPLACEMENT WORK.

TRAFFIC:
CONSTRUCTION SHALL TAKE PLACE IN SEVERAL STAGES AND THE BRIDGE WILL BE OPEN TO THRU-TRAFFIC IN ONE DIRECTION AND DETOURED IN THE OTHER DIRECTION. REFER TO THE STAGE CONSTRUCTION PLANS AND SECTIONS, THE TRAFFIC MANAGEMENT AND/OR DETOUR PLANS FOR TRAFFIC CONTROL DURING DEMOLITION AND CONSTRUCTION.

ESTIMATED QUANTITIES (NOT GUARANTEED)

ITEM NO	DESCRIPTION	QTY	UNIT
100.91	PRECONSTRUCTION SURVEY AND MONITORING OF EXISTING STRUCTURES	1	LS
114.2	DEMOLITION OF SUPERSTRUCTURE OF BRIDGE NO S-24-026	1	LS
127.1	REINFORCED CONCRETE EXCAVATION	180	CY
140.0	BRIDGE EXCAVATION	1627	CY
144	CLASS B ROCK EXCAVATION	172	CY
151.2	GRAVEL BORROW FOR BACKFILLING STRUCTURES AND PIPES	815	CY
156	CRUSHED STONE	191	TON
450.611	SUPERPAVE BRIDGE SURFACE COURSE - 12.5 POLYMER (SSC-B - 12.5 - P)	35	TON
450.711	SUPERPAVE BRIDGE PROTECTIVE COURSE – 12.5P POLYMER (SPC-B - 12.5 - P)	47	TON
458.7	LIGHTWEIGHT AGGREGATE	1048	CY
853.33	TEMPORARY BARRIER - LIMITED DEFLECTION (TL-3)	106	FT
904.3	5000 PSI 3/4IN 685 HP CEMENT CONCRETE	623	CY
904.33	PRECAST CONCRETE PANELS 5 1144	2439	SF
909.5	RAPID HARDENING CEMENTITIOUS PRODUCTS	8	CY
910.2	STEEL REINFORCEMENT FOR STRUCTURES - COATED	62090	LB
912.5	DRILLED AND GROUTED #5 DOWELS	57	EA
942.283	STEEL PILE W18X283	326	FT
942.311	STEEL PILE W18X311	1006	FT
942.89	STEEL PILE W16X89	1119	FT
945.10	DRILLED MICROPILES	9076	FT
945.101	DRILLED SHAFT EXCAVATION 3.0 FOOT DIAMETER	2039	FT
945.301	OBSTRUCTION EXCAVATION 3.0 FOOT DIAMETER	25	FT
945.501	DRILLED SHAFT 3.0 FOOT DIAMETER	2039	FT
948.60	MICROPILE VERIFICATION LOAD TEST	2	EA
948.61	MICROPILE PROOF LOAD TEST	8	EA
951.1	GRANITE CORING	120	FT
951.2	STEEL SLEEVE / CONCRETE CORING	360	FT
953.31	TEMPORARY EXCAVATION SUPPORT SYSTEM	1	LS
970	DAMP-PROOFING	4165	SF
975.4	PROTECTIVE SCREEN TYPE II	168	FT
975.5	ALUMINUM HANDRAIL	150	FT
992.35	TEMPORARY SUPPORTS FOR UTILITIES - SYSTEM 3	1	LS
995.02	BRIDGE STRUCTURE, BRIDGE NO. S-24-026	1	LS

SPRINGFIELD
ARMORY STREET/RR CSX (ABANDONED)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-0035(924)	132	204
PROJECT FILE NO. 609409			

GENERAL NOTES & QTY'S

PROJECT INFORMATION
PROJECT FILE NO.: 609409
PROJECT DESCRIPTION: BRIDGE REPLACEMENT BRIDGE NO. S-24-026
BRIDGE DESIGN LOADING: HL-93
SURVEY: SURVEY BY GREEN INTERNATIONAL AFFILIATES, INC.
ELEVATION REFERENCE: NAVD OF 1988
BENCH MARK [502] CHSQ CONC BASE ELEC BOX EL = 156.57'

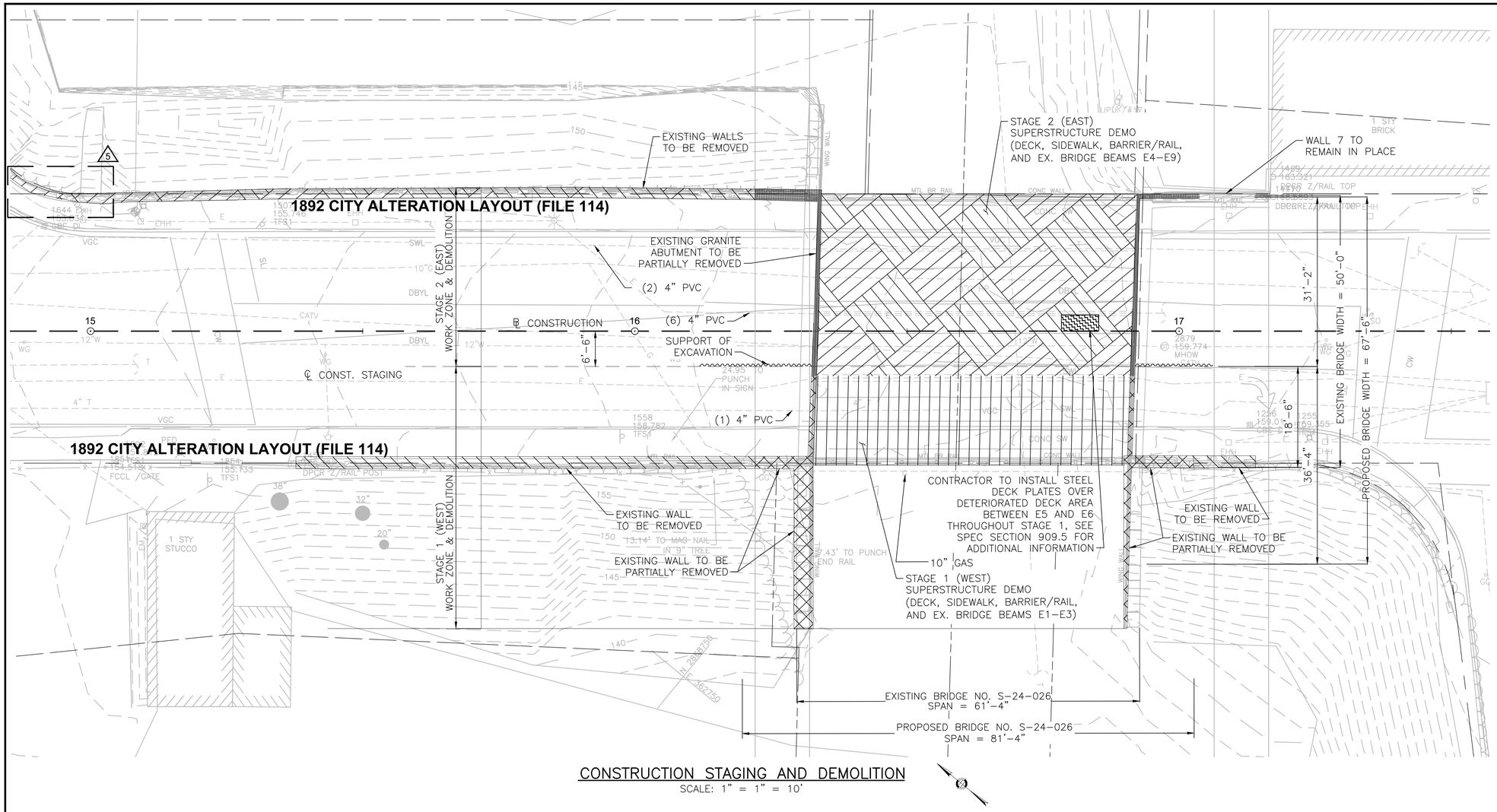
TRAFFIC DATA	ROADWAY OVER	ROADWAY UNDER
DESIGN YEAR	2024	
AVERAGE DAILY TRAFFIC-PRESENT	15800	
AVERAGE DAILY TRAFFIC-DESIGN YEAR	16200	
DESIGN HOURLY VOLUME (2019)	1280	
DIRECTIONAL DISTRIBUTION	55%	
TRUCK PERCENTAGE-AVERAGE DAY	3.5%	
TRUCK PERCENTAGE-PEAK HOUR	7.5%	
DESIGN SPEED	25 mph	
DIRECTIONAL DESIGN HOURLY VOLUME (2019)	920	

SEISMIC DESIGN CRITERIA	
DESIGN RETURN PERIOD:	1000-YEAR
DESIGN SPECTRA	
As	0.148
SDs	0.325
SD1	0.133
SITE CLASS	E
SEISMIC DESIGN CATEGORY (SDC)	A

DEC 20, 2025	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION

THIS SHEET IS APPROVED FOR CONSTRUCTION BY MASSDOT
AUTHORIZED SIGNATORY: _____ STATE BRIDGE ENGINEER
USE ONLY PRINTS OF LATEST DATE

S-24-026 (GENERAL NOTES & QTY'S).DWG Plotted on 27-Mar-2026 10:39 AM
Xxxxx Structural Submittal (S#) DD-Month-YYYY



CONSTRUCTION STAGING AND DEMOLITION
SCALE: 1" = 1" = 10'

SPRINGFIELD
ARMORY STREET/RR CSX (ABANDONED)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-0035(924)	144	204
PROJECT FILE NO. 609409			

CONSTRUCTION STAGING AND DEMOLITION

NOTES:

1. AREA SHOWN THUS ▨ & ▨ INDICATES A THE EXISTING STRUCTURE/WALL TO BE DEMOLISHED IN STAGE 1 AND STAGE 2 RESPECTIVELY.
2. AREA SHOWN THUS ▩ & ▥ INDICATES A PORTION OF EXISTING STRUCTURE/WALL TO BE DEMOLISHED IN STAGE 1 AND STAGE 2 RESPECIVELY.
3. EXISTING DIMENSIONS ARE BASED UPON EXISTING DRAWINGS AND SURVEY DATA AND SHALL BE VERIFIED BY THE CONTRACTOR IN THE FIELD.
4. SEE SHEETS 15–21 FOR ADDITIONAL DEMOLITION DETAILS AND CONSTRUCTION STAGING.

	STAGE 1 (WEST)	STAGE 2 (EAST)
DEMOLITION OF EXISTING STRUCTURE/WALL	▨	▨
PARTIAL DEMOLITION OF EXISTING STRUCTURE/WALL	▩	▥

DEC 20, 2025	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION

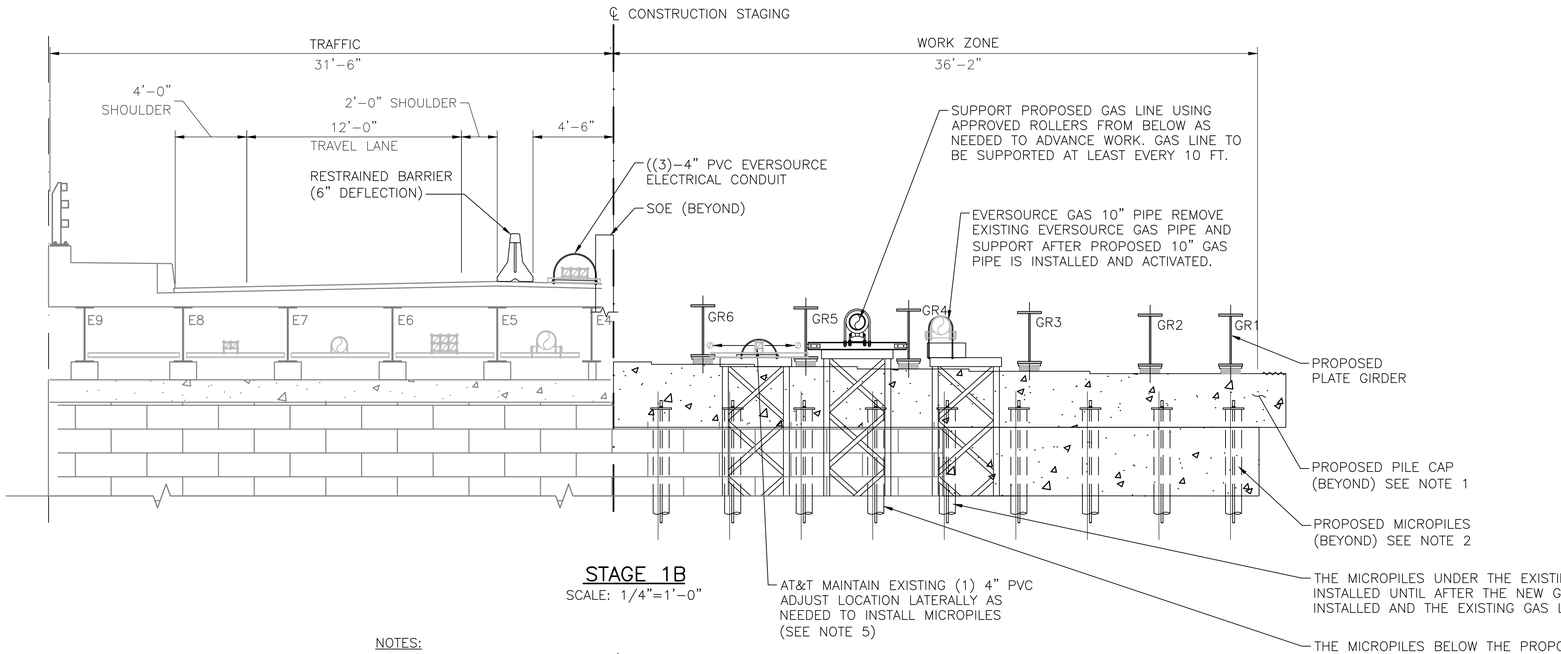
THIS SHEET IS APPROVED FOR CONSTRUCTION BY MASSDOT
AUTHORIZED SIGNATORY: _____ STATE BRIDGE ENGINEER
USE ONLY PRINTS OF LATEST DATE

S-24-026 (Exist Wall Demolition Plan).dwg
S-24-026 (EXIST WALL DEMOLITION PLAN).DWG Plotted on 27-Mar-2026 10:41 AM
Xxxxx Structural Submittal (S#) DD-Month-YYYY

SPRINGFIELD
ARMORY STREET/RR CSX (ABANDONED)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-0035(924)	149	204
PROJECT FILE NO. 609409			

CONSTRUCTION STAGING

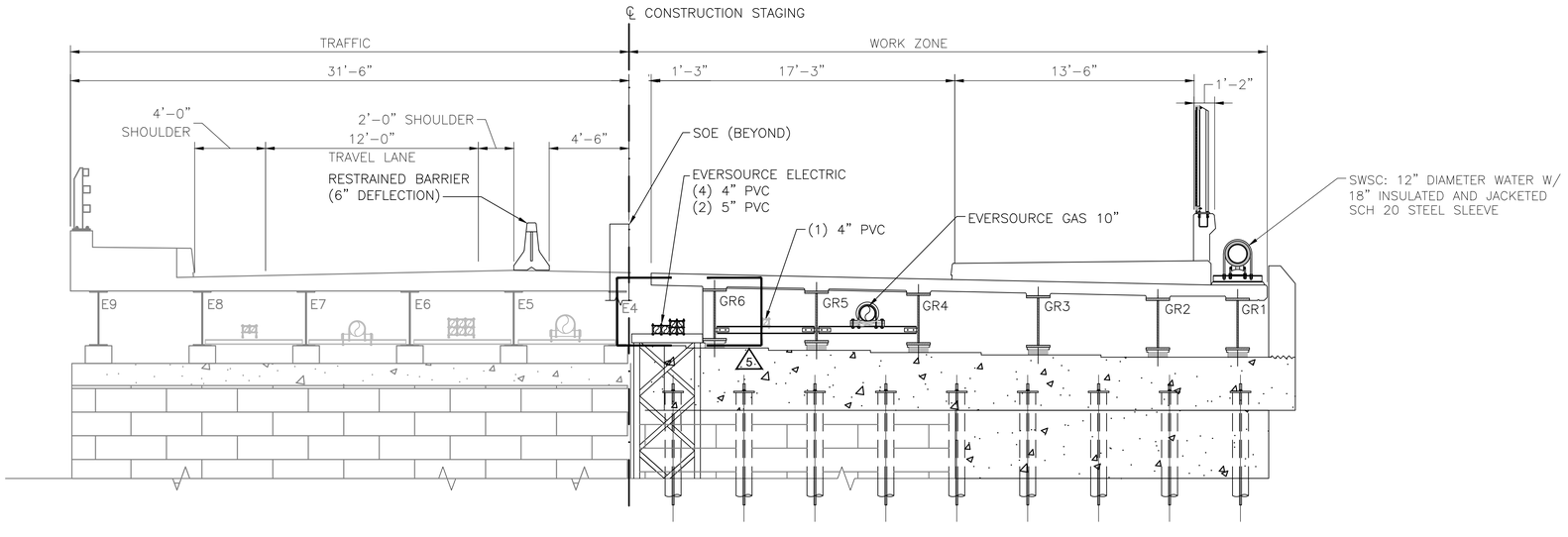


STAGE 1B
SCALE: 1/4"=1'-0"

NOTES:
CONSTRUCT ABUTMENT EXTENSION/CRASH WALL. CONSTRUCT ABUTMENT PILE CAP AND BRIDGE SEATS INSTALL MICROPILES (INTO SOIL) BEHIND THE EXISTING GRANITE ABUTMENT. INSTALL NEW GIRDERS. RELOCATE UTILITIES IN PROPOSED BAYS. MAINTAIN UTILITY SUPPORT STRUCTURE FOR ALL ACTIVE UTILITIES AS NOTED.

NOTES:

1. THE PROPOSED SOUTH AND NORTH PILE CAP IS TO BE INSTALLED BEHIND THE EXISTING GRANITE ABUTMENT AND THE PROPOSED ABUTMENT EXTENSION (CRASH WALL).
2. THE PROPOSED SOUTH AND NORTH ABUTMENT MICROPILES ARE TO BE BE INSTALLED INTO SOIL AND BEHIND THE EXISTING GRANITE ABUTMENT AND THE PROPOSED ABUTMENT EXTENSION (CRASH WALL).
3. SOUTH ABUTMENT SHOWN AND NORTH ABUTMENT SIMILAR.
4. THROUGHOUT CONSTRUCTION, UTILITIES SHALL BE PROTECTED FROM FALLING DEBRIS AND CONSTRUCTION OPERATIONS BY THE CONTRACTOR.
5. AT&T SHALL BREAK THE LINE OUT OF THE CONDUIT TO ACHIEVE THE DESIRED SLACK DURING THE TEMPORARY RELOCATION AND INSTALLING SPLIT CASING AFTER THE MICROPILE WORK IS COMPLETE. WHEN IN CONDUIT, SUPPORT MUST BE PROVIDED AT LEAST EVERY 10 FT. WHEN OUT OF THE CONDUIT, CONTINUOUS SUPPORT IS REQUIRED.



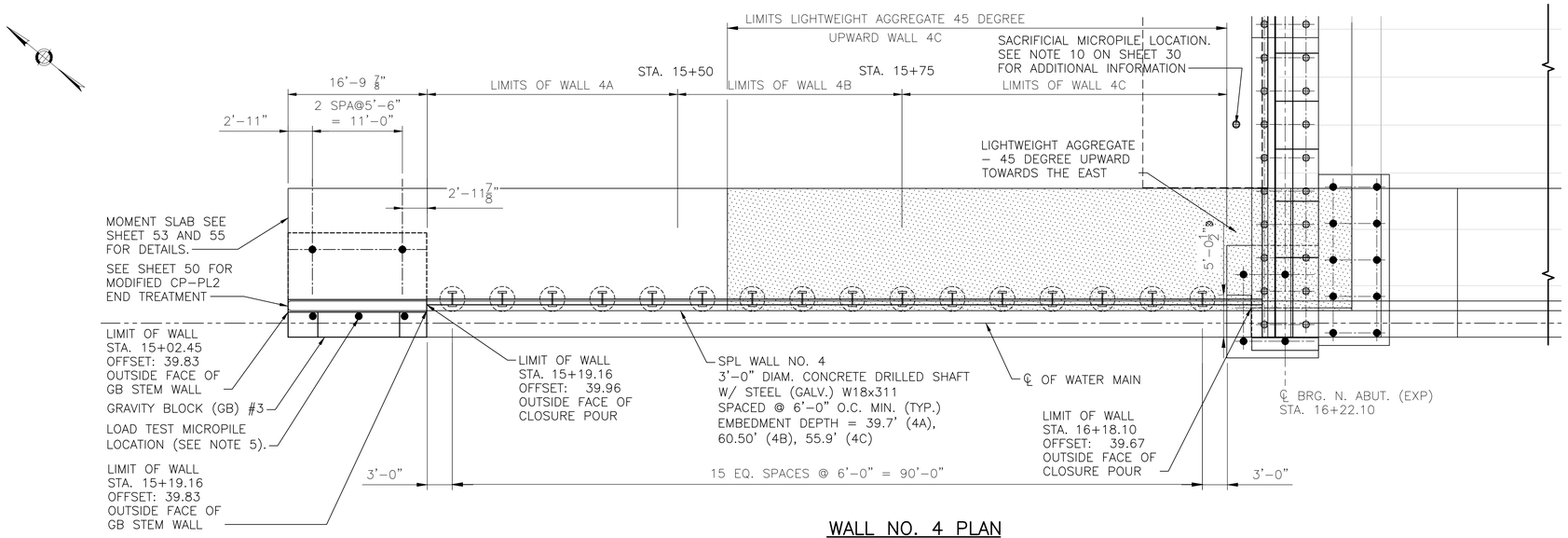
STAGE 1C
SCALE: 1/4"=1'-0"

NOTES:
CONSTRUCT DECK, DECK SLAB EXTENSION, SHARED USED PATH & BRIDGE BARRIER. PROPOSED WATER MAIN TO BE INSTALLED ON PROPOSED DECK SLAB EXTENSION. REMOVE UTILITY SUPPORTS AFTER RELOCATED UTILITIES HAVE BEEN ACTIVATED.

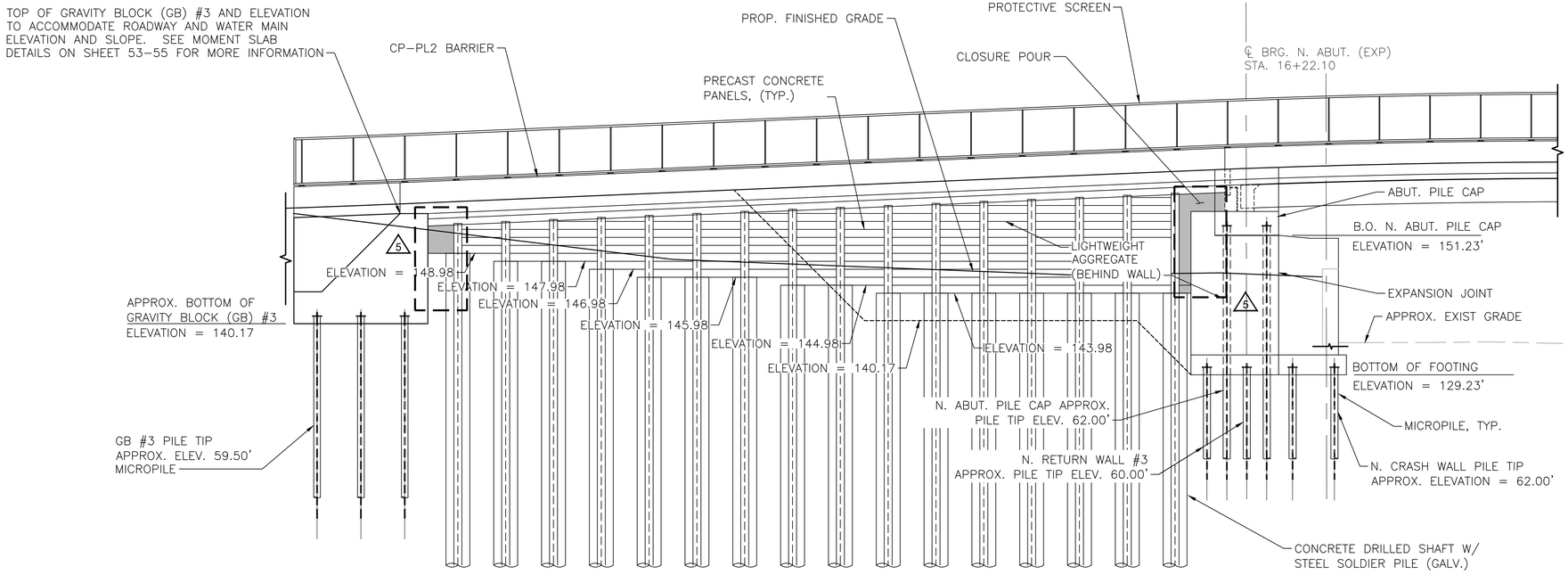
DEC 20, 2025	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION

THIS SHEET IS APPROVED FOR CONSTRUCTION BY MASSDOT
AUTHORIZED SIGNATORY: _____ STATE BRIDGE ENGINEER
USE ONLY PRINTS OF LATEST DATE

S-24-026 (CONSTRUCTION STAGING PLAN-DET).DWG Plotted on 27-Mar-2026 10:44 AM
Xxxxxx Structural Submittal (S#) DD-Month-YYYY



WALL NO. 4 PLAN
SCALE: 1/8" = 1'-0"



WALL NO. 4 ELEVATION
SCALE: 1/8" = 1'-0"

SPRINGFIELD
ARMORY STREET/RR CSX (ABANDONED)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-003S(924)	154	204
PROJECT FILE NO. 609409			

RETAINING WALLS, SOLDIER PILE AND LAGGING WALLS NO. 4

NOTES:

1. SEE SHEETS 27, 28 & 29 FOR WALL SECTIONS AND DETAILS.
2. SEE SHEETS 33 & 34 FOR SOLDIER PILE AND LAGGING WALL DETAILS AND ADDITIONAL INFORMATIONS.
3. SEE SHEETS 30 & 31 FOR MICROPILE DETAILS AND ADDITIONAL INFORMATION.
4. REFER TO HIGHWAY PLANS FOR ROADWAY GRADES TO DETERMINE WALL ELEVATIONS.
5. SUGGESTED LOCATION(S) OF PRODUCTION MICROPILE FOR PROOF LOAD TEST (ITEM 948.61). CONTRACTOR TO SELECT THE PROOF LOAD TEST LOCATION(S) WITH THE APPROVAL OF THE ENGINEER.

DEC 20, 2025	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION

THIS SHEET IS APPROVED FOR CONSTRUCTION BY MASSDOT
AUTHORIZED SIGNATORY: _____ STATE BRIDGE ENGINEER
USE ONLY PRINTS OF LATEST DATE

S-24-026 (PROPOSED RETAINING WALLS NO 4-7).DWG Plotted on 27-Mar-2026 10:52 AM
Xxxxx Structural Submittal (S#) DD-Month-YYYY

5 ADDENDUM NO.5, APRIL 1, 2026

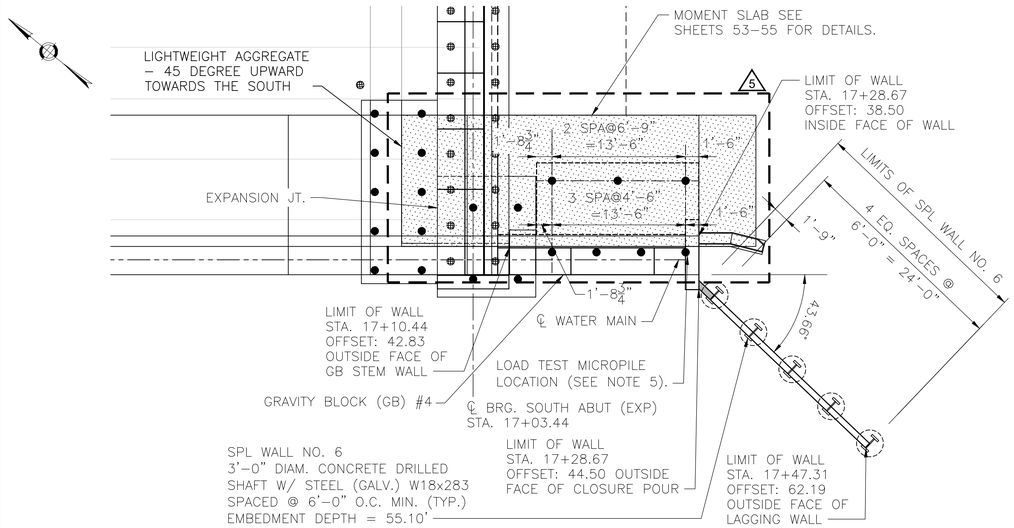
SPRINGFIELD
ARMORY STREET/RR CSX (ABANDONED)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-003S(924)	155	204
PROJECT FILE NO. 609409			

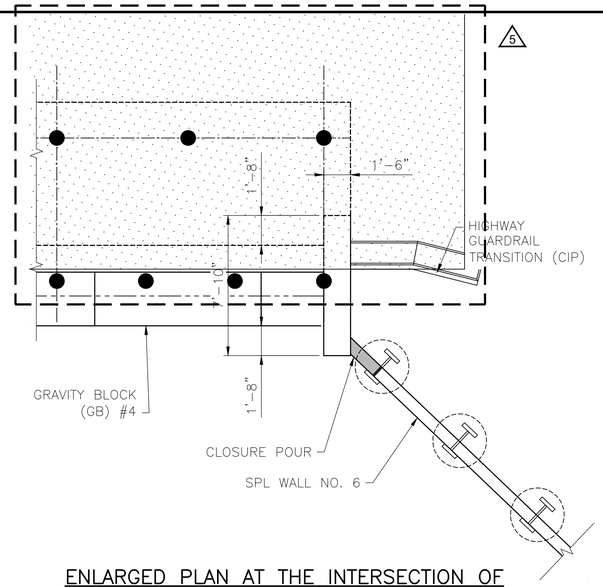
RETAINING WALLS, SOLIDER PILE AND LAGGING WALL NO. 6

NOTES:

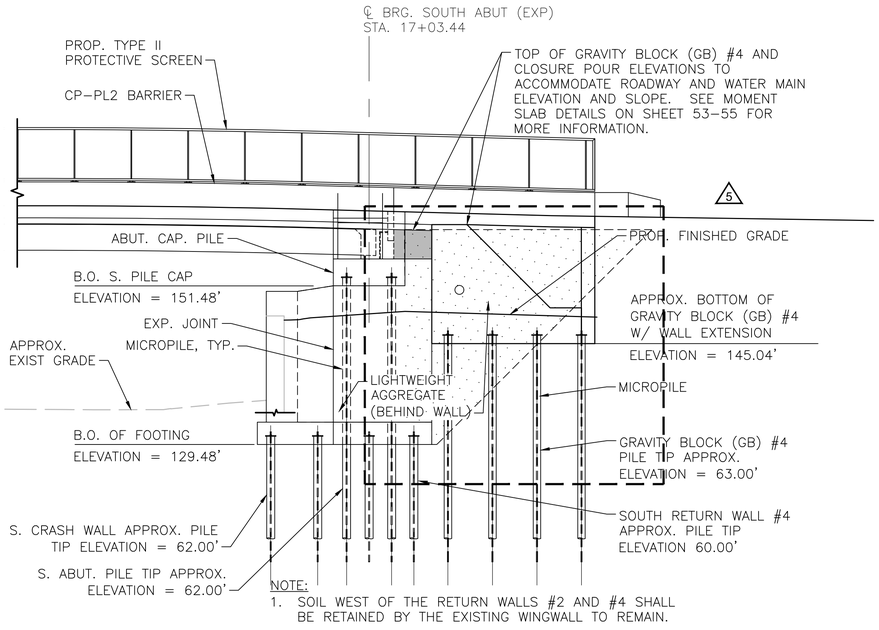
1. SEE SHEETS 27, 28 & 29 FOR WALL SECTIONS AND DETAILS.
2. SEE SHEETS 33 & 34 FOR SOLDIER PILE AND LAGGING WALL DETAILS AND ADDITIONAL INFORMATION.
3. SEE SHEETS 30 & 31 FOR MICROPILE DETAILS AND ADDITIONAL INFORMATION.
4. REFER TO HIGHWAY PLANS FOR ROADWAY GRADES TO DETERMINE WALL ELEVATIONS.
5. SUGGESTED LOCATION(S) OF PRODUCTION MICROPILE FOR PROOF LOAD TEST (ITEM 948.61). CONTRACTOR TO SELECT THE PROOF LOAD TEST LOCATION(S) WITH THE APPROVAL OF THE ENGINEER.



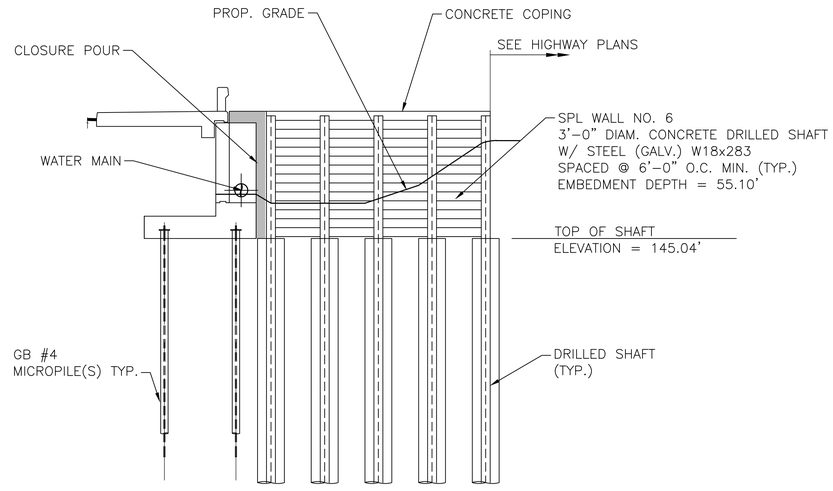
WALL NO. 6 PLAN
SCALE: 1/8" = 1'-0"



ENLARGED PLAN AT THE INTERSECTION OF GB #4 AND SPL WALL NO. 6 PLAN
SCALE: 1/4" = 1'-0"

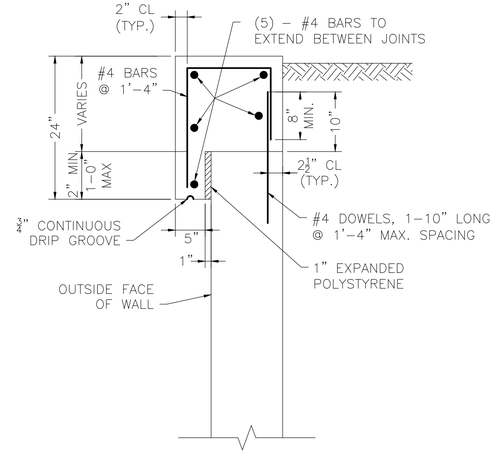


GRAVITY BLOCK (GB) #4
SCALE: 1/8" = 1'-0"



NOTE:
HGT (BEYOND) NOT SHOWN FOR CLARITY.

WALL NO. 6 ELEVATION
SCALE: 1/8" = 1'-0"



CAST–IN–PLACE CONCRETE COPING DETAIL
SCALE: 1 1/2" = 1'-0"

DEC 20, 2025	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION

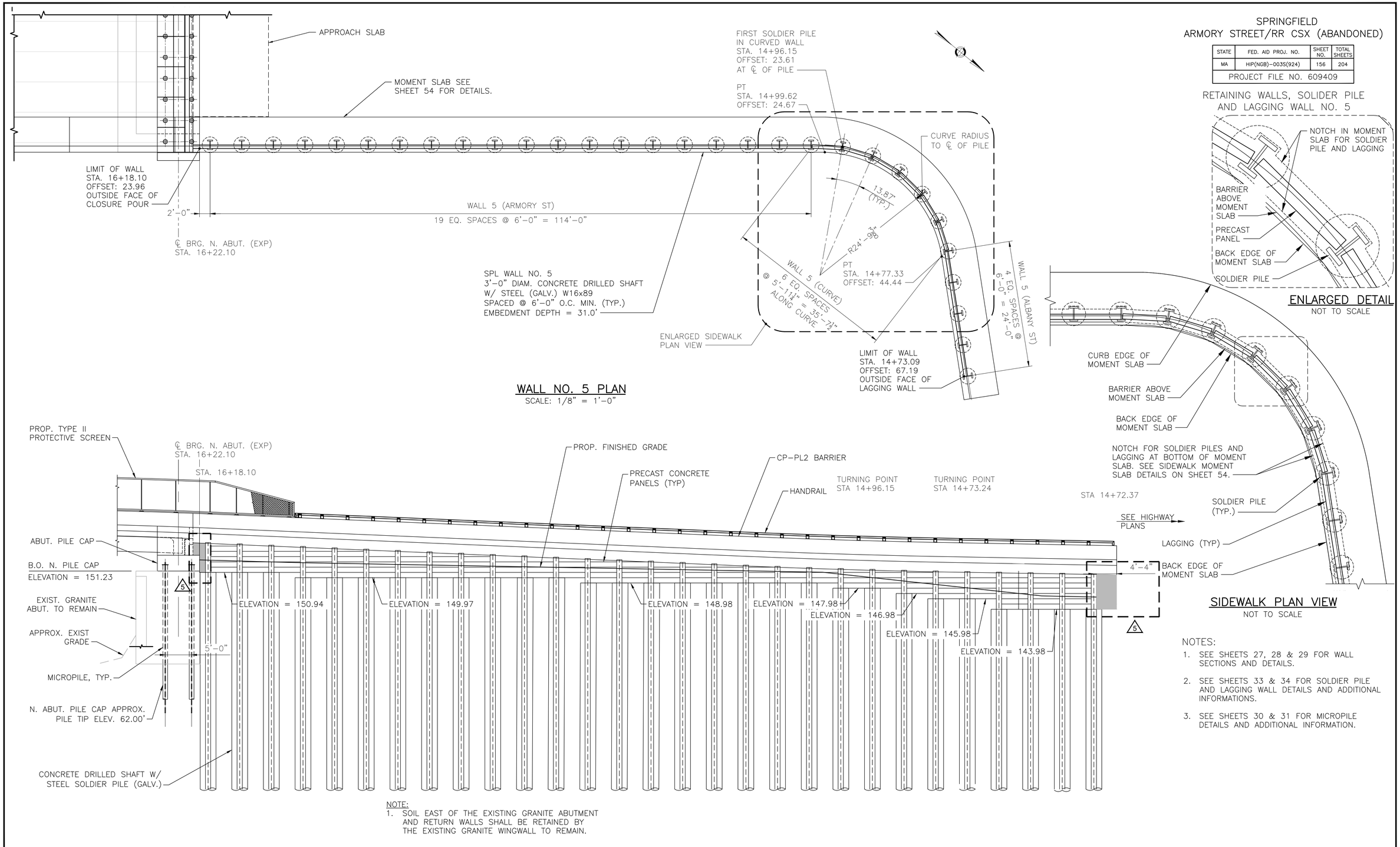
THIS SHEET IS APPROVED FOR CONSTRUCTION BY MASSDOT
AUTHORIZED SIGNATORY: STATE BRIDGE ENGINEER
USE ONLY PRINTS OF LATEST DATE

S-24-026 (PROPOSED RETAINING WALLS NO 4-7).DWG Plotted on 27-Mar-2026 10:53 AM
Xxxxxx Structural Submittal (S#) DD-Month-YYYY

SPRINGFIELD
ARMORY STREET/RR CSX (ABANDONED)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-003S(924)	156	204
PROJECT FILE NO. 609409			

RETAINING WALLS, SOLIDER PILE AND LAGGING WALL NO. 5



WALL NO. 5 PLAN
SCALE: 1/8" = 1'-0"

NOTE:
1. SOIL EAST OF THE EXISTING GRANITE ABUTMENT AND RETURN WALLS SHALL BE RETAINED BY THE EXISTING GRANITE WINGWALL TO REMAIN.

WALL NO. 5 ELEVATION (DEVELOPED LENGTH)
SCALE: 1/8" = 1'-0"

ENLARGED DETAIL
NOT TO SCALE

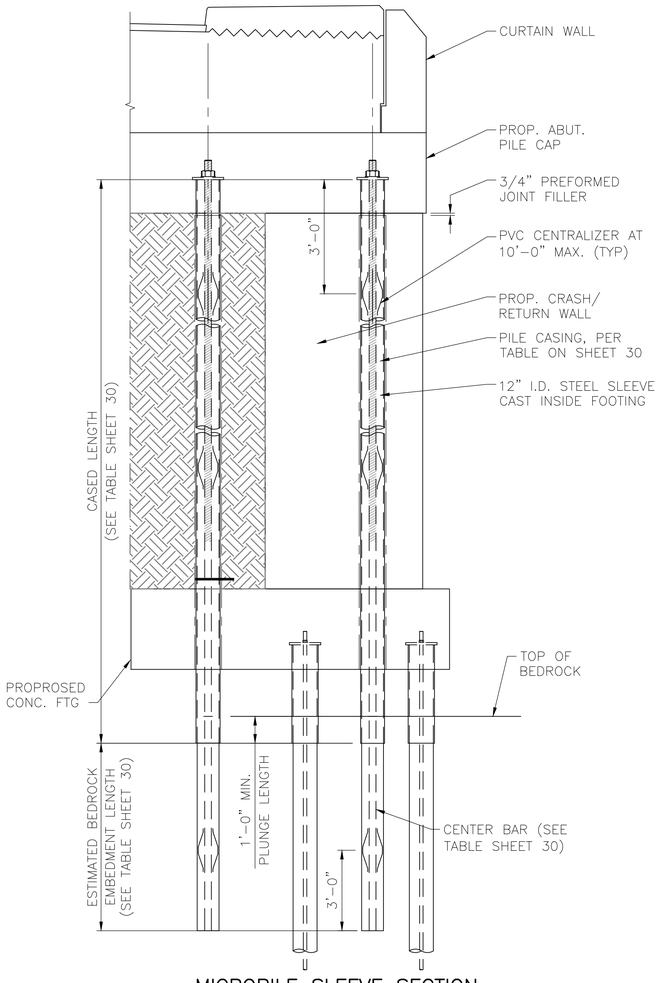
SIDEWALK PLAN VIEW
NOT TO SCALE

NOTES:
1. SEE SHEETS 27, 28 & 29 FOR WALL SECTIONS AND DETAILS.
2. SEE SHEETS 33 & 34 FOR SOLDIER PILE AND LAGGING WALL DETAILS AND ADDITIONAL INFORMATIONS.
3. SEE SHEETS 30 & 31 FOR MICROPILE DETAILS AND ADDITIONAL INFORMATION.

DEC 20, 2025	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION

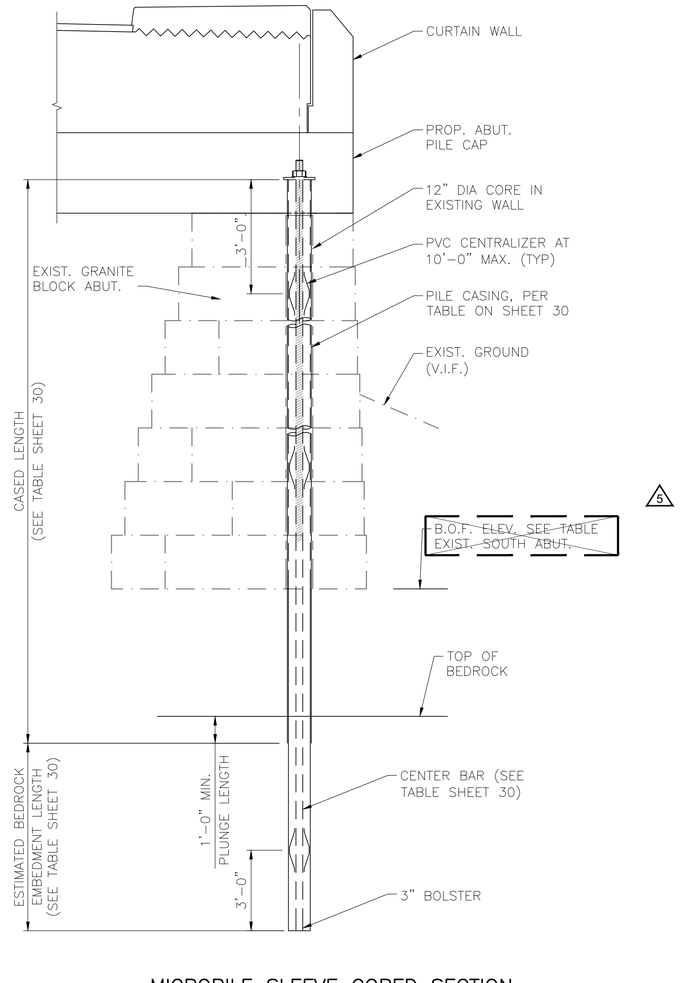
THIS SHEET IS APPROVED FOR CONSTRUCTION BY MASSDOT
AUTHORIZED SIGNATORY: STATE BRIDGE ENGINEER
USE ONLY PRINTS OF LATEST DATE

S-24-026 (PROPOSED RETAINING WALLS NO 4-7).DWG Plotted on 27-Mar-2026 10:54 AM
Xxxxxx Structural Submittal (S#) DD-Month-YYYY



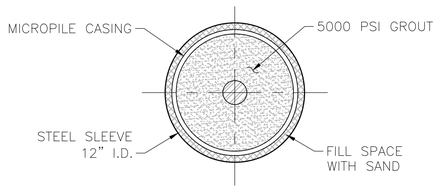
MICROPILE SLEEVE SECTION

SCALE: 3/8" = 1'-0"

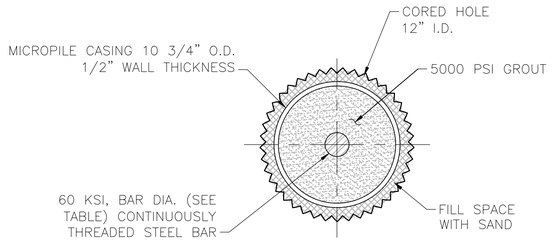


MICROPILE SLEEVE CORED SECTION

SCALE: 3/8" = 1'-0"



MICROPILE AT SLEEVE ZONE



MICROPILE AT CORED ZONE

SPRINGFIELD
ARMORY STREET/RR CSX (ABANDONED)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-0035(924)	161	204
PROJECT FILE NO. 609409			

TYPICAL MICROPILE – SECTIONS AND DETAILS SHEET 2 OF 2

NOTES:

1. SEE TABLE ON SHEET 30 FOR FACTORED AXIAL DESIGN LOAD PER MICROPILE.
2. STEEL SLEEVE SHALL BE PRIME STEEL AND MEET THE REQUIREMENTS OF API 5L PSL1 GRADE 52 WITH SR 15 SUPPLEMENTAL REQUIREMENTS. NO CASING JOINT SHALL BE IN THE TOP THREE FEET OF THE PILE BELOW THE PILE CAP AND PROPOSED CONCRETE FOOTING.

PRE-DRILLING NOTES:

1. PRIOR TO INSTALLING THE MICROPILES THROUGH THE EXISTING ABUTMENT, AN APPROXIMATELY 12-INCH DIAMETER HOLE NEEDS TO BE CORED THROUGH THE ENTIRE HEIGHT OF THE EXISTING ABUTMENT. AFTER THE MICROPILE INSTALLATION, THE ANNULUS OF THE MICROPILE CASING AND THE CORED HOLES IN THE EXISTING ABUTMENT OR PREVIOUSLY EMBEDDED OPENING THROUGH THE ABUTMENT EXTENSION SHALL BE FILLED WITH SAND AFTER THE MICROPILES ARE INSTALLED.

MICROPILE STEEL SLEEVE NOTES:

1. STEEL SLEEVES SHALL HAVE A INSIDE DIAMETER OF 12" MIN. AND EXTEND FROM THE BOTTOM OF THE BRIDGE PILE CAP TO THE BOTTOM OF FOOTING.
2. STEEL SLEEVES SHALL BE INSTALLED PRIOR TO THE CRASH & RETURN WALLS.

DEC 20, 2025	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION

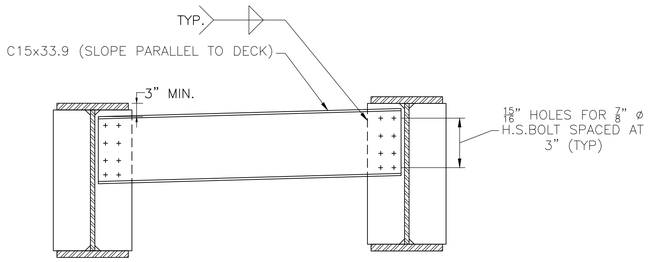
THIS SHEET IS APPROVED FOR CONSTRUCTION BY MASSDOT
AUTHORIZED SIGNATORY: _____ STATE BRIDGE ENGINEER
USE ONLY PRINTS OF LATEST DATE

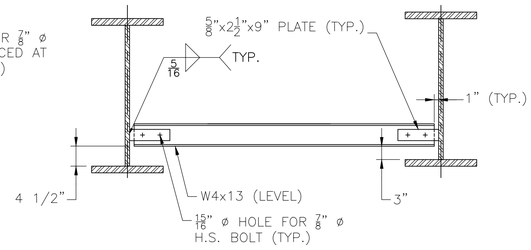
S-24-026 (Micropile Details).dwg
S-24-026 (MICROPILE DETAILS).DWG Plotted on 27-Mar-2026 11:06 AM
Xxxxx Structural Submittal (S#) DD-Month-YYYY

SPRINGFIELD
ARMORY STREET/RR CSX (ABANDONED)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-003S(924)	176	204
PROJECT FILE NO. 609409			

DIAPHRAGM AND
UTILITY SUPPORT DETAILS



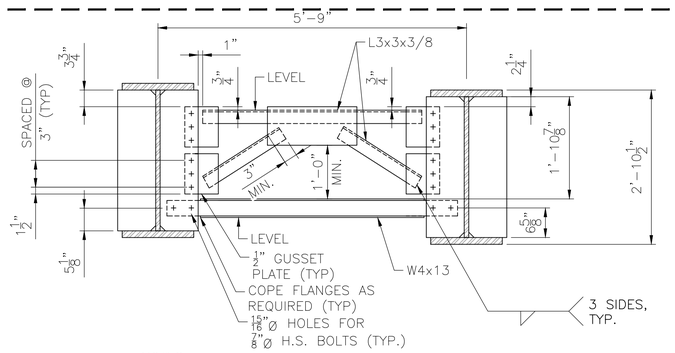


NOTES:
1. SEE CLIP DETAIL ON SHEET 44.
2. TERMINATE FILLET WELDS 1/2" SHORT OF ALL PLATE EDGES.

TYPICAL END DIAPHRAGM FRAME DETAIL (C1)
SCALE: 3/4" = 1'-0"

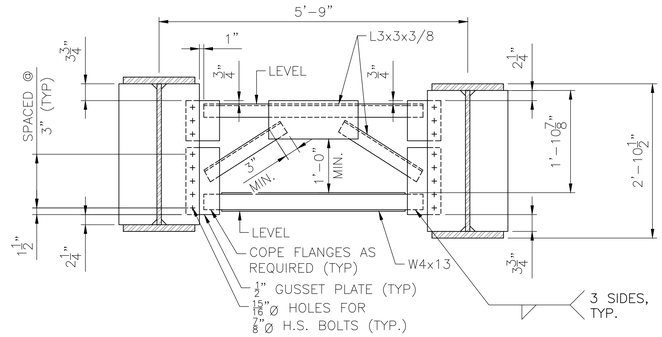
TYPICAL UTILITY SUPPORT FRAME BETWEEN DIAPHRAGMS DETAIL (U1)
SCALE: 3/4" = 1'-0"

5



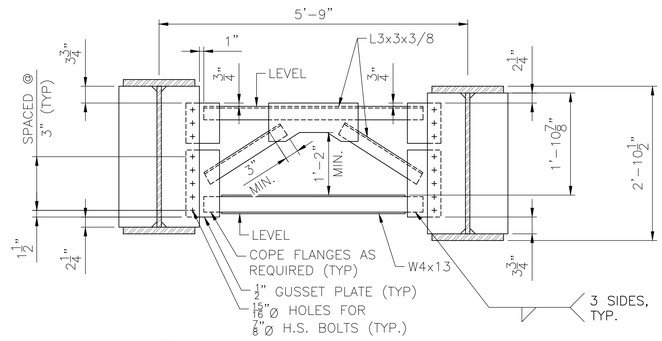
NOTES:
1. SEE CLIP DETAIL ON SHEET 44.
2. TERMINATE FILLET WELDS 1/2" SHORT OF ALL PLATE EDGES.
3. FOR USE AS REQUIRED BY CONTRACTOR.

ALTERNATE INTERMEDIATE DIAPHRAGM/UTILITY SUPPORT FRAME DETAIL (U2)
SCALE: 3/4" = 1'-0"



NOTES:
1. SEE CLIP DETAIL ON SHEET 44.
2. TERMINATE FILLET WELDS 1/2" SHORT OF ALL PLATE EDGES.

TYPICAL INTERMEDIATE DIAPHRAGM/UTILITY SUPPORT FRAME DETAIL (U2)
SCALE: 3/4" = 1'-0"



NOTES:
1. SEE CLIP DETAIL ON SHEET 44.
2. TERMINATE FILLET WELDS 1/2" SHORT OF ALL PLATE EDGES.
3. GUSSET PLATE TO BE CHAMFERED AT AN ANGLE FOLLOWING THE SLOPE OF THE L3 DIAGONALTO PROVIDE A MINIMUM EDGE DISTNACE OF 1".

TYPICAL INTERMEDIATE DIAPHRAGM/UTILITY SUPPORT FRAME DETAIL (U3)
SCALE: 3/4" = 1'-0"

DEC 20, 2025	ISSUED FOR CONSIRUCIION
DATE	DESCRIPTION

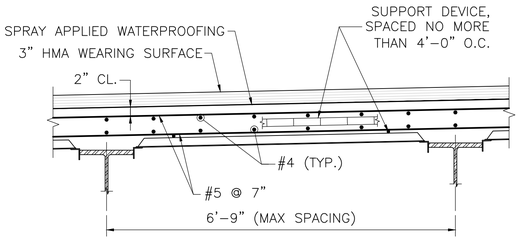
THIS SHEET IS APPROVED FOR CONSTRUCTION BY MASSDOT
AUTHORIZED SIGNATORY: _____ STATE BRIDGE ENGINEER
USE ONLY PRINTS OF LATEST DATE

S-24-026 (UTILITY SUPPORT DETAILS).DWG Plotted on 27-Mar-2026 11:09 AM
Xxxxxx Structural Submittal (S#) DD-Month-YYYY

SPRINGFIELD
ARMORY STREET/RR CSX (ABANDONED)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-003S(924)	180	204
PROJECT FILE NO. 609409			

DECK DETAILS 1 OF 3

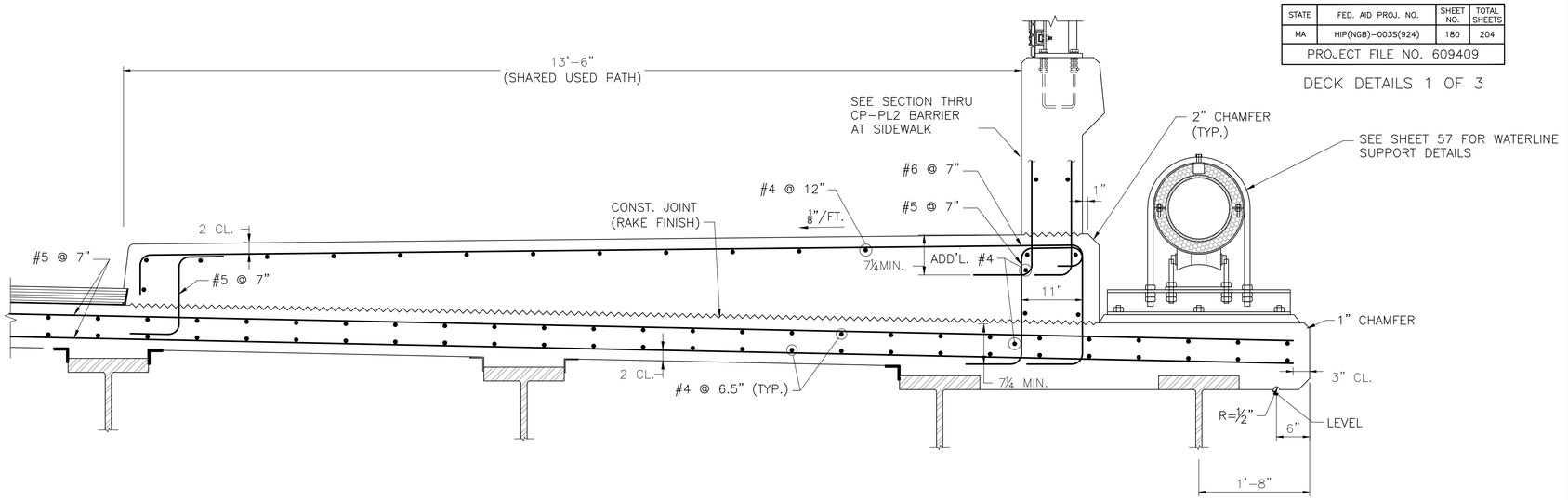


NOTES:

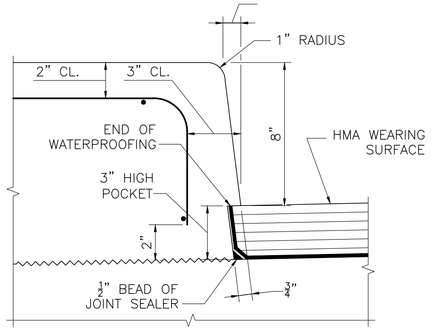
1. ROADWAY DECK SLAB SHALL BE 904.3 – 5000 PSI, ¾ IN, 685 HP CEMENT CONCRETE.
2. LONGITUDINAL REINFORCEMENT SHALL BE PLACED PARALLEL TO THE ℄ OF CONSTRUCTION. TRANSVERSE (PRIMARY) REINFORCEMENT SHALL BE PLACED PERPENDICULAR TO THE ℄ OF CONSTRUCTION.
3. ALL REINFORCEMENT AND SUPPORT DEVICES SHALL BE COATED.
4. THE FINISHED SURFACE OF BRIDGE DECK SHALL BE SMOOTH AND WITHOUT ANY PROJECTIONS THAT COULD PUNCTURE THE WATERPROOFING OR DEPRESSIONS THAT COULD RETAIN WATER.

5
~~4. BRIDGE DECK SHALL BE GROOVED TRANSVERSELY USING MULTI-BLADED SELF-PROPELLED SAWCUTTING EQUIPMENT.~~

TYPICAL DECK REINFORCEMENT
SCALE: ¾" = 1'-0"

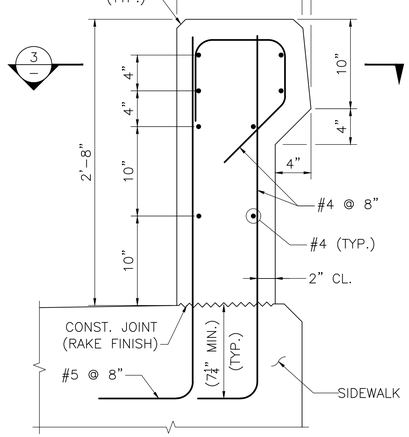


SECTION THRU SHARED USE PATH
SCALE: 1" = 1'-0"



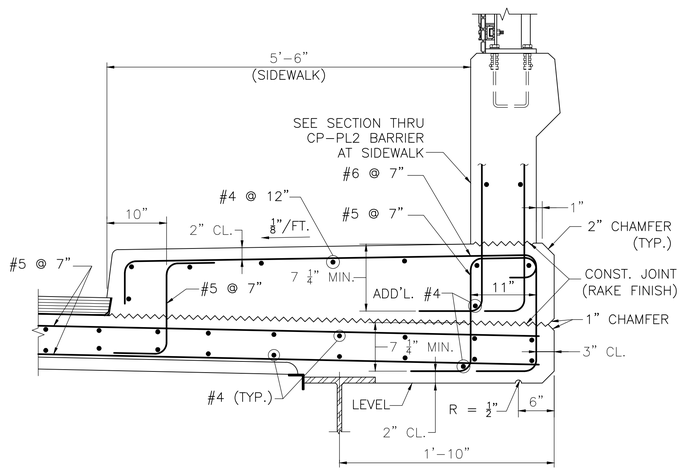
NOTE:
1. APPLY WATERPROOFING INTO 3" HIGH POCKET.

FACE OF SIDEWALK CURB DETAILS
SCALE: 3" = 1'-0"



NOTE:
FOR SIDEWALK REINFORCEMENT SEE SECTION THRU SIDEWALK.

SECTION THRU BARRIER AT SIDEWALK
SCALE: 1½" = 1'-0"



SECTION THRU SIDEWALK
SCALE: 1" = 1'-0"

DEC 20, 2025	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION

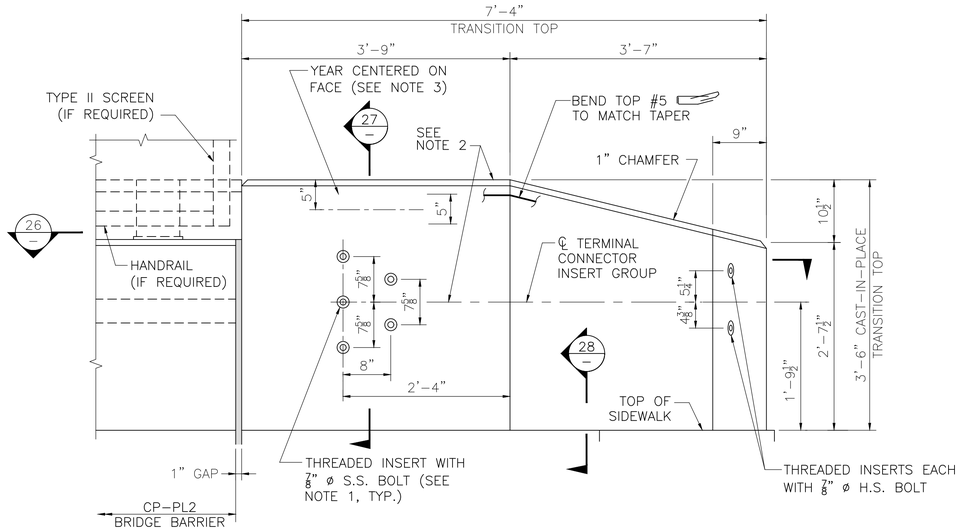
THIS SHEET IS APPROVED FOR CONSTRUCTION BY MASSDOT
AUTHORIZED SIGNATORY: _____ STATE BRIDGE ENGINEER
USE ONLY PRINTS OF LATEST DATE

S-24-026 (Deck Details).dwg
S-24-026 (DECK DETAILS).DWG Plotted on 27-Mar-2026 11:10 AM
Xxxxxx Structural Submittal (S#) DD-Month-YYYY

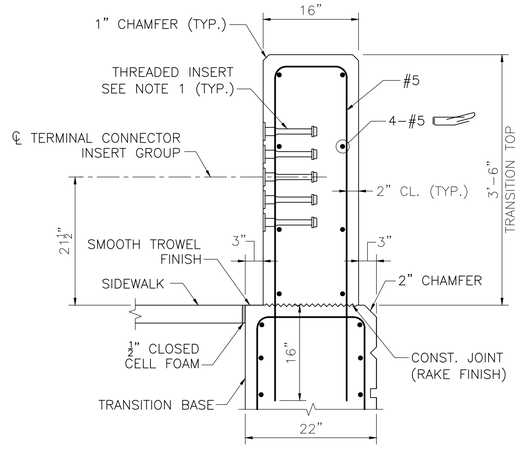
SPRINGFIELD
ARMORY STREET/RR CSX (ABANDONED)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	HIP(NGB)-0035(924)	191	204
PROJECT FILE NO. 609409			

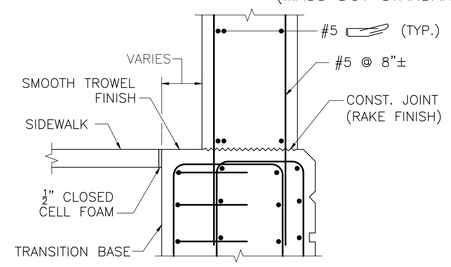
HIGHWAY GUARDRAIL TRANSITION
(MASS DOT STANDARD SHEETS)



ELEVATION AT SIDEWALK
SCALE: 1" = 1'-0"



SECTION 27 AT SIDEWALK
SCALE: 1" = 1'-0"

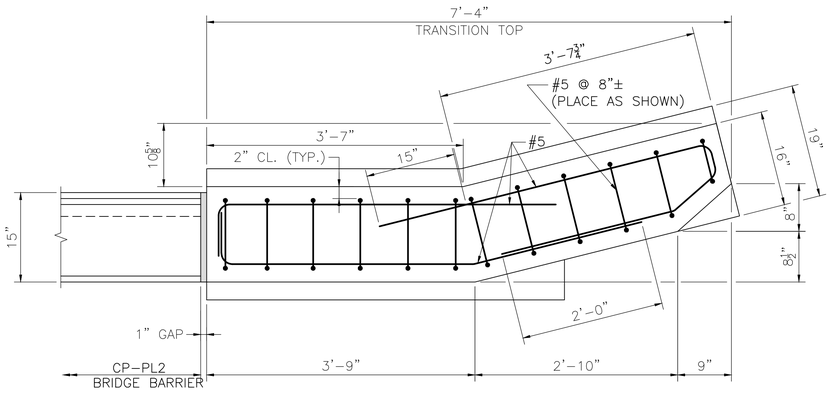


SECTION 28 AT SIDEWALK
SCALE: 1" = 1'-0"

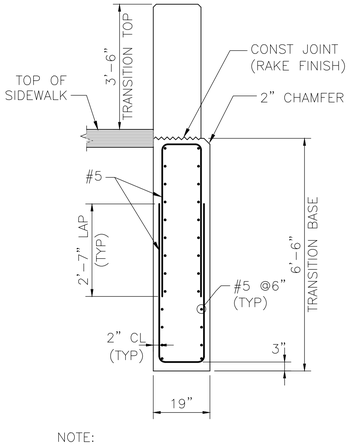
NOTES:

1. THREADED INSERTS SHALL BE PREQUALIFIED BY THE MANUFACTURER AS BEING CAPABLE OF DEVELOPING A NOMINAL SHEAR RESISTANCE OF 20 KIPS PER ⅞" ø S.S. BOLT. S.S. BOLTS SHALL BE ⅞" ø x 1½" LONG FULLY THREADED AISI TYPE 304N STAINLESS STEEL. INSERTS FOR ⅞" S.S. BOLTS SHALL BE GALVANIZED AND CAST INTO THE TRANSITION.
2. FOR AN APPROACH GRADE UP TO 3%, THE TRANSITION MAY BE CAST SQUARE AND SET PLUMB WITH THE MINIMUM EMBEDMENT DEPTH SHOWN. THE TERMINAL CONNECTOR INSERT GROUP SHALL BE SQUARE TO THE POST.

   FOR AN APPROACH GRADE IN EXCESS OF 3%, THE TRANSITION TOP AND THE TOP OF THE BRIDGE BARRIERS SHALL FOLLOW THE APPROACH GRADE. THE HEIGHT OF THE TRANSITION TOP SHALL VARY PROVIDED THAT THE MINIMUM DIMENSIONS SHOWN ON THE CONSTRUCTION DRAWINGS ARE MET. THE BOTTOM OF THE TRANSITION BASE SHALL BE SET LEVEL WITH THE MINIMUM EMBEDMENT DEPTH SHOWN. THE TERMINAL CONNECTOR INSERT GROUP SHALL BE SLOPED TO FOLLOW THE APPROACH GRADE.
3. USE LATEST CONTRACT COMPLETION YEAR IN EFFECT WHEN THE FIRST GUARDRAIL TRANSITION IS CAST. USE THIS YEAR FOR ALL GUARDRAIL TRANSITIONS.
4. ALL CONCRETE FOR THE PRECAST HIGHWAY GUARDRAIL TRANSITION SHALL BE 5000 PSI, ¾", 685 HP CEMENT CONCRETE. (5)
5. LIFTING DEVICES (NOT SHOWN), INCLUDING THEIR NUMBER AND LOCATION, SHALL BE DESIGNED AND DETAILED BY THE PRECASTER. THEY SHALL BE GALVANIZED AND SHALL BE PLACED AND RECESSED IN POCKETS TO PROVIDE 1½" CLEAR COVER TO THE FACE OF THE TRANSITION CONCRETE. THESE DEVICES SHALL BE CLEARLY SHOWN ON THE SHOP DRAWINGS ALONG WITH ALL SUPPORTING CALCULATIONS AND/OR CATALOG CUTS. ONCE THE PRECAST TRANSITION IS SET IN PLACE, THE LIFTING DEVICE POCKETS SHALL BE FILLED WITH A NON-SHRINK GROUT THAT MATCHES THE COLOR OF THE TRANSITION CONCRETE WHEN CURED AND THE FILLED POCKETS SHALL BE RUBBED WITH A CORUNDUM STONE TO BLEND OUT THE JOINTS.

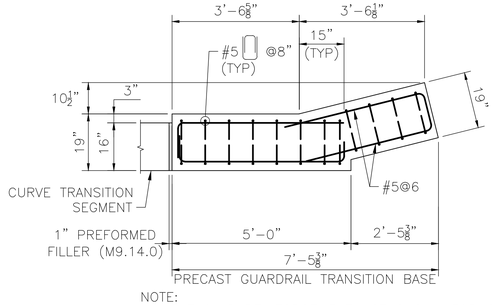


SECTION 26
SCALE: 1" = 1'-0"



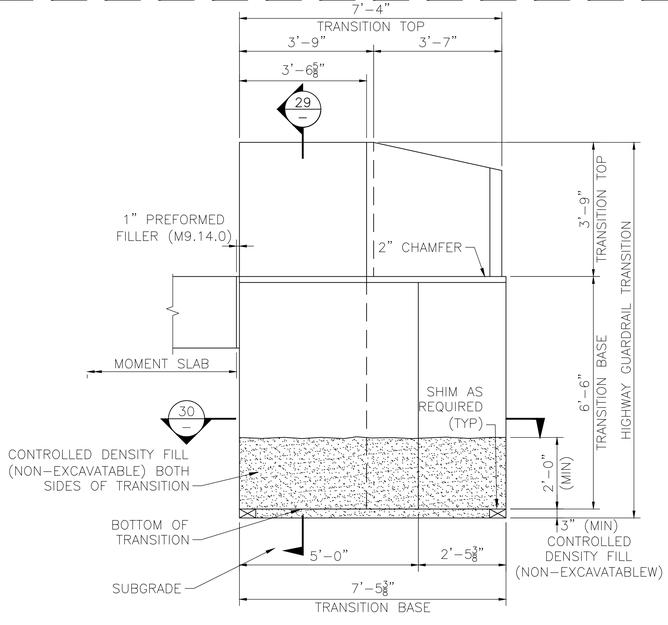
NOTE:
REINFORCEMENT OF THE TRANSITION TOP NOT SHOWN FOR CLARITY

SECTION 29
SCALE: 1/2" = 1'-0"



NOTE:
MOMENT SLAB REINFORCEMENT NOT SHOWN FOR CLARITY

SECTION 30
SCALE: 1/2" = 1'-0"



CIP GUARDRAIL TRANSITION ELEVATION
SCALE: 1/2" = 1'-0"

DEC 20, 2025	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION

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AUTHORIZED SIGNATORY: _____ STATE BRIDGE ENGINEER
USE ONLY PRINTS OF LATEST DATE

S-24-026 (MassDot Standard Sheets).dwg
S-24-026 (MASSDOT STANDARD SHEETS).DWG Plotted on 27-Mar-2026 11:12 AM
Xxxxxx Structural Submittal (S#) DD-Month-YYYY