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DESIGN MEMORANDUM

Date: September 8, 2023

To: Mr. Paul Durham, Stantec.

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

RE: **Geotechnical Design Memorandum**
Project HAM-LMST Extension to Elstun, PID 113602
Reinforced Soil Slopes
City of Cincinnati, Hamilton County, Ohio

INTRODUCTION

Per your request, this memorandum presents design information for the proposed reinforced soil slopes (RSS) as part of the overall Ohio Department of Transportation (ODOT) Little Miami Scenic Trail (LMST) extension to Elstun Road (Rd) project located in the City of Cincinnati, Hamilton County, Ohio. A summary of: 1) the proposed embankment section requiring slope reinforcement; 2) the existing site conditions; 3) the surficial and subsurface conditions via project borings; and, 4) our recommendations for RSS foundation design, are presented below.

NEAS's preliminary analyses have been performed in accordance with Load and Resistance Factor Design (LRFD) method as set forth in AASHTO's Publication LRFD Bridge Design Specifications, 9th Edition (BDS) (AASHTO, 2020), ODOT's 2021 LRFD Bridge Design Manual (BDM) (ODOT [1], 2023) and ODOT’s 2023 Geotechnical Design Manual (GDM) (ODOT [2], 2023).

To date NEAS has performed the subsurface exploration for the project and provided deliverables for the proposed two-span bridge over Clough Creek (Bridge HAM-LMST ELSTUN-0.09) which included the Structure Foundation Exploration (SFE) Report for the proposed bridge submitted by NEAS on December 15, 2022. As the slopes requiring reinforcement are immediately adjacent to the referenced bridge structure’s abutments, the existing site conditions, site exploration and findings presented with the referenced SFE are generally representative of the proposed RSS locations.

PROPOSED/EXISTING SITE CONDITIONS

Proposed Construction

NEAS understands that Stantec is developing construction plans for the LMST extension to Elstun Rd project. As part of the project, it is our understanding that to support the referenced trail extension new embankment fill is proposed along segments of the project as well as a new two span bridge to carry the LMST over Clough Creek (Bridge HAM-LMST ELSTUN-0.09). During the early design stages of the project and after discussions with Duke Energy regarding an existing utility easement, it has been identified that a new retaining wall and sections of RSS will be required to facilitate the construction of the new bridge and the associated new embankment.

It is our understanding that the proposed RSS sections will consist of slopes between 66 and 81 ft in length with proposed slope grades ranging from 1.5 Horizonal to 1 Vertical (1.5H:1V) to 1.9H:1V. Specifically, the segments requiring reinforcement include: 1) the proposed embankment slopes from approximate STA. 76+50 to the rear abutment of the proposed bridge over Clough Creek at STA.77+16.2 (Elstun Connection alignment); and, 2) the proposed embankment slopes from the forward abutment of the proposed bridge over Clough Creek at approximate STA. 79+69 to STA.80+50 (Elstun Connection alignment).

GEOLOGY AND OBSERVATIONS OF THE PROJECT

A summary of the geology, hydrogeology, site records and site reconnaissance representative to the proposed RSS locations can be found in the referenced SFE report submitted by NEAS on December 15, 2022.

FIELD EXPLORATION AND LABORATORY TESTING PROGRAM

The exploration for the project between July 6, 2022 and August 11, 2022 and included 4 borings drilled to depths between 33.3 and 41.0 ft bgs. The boring locations were selected and performed by NEAS with the intent to evaluate subsurface soil and groundwater conditions along the Elstun Connection alignment as well as the existing embankment soils of the adjacent ramp from State Route 32 (SR-32) Southbound (SB) to SR-125 eastbound (EB).

The laboratory testing program implemented for the project included classification testing, moisture content streambed grain size distribution, unconfined compressive strength of soil, consolidation testing, and unconfined compressive strength of bedrock. A summary of the field and laboratory programs as well as their results are presented in the referenced SFE report submitted by NEAS on December 15, 2022.

GEOTECHNICAL FINDINGS / SUBSURFACE CONDTIONS

The subsurface conditions encountered during NEAS's explorations are described in the referenced SFE report submitted by NEAS on December 15, 2022, as well as on the attached boring logs. The boring logs represent NEAS's interpretation of the subsurface conditions encountered at each boring location based on our site observations, field logs, visual review of the soil samples by NEAS's geologist, and laboratory test results. The lines designating the interfaces between various soil strata on the boring logs represent the approximate interface location; the actual transition between strata may be gradual and indistinct. The subsurface soil and groundwater characterizations, including summary test data, are based on the subsurface findings from the geotechnical explorations performed by NEAS as part of the referenced project, results of historical explorations, and consideration of the geological history of the site.

ANALYSIS AND RECOMMENDATIONS

We understand that two (2) separate sections of reinforced soil slopes (RSS) will be required to facilitate the construction of the proposed bridge (Bridge HAM-LMST ELSTUN-0.09) and the associated proposed embankment as part of the proposed HAM-LMST Extension to Elstun project (PID 113602) within the City of Cincinnati, Hamilton County, Ohio. During the early design stages of the project and after discussions with Duke Energy regarding an existing utility easement, it was identified that approximately 250 ft of RSS will be required to facilitate the construction of the newly proposed bridge structure planned to carry the LMST over Clough Creek and its associated new embankment. It is our understanding that slopes exceeding a 2H:1V (i.e., slopes requiring reinforcement per ODOT policy) are required: 1) from approximate STA. 76+50 to the rear abutment of the proposed bridge over Clough Creek at STA.77+16.2; and, 2) from the forward abutment of the proposed bridge over Clough Creek at approximate STA. 79+69 to STA.80+50 (Elstun Connection alignment).

Geotechnical analyses consisting of external stability (i.e., sliding resistance) and global stability were performed for each of the proposed RSS sections. The analyses performed are based on: 1) the soil characteristics gathered during the subsurface exploration (i.e., SPT results, laboratory test results, etc.); 2) the proposed Stage 3 plans prepared by Stantec dated July 21, 2023; and, 3) other design assumptions presented in subsequent sections of this memo.

Analyses were performed in accordance with LRFD BDS (AASHTO, 2020), ODOT's 2020 BDM (ODOT [1], 2023) and ODOT's GDM (ODOT [2], 2023). Specifically, the specified publications within these documents include the Federal Highway Administration's (FHWA Geotechnical Engineering Circular 11 (GEC 11) (FHWA-NHI-10-024/025, 2009) and ODOT's Supplemental Specification 863 (SS863).

Based on the results of the analysis, it is our opinion that the subsurface conditions encountered are generally satisfactory and will provide adequate resistance to translational and global stability assuming the proposed RSS(s) are constructed in accordance with the recommendations provided within this memo, as well as all applicable standards and specifications (i.e., ODOT, manufacture, etc.) for reinforced soil slope

Reinforced Soil Slope Design Assumptions

As reinforced soil slopes are proposed along segments of the proposed LMST embankments, ODOT's BDM, ODOT's GDM 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:

- Maximum primary reinforcement vertical spacing of 32-inches;
- Maximum secondary reinforcement vertical spacing of 16-inches between primary reinforcement;
- Secondary reinforcement lengths of 5 feet at each RSS section;
- No wrap around facing system is required for the embankment slope grades proposed;
- Primary and Secondary reinforcement consisting of Type P1 geogrid and Type S1 geogrid, respectively, furnished and installed in accordance with ODOT's SS863 with minimum tensile strengths as indicated in Table 1 below;
- RSS fill material will be comprised of well compacted engineered COHESIVE embankment fill (Item 203 Cohesive Embankment), per Item 203 of the ODOT C&MS;
- Cohesive soils classifying as Clay (A-7-6) will not be used as RSS backfill;

Table 1: Design Geogrid Properties

Geogrid Type	Ultimate Tensile Strength (lb/ft)	Long-Term Design Tensile Strength (lb/ft)
P1	-	1300
S1	1400	-
Notes: *1 Table reproduced from Table 863.02-1 of the ODOT SS 863.*		

The soil parameters of the new embankment fill were assumed to be consistent with those recommended in Table 500-2 of the ODOT GDM for "Assumed Embankment Fill Properties" and as presented in Table 2 below.

Table 2: Minimum Design Soil Parameters for Backfill Materials

Fill Zone	Type of Soil	Soil Unit Weight (pcf)	Undrained Shear Strength (psf)	Cohesion (psf)	Friction Angle (^{o})
Side Slope Backfill	Item 203 Cohesive Embankment (A-6a and A-6b)	120	2500	250	28

Additionally, the proposed RSS embankment fill soils material should also meet the parameters summarized in Table 3 below.

Table 3: Additional Requirements for Reinforced Embankment

Property	Test Method	Required Value
Organic Content	AASHTO T 267	≤ 4.0%
Plasticity Index	AASHTO T 90	≤ 20

Notes:

1. Table reproduced from Table 863.02-3 of the ODOT SS863.

With respect to design constraints and assumptions specific to the proposed RSS's, the geometry of the proposed embankment slopes (i.e., embankment slope grades, total slope heights, existing ground elevations, etc.) is assumed to be consistent with that shown in the proposed Stage 3 plans prepared by Stantec dated July 21, 2023.

Generalized Soil Profile for Analysis

For analysis purposes, each boring log within the area of the proposed RSS(s) were reviewed and a generalized material profile was developed for analysis to represent worse case conditions at each location. Utilizing the generalized soil profile, engineering properties for each soil strata were estimated based on the field (i.e., SPT N_{60} Values, hand penetrometer values, etc.) and laboratory (i.e., Atterberg Limits, grain size, etc.) test results using correlations provided in published engineering manuals, research reports and guidance documents. The generalized material profile and estimated engineering soil properties determined for borings B-001-0-20 and B-002-0-20 (for STA.77+16.20) and boring B-004-0-20 (for STA. 79+69) were utilized in the development of the indicated cross-sectional models. The developed soil profile and estimated engineering soil properties for use in analysis (with sited correlation/reference material) is summarized within Tables 4 and 5 below.

Table 4: Soil Profile and Estimated Engineering Properties - At Boring B-001-0-20 & B-002-0-20

Reinforced Soil Slope Analysis: From STA. 76+50 to STA. 77+16.20, B-001-0-20 & B-002-0-20				
Soil Description	Unit Weight(1) (pcf)	Undrained Shear Strength(2) (psf)	Effective Cohesion(3) (psf)	Effective Friction Angle(3) (degrees)
Silty Clay Elevation (499.5 ft - 473.1 ft)	125	2150	200	24
Silty Clay Elevation (473.1 ft - 468.4 ft)	125	1100	100	22
Gravel with Sand Elevation (468.4 ft - 463.8 ft)	118	-	-	34
Silt and Clay Elevation (463.8 ft - 456.6 ft)	125	1100	100	22
Coarse and Fine Sand Elevation (456.6 ft - 454.8 ft)	120	-	-	28
Silt and Clay Elevation (454.8 ft - 453.1 ft)	122	2100	200	24
Gravel with Sand and Silt Elevation (453.1 ft - 449.3 ft)	130	-	-	36

:
1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if N160<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*

Table 5: Soil Profile and Estimated Engineering Properties - At Boring B-004-0-20

Reinforced Soil Slope Analysis: From STA. 79+69 to STA. 80+50, B-004-0-20				
Soil Description	Unit Weight(1) (pcf)	Undrained Shear Strength(2) (psf)	Effective Cohesion(3) (psf)	Effective Friction Angle(3) (degrees)
Silt and Clay Elevation (477.7 ft - 473.1 ft)	120	1350	150	23
Clay Elevation (473.1 ft - 466.5 ft)	120	1300	150	22
Gravel with Sand Elevation (466.5 ft - 458.2 ft)	125	-	-	35
Clay Elevation (458.2 ft - 455.2 ft)	115	600	75	20

Votes:
1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if N160<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*

Reinforced Soil Slope Analysis and Recommendations

For purposes of designing the reinforced soil slope as part of the planned LMST project, NEAS reviewed cross-sections along the referenced segments of the project trail where the proposed embankment slopes exceed 2H:1V to identify sections that were interpreted to be the most critical along each of the indicated segments. Based on our review of the available information along the referenced alignment and the associated soil properties, one cross-section at each of the referenced locations requiring soil reinforcement was estimated to be most "critical" and was utilized in the design of the reinforced soil slope for the associated segment. The cross-sections selected for use in our evaluation include 1) the proposed cross-section at approximate STA. 77+16.20 which was identified as the steepest slope for the RSS segment from STA. 76+50 to STA. 77+16.20 (Elstun Connection alignment); and, 2) the proposed cross-section at approximate STA. 79+69 which was identified as the steepest slope for the RSS segment from STA. 79+69 to STA. 80+50 (Elstun Connection alignment).

For the referenced locations, NEAS developed a representative cross-sectional model to use as the basis for reinforced soil slope design. The model was developed from NEAS's interpretation of the available information which included: 1) HAM-LMST Ext to Elstun Phase 2, Stage 3 plans developed by Stantec and dated July 21, 2023; 2) a live load surcharge of 250 pounds per square foot (psf) to account for traffic induced loads; 3) a live load surcharge of 100 psf to account for bike trail/construction induced loads; 4) test borings and laboratory data developed as part of this report; 5) the design assumptions presented in the previous section of this memo; and, 6) the generalized material profile and estimated engineering properties presented in Tables 4 and 5 of this memo.

The above referenced critical sections were analyzed for stability utilizing the software entitled ReSSA by Amada Engineering, Inc. Specifically, the factor of safety (FOS) of the proposed RSS was calculated for rotational, sliding and three-part wedge type failures. The FOS is the ratio of the resisting forces and the driving forces, with the desired safety factor being more than about 1.3 which approximately equates to an AASHTO resistance factor less than 0.75 (per AASHTO's LRFD BDS, the specified resistance factors are essentially the inverse of the FOS that should be targeted in slope stability programs). For this analysis, a resistance factor of 0.75 or lower is targeted as the slope does not contain or support a structural element.

Based on our analysis for the proposed reinforced soils slopes, NEAS recommends minimum primary reinforcement lengths 20 feet (measured horizontally from the proposed face of slope) for the segment of embankment from STA. 76+50 to STA. 77+16.20 (Elstun Connection alignment) and a minimum primary reinforcement length of 13 ft for the segment of embankment from STA. 79+69 to STA. 80+50 (Elstun Connection alignment). The primary reinforcement should consist of geogrid Type P1 geogrid while secondary reinforcement should consist of Type S1 geogrid with each geogrid being furnished and installed in accordance with ODOT’s SS863. The first primary reinforcement should be placed at the toe of the reinforced soil embankment slope and should be spaced a maximum of 32 inches vertically. The secondary reinforcement should be spaced 16-inches vertically between the primary geogrid layers. It is recommended that the embankment fill material be placed and compacted in accordance with ODOT’s C&MS 203 Embankment. Proper lift thicknesses and material density should be maintained in the RSS backfill, per Item 203.06 and ODOT’s SS863.

Based on our evaluation of the indicated RSS design, the min FOS for the rotational, sliding and three-part wedge type failures is 1.79, 1.56 and 1.81, respectively, at the STA. 77+16.20 section and is 1.97, 1.59 and 2.00, respectively, at the STA. 79+69 section. The graphical outputs of the RSS stability analysis (cross-sectional model, generalized soil profile, calculated factor of safety, and slip surface) are attached.

Temporary Excavations

It is recommended that all temporary excavations comply with the most recent Occupational Safety and Health Administration (OSHA) Excavating and Trenching Standard, Title 29 of the Code of Federal Regulation (CFR) Part 1926, Subpart P. The contractor is responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. Per Title 29 CFR Part 1926, the contractor's competent person should evaluate the soil exposed in the excavations as part of the their safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations. Based on the natural soils encountered at the site (Type B Soil), it is recommended that temporary excavation slopes (exceeding a depth of 3 ft and less than 20 ft) be laid back to at least 1H:1V and these slopes should be braced or backfilled if the excavation slope will be maintained for more than a day.

REFERENCES

AASHTO. (2020). *LRFD Bridge Design Specifications; 9th Edition.* Washington, D.C.: American Association of State Highway and Transportation Officials.

FHWA-NHI-10-024/025. (2009). *Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes.* U.S. Department of Transpotation. Federal Highway Administration.

ODOT [1]. (2023). *2020 Bridge Design Manual.* Columbus, OH: Ohio Department of Transportation: Office of Structural Engineering. Retrieved from https://www.dot.state.oh.us/divisions/engineering/ structures/standard/bridges/bdm/forms/bdm.aspx

ODOT [2]. (2023). *Geotechnical Design Manul.* Columbus, OH: Ohio Department of Transportation: Office of Geotechnical Engineering.

SOIL BORING LOGS

PROJECT: HAM-LMST EXT	DRILLING FIRM / OPERATOR: NEAS / J. HODGES	DRILL RIG: CME 55X	STATION / OFFSET: 76+65, 34' LT.	EXPLORATION ID B-001-0-20
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: NEAS / J. HODGES	HAMMER: CME AUTOMATIC	ALIGNMENT: ELSTUN CONNECTION	
PID: 113602 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 1/24/22	ELEVATION: 499.5 (MSL) EOB: 36.5 ft.	PAGE 1 OF 2
START: 8/11/22 END: 8/11/22	SAMPLING METHOD: SPT	ENERGY RATIO (%): 79	LAT / LONG: 39.106434, -84.400284	

MATERIAL DESCRIPTION AND NOTES	ELEV. 499.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
VERY STIFF, BROWN AND LIGHT BROWN, **SILTY CLAY**, LITTLE SAND, TRACE TO LITTLE GRAVEL, DAMP TO MOIST		1, 2																
		3, 4	2 3 5	11	56	SS-1	3.25	13	7	10	35	35	39	21	18	17	A-6b (10)	
		5, 6, 7	2 3 2	7	39	SS-2	3.00	5	5	13	39	38	39	20	19	20	A-6b (12)	
	490.0	8, 9	2 4 9	17	33	SS-3	2.50	-	-	-	-	-	-	-	-	21	A-6b (V)	
HARD, GRAYISH BROWN, **SILTY CLAY**, TRACE SAND, TRACE GRAVEL, DAMP		10, 11, 12	3 6 9	20	100	SS-4	4.25	-	-	-	-	-	-	-	-	18	A-6b (V)	
	485.0	13, 14	3 6 11	22	67	SS-5	4.25	-	-	-	-	-	-	-	-	18	A-6b (V)	
HARD, GRAYISH BROWN AND BROWN, **SILTY CLAY**, SOME GRAVEL AND STONE FRAGMENTS, SOME SAND, DAMP		15, 16, 17	3 14 8	29	100	SS-6	4.25	24	14	9	30	23	35	19	16	15	A-6b (6)	
		18, 19	5 6 7	17	44	SS-7	4.50	-	-	-	-	-	-	-	-	16	A-6b (V)	
	477.5	20, 21, 22	7 7 8	20	28	SS-8	4.25	-	-	-	-	-	-	-	-	14	A-6b (V)	
HARD, BROWN AND BROWNISH GRAY, **SILTY CLAY**, TRACE TO LITTLE SAND, TRACE GRAVEL, DAMP		23, 24	5 5 6	14	39	SS-9	4.25	-	-	-	-	-	-	-	-	19	A-6b (V)	
		25, 26, 27	3 4 6	13	56	SS-10	4.25	4	6	8	44	38	39	21	18	19	A-6b (11)	
		28, 29	4 6 8	18	28	SS-11	4.25	-	-	-	-	-	-	-	-	19	A-6b (V)	

PID: 113602	SFN:	PROJECT: HAM-LMST EXT	STATION / OFFSET: 76+65, 34' LT.	START: 8/11/22	END: 8/11/22	PG 2 OF 2	B-001-0-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 469.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
HARD, BROWN AND BROWNISH GRAY, **SILTY CLAY**, TRACE TO LITTLE SAND, TRACE GRAVEL, DAMP *(continued)*		31	5 7 8	20	50	SS-12	4.25	-	-	-	-	-	-	-	-	21	A-6b (V)	
	467.5	32																
VERY STIFF TO HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP		33	4 6 7	17	44	SS-13	4.25	4	5	10	49	32	35	20	15	20	A-6a (10)	
		34																
		35																
	463.0	EOB 36	4 5 6	14	39	SS-14	4.00	-	-	-	-	-	-	-	-	13	A-6a (V)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 50 GAL. BENTONITE GROUT; SHOVELED SOIL CUTTINGS

PROJECT: HAM-LMST EXT	DRILLING FIRM / OPERATOR: NEAS / J. HODGES	DRILL RIG: CME 55X	STATION / OFFSET: 76+68, 36' RT.	EXPLORATION ID B-002-0-20
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: NEAS / J. HODGES	HAMMER: CME AUTOMATIC	ALIGNMENT: ELSTUN CONNECTION	
PID: 113602 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/24/22	ELEVATION: 477.6 (MSL) EOB: 41.0 ft.	PAGE 1 OF 2
START: 7/7/22 END: 7/8/22	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 79	LAT / LONG: 39.106323, -84.400483	

MATERIAL DESCRIPTION AND NOTES	ELEV. 477.6	DEPTHS
HARD, BROWN, **SILT AND CLAY**, SOME GRAVEL, LITTLE SAND, CONTAINS ROOTS, DAMP	473.1	0 – 4.5
STIFF TO VERY STIFF, BROWN AND BROWNISH GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, CONTAINS IRON STAINING, MOIST TO DAMP @7.9' TO 8.4'; Qu = 2271 PSF @ 15.0%	468.4	4.5 – 9.2
MEDIUM DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, DAMP	465.6	9.2 – 12.0
MEDIUM DENSE, GRAY, **STONE FRAGMENTS**, LITTLE SAND, TRACE SILT, TRACE CLAY, ENCOUNTER WITH COBBLE, MOIST	463.8	12.0 – 13.8 (W 465.1)
SOFT TO STIFF, GRAY, **SILT AND CLAY**, TRACE TO LITTLE SAND, TRACE GRAVEL, MOIST TO WET	456.6	13.8 – 21.0
LOOSE TO MEDIUM DENSE, GRAY, **COARSE AND FINE SAND**, SOME GRAVEL, TRACE SILT, TRACE CLAY, WET	454.8	21.0 – 22.8
STIFF, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST	453.1	22.8 – 24.5
DENSE, GRAY, **STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, WET	449.3	24.5 – 28.3
VERY STIFF, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, RELIC ROCK STRUCTURE, DAMP		28.3 –

SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
3 7 8	20	61	SS-1	4.50	24	11	9	36	20	34	20	14	14	A-6a (6)	
2 3 3	8	100	SS-2	3.25	-	-	-	-	-	-	-	-	22	A-6b (V)	
		83	ST-1	2.00	9	6	9	41	35	38	20	18	20	A-6b (11)	
10 8 9	22	50	SS-3	-	-	-	-	-	-	-	-	-	5	A-1-b (V)	
4 9 12	28	44	SS-4	-	-	-	-	-	-	-	-	-	9	A-1-a (V)	
1 2 3	7	100	SS-5	1.75	3	2	6	56	33	32	20	12	26	A-6a (9)	
3 4 4	11	39	SS-6	0.75	-	-	-	-	-	-	-	-	31	A-6a (V)	
4 4 3	9	100	SS-7A	0.50	-	-	-	-	-	-	-	-	29	A-6a (V)	
			SS-7B	-	-	-	-	-	-	-	-	-	16	A-3a (V)	
3 5 8	17	100	SS-8A	-	-	-	-	-	-	-	-	-	13	A-3a (V)	
			SS-8B	1.50	-	-	-	-	-	-	-	-	23	A-6a (V)	
7 10 18	37	44	SS-9	-	-	-	-	-	-	-	-	-	15	A-2-4 (V)	

PID: 113602	SFN:	PROJECT: HAM-LMST EXT	STATION / OFFSET: 76+68, 36' RT.	START: 7/7/22	END: 7/8/22	PG 2 OF 2	B-002-0-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 447.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
	446.6	TR 31	17 50/3"	-	89	SS-10	3.50	-	-	-	-	-	-	-	-	12	A-6a (V)	
INTERBEDDED LIMESTONE (51%) AND SHALE (49%), CONTAINS MANY INTERBEDDED 1/8" - 1/2" CLAY SEAMS, BEDDING DISCONTINUITIES: LOW ANGLE, HIGHLY FRACTURED TO MODERATELY FRACTURED, OPEN TO NARROW, SLIGHTLY ROUGH TO VERY ROUGH, BLOCKY/DISTURBED/SEAMY, GOOD TO FAIR SURFACE CONDITION, RQD 24%, REC. 90%; **LIMESTONE**, GRAY AND LIGHT GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG, FINE TO COARSE GRAINED, LAMINATED TO THIN BEDDED, FOSSILIFEROUS, STYLOLITIC; **SHALE**, GRAY, SEVERELY TO HIGHLY WEATHERED, VERY WEAK TO WEAK, FISSILE.	436.6	32 33 34 35 36 37 38 39 40 EOB 41	24		90	NQ2-1											CORE	

NOTES: GROUNDWATER ENCOUNTERED AT 12.5' DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 100 GAL. BENTONITE GROUT

NEAS
National Engineering & Architectural Services Inc.

5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

Unconfined Compressive Strength of Cohesive Soil (ASTM D2166)

(Project: HAM-LMST Ext, Boring Location: B-002-0-20, ST-1, Depth: 7.9 - 8.4ft)

Tested Date: 7/11/2022

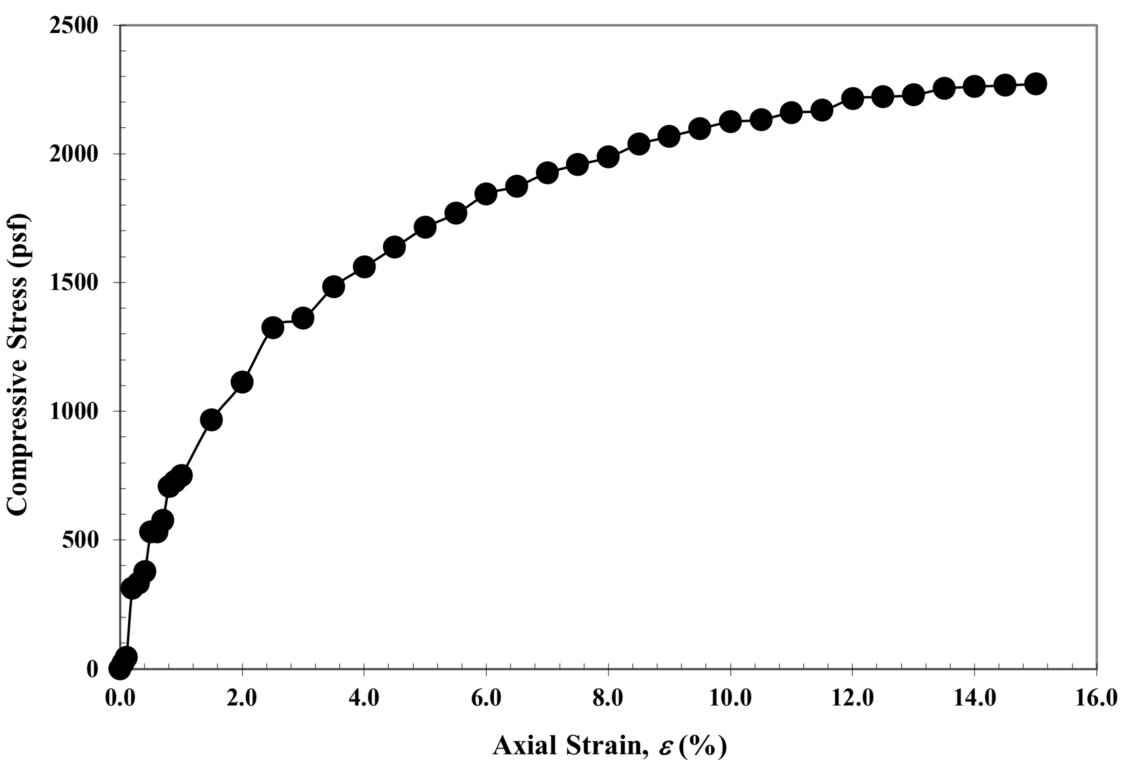
Specimen Properties

Average Dia., D_{avg} (in):	2.87
Average Height, H_{avg} (in):	5.75
Area, A (in^2):	6.47
Volume, V (in^3):	37.21
Wet Mass of Specimen (lb):	2.8
Moisture Content (%):	21.9
Dry Mass of Specimen (lb):	2.3
Wet Unit Weight, γ (lb/ft^3):	129.1
Dry Unit Weight, γ_d (lb/ft^3):	105.9

Final Specimen Figure

Results

Unconfined Compressive Strength (psf):	**2271**
Strain (%):	**15.0**



Notes: Stiff, brownish gray, SILTY CLAY, little sand, trace gravel, damp. Specimen contains gravel >1/6 specimen diameter. Results reported may differ from a specimen that meets the maximum particle size allowance of D2166. Specimen exceeded strain limitations of 15.0%.

NEAS
National Engineering & Architectural Services Inc.

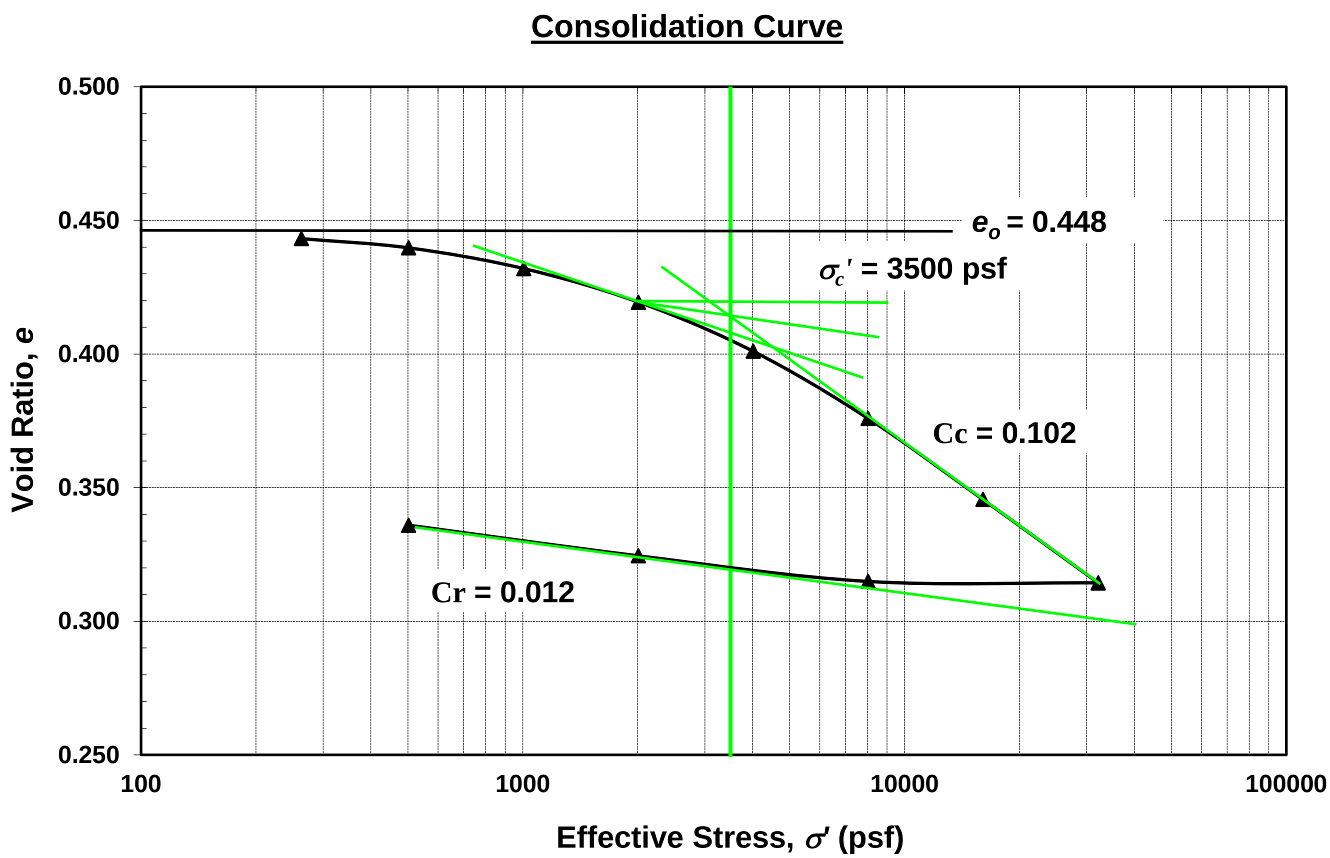
5710 Westbourne Avenue
Columbus, OH 43213
614.892.0162

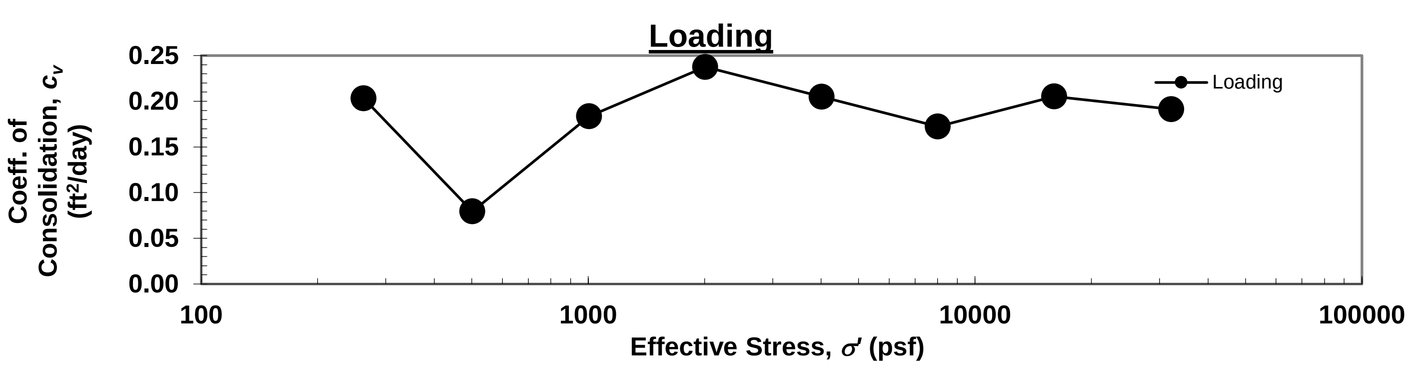
Consolidation Test

Project Name:	HAM-LMST Ext	Prepared by:	LR
Source:	B-002-0-20 ST-1 (8.4' - 8.5')	Checked by:	ZM
Description:	Stiff to very stiff, gray, SILTY CLAY, little sand, trace gravel, damp. After testing, a 7/16" gravel piece was found within the specimen.	Date:	7/29/2022
Test Specification:	ASTM D 2435		
Initial Void Ratio:	0.448	Initial Bulk Unit Weight (lb/ft^3):	135
In-situ Vertical Effective Stress (psf):	1100	Dry Unit Weight (lb/ft^3):	116

Compression and Swelling Index

Compression Index (*Cc*):	0.102	Preconsolidation Pressure (σ_c')(psf):	**3500**
Recompression Index (*Cr*):	0.012	Over-Consolidation Ratio (*OCR*):	**3.18**





Ohio Department of Transportation
Division of Engineering

Office of Geotechnical Engineering

B-002-0-20

Run #:	Depth		Recovery		RQD	
NQ2-1	31.0’	41.0’	108”/120”	90%	28.5”/120”	24%

HAM-LMST Extension to Ranchvale (PID #113602)

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 12/15/22 11:49 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\HAM LMST EXT\GINT FILES\HAM-LMST EXT.GPJ

PROJECT: HAM-LMST EXT TYPE: RETAINING WALL PID: 113602 SFN: START: 7/6/22 END: 7/6/22	DRILLING FIRM / OPERATOR: NEAS / J. HODGES SAMPLING FIRM / LOGGER: NEAS / J. HODGES DRILLING METHOD: 3.25" HSA / NQ2 SAMPLING METHOD: SPT / NQ2	DRILL RIG: CME 55X HAMMER: CME AUTOMATIC CALIBRATION DATE: 1/24/22 ENERGY RATIO (%): 79	STATION / OFFSET: 78+78, 41' RT. ALIGNMENT: ELSTUN CONNECTION ELEVATION: 470.0 (MSL) EOB: 33.3 ft. LAT / LONG: 39.105798, -84.400302

EXPLORATION ID B-003-0-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 470.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM STIFF, BROWN, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, CONTAINS NO INTACT SOIL FOR HP READINGS, DAMP	468.5	1	3 3 3	8	22	SS-1	-	1	0	6	65	28	40	25	15	20	A-6a (10)	
LOOSE, BROWN, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP	467.0	2–3	2 4 3	9	100	SS-2	-	16	39	30	11	4	NP	NP	NP	7	A-1-b (0)	
VERY LOOSE, BROWN, **GRAVEL WITH SAND AND SILT**, TRACE CLAY, DAMP	465.5	4	1 1 1	3	28	SS-3	-	21	28	20	22	9	NP	NP	NP	10	A-2-4 (0)	
MEDIUM DENSE, GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, ENCOUNTER WITH COBBLE, LARGE STONE FRAGMENTS, DAMP	464.0	5	3 11 10	28	100	SS-4	-	46	23	14	12	5	NP	NP	NP	5	A-1-b (0)	
LOOSE TO MEDIUM DENSE, ORANGISH BROWN AND GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, CONTAINS IRON STAINING, WET TO MOIST		6–7	8 8 7	20	89	SS-5	-	33	32	20	11	4	NP	NP	NP	14	A-1-b (0)	
		8 (W 461.0)	3 10 9	25	39	SS-6	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
	458.7	9–10	3 4 2	8	28	SS-7	-	-	-	-	-	-	-	-	-	12	A-1-b (V)	
STIFF, GRAY, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, MOIST		11–12																
	455.5	13	2 2 2	5	100	SS-8	1.50	1	2	31	33	33	31	18	13	26	A-6a (7)	
DENSE, GRAY, **STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, WET	453.0	15–16	7 12 12	32	100	SS-9	-	-	-	-	-	-	-	-	-	19	A-2-4 (V)	
VERY STIFF, GRAY, **SILT AND CLAY**, SOME SAND, LITTLE GRAVEL AND STONE FRAGMENTS, DAMP	450.5	18	5 10 7	22	100	SS-10	2.75	16	18	20	22	24	29	17	12	15	A-6a (3)	
DENSE, GRAY, **STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP	448.0	20–21	6 8 17	33	100	SS-11	-	-	-	-	-	-	-	-	-	9	A-2-4 (V)	
HARD, GRAY, **SANDY SILT**, LITTLE CLAY, LITTLE STONE FRAGMENTS, RELIC ROCK STRUCTURE, DAMP	446.7	22–23 (TR)	10 50/4"	-	60	SS-12	4.50	-	-	-	-	-	-	-	-	9	A-4a (V)	
@23.7'-24.1'; Qu = 5634 PSI @ 0.5%		24–29	33		96	NQ2-1											CORE	

PID: 113602	SFN:	PROJECT: HAM-LMST EXT	STATION / OFFSET: 78+78, 41' RT.	START: 7/6/22	END: 7/6/22	PG 2 OF 2	B-003-0-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 440.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
INTERBEDDED LIMESTONE (61%) AND SHALE (39%), CONTAINS MANY INTERBEDDED 1/8" - 1/2" CLAY SEAMS, BEDDING DISCONTINUITIES: LOW ANGLE, HIGHLY FRACTURED TO MODERATELY FRACTURED, OPEN TO NARROW, SLIGHTLY ROUGH TO VERY ROUGH, BLOCKY/DISTURBED/SEAMY, GOOD TO FAIR SURFACE CONDITION, RQD 33%, REC. 96%; **LIMESTONE**, GRAY AND LIGHT GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG, FINE TO COARSE GRAINED, LAMINATED TO THIN BEDDED, FOSSILIFEROUS, STYLOLITIC; **SHALE**, GRAY, SEVERELY WEATHERED, VERY WEAK, FISSILE. *(continued)* @32.8'-33.2'; Qu = 7935 PSI @ 0.7%	436.7	31 32 33 EOB																

NOTES: GROUNDWATER ENCOUNTERED AT 9.0' DURING DRILLING. HOLE DID NOT CAVE.

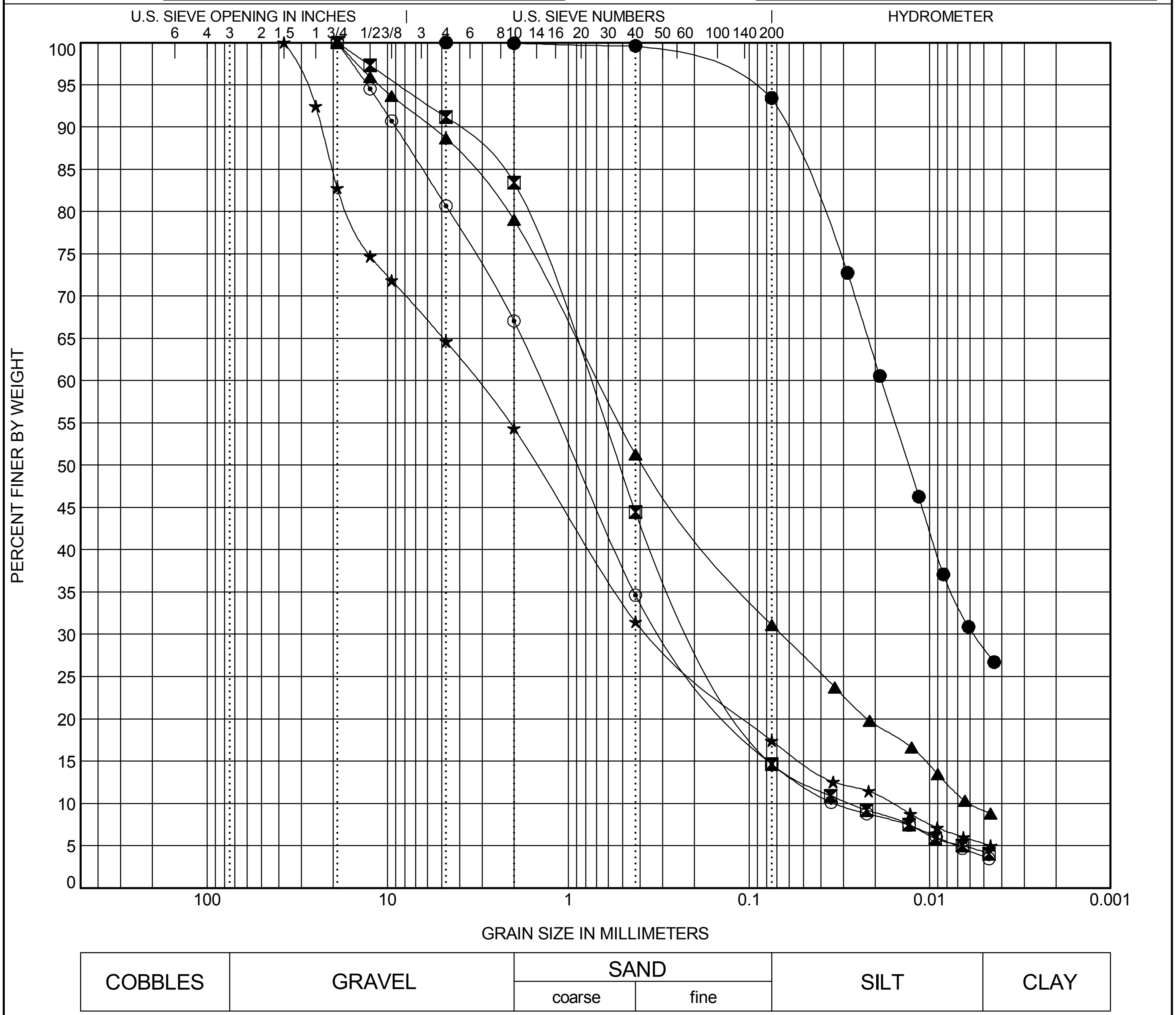
ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 100 GAL. BENTONITE GROUT

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT HAM-LMST EXT **PID** 113602

OGE NUMBER 0 **PROJECT TYPE**



Specimen Identification		ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
● B-003-0-20	0.0	**A-6a ~ LEAN CLAY(CL)**	40	25	15
⊠ B-003-0-20	1.5	**A-1-b ~ SILTY SAND(SM)**	NP	NP	NP
▲ B-003-0-20	3.0	**A-2-4 ~ SILTY SAND(SM)**	NP	NP	NP
★ B-003-0-20	4.5	**A-1-b ~ SILTY SAND with GRAVEL(SM)**	NP	NP	NP
⊙ B-003-0-20	6.0	**A-1-b ~ SILTY SAND with GRAVEL(SM)**	NP	NP	NP

Specimen Identification		D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
● B-003-0-20	0.0	0.064	0.013	0.006		1	0	6	65	28		
⊠ B-003-0-20	1.5	4.165	0.53	0.183	0.028	16	39	30	11	4	1.53	28.29
▲ B-003-0-20	3.0	5.705	0.38	0.067	0.006	21	28	20	22	9	1.07	115.61
★ B-003-0-20	4.5	23.308	1.488	0.355	0.016	46	23	14	12	5	2.39	196.07
⊙ B-003-0-20	6.0	9.042	0.886	0.285	0.034	33	32	20	11	4	1.68	42.22

5710 Westbourne Avenue
Columbus, OH 43213
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Unconfined Compressive Strength of Rock Core (ASTM D7012 Method C)

(Project: HAM-LMST Extension, Boring Location: B-003-0-20, NQ2-1, Depth: 23.7 - 24.1ft)

Tested Date: 7/14/2022

Specimen Properties

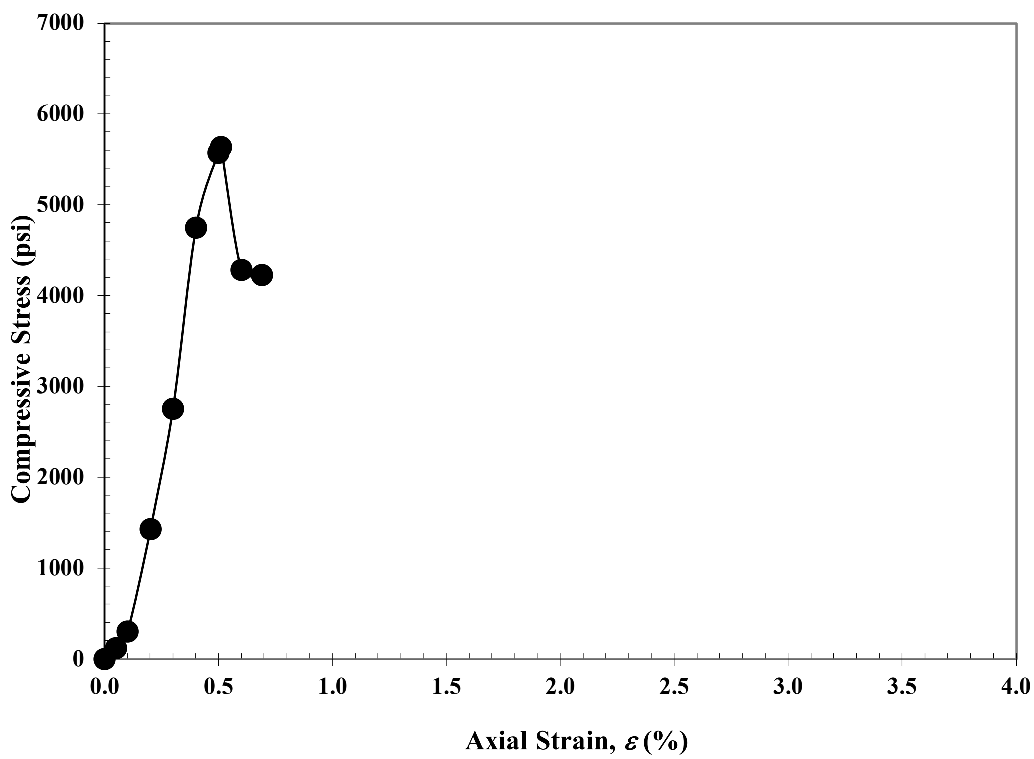
Average Dia., D_{avg} (in):	1.97
Average Height, H_{avg} (in):	4.50
Length to Diameter Ratio:	2.28
Area, A (in^2):	3.06
Volume, V (in^3):	13.75
Wet Mass of Specimen (lb):	1.3
Moisture Content (%):	0.5
Dry Mass of Specimen (lb):	1.3
Wet Unit Weight, γ (lb/ft^3):	168.1
Dry Unit Weight, γ_d (lb/ft^3):	167.2

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **5634** **39** (MPa)

Strain (%): **0.5**



Notes: Limestone, gray, unweathered, fine to coarse grained, moderately strong, fossiliferous.

Sample trimming procedure does not conform to ASTM D4543 and the results reported may differ from the results obtained from a test specimen that meets the requirements of Practice D4543.

5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

Unconfined Compressive Strength of Rock Core (ASTM D7012 Method C)

(Project: HAM-LMST Extension, Boring Location: B-003-0-20, NQ2-1, Depth: 32.8 - 33.2ft)

Tested Date: 7/14/2022

Specimen Properties

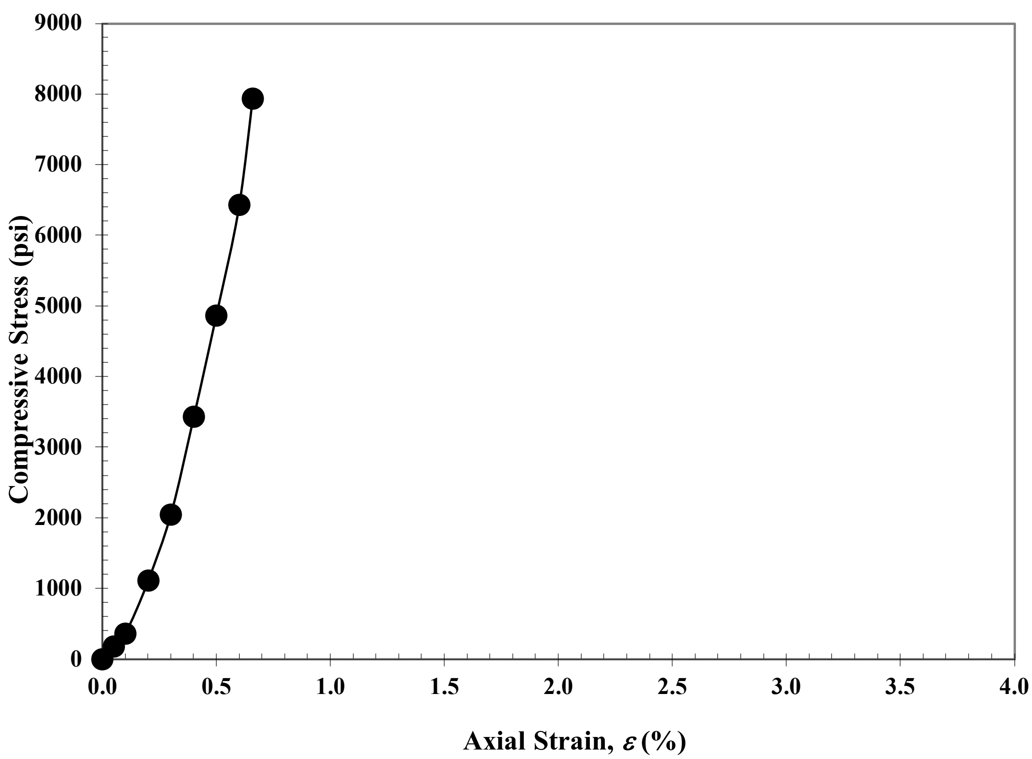
Average Dia., D_{avg} (in):	1.97
Average Height, H_{avg} (in):	4.41
Length to Diameter Ratio:	2.24
Area, A (in^2):	3.04
Volume, V (in^3):	13.41
Wet Mass of Specimen (lb):	1.3
Moisture Content (%):	1.4
Dry Mass of Specimen (lb):	1.3
Wet Unit Weight, γ (lb/ft^3):	166.4
Dry Unit Weight, γ_d (lb/ft^3):	164.1

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **7935** **55** (MPa)

Strain (%): **0.7**



Notes: Limestone, gray, unweathered, fine to medium grained, strong, slightly fossiliferous, slightly argillaceous.

Sample trimming procedure does not conform to ASTM D4543 and the results reported may differ from the results obtained from a test specimen that meets the requirements of Practice D4543.

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-003-0-20

Run #:	Depth		Recovery		RQD	
NQ2-1	23.3’	33.3’	115”/120”	96%	39.25”/120”	33%
HAM-LMST Extension to Ranchvale (PID #113602)						

PROJECT: HAM-LMST EXT	DRILLING FIRM / OPERATOR: NEAS / J. HODGES	DRILL RIG: CME 55X	STATION / OFFSET: 79+48, 51' RT.	EXPLORATION ID B-004-0-20
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: NEAS / J. HODGES	HAMMER: CME AUTOMATIC	ALIGNMENT: ELSTUN CONNECTION	
PID: 113602 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/24/22	ELEVATION: 477.7 (MSL) EOB: 41.0 ft.	PAGE 1 OF 2
START: 7/7/22 END: 7/7/22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 79	LAT / LONG: 39.105605, -84.400275	

MATERIAL DESCRIPTION AND NOTES	ELEV. 477.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
HARD, BROWN, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, DAMP	473.2	1 2 3 4	4 4 4	11	83	SS-1	4.25	1	1	3	63	32	36	22	14	21	A-6a (10)	
VERY STIFF TO HARD, BROWN, **CLAY**, "AND" SILT, TRACE SAND, TRACE GRAVEL, DAMP		5 6 7	2 4 5	12	100	SS-2	4.25	-	-	-	-	-	-	-	-	21	A-7-6 (V)	
		8 9 10	3 3 4	9	100	SS-3	3.00	0	1	9	55	35	46	25	21	25	A-7-6 (14)	
	466.5	11	3 4 7	14	100	SS-4A	2.75	-	-	-	-	-	-	-	-	23	A-7-6 (V)	
MEDIUM DENSE, BROWN, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, DAMP	465.7	12				SS-4B	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
DENSE, GRAY, **STONE FRAGMENTS**, LITTLE SAND, TRACE SILT, TRACE CLAY, ENCOUNTER WITH COBBLE, DAMP	463.2	13 14	38 13 19	42	67	SS-5	-	-	-	-	-	-	-	-	-	2	A-1-a (V)	
MEDIUM DENSE, BROWN, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP		15 16 17	8 6 4	13	100	SS-6	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
SS-7 BECOMES ORANGISH BROWN, CONTAINS IRON STAINING, WET	458.2	W 460.2 18 19	7 10 8	24	78	SS-7	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
MEDIUM STIFF TO VERY STIFF, GREENISH GRAY, **CLAY**, SOME SILT, TRACE TO LITTLE SAND, TRACE GRAVEL, SS-8 CONTAINS NO INTACT SOIL FOR HP READINGS, DAMP		20 21 22	2 2 2	5	22	SS-8	-	-	-	-	-	-	-	-	-	17	A-7-6 (V)	
		23 24	6 6 15	28	100	SS-9	3.50	5	6	6	34	49	42	21	21	20	A-7-6 (13)	
	449.4	25 26 27 28	5 20 13	43	100	SS-10	3.25	-	-	-	-	-	-	-	-	16	A-7-6 (V)	
HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS, RELIC ROCK STRUCTURE, CONTAINS NO INTACT SOIL FOR HP READINGS, DAMP		29																

PID: 113602	SFN:	PROJECT: HAM-LMST EXT	STATION / OFFSET: 79+48, 51' RT.	START: 7/7/22	END: 7/7/22	PG 2 OF 2	B-004-0-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 447.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
	446.7	TR 31	8 50/3"	-	67	SS-11	-	-	-	-	-	-	-	-	-	16	A-6a (V)	
INTERBEDDED LIMESTONE (57%) AND SHALE (43%), CONTAINS MANY INTERBEDDED 1/8" - 1/2" CLAY SEAMS, BEDDING DISCONTINUITIES: LOW ANGLE, HIGHLY FRACTURED TO MODERATELY FRACTURED, OPEN TO NARROW, SLIGHTLY ROUGH TO VERY ROUGH, BLOCKY/DISTURBED/SEAMY, GOOD TO FAIR SURFACE CONDITION, RQD 24%, REC. 94%; **LIMESTONE**, GRAY AND LIGHT GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG, FINE TO COARSE GRAINED, LAMINATED TO THIN BEDDED, FOSSILIFEROUS, STYLOLITIC; **SHALE**, GRAY, SEVERELY TO HIGHLY WEATHERED, VERY WEAK, FISSILE.	436.7	32 33 34 35 36 37 38 39 40 EOB 41	24		94	NQ2-1											CORE	

NOTES: GROUNDWATER ENCOUNTERED AT 17.5' DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 100 GAL. BENTONITE GROUT

Ohio Department of Transportation
Division of Engineering

Office of Geotechnical Engineering

B-004-0-20

Run #:	Depth		Recovery		RQD	
NQ2-1	31.0'	41.0'	112.75"/120"	94%	28.5"/120"	24%

HAM-LMST Extension to Ranchvale (PID #113602)

STABILITY ANALYSIS

HAM-LMST EXTENSION TO ELSTUN ROAD

ReSSA+: Update #0.179

PROJECT IDENTIFICATION

Title:	HAM-LMST EXTENSION TO ELSTUN ROAD
Project Number:	PID 113602 -
Client:	Stantec
Designer:	KCA
Station Number:	STA. 76+50

Description:
Reinforced soil slope at STA. 76+50

Company's information:

Name:	NEAS Inc.
Street:	2800 Corporate Exchange Drive Suite 240 Columbus, OH 43231
Telephone #:	614-714-0299 Ext. 129
Fax #:	
E-Mail:	brendan.andrews@neasinc.com

File path and name: P:\22-0029 ..... nalysis\ReSSA1\STA77+16\STA77+16_ReSSA_081423.MSEp
Original date and time of creating this file: Mon Aug 14 09:50:24 2023

PROGRAM MODE: Analysis of a General Slope using GEOSYNTHETIC as reinforcing material.

INPUT DATA (EXCLUDING REINFORCEMENT LAYOUT)

SOIL DATA

=========== Soil Layer #: ===========	Unit weight, γ [lb/ft ³]	Internal angle of friction, ϕ [deg.]	Cohesion, c [lb/ft ²]
.1.......Item 203 Embankment Fill....................	125.0	26.0	200.0
.2.......Subsoil Layer 1: Silty Clay....................	125.0	24.0	200.0
.3.......Subsoil Layer 2: Silty Clay....................	125.0	22.0	100.0
.4.......Subsoil Layer 3: Gravel with Sand........	118.0	34.0	0.0
.5.......Subsoil Layer 4: Silt and Clay..............	125.0	22.0	100.0

REINFORCEMENT

Reinforcement Type #	Geosynthetic Designated Name	Ultimate Strength, Tult [lb/ft]	Reduction Factor for Installation Damage, RFid	Reduction Factor for Durability, RFd	Reduction Factor for Creep, RFc	Additional Reduction Factor, RFa	Coverage Ratio, Rc
1	Geosynthetic type #1	1300.00	1.00	1.00	1.00	1.00	1.00

Interaction Parameters Type #	Geosynthetic Designated Name	== Direct Sliding == Cds-phi	Cds-c	==== Pullout ==== Ci	Alpha
1	Geosynthetic type #1	0.67	0.00	0.67	0.80

Relative Orientation of Reinforcement Force, ROR = 0.00. Assigned Factor of Safety to resist pullout, Fs-po = 2.00
Design method for Global Stability: Comprehensive Bishop.

WATER

Unit weight of water = 62.45 [lb/ft ³]
Water pressure is defined by phreatic surface in Effective Stress Analysis.

SEISMICITY

Not Applicable

DRAWING OF SPECIFIED GEOMETRY - GENERAL

-- Problem geometry is defined along sections selected by user at x,y coordinates.
-- X1,Y1 represents the coordinates of soil surface. X2,Y2 represent the coordinates of the end of soil layer 1 and start of soil layer 2, and so on.
-- Xw,Yw represents the coordinates of phreatic surface.

GEOMETRY

Soil profile contains 5 layers

WATER GEOMETRY

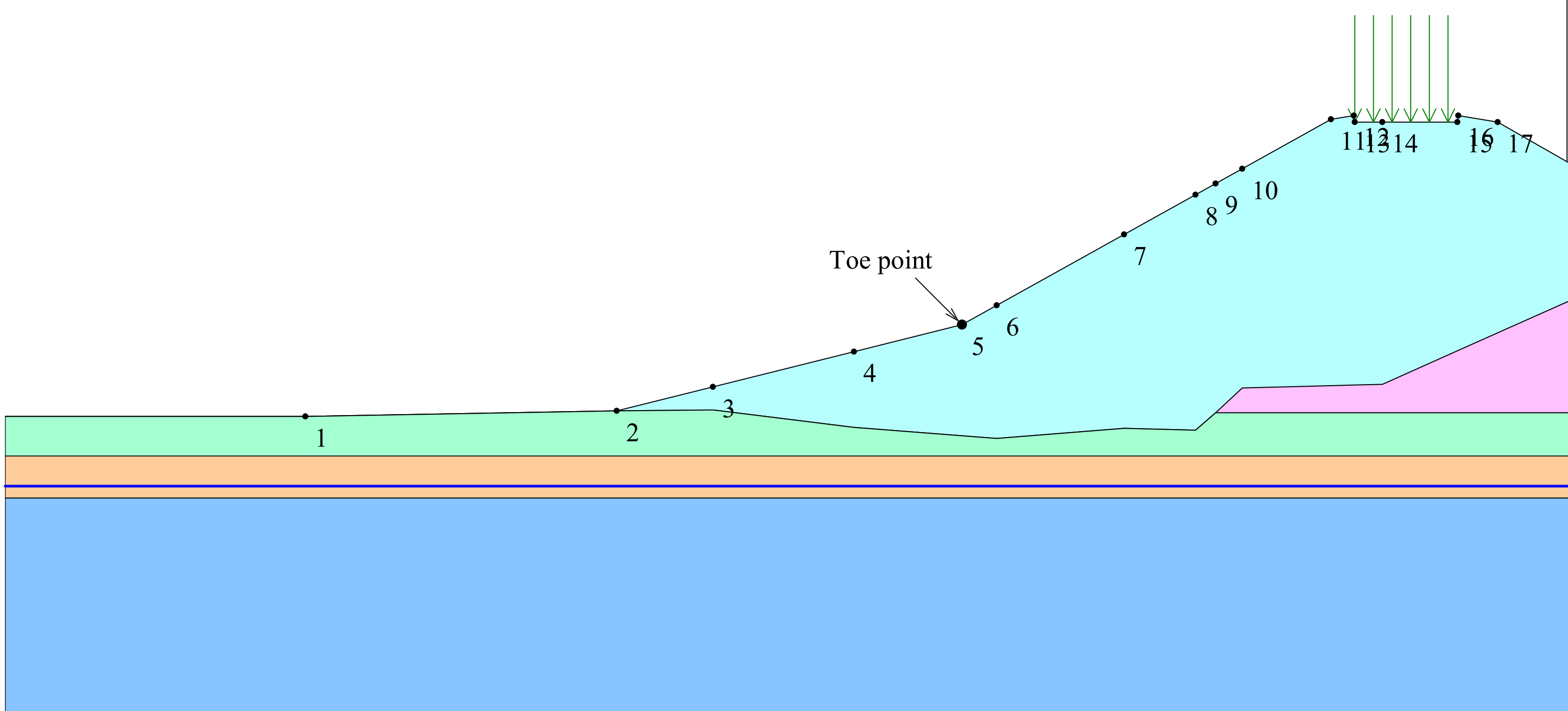
Phreatic line was specified.

UNIFORM SURCHARGE

Load Q1 = 250.00 [lb/ft²] inclined from verical at 0.00 degrees, starts at X1s = -5.40 and ends at X1e = 5.80 [ft].
Surcharge load, Q2.....................................None
Surcharge load, Q3.....................................None

STRIP LOAD

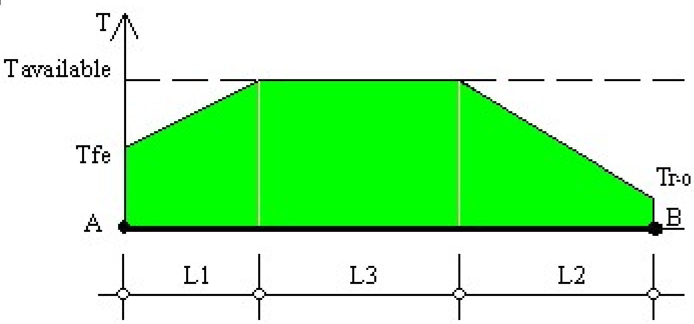
............................None...................................



SCALE:

0 2 4 6 [ft]

DISTRIBUTION OF AVAILABLE STRENGTH ALONG EACH REINFORCEMENT LAYER



A = Front-end of reinforcement (at face of slope)
B = Rear-end of reinforcement
AB = L1 + L2 + L3 = Embedded length of reinforcement

Tavailable = Long-term strength of reinforcement
Tfe = Available front-end strength (e.g., connection to facing)
Tr-o = Pullout resistance at rear-end

L1 = Front-end 'pullout' length
L2 = Rear-end pullout length
Tavailable prevails along L3

Factor of safety on resistance to pullout on either end of reinforcement, Fs-po = 2.00

Reinforcement Layer #	Designated Name	Height Relative to Toe [ft]	L [ft]	L1 [ft]	L2 [ft]	L3 [ft]	Tfe [lb/ft]	Tr-o [lb/ft]	Tavailable [lb/ft]
1	Geosynthetic type #1	0.00	20.00	0.00	2.95	17.05	1300.00	0.00	1300.00
2	Geosynthetic type #1	2.66	20.00	0.00	2.95	17.05	1300.00	0.00	1300.00
3	Geosynthetic type #1	5.32	20.00	0.00	2.95	17.05	1300.00	0.00	1300.00
4	Geosynthetic type #1	7.98	20.00	0.00	2.95	17.05	1300.00	0.00	1300.00
5	Geosynthetic type #1	10.64	20.00	0.00	2.95	17.05	1300.00	0.00	1300.00
6	Geosynthetic type #1	13.30	20.00	0.00	3.22	16.78	1300.00	0.00	1300.00
7	Geosynthetic type #1	15.96	20.00	0.00	4.23	15.77	1300.00	0.00	1300.00
8	Geosynthetic type #1	18.62	20.00	0.00	5.91	14.09	1300.00	0.00	1300.00

RESULTS OF ROTATIONAL STABILITY ANALYSIS

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.)
The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each entry point (considering all specified exit points)

Entry Point #	Entry Point (X, Y) [ft]		Exit Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
1	-48.30	482.70	-48.30	482.70	-48.30	482.70	0.00	N/A	#10 - Overhanging Cliff
2	-48.30	482.70	-48.30	482.70	-48.30	482.70	0.00	N/A	#10 - Overhanging Cliff
3	-48.30	482.70	-48.30	482.70	-48.30	482.70	0.00	N/A	#10 - Overhanging Cliff
4	-38.27	488.28	-51.29	481.99	-46.31	488.30	8.04	22.27	
5	-35.13	490.02	-51.61	481.90	-45.40	490.08	10.27	9.76	
6	-32.00	491.76	-51.77	482.02	-44.33	491.86	12.33	6.70	
7	-28.87	493.50	-51.82	482.06	-43.30	493.71	14.43	5.21	
8	-25.73	495.24	-51.65	481.93	-42.16	495.34	16.43	4.39	
9	-22.60	496.98	-51.81	482.04	-41.19	497.29	18.59	3.55	
10	-19.47	498.73	-51.66	481.94	-40.06	498.96	20.60	2.86	
11	-16.33	500.47	-51.93	482.12	-38.94	500.62	22.61	2.57	
12	-13.20	502.21	-51.83	482.05	-37.82	502.29	24.62	2.40	
13	-10.07	503.95	-51.71	481.97	-37.20	504.90	27.15	2.26	
14	-6.93	505.27	-51.60	481.89	-37.55	509.41	30.90	2.14	
15	-3.80	504.80	-52.09	482.11	-37.43	513.66	34.78	2.01	
16	-0.67	504.80	-52.04	482.03	-38.75	521.38	41.53	1.90	
17	2.47	504.80	-51.99	481.99	-39.78	529.23	48.80	1.81	
18	5.60	504.80	-51.94	482.04	-34.51	522.09	43.68	1.86	
19	8.73	505.04	-51.88	481.93	-41.48	545.69	64.60	1.79 .	OK
20	11.87	503.85	-51.84	481.92	-41.32	554.87	73.71	1.89	
21	15.00	502.05	-51.79	481.92	-39.10	560.66	79.76	2.04	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-entry' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.
****

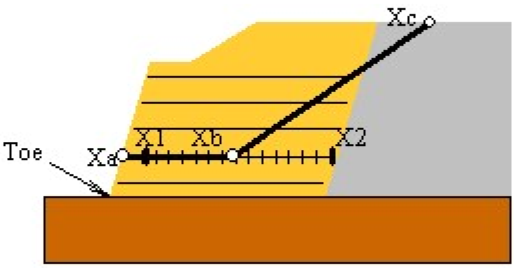
Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.)
The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each exit point (considering all specified entry points).

Exit Point #	Exit Point (X, Y) [ft]		Entry Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
. 1	-51.88	481.93	8.73	505.04	-41.48	545.69	64.60	1.79 .	On extreme X-exit
2	-51.40	481.99	8.73	505.04	-41.21	545.37	64.19	1.79	
3	-51.57	482.15	8.73	505.04	-40.95	545.05	63.79	1.80	
4	-51.09	482.21	8.73	505.04	-40.68	544.73	63.38	1.80	
5	-50.60	482.26	8.73	505.04	-40.42	544.41	62.97	1.80	
6	-50.11	482.32	8.73	505.04	-40.15	544.09	62.57	1.80	
7	-49.62	482.37	8.73	505.04	-39.89	543.77	62.16	1.80	
8	-49.78	482.54	8.73	505.04	-38.87	541.52	59.97	1.81	
9	-49.29	482.59	8.73	505.04	-38.61	541.21	59.58	1.81	
10	-48.80	482.65	8.73	505.04	-38.35	540.91	59.19	1.81	
11	-48.30	482.70	8.73	505.04	-38.09	540.61	58.80	1.82	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-exit' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

RESULTS OF TRANSLATIONAL ANALYSIS



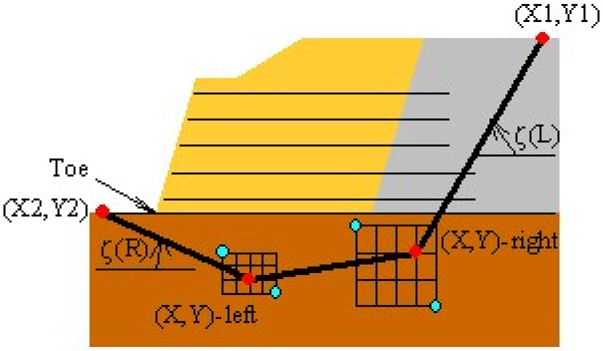
Results in the table below represent critical two-part wedges identified between specified starting (X1) and ending (X2) search points. Wedges along all reinforcement layers and at elevation zero are reported. The critical two-part wedge, one for each predetermined elevation, is defined by Xa, Xb and Xc where Xa is the front end of the passive wedge (slope face), Xb is where the passive wedge ends and the active one starts, and Xc is the X-ordinate at which the active wedge starts.

Critical two-part wedge along each interface:

Interface	Height Relative to Toe [ft]	(Xa, Ya) [ft]		(Xb, Yb) [ft]		(Xc, Yc) [ft]		Fs	STATUS
At toe elevation	0.00	-48.30	482.70	-28.40	482.70	9.95	504.84	1.96	Minimum on Edge
Reinf. Layer #1	0.00	-48.30	482.70	-27.80	482.70	10.34	504.72	1.56	Minimum on Edge
Reinf. Layer #2	2.66	-43.51	485.36	-23.10	485.36	10.39	504.69	1.73	Minimum on Edge
Reinf. Layer #3	5.32	-38.73	488.02	-18.30	488.02	10.48	504.64	1.97	Minimum on Edge
Reinf. Layer #4	7.98	-33.94	490.68	-13.50	490.68	10.58	504.58	2.26	Minimum on Edge
Reinf. Layer #5	10.64	-29.16	493.34	-8.70	493.34	9.76	504.87	2.74	Minimum on Edge
Reinf. Layer #6	13.30	-24.37	496.00	-11.78	496.00	1.27	504.80	3.32	OK
Reinf. Layer #7	15.96	-19.59	498.66	-10.96	498.66	-0.74	504.80	3.92	OK
Reinf. Layer #8	18.62	-14.80	501.32	-6.16	501.32	-1.19	504.80	5.02	OK

Note: In the 'Status' column, OK means the critical two part-wedge was identified within the specified search domain. 'Minimum on Edge' means the critical result corresponds to a minimum on the edge of the search domain; i.e., either on X1 or X2 or the internally preset limits on Xc.

RESULTS OF 3-PART WEDGE ANALYSIS



Results in the table below represent the critical slip surface composed of a three-part wedge and identified by the specified points (X-left, Y-left) and (X-right, Y-right) and angles Zeta(L) and Zeta(R). ReSSA finds the (X,Y) coordinates, as well as the angles Zeta, based on user-specified search domain. The trace of the critical three-part wedge is fully defined by four points: (X1, Y1), (X-left, Y-left), (X-right, Y-right), (X2, Y2).

Critical 3-part wedge (Automatic search):

(X2, Y2) [ft]	Zeta(L) [degrees]	(X-left, Y-left) [ft]	(X-right, Y-right) [ft]	Zeta(R) [degrees]	(X1, Y1) [ft]	Fs
(-52.50, 481.65)	10.00	(-40.30, 479.50)	(-20.55, 484.33)	35.00	(8.97, 505.00)	1.806

CRITICAL RESULTS OF ROTATIONAL AND TRANSLATIONAL STABILITY ANALYSES

Rotational (Circular Arc; Bishop) Stability Analysis

Minimum Factor of Safety = 1.79
Critical Circle: Xc = -41.48[ft], Yc = 545.69[ft], R = 64.60[ft]. (Number of slices used = 59)

Translational (2-Part Wedge; Spencer), Direct Sliding, Stability Analysis

Minimum Factor of Safety = 1.56
Critical Two-Part Wedge: (Xa = -48.30, Ya = 482.70) [ft]
(Xb = -27.80, Yb = 482.70) [ft]
(Xc = 10.34, Yc = 504.72) [ft]
(Number of slices used = 30)
Interslice resultant force inclination = 19.33 [degrees]

Three-Part Wedge Stability Analysis

Minimum Factor of Safety = 1.81
Critical Three-Part Wedge: (X2 = -52.50, Y2 = 481.65) [ft]
(X-left = -40.30, Y-left = 479.50) [ft]
(X-right = -20.55, Y-right = 484.33) [ft]
(X1 = 8.97, Y1 = 505.00) [ft]
(Number of slices used = 45)
Interslice resultant force inclination = 19.60 [degrees]

HAM-LMST EXTENSION TO ELSTUN ROAD

ReSSA+: Update #0.179

PROJECT IDENTIFICATION

Title:	HAM-LMST EXTENSION TO ELSTUN ROAD
Project Number:	PID 113602 -
Client:	Stantec
Designer:	KCA
Station Number:	STA. 79+69

Description:
Reinforced soil slope at STA. 79+69

Company's information:

Name:	NEAS Inc.
Street:	2800 Corporate Exchange Drive Suite 240 Columbus, OH 43231
Telephone #:	614-714-0299 Ext. 129
Fax #:	
E-Mail:	brendan.andrews@neasinc.com

File path and name: P:\22-0029 ..... nalysis\ReSSA1\STA79+69\STA79+69_ReSSA_081423.MSEp
Original date and time of creating this file: Mon Aug 14 09:50:24 2023

PROGRAM MODE: Analysis of a General Slope using GEOSYNTHETIC as reinforcing material.

INPUT DATA (EXCLUDING REINFORCEMENT LAYOUT)

SOIL DATA

=========== Soil Layer #: ===========	Unit weight, γ [lb/ft ³]	Internal angle of friction, ϕ [deg.]	Cohesion, c [lb/ft ²]
1.......Item 203 Embankment Fill...................	125.0	26.0	200.0
2.......Subsoil Layer 1: Silt and Clay..............	120.0	23.0	150.0
3.......Subsoil Layer 2: Clay...........................	120.0	22.0	150.0
4.......Subsoil Layer 3: Gravel with Sand.......	125.0	35.0	0.0
5.......Subsoil Layer 4: Clay...........................	115.0	20.0	75.0

REINFORCEMENT

Reinforcement Type #	Geosynthetic Designated Name	Ultimate Strength, Tult [lb/ft]	Reduction Factor for Installation Damage, RFid	Reduction Factor for Durability, RFd	Reduction Factor for Creep, RFc	Additional Reduction Factor, RFa	Coverage Ratio, Rc
1	Geosynthetic type #1	1300.00	1.00	1.00	1.00	1.00	1.00

Interaction Parameters Type #	Geosynthetic Designated Name	== Direct Sliding == Cds-phi	Cds-c	==== Pullout ==== Ci	Alpha
1	Geosynthetic type #1	0.67	0.00	0.67	0.80

Relative Orientation of Reinforcement Force, ROR = 0.00. Assigned Factor of Safety to resist pullout, Fs-po = 2.00
Design method for Global Stability: Comprehensive Bishop.

WATER

Unit weight of water = 62.45 [lb/ft ³]
Water pressure is defined by phreatic surface in Effective Stress Analysis.

SEISMICITY

Not Applicable

DRAWING OF SPECIFIED GEOMETRY - GENERAL

-- Problem geometry is defined along sections selected by user at x,y coordinates.
-- X1,Y1 represents the coordinates of soil surface. X2,Y2 represent the coordinates of the end of soil layer 1 and start of soil layer 2, and so on.
-- Xw,Yw represents the coordinates of phreatic surface.

GEOMETRY

Soil profile contains 5 layers

WATER GEOMETRY

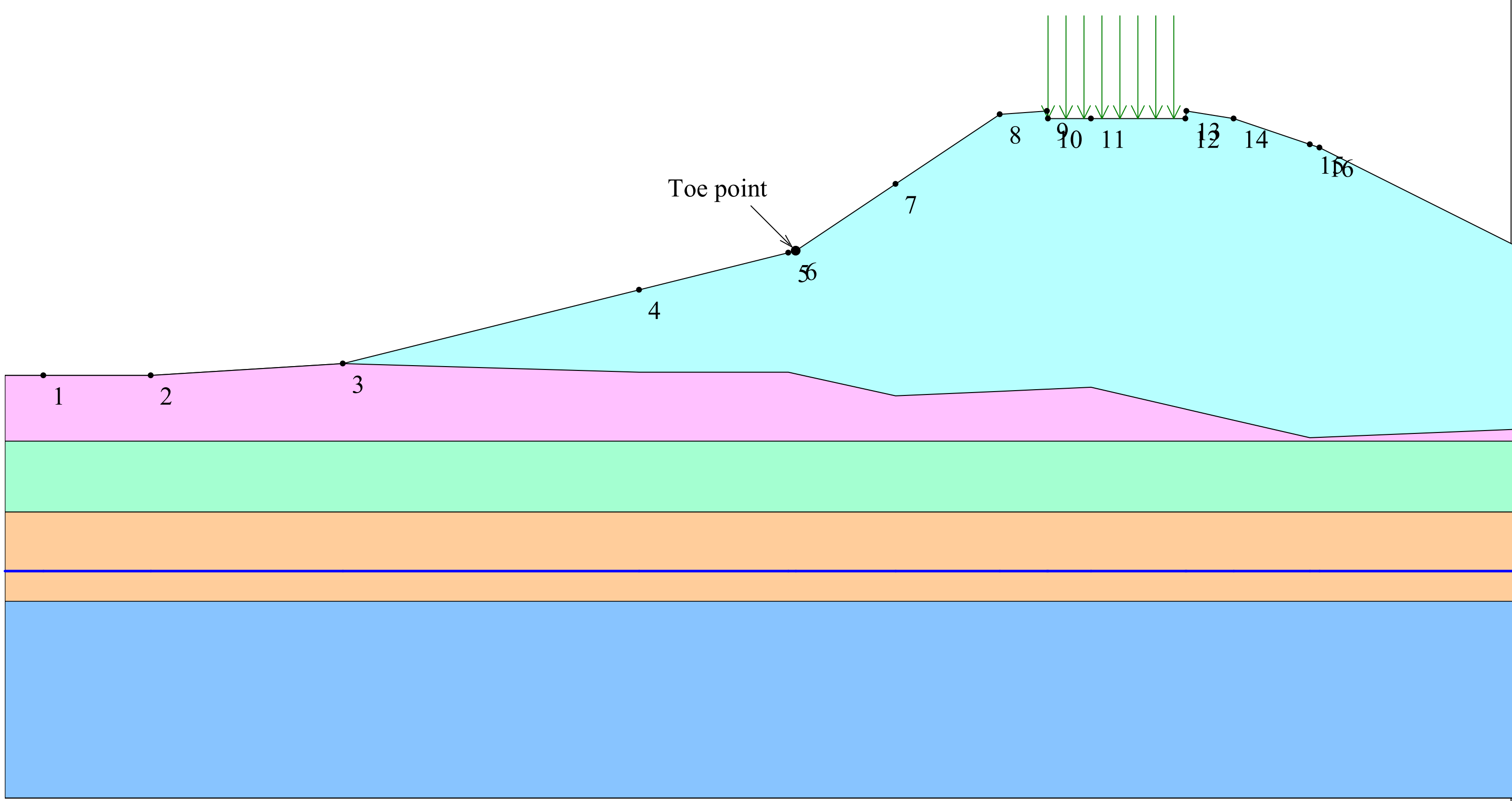
Phreatic line was specified.

UNIFORM SURCHARGE

Load Q1 = 250.00 [lb/ft²] inclined from verical at 0.00 degrees, starts at X1s = -6.40 and ends at X1e = 6.40 [ft].
Surcharge load, Q2....................................None
Surcharge load, Q3....................................None

STRIP LOAD

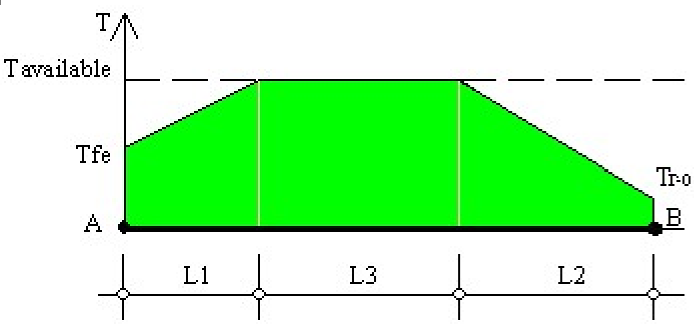
............................None...................................



SCALE:

0 2 4 6 8 10[ft]

DISTRIBUTION OF AVAILABLE STRENGTH ALONG EACH REINFORCEMENT LAYER



A = Front-end of reinforcement (at face of slope)
B = Rear-end of reinforcement
AB = L1 + L2 + L3 = Embedded length of reinforcement

Tavailable = Long-term strength of reinforcement
Tfe = Available front-end strength (e.g., connection to facing)
Tr-o = Pullout resistance at rear-end

L1 = Front-end 'pullout' length
L2 = Rear-end pullout length
Tavailable prevails along L3

Factor of safety on resistance to pullout on either end of reinforcement, Fs-po = 2.00

Reinforcement Layer #	Designated Name	Height Relative to Toe [ft]	L [ft]	L1 [ft]	L2 [ft]	L3 [ft]	Tfe [lb/ft]	Tr-o [lb/ft]	Tavailable [lb/ft]
1	Geosynthetic type #1	0.00	13.00	0.00	3.74	9.26	1300.00	0.00	1300.00
2	Geosynthetic type #1	2.66	13.00	0.00	3.74	9.26	1300.00	0.00	1300.00
3	Geosynthetic type #1	5.32	13.00	0.00	3.84	9.16	1300.00	0.00	1300.00
4	Geosynthetic type #1	7.98	13.00	0.00	4.99	8.01	1300.00	0.00	1300.00
5	Geosynthetic type #1	10.64	13.00	0.00	7.78	5.22	1300.00	0.00	1300.00

RESULTS OF ROTATIONAL STABILITY ANALYSIS

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each entry point (considering all specified exit points)

Entry Point #	Entry Point X [ft]	Entry Point Y [ft]	Exit Point X [ft]	Exit Point Y [ft]	Critical Circle Xc [ft]	Critical Circle Yc [ft]	Critical Circle R [ft]	Fs	STATUS
1	-7.00	503.77	-36.20	489.41	-25.93	505.40	19.00	2.31	
2	-6.08	503.10	-36.19	489.38	-26.29	507.55	20.69	2.22	
3	-5.16	503.10	-36.15	489.35	-26.77	510.01	22.69	2.15	
4	-4.25	503.10	-36.10	489.32	-27.15	512.34	24.70	2.09	
5	-3.33	503.10	-36.05	489.30	-27.09	513.75	26.04	2.04	
6	-2.41	503.10	-36.00	489.28	-27.34	515.95	28.04	2.00	
7	-1.50	503.10	-36.34	489.38	-27.98	519.23	31.00	1.98	
8	-0.58	503.10	-36.30	489.36	-28.04	521.19	32.89	1.97	
. 9	0.34	503.10	-37.55	488.92	-28.88	523.47	35.62	1.97 .	OK
10	1.25	503.10	-37.92	489.02	-28.60	524.61	36.79	1.99	
11	2.17	503.10	-39.08	488.56	-29.43	526.94	39.58	2.01	
12	3.09	503.10	-40.62	488.19	-29.81	528.04	41.28	2.02	
13	4.00	503.10	-42.11	487.82	-30.61	530.32	44.03	2.04	
14	4.92	503.10	-43.70	487.47	-31.39	532.61	46.79	2.06	
15	5.83	503.10	-45.25	487.11	-32.17	534.92	49.57	2.08	
16	6.75	503.76	-45.25	487.17	-27.51	521.37	38.52	2.18	
17	7.67	503.61	-45.25	487.11	-31.69	536.72	51.43	2.13	
18	8.58	503.47	-45.25	487.11	-31.33	538.06	52.82	2.16	
19	9.50	503.32	-45.25	487.11	-30.96	539.42	54.23	2.20	
20	10.42	503.18	-45.25	487.11	-30.59	540.80	55.66	2.24	
21	11.33	502.95	-45.25	487.11	-30.19	542.30	57.21	2.28	
22	12.25	502.64	-45.25	487.11	-29.75	543.94	58.90	2.33	
23	13.17	502.33	-45.25	487.12	-28.78	543.61	58.85	2.39	
24	14.08	502.03	-45.25	487.12	-28.31	545.23	60.53	2.45	
25	15.00	501.72	-45.25	487.12	-27.84	546.89	62.25	2.51	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-entry' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

****

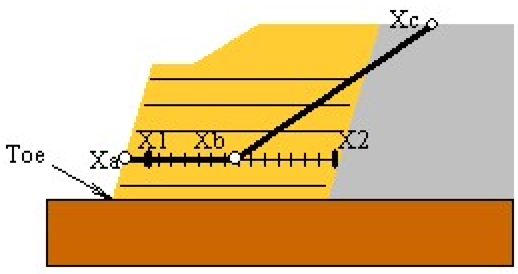
Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each exit point (considering all specified entry points).

Exit Point #	Exit Point X [ft]	Exit Point Y [ft]	Entry Point X [ft]	Entry Point Y [ft]	Critical Circle Xc [ft]	Critical Circle Yc [ft]	Critical Circle R [ft]	Fs	STATUS
1	-45.25	487.12	0.34	503.10	-33.59	526.85	41.41	2.00	
2	-43.60	487.44	0.34	503.10	-32.50	525.77	39.90	1.99	
3	-42.35	487.88	0.34	503.10	-31.81	525.81	39.36	1.99	
4	-40.81	488.25	0.34	503.10	-30.71	524.69	37.82	1.98	
5	-39.23	488.59	0.34	503.10	-30.00	524.63	37.20	1.97	
. 6	-37.55	488.92	0.34	503.10	-28.88	523.47	35.62	1.97 .	OK
7	-36.30	489.36	-0.58	503.10	-28.04	521.19	32.89	1.97	
8	-34.54	489.66	-0.58	503.10	-27.28	520.94	32.11	1.98	
9	-33.10	490.05	-0.58	503.10	-26.14	519.75	30.50	1.98	
10	-31.60	490.43	-0.58	503.10	-24.68	517.78	28.21	2.00	
11	-30.05	490.79	-0.58	503.10	-23.25	515.95	26.06	2.04	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-exit' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

RESULTS OF TRANSLATIONAL ANALYSIS



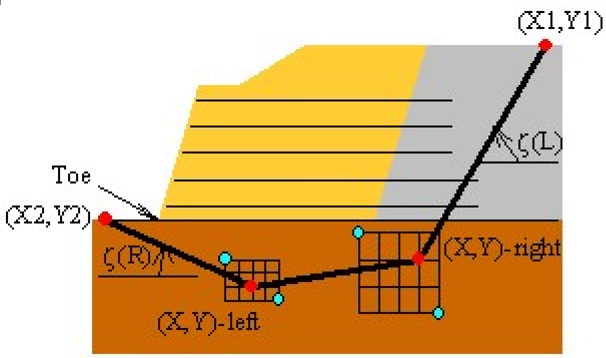
Results in the table below represent critical two-part wedges identified between specified starting (X1) and ending (X2) search points. Wedges along all reinforcement layers and at elevation zero are reported. The critical two-part wedge, one for each predetermined elevation, is defined by Xa, Xb and Xc where Xa is the front end of the passive wedge (slope face), Xb is where the passive wedge ends and the active one starts, and Xc is the X-ordinate at which the active wedge starts.

Critical two-part wedge along each interface:

Interface	Height Relative to Toe [ft]	(Xa, Ya) [ft]		(Xb, Yb) [ft]		(Xc, Yc) [ft]		Fs	STATUS
At toe elevation	0.00	-29.90	490.80	-17.00	490.80	1.94	503.10	2.11	Minimum on Edge
. Reinf. Layer #1	0.00	-29.90	490.80	-16.40	490.80	1.17	503.10	1.59	Minimum on Edge
Reinf. Layer #2	2.66	-25.92	493.46	-12.50	493.46	1.27	503.10	2.04	Minimum on Edge
Reinf. Layer #3	5.32	-21.94	496.12	-8.50	496.12	1.47	503.10	2.88	Minimum on Edge
Reinf. Layer #4	7.98	-17.96	498.78	-7.04	498.78	-0.39	503.10	4.39	OK
Reinf. Layer #5	10.64	-13.98	501.44	-10.66	501.44	-7.97	503.70	11.68	OK

Note: In the 'Status' column, OK means the critical two part-wedge was identified within the specified search domain. 'Minimum on Edge' means the critical result corresponds to a minimum on the edge of the search domain; i.e., either on X1 or X2 or the internally preset limits on Xc.

RESULTS OF 3-PART WEDGE ANALYSIS



Results in the table below represent the critical slip surface composed of a three-part wedge and identified by the specified points (X-left, Y-left) and (X-right, Y-right) and angles Zeta(L) and Zeta(R). ReSSA finds the (X,Y) coordinates, as well as the angles Zeta, based on user-specified search domain. The trace of the critical three-part wedge is fully defined by four points: (X1, Y1), (X-left, Y-left), (X-right, Y-right), (X2, Y2).

Critical 3-part wedge (Automatic search):

(X2, Y2) [ft]	Zeta(L) [degrees]	(X-left, Y-left) [ft]	(X-right, Y-right) [ft]	Zeta(R) [degrees]	(X1, Y1) [ft]	Fs
(-37.45, 488.92)	10.00	(-26.55, 487.00)	(-14.03, 491.10)	40.00	(0.28, 503.10)	2.003

CRITICAL RESULTS OF ROTATIONAL AND TRANSLATIONAL STABILITY ANALYSES

Rotational (Circular Arc; Bishop) Stability Analysis

Minimum Factor of Safety = 1.97
Critical Circle: Xc = -28.88[ft], Yc = 523.47[ft], R = 35.62[ft]. (Number of slices used = 56)

Translational (2-Part Wedge; Spencer), Direct Sliding, Stability Analysis

Minimum Factor of Safety = 1.59
Critical Two-Part Wedge: (Xa = -29.90, Ya = 490.80) [ft]
(Xb = -16.40, Yb = 490.80) [ft]
(Xc = 1.17, Yc = 503.10) [ft]
(Number of slices used = 30)
Interslice resultant force inclination = 20.86 [degrees]

Three-Part Wedge Stability Analysis

Minimum Factor of Safety = 2.00
Critical Three-Part Wedge: (X2 = -37.45, Y2 = 488.92) [ft]
(X-left = -26.55, Y-left = 487.00) [ft]
(X-right = -14.03, Y-right = 491.10) [ft]
(X1 = 0.28, Y1 = 503.10) [ft]
(Number of slices used = 45)
Interslice resultant force inclination = 19.38 [degrees]