

ADDENDUM NO. 5, November 1, 2024

⑦ ADDENDUM NO. 7, November 22, 2024

SUBITEM 981.01**INSTRUMENTATION AND STRUCTURE MONITORING**

The work under this subitem includes furnishing, installing, and recording geotechnical and structural monitoring instrumentation to measure vibrations and displacements of the two existing bridges during phased bridge demolition and replacement, and causeway widening construction. Settlement and lateral movement of the new causeway retaining wall during and following embankment reconstruction activities shall also be monitored. This geotechnical and structural monitoring instrumentation program is intended to provide early warning of stability and settlement issues so that construction procedures can be modified in a timely manner, if necessary.

- ⑦ Construction activities that cause vibrations and could result in the movement of the existing bridges include the following:
- **SOE Wall Installation:** Prior to the start of bridge demolition activities, excavation support walls (SOE) will be driven between the Stage 1 and Stage 2 work areas and along the toe of the causeway slope as shown on the BTC plans. The Design-Builder shall monitor the lateral movement of temporary earth support walls during construction.
 - **Stage 1 Bridge Demolition:** The BTC plans show the southern half of the two bridges will be demolished and replaced during Stage 1 Construction, while traffic is diverted to the northern half of the bridges. Demolition in the Stage 1 area will involve removal of the existing bridge superstructure, removal of the existing pier stems, partial removal of the existing abutments, extraction of existing timber piles that conflict with new structures, and removal of the existing wingwalls.
 - ⑦ ● **Stage 1 Bridge Construction:** Following completion of demolition in the Stage 1 area, drilled shafts will be installed at abutment and pier locations. Steel sheeting for cofferdam construction will also be installed at the pier locations.
 - **Stage 1 Bridge Monitoring:** The Design-Builder shall monitor movement of the in-service portion of the existing bridge and any newly constructed Stage 1 Bridge permanent structures during Stage 1 Demolition and Construction.
 - **Stage 2 Bridge Demolition, Construction, and Monitoring:** The process will be repeated for Stage 2 with the Design-Builder monitoring movement of the newly constructed Stage 1 permanent bridges during Stage 2 cofferdam construction, pier and abutment demolition, foundation installation, and bridge superstructure construction. Also monitor completed substructures of the Stage 2 bridge during construction of other parts of the Stage 2 bridge.
 - **Causeway Retaining Walls:** Monitor lateral movement of the top of the newly constructed Causeway retaining walls prior to and during the Causeway backfilling at optical survey points spaced at 25 ft along the horizontal alignment. In addition, inclinometers should be installed in critical areas to monitor for deep seated lateral movement of the retaining walls. Install inclinometers 5 ft outboard of the Post and Panel wall (river side), midway between the post locations.

MATERIALS**Seismographs:**

- ⑦ Portable engineering seismographs shall be used to monitor ground vibrations (frequency and velocity) resulting from vibration-producing construction activities, such as sheet pile driving and demolition. The seismographs used to monitor vibrations will be calibrated within 6 months of use. Geophones shall be coupled to the ground using ballast (e.g., sandbags) or to a structure using epoxy. Based on the anticipated construction activities, air blast monitoring will not be needed. One (1) Seismograph shall be installed at each existing pier and abutment.

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The seismographs shall have the following minimum features:

- Seismic range: 0.01 to 10 inches per second with an accuracy of 5 percent and no more than 3db roll off at the low frequency.
- Flat frequency response: 20 to 200 Hertz.
- Three component sensor.
- Fourth channel for air blast monitoring.
- Two power sources: Internal rechargeable battery and charger and 115-volt AC. Battery shall be capable of supplying power to monitor vibrations continuously for up to 24 hours.
- Capable of internal dynamic calibration.
- Direct writing to printer and to an electronic data storage device such as a PC computer, or equivalent. Instruments provided will be capable of producing strip chart recordings of readings on-site within one hour of obtaining the readings.
- Continuous monitoring mode shall be capable of recording peak velocities.

Seismographs shall be installed at least 7 days prior to any vibration-producing construction activities to obtain background readings. Threshold and limiting values shown below may need to be adjusted to account for background vibrations, once the baseline vibration levels are better understood.

Deformation Monitoring Points (DMPs):

DMPs shall be used to monitor vertical and horizontal movement of temporary SOE systems, the existing and proposed bridges during phased demolition and replacement, and permanent retaining walls. The DMPs will be clearly marked, labeled, and protected to avoid being obstructed or otherwise damaged by construction operations or the public. Protections such as fixed wood barricades may be used.

- ⑦ Optical Prisms – Optical prisms shall be used to monitor vertical and horizontal deformation by means of optical survey without the need to hold a rod on the monitoring point. Optical prisms are proposed for DMPs on the existing abutments and piers and permanent retaining walls and at any other locations where, due to the required frequency of measurement and difficulty in accessing points, it is more efficient to use them. Optical prisms or other targets capable of being monitored for horizontal movement should also be installed on the face of SOE walls and permanent retaining walls.

DMPs shall be installed at least seven days prior to any intrusive construction in the area of the structure being monitored. Immediately following installation, the location of each DMP will be surveyed to provide location coordinates to an accuracy of ± 0.03 ft, and in elevation to an accuracy of ± 0.01 ft. A minimum of two sets of initial readings will be taken to provide pre-construction baseline data and to demonstrate that the survey techniques being used are adequate. All elevation readings will be referenced to the same survey benchmark. Monitoring points that are damaged or no longer functioning will be replaced and re-initialized within five days of discovery of damage.

DMP's for monitoring vertical settlement shall also be installed at regular intervals on the roadway surfaces paved with base coarse and monitored until it can be established that there is no significant ongoing settlement.

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Inclinometers (INCL):

Inclinometer casing shall be installed at 8 locations along the length of the causeway retaining walls. Each inclinometer casing shall be installed in a cased borehole which extends at least 5 ft into very dense glacial till or bedrock to insure bottom fixity. The casing should be installed 5 feet outboard of the front face of the permanent post and panel retaining wall (on the river side) prior to backfill of the retaining wall. The inclinometers shall be located at the midpoint between adjacent posts of the Post and Panel Retaining wall. Initial reading shall be taken, and the inclinometers monitored on a weekly basis during wall backfilling and for at least 2 months following the completion of final paving of the roadway. The boreholes to install the inclinometers may have to be drilled through riprap in the upper part of the boring.

- ⑦ Inclinometer casing shall be 2.75-inch O.D. ABS plastic casing with 4 grooves machined at 90 degrees. Inclinometer inner casings and associated couplings and end caps shall be furnished and installed by the Design Builder's Geotechnical Instrumentation Specialist.

Extend inclinometer casing vertically to no less than 2 ft above the ground surface and provide protective casing and cap to prevent damage to inclinometer casing.

- ⑦ The inclinometer probe, readout unit cable and pulley assembly shall be provided by the Design-Builder's Geotechnical Instrumentation Specialist.

The Design Builder's Geotechnical Instrumentation Specialist shall propose locations and submit to MassDOT for acceptance prior to installation.

Casing Installation:

- Drill inclinometer hole using temporary steel casing and rotary wash drilling methods to a minimum 5 ft into glacial till or bedrock.
- Grout the annular space between the casing and drill hole. Grout shall be a weak bentonite cement grout and extend over the full height of the inclinometer.
- Provide a cap at the top of the inclinometer inner casing to prevent debris from entering the casing. Remove any debris that enters the casing. Replace inclinometer if it becomes blocked or unusable due to construction activities at no additional cost to MassDOT.
- Provide a bolt through the inclinometer inner casing 2 ft above the bottom of the casing to serve as a repeatable start point for each inclinometer reading. Wrap all joints and penetrations in the inclinometer casing with duct tape or acceptable alternative to provide a watertight seal.
- The Design Builder's Geotechnical Instrumentation Specialist shall accurately measure the length of casing cut, label the cut portion, and provide the cut portion to MassDOT.
- Without exception, once the inclinometers have been initialized, the inclinometer casing shall not be cut.

Maintain and protect inclinometers at all times during construction and provide access to the inclinometer casings for reading until no less than 2 months after all construction is completed and as directed by MassDOT.

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- b. Readings: Readings shall be performed under the supervision of a Professional Surveyor, licensed in the State of Massachusetts, using appropriate equipment to survey locations in three (3) dimensions (Northing, Easting, and Elevation) accurate to within 0.125 inches.
- c. Monitoring Schedule: The minimum monitoring shall be daily for the first week when construction begins, then once per week while construction activities are on-going. The monitoring frequency may be reduced or suspended after the construction activities have ceased and instrument readings have stabilized, following approval by MassDOT.

Threshold and Limiting Values

- ⑦ Immediately after taking a reading, the reading will be compared with the baseline readings and previous readings of that instrument. When a reading indicates that a threshold or limiting value has been exceeded as specified below, the Contractor will initiate the response action(s) specified below in the “Contingency Plan” section of this special provision. The Engineer of Record may propose different response values consistent with their proposed design, subject to the acceptance of MassDOT.

Table 1 - DMP Threshold and Limiting Response Values

Instrumentation Type/Location	Response Values	
	Threshold	Limiting
DMPs on Bridge Piers and Abutments	Vertical or horizontal movement = 0.25 in.	Vertical or horizontal movement = 0.5 in.
DMP's - Retaining Walls	0.5 in.	1.0 in.
INCL	0.5 in.	1.0 in.
Seismographs	Refer to Table 2	Refer to Table 2

Table 2 – Threshold and Limiting Response Values – Seismographs

Type	Source M ¹			Source S ²		
	Freq. (Hz)	Peak Particle Velocity (PPV)		Freq. (Hz)	Peak Particle Velocity (PPV)	
		Threshold Value (in./sec)	Limiting Value (in./sec)		Threshold Value (in./sec)	Limiting Value (in./sec)
Existing/ Proposed Bridges	<30	0.37	0.5	<60	0.9	1.2
	30-60	0.37	0.5-0.7*	60-90	0.9	1.2-1.6**

Notes:

1. Source M: continuous or steady state vibrations such as: vibratory pile drivers, hydromills, large pumps and compressors, bulldozers, trucks, cranes, scrapers and other large machinery, jackhammers, reciprocating pavement breakers and compactors.
2. Source S: transient or impact vibrations such as: blasting with explosives, drop chisels for rock breaking, buckets, impact pile drivers, wrecking balls and building demolition, gravity drop ground compactors and pavement breakers.