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DESIGN DIRECTIVE

To: Distribution

From: Erik Stoothoff, P.E. *EJS*
Chief Engineer

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RE: Construction Monitoring Programs

This design directive is intended to provide guidance on the MBTA's requirements for the development and implementation of construction monitoring programs ("Programs") for all MBTA and 3rd party projects (collectively referred to herein as "Projects") which have the potential to impact MBTA-owned infrastructure and/or operations.

In the event that conditions warrant deviation from this directive, a design waiver signed by the Chief Engineer and department owning the scope of work will be required of the Project.

OBJECTIVE

To ensure that all Projects take the necessary measures to protect existing MBTA infrastructure, provide sufficient construction monitoring, and to effectively identify and mitigate potential hazards before they create unsafe conditions, inflict damage, and/or cause impacts to service.

PROGRAM CRITERIA

MBTA property and infrastructure including stations, facilities, substations, bridges, culverts, tunnels, retaining walls, trackwork, utilities, other like structures, and persons thereon (collectively referred to herein as "Assets") shall be protected from damage and injury during construction and/or demolition work (collectively referred to herein as "Work") in accordance with the requirements of all applicable codes. Where Work has the potential to cause undue movement, stresses, vibration, and/or destabilization; create unsafe conditions; or otherwise cause damage to Assets, a Program shall be designed to ensure that appropriate measures are being taken to minimize these effects.

Programs shall be developed based on Asset age, construction type, existing condition, underlying soil conditions, proximity to the Work, and the proposed methods of the Work. Programs shall consist of the following components:

1. Pre-Construction Survey
2. Instrumentation and Monitoring Plan
3. Post-Construction Survey

Pre-Construction Survey: Projects shall retain the services of a licensed engineer registered in the Commonwealth of Massachusetts with experience in performing condition assessments on similar Assets to complete the pre-construction survey and prepare a survey report. The pre-construction survey shall document all aspects of each Asset's condition through observations, field measurements, sketches, photographs, video, LiDAR and/or any other methods of data collection as determined to be appropriate. The pre-construction survey shall be performed such that it can be reproduced and compared to a post-construction survey. A pre-construction survey plan submittal including limits and data collection methodologies shall be submitted to the MBTA's Capital Delivery Project Office (collectively referred to herein as "Project Office") for approval in advance of initiating a survey. At a minimum, the Project Office shall consist of the assigned project manager, but may also include resident engineer, inspector and other project support staff. Scheduling of pre-construction surveys shall be coordinated with the Project Office and shall be performed under the observation of an MBTA engineer.

The pre-construction survey shall also consist of the collection of data including underlying soil conditions and Asset information such as age, foundation type, and structural framing type. Underlying soil conditions shall be collected from available existing boring data or through the performance of a soil boring investigation. Asset information shall be collected by requesting as-built drawings from the MBTA's Document Control Department (rxcroteau@MBTA.com).

A pre-construction survey report shall be generated which compiles all documentation collected. The report shall be submitted to the Project Office for review and must be approved prior to the beginning of Work.

Instrumentation and Monitoring Plan: An instrumentation and monitoring plan shall be designed based on the preconstruction survey, the soil investigation report, Asset characteristics, and the proposed Work. Instrumentation may include inclinometers, extensometers, piezometers, seismographs, geophones, accelerometers, tilt beams, observation wells, crack gauges, total station surveys, noise monitors, or other device types as determined to be appropriate and approved by the MBTA.

Where dewatering may cause changes in the ground water level adjacent to MBTA Assets, the effects of such changes shall be investigated, provisions shall be made to prevent negative impacts, and groundwater levels shall be monitored and reported.

Where Work has the potential to impact track structure, the applicable track department (Commuter Rail/Transit) shall be consulted with during the development of the instrumentation and monitoring plan.

The instrumentation and monitoring plan shall be prepared by a licensed engineer registered in the Commonwealth of Massachusetts and submitted to the Project Office for review and approval prior to the beginning of Work. All instrumentation and monitoring plans shall include the following components:

- a. Narrative including Project description, description of adjacent Assets, sequence of Work, and Work methodologies.
- b. Description of underlying soil conditions, soil profile, and soil boring data.
- c. Findings of the pre-construction survey report.
- d. Plans and sections to scale detailing the proximity of the proposed Work to existing Assets and proposed locations of instrumentation.
- e. Technical data for proposed instrumentation including tolerances, ranges, calibration requirements, dimensions, outputs, power requirements, operating temperatures, etc. All instrumentation located in view of MBTA customers, personnel, or the general public shall be clearly labeled with contact information of the monitoring contractor.
- f. Deployment plan, including mounting details when fixing equipment to existing structures. Survey monitoring points shall be securely established or marked using nails, paint, keel crayon, or other approved methods. If temporary power must be provided via MBTA facilities, an electrical plan shall be submitted for review and approval by the MBTA Electrical Inspector.
- g. Monitoring plan, including schedule, frequency, and threshold & limiting criteria for each piece of equipment or monitoring point. Monitoring shall be scheduled such that sufficient baseline data can be collected prior to the start of the Work. Threshold and limiting criteria shall be established on an Asset-by-Asset basis, taking into consideration data collected through the preconstruction survey, soils investigations, and existing plan review; as well as the proposed Work and its proximity to existing Assets. Threshold and limiting values shall be set such that they identify unexpected behavior, which could be an indication of poor performance or the development of an unidentified failure mode and allow for intervention prior to unacceptable movements, damage, or failure. In areas where access to the monitoring location requires frequent MBTA resources, such as flagging, remote or automated monitoring methods shall be required. In locations where the Work has the potential to affect the safety of MBTA customers, employees, and or operations during revenue hours, real-time monitoring shall be required.
- h. Proposed mitigation plan in the event that either threshold or limiting values are exceeded. At a minimum, the following requirements shall be included:
 1. Should either a threshold or limiting value be exceeded, the Project Office shall be notified by phone immediately and the engineer of record shall prepare a draft monitoring exceedance findings memo which includes the following content:
 - i. Date and time of the exceedance(s);
 - ii. Location and description of the instrumentation which measured the exceedance(s);
 - iii. Description of the asset to which the equipment measuring the exceedance(s) is monitoring and its relation to MBTA operations.
 - iv. Measured value(s) compared to threshold and limiting values;
 - v. Description of the Work in the vicinity of the exceedance(s) which occurred in the weeks, days, and hours leading up to the exceedance(s);

- vi. Description of the site conditions in the vicinity of the exceedance(s);
and
 - vii. The Project's instrumentation and monitoring plan as an attachment.
- The engineer of record shall complete all necessary investigations and assessments as soon as possible and submit to the Project Office a final monitoring exceedance findings memo including the following additional content:
- viii. Findings of response investigations and assessments;
 - ix. Likely causes of the exceedance(s);
 - x. Steps to be taken by the Project to mitigate the exceedance(s);
 - xi. Steps to be taken by the Project should limiting values, or continued exceedance(s) beyond the limiting values be realized; and
 - xii. Proposed improvements to the monitoring plan.
2. Should a limiting value be exceeded, the Project shall immediately cease all Work and implement the accepted plan for arresting further exceedances.
- i. Emergency contact list and proposed communication plan. At least two MBTA employees from the Project Office shall be included in the emergency contact list. It shall be the Project Office's responsibility to immediately communicate exceedances of threshold values, limiting values, and/or other unsafe conditions to a predetermined list of MBTA stakeholder department contacts. The initial communication to MBTA stakeholders shall include a description of the exceedance (i.e. time, location/service line, measured values compared to limiting and threshold values) and the steps being taken by the Project to respond. This shall be followed with distribution of the engineer of record's monitoring exceedance findings memos as soon as they become available.

Post Construction Survey: After the completion of Work which has the potential to impact MBTA-owned infrastructure and/or operations, a post-construction survey shall be completed by the same firm who performed the pre-construction survey. The post-construction survey shall recreate all measurements and documentation established in the pre-construction survey and shall include a comparative analysis. Any discrepancies found and/or damages not previously documented shall be immediately brought to the attention of the Project Office. Such instances will require a root cause analyses and may require additional monitoring. Any damages found to be the result of the Work shall be repaired by, and at the sole cost, of the Project to the satisfaction of the Project Office. The post-construction survey report shall be prepared by a licensed engineer registered in the Commonwealth of Massachusetts submitted to the Project Office for review and approval prior to project close-out.