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DESIGN MEMORANDUM

Date: February 11, 2025

To: Mr. Zack Deems, AECOM

From: Brendan P. Andrews P.E., NEAS Inc.

RE: **Geotechnical Design Addendum**
Project CUY-14-6.93, PID 104132
Retaining Wall 3, Temporary Retaining Wall 4, and Retaining Wall 6
Cuyahoga County, Ohio

INTRODUCTION

This memorandum presents updated foundation design information for the proposed Retaining Wall 3 (RW-3), temporary Retaining Wall 4 (RW-4), and Retaining Wall 6 (RW-6) as part of the overall Ohio Department of Transportation (ODOT) CUY-14-6.93 (PID 104132) project located in Cuyahoga County, Ohio. An updated summary of the proposed structure and our recommendations for retaining foundation design is presented below.

This document is an addendum to our Structure Foundation Exploration Report dated February 29, 2024 for the Project Retaining Walls associated with the CUY-14-6.93 project. Information regarding geology, site observations, the geotechnical exploration performed, and subsequent findings can be found in the referenced report.

PROPOSED/EXISTING SITE CONDITIONS

Proposed Construction

It is our understanding that ODOT plans to replace the existing bridge CUY-14-0693 with a new shortened structure on a new alignment as well as remove the existing bridge CUY-CR24-0062. To facilitate the proposed bridge replacement, bridge removal, and realignment at the forward abutment, the construction of two (2) permanent and one (1) temporary retaining wall is required.

Two (2) permanent retaining walls, designated as Retaining Walls 3 and 6 (RW 3 & RW-6), are proposed following the forward abutment of the realigned bridge CUY-14-0693 and extending north/east tying into the existing SR-14 grades beyond the existing bridge. Each wall will facilitate the removal of the existing bridge at this location by supporting the proposed SR-14 embankment soils and providing grade separation between SR-14 and both Old Broadway Ave (RW-3) and the adjacent industrial property (RW-6). Temporary RW-4 is also proposed at this location to facilitate the construction phasing and MOT scheme by supporting the proposed SR-14 embankment soils in order to maintain at least one lane of SR-14 during construction.

Based on the project plan set dated August 5, 2024, produced by AECOM, each wall is proposed to be supported on either varying heights of proposed embankment fill or the existing fill/possible fill soils encountered at the site. RW-3 will be approximately 380 ft in length with a maximum wall height of approximately 36.8 ft, while RW-6 will be approximately 369 ft in length with a maximum wall height of approximately 36.8 ft. Temporary RW-4 will be a temporary wire-faced MSE wall that will likely be a back-to-back wall with RW-3 for first approximately 380 ft of approximately 475 ft total length and will have a maximum wall height of approximately 36 ft.

Project Background and Updates

As part of the referenced SFE Report dated February 29, 2024 for the Project Retaining Walls, NEAS recommended a significant undercut be performed under portions of RW-3 and RW-6 to satisfy LRFD and ODOT BDM requirements due to the soils conditions encountered during our exploration and the results of the subsequent RW-3 and RW-6 analyses performed. Additionally, MSE wall reinforcement straps outside of the recommended undercut were increased to lengths up to 130% of the height of the wall. These undercut and strap length recommendations can be found within the referenced report.

Following the submission of the referenced SFE Report, a meeting between AECOM, NEAS and ODOT's Office of Geotechnical Engineering was held on May 21, 2024 to discuss potential alternatives to the recommended undercut beneath RW-3 and RW-6 as well as other pile driving issues associated with the proposed forward abutment foundation of the bridge CUY-14-0693. Within that meeting and following additional research into alternatives, ODOT recommended that ground improvement be performed within the area of undercut as well as beneath the forward abutment to improve the soils such that: 1) an undercut does not need to be performed; and, 2) the forward abutment be altered to utilize a shallow foundation system. ODOT recommended that the ground improvement be constructed by employing a contractor performance specification and ODOT would provide plan sheets that have been utilized on similar past projects for adaption to this project.

During the week of February 3, 2025, temporary RW-4 was reviewed to develop foundation recommendations for the wall. During the foundation review, it was identified that similar to what was encountered beneath walls RW-3 and RW-6, soil conditions dictated that an undercut and/or extended MSE wall reinforcement straps would be required. Furthermore, it was identified that the increased strap lengths of either RW-3, RW-4 or RW-6 would potentially interfere with the face of the surrounding walls in the area. Therefore, NEAS recommended that the ODOT prescribed ground improvement area be increased to include the footprints associated with RW-3, RW-4 and RW-6. Increasing the footprint to include the complete lengths of RW-3, RW-4, and RW-6 would: 1) remove the need for an undercut; 2) allow for the use of the minimum MSE wall reinforcement strap lengths (i.e., 70% of the total wall height or 8 ft, whichever is greater); and, 3) alleviate concerns regarding deferential settlement along each wall.

ANALYSES AND RECOMMENDATIONS

Based on design information for RW-3, temporary RW-4 and RW-6 within the project plan set dated August 5, 2024, produced by AECOM, it is our understanding that each wall will be constructed as a mechanically stabilized earth (MSE) wall with RW-4 being a temporary wire face MSE wall. Geotechnical analyses consisting of external stability (i.e., bearing resistance, eccentricity, and sliding resistance), global stability, and settlement were performed for the proposed walls. The analyses performed are based on the geotechnical information presented in the Structure Foundation Exploration Report for the Project Retaining Walls dated February 29, 2024 in addition to: 1) the soil characteristics gathered during the

subsurface exploration (i.e., SPT results, laboratory test results, etc.); 2) the above indicated proposed design information for the referenced retaining walls provided by AECOM; 3) the assumption that each wall will be constructed upon soil in which a ground improvement plan has been implemented such that specified bearing and settlement requirement have been met; and, 4) other design assumptions presented in subsequent sections of this memo.

The geotechnical engineering analyses were performed in accordance with AASHTO's Publication LRFD BDS (AASHTO, 2020) and ODOT's 2021 BDM (ODOT, 2021). Based on the results of the analysis, it is our opinion that following ground improvement, the subsurface conditions will provide adequate resistance to bearing, sliding and overturning along segments of the proposed RW-3, RW-4 and RW-6 alignments based on the assumptions presented in this memo as well as Structure Foundation Exploration Report for the Project Retaining Walls dated February 29, 2024.

Soil Profile for Analysis

For retaining wall foundation analyses purposes, each boring drilled for RW-3, temporary RW-4 and RW-6 was reviewed and a generalized material profile was developed. Utilizing the generalized soil profile, engineering properties for each soil stratum were estimated based on their field (i.e., SPT N_{60} Values, hand penetrometer values, etc.) and laboratory test (i.e., Atterberg Limits, grain size, etc.) results using correlations provided in published engineering manuals, research reports and guidance documents. Soil layers from each boring with similar behavior (i.e., cohesive or non-cohesive/granular) and characteristics (i.e., relative compactness/consistency, moisture content, etc.) were grouped into generalized soil units (i.e., Soil Types) and weighted average values of the estimated engineering soil properties were assigned to each Soil Type to develop a generalized soil profile for analysis. For RW-3, temporary RW-4 and RW-6, borings B-010-21, B-011-0-21, B-012-0-21, B-013-0-21, B-014-0-21, B-015-0-21 and B-016-0-21. were reviewed for analysis purposes. A summary of the generalized soil profile at these boring locations, including designated Soil Types, elevations, average engineering soil properties are presented the referenced project retaining wall SFE report.

Retaining Wall Design Assumptions

As the proposed project retaining walls are planned as MSE type, ODOT's BDM and AASHTO's LRFD BDS dictate analysis parameters and design minimums/constraints to be used in the analysis and design process. The referenced parameters and design minimums/constraints that were significant to our analyses consist of the following:

- Minimum reinforcement strap lengths of proposed MSE walls are to be 70% of the total wall height (as measured from proposed profile grade at the face of the wall to the top of the leveling pad) or 8 ft, whichever is greater, at the section of wall being analyzed, per ODOT's BDM section 307.4-A;
- Minimum MSE wall embedment depths (as measured from top of the leveling pad to the lowest point on the ground surface within 4-ft of the face of the wall) are to conform to Figure 201-5 presented in ODOT's BDM and be the larger of 3 ft or the local frost depth;
- Soils below the bottom of leveling pad will be undercut a minimum of 1 ft and replaced Granular Material Type C according to the requirements of ODOT Construction & Materials Specifications Section 204.07 (CMS 204.07);
- Maximum allowable differential settlement in the longitudinal direction is 1%. (BDM Section 307.1.6); and,

- Reinforced Zone and Retained Fill soils will meet the minimum design soil parameters per Table 840.04-1 of the ODOT Supplemental Specification 840 (SS-840) as shown in Table 5 below.

Table 1: Design Soil Parameters for Fill Materials

Fill Zone	Type of Soil	Soil Unit Weight (pcf)	Friction Angle (°)	Cohesion (psf)
Reinforced Zone	Select Granular Backfill	120	34	0
Retained Soil	On-site soil varying from sandy lean clay to silty sand	120	30	0

Notes:
1. Table reproduced from Section 840.04 - A-1 of ODOT's SS 840.

With respect to design constraints and assumptions specific to the proposed retaining walls, the geometry of the proposed walls (i.e., exposed wall heights, existing ground elevations, proposed final grade behind/at the toe of the wall, etc.) is assumed to be consistent with that shown in the within the project plan set dated August 5, 2024, produced by AECOM.

External Stability Analysis and Recommendations

Based on our estimated engineering soil properties and the developed generalized profile presented in the Structure Foundation Exploration Report for the Project Retaining Walls dated February 29, 2024, as well as in the retaining wall design assumptions provided in the preceding section of this report, external stability analyses of the proposed RW-3, RW-4 and RW-6 were performed. External stability was evaluated at cross-sections along the length of the proposed retaining wall alignments. As the ground improvement under each wall will be consistent along the length of the alignment, only the tallest wall section was analyzed for each wall. These sections evaluated for external stability included RW-3 at approximate STA. 10+18, RW-4 at approximate STA. 10+00 and RW-6 at approximate STA. 10+00. These cross-sections were evaluated for resistance to bearing pressure, sliding forces and overturning at the Strength Limit State in accordance with Section 11.10.5 of the AASHTO's LRFD BDS.

The capacity to demand ratios (CDRs) calculated for the referenced cross-sections with respect to bearing, sliding and overturning, as well as the calculated factored bearing resistances are presented in Table 1 below. As ground improvement is to be performed, the minimum factored bearing resistance to be specified in the ground improvement plans is equal to the calculated maximum (Strength or Extreme Limit State) factored bearing stress. Typically, bearing resistance is a function of the soil type (and other factors), but in this case, it is a performance specification and the below reported factored bearing resistance is the target value for a CDR = 1.00.

Table 1: External Stability Analysis

Dimensions			
Retaining Wall	RW-3	RW-4	RW-6
Design Wall Height (feet)	36.8	40.1	36.8
Exposed Wall Height (feet)	33.3	36.6	33.3
Length of Reinforcement (feet)	25.8	28.1	25.8
Length of Reinf. To Height Ratio	0.7	0.7	0.7
Approximate Station(1)	10+18.00	10+00.00	10+00.00
Boring(s) Used in Analysis	B-010-0-21	B-010-0-21	B-011-0-21
Capacity Demand Ratio (CDR)			
Sliding	>=1.0(4)		
Overturning / Eccentricity	1.83	1.86	1.83
Bearing Capacity	>=1.0(4)		
Factored Bearing Resistance (ksf)(2)	8.54	9.23	8.54
Minimum Global Stability FOS(3)	>=1.3(4)		

Notes:

1. *Stationing in reference to baseline of each wall.*
2. *Noted Factored Bearing Resistance is the required Factored Bearing Resistance following ground improvement such that a CDR > 1.0 is achieved. This value is equal to the calculated maximum (Strength or Extreme Limit State) factored bearing stress.*
3. *Minimum FOS of 1.3 required for proposed MSE walls.*
4. *Sliding, Bearing Capacity, and Global Stability assumed to be grater than LRFD/ODOT BDM requirements following ground improvement.*

Global Stability and Settlement Analysis

With respect to global stability and settlement, as the ground improvement is planned beneath each wall and improvement parameters (strength, consolidation, etc.) for the underlying soil are unknown, it is assumed that the ground improvement will improve soil conditions such that LRFD and ODOT requirements are met. Settlement performance requirements for the ground improvement area will be specified within the plans.