# STRUCTURE GEOTECHNICAL REPORT

## F.A.P. 332 (IL 1) over CSX RR Retaining Wall

## Proposed S.N. 012-W009

## Clark County, Illinois

**F.A.P. 332 (IL 1)**
**SECTION (FX-VBR) B-1**
**CLARK COUNTY, ILLINOIS**
**JOB NO. P-97-098-20**
**CONTRACT NO. 74433**
**PTB 198-025**
**KEG NO. 21-1009.01**

PROFESSIONAL ENGINEER
LICENSED
MATT D. MASTERSON
NO. 062-061885
STATE OF ILLINOIS

12/16/2022
Exp. 11/30/2023


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**September 21, 2021**
**REVISED December 16, 2022**

Kaskaskia
Engineering Group, LLC

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# TABLES/FIGURES

## 1.0 Project Description and Scope

### 1.1 Introduction

The geotechnical study summarized in this report was performed by Kaskaskia Engineering Group, LLC (KEG) for the proposed MSE wall along IL 1 over CSX railroad in Marshall, in Clark County, Illinois. The purpose of this report is to present geotechnical design and construction recommendations for the proposed structure.

### 1.2 Project Description

The project consists of constructing an MSE wall to provide embankment support of IL 1 during reconstruction of the existing bridge over the CSX railroad from Station 1169+25.00 to Station 1175+38.54. The general location of the wall is shown on a Location Map, included in Exhibit A. The site lies within the Springfield Plain of the Till Plains Section of the Central Lowland Province.

### 1.3 Proposed Structure Information

The proposed MSE wall will run South-North along the west side of IL 1 from a bridge structure over the CSX railroad, from Station 1169+25.00 to Station 1175+38.54. It will measure approximately 615 lineal feet along the front face of the wall. Based on the proposed cross-sections provided, the MSE wall will have a maximum exposed face height of 20-feet and 11-inches, with a total maximum wall height of 24-feet and 5-inches. See Exhibit C -Type, Size and Location Plan (TS&L) for additional information.

## 2.0 Existing Site Information

The new MSE wall will be a permanent structure that would avoid encroachment onto a Superfund site in the northwest quadrant of the crossing of IL 1 over the CSX railroad (Structure Number 012-0014).

## 3.0 Subsurface Exploration and Generalized Subsurface Conditions

The site investigation plan was developed and performed by KEG. A KEG representative was on-site to coordinate and log the borings, make site observations, and collect soil samples.

Eight standard penetration test (SPT) borings, designated RWB-1, RWB-2, RWB-3, RWB-4, RWB-5, RWB-6, RWB-7, and RWB-8 were drilled from June 28 through June 30, 2021. The boring layout is shown in Exhibit B. Detailed information regarding the nature and thickness of the soils encountered and the results of the field sampling and laboratory testing are shown on the Boring Logs, Exhibit D. A soil profile can be found in Exhibit E - Subsurface Profile.

**Table 3.0 - Boring Depth and Location**

| Designation | Boring Depth (ft.) | Station | Offset (ft.) |
|---|---|---|---|
| RWB-1 | 20.0 | 1170+00.13 | 62.0 LT |
| RWB-2 | 16.3 | 1170+72.26 | 57.1 LT |
| RWB-3 | 20.0 | 1171+45.60 | 56.2 LT |
| RWB-4 | 20.0 | 1172+18.90 | 56.3 LT |
| RWB-5 | 20.0 | 1173+01.99 | 55.9 LT |
| RWB-6 | 20.0 | 1173.75.89 | 54.3 LT |
| RWB-7 | 20.0 | 1174+50.33 | 53.9 LT |
| RWB-8 | 20.0 | 1175+24.19 | 50.5 LT |

The overburden soils were predominantly medium-stiff to stiff clays, clay loams, silty clay loams, sandy clay loams, and sandy clay loam tills down to shale and sandstone bedrock. Detailed information regarding the nature and thickness of the soils and rock encountered are shown on the Boring Logs - Exhibit D and Subsurface Profiles – Exhibit E.

### 3.1 Bedrock

Elevations of top of sandstone bedrock for all the borings are shown in Table 3.1 below:

**Table 3.1 - Elevation of Top of Bedrock**

| Designation | Station | Offset | Top of Rock Elevation (ft.) |
|---|---|---|---|
| RWB-1 | 1170+00.13 | 62.0 LT | 619.8 |
| RWB-2 | 1170+72.26 | 57.1 LT | 619.6 |
| RWB-3 | 1171+45.60 | 56.2 LT | 620.3 |
| RWB-4 | 1172+18.90 | 56.3 LT | 620.7 |
| RWB-5 | 1173+01.99 | 55.9 LT | 620.9 |
| RWB-6 | 1173.75.89 | 54.3 LT | 621.4 |
| RWB-7 | 1174+50.33 | 53.9 LT | 622.2 |
| RWB-8 | 1175+24.19 | 50.5 LT | 622.5 |

### 3.2 Groundwater

Groundwater was first encountered during drilling at a depth of 13.5 feet in Boring RWB-2, 16 feet in Boring RWB-5 and 7, and 16.5 feet in Boring RWB-8.

Without extended periods of observation, measurement of true groundwater levels may not be possible. It should be further noted that the groundwater level is subject to seasonal and climatic variations, including the level of adjacent affluents.

## 4.0 Geotechnical Evaluations

### 4.1 Settlement

Based on the borings completed for the proposed wall and the nature of the soils encountered in the borings, estimates of settlement were necessary. Although the existing soils of the current approach embankment have most likely consolidated and settled over time in response to the current loading conditions, the proposed new wall-supported embankment configuration will result in potential settlements during and after construction completion.

Borings RWB-3 and RWB-5 were utilized for the settlement analysis. No specific consolidation testing was completed, and empirical methods were used for estimation of the settlement.

Settlement ranging from to 7.49 in. to 15.29 in. was calculated for the proposed wall-supported embankment. This settlement included three layers estimated as being normally consolidated relative to the overburden pressure plus the load from the new fill. The time for 50 percent consolidation (t50) was calculated as ranging from about 4 to 15 days, and the time for 90 percent consolidation (t90) ranging from 20 to 60 days. Times were also calculated utilizing wick drains on a 5-ft. triangular spacing, assuming that the drains were extended to the sandstone below the base of the new fill. With the wick drains, t50 was calculated to range from 1 to 2 days and t90 ranging from 3 to 10 days. While the wick drains will help to reduce the time for consolidation, they will not reduce the magnitude of settlement.

Due to the high estimated settlement amounts for the wall-supported embankment, its backfill, and the structures it will support, ground improvement will be required for support of the embankment. Ground improvement could consist of surcharging the fill area before the wall is constructed if the construction schedule would allow. If the layout of the site is such that the surcharge fill cannot be placed or if the construction schedule will not allow for an estimated 60 - day surcharge without wick drains, or a 10-day surcharge with wick drains, then other methods will need to be considered, such as aggregate column ground improvement (ACGI). We recommend that settlement platforms be utilized during embankment and/or surcharge construction for monitoring of the settlement. Once settlement monitoring indicates that movement is essentially complete, the surcharge could be removed, and the proposed wall could be installed. Calculations are attached as Exhibit F - Settlement Calculations.

In our opinion, removal and replacement is not a viable option due to the need to support the existing roadway to keep it open to traffic and to overexcavate the settlement impacted material out, as the material would need to be excavated out for the entire retained zone down to the top of bedrock, or within 1-foot of the top of bedrock behind the wall, not just the wall face. Due to the proximity of the wall and retained zone to that of the section of roadway embankment to remain, extensive shoring would be required to support such a large exposed soil excavation. ACGI would allow for installation of columns below the depth of the retained zone of the wall while leaving the soils in place for proper support of the existing embankment to remain in place.

### 4.2 Slope Stability

A stability analysis using SLOPE/W was performed for the proposed MSE wall using the proposed geometry on the cross-sections provided at Station 1171+50 and Station 1173+00 and the soil characteristics from Boring RWB-3 and Boring RWB-5. Two conditions were modeled: end-of-construction (Undrained) and long-term (Drained). A critical factor of safety (FOS) was calculated for each condition. According to current standard of practice, the target FOS is 1.5 for end of construction (EOC) and long-term conditions, which was achieved during the analysis.

In order to model the EOC and Long Term conditions, composite values for cohesion and friction angle were used to model the natural soils improved with Aggregate Column Ground Improvements.

The Bishop Circular Method, which generates circular-shaped failure surfaces, was used to calculate the critical failure surfaces and FOS for the proposed conditions, as shown in Table 4.2. SLOPE/W program output from this analysis for the wall can be found in Exhibit G - SLOPE/W Slope Stability Analysis.

**Table 4.2 – Slope Stability Critical FOS**

| Station | End-of- Construction | Long-Term |
|---|---|---|
| 1171+50 | 2.3 | 1.5 |
| 1173+00 | 2.4 | 1.6 |

Acceptable FOS were obtained for the end-of-construction and long-term conditions as described above, with improvements to the natural soils supporting the proposed MSE wall as recommended in this report.

### 4.3 Seismic Considerations

Based on procedures outlined in AASHTO specifications and the subsurface conditions encountered, the site can be classified as Site Class D for foundation design. Seismic design parameters for the site based on Site Class D are listed below in Table 4.3, as follows:

**Table 4.3 - Seismic Design Parameters**

| Parameter | Value |
|---|---|
| Soil Site Class | D |
| Spectral Response Acceleration, 0.2 Sec, $S_{DS}$ | 0.355g (Site Class D) |
| Spectral Response Acceleration, 1.0 Sec, $S_{D1}$ | 0.172g (Site Class D) |
| Seismic Performance Zone | 2 |

## 5.0 Foundation Recommendations

### 5.1 Bearing Resistance

Based on the 2017 AASHTO LRFD Bridge Design Specifications, 8$^{th}$ Edition, with an estimated footing width of 2 feet; equation 10.6.3.1.2a-1, Table 10.5.5.2.2-1, and related sub-sections; a factored bearing resistance of 2,780 psf was estimated for wall footings bearing in competent clay, based on a Resistance Factor of 0.5. Calculations are included in Exhibit H – Bearing Resistance Calculations.

Retaining walls can be designed with an allowable coefficient of friction (resistance factor) between the base of the concrete footing and a clay subgrade of 0.85.

### 5.2 Site Grading and Drainage

Positive site drainage should be provided to reduce surface water infiltration around the perimeter of the wall. All grades should be sloped away from the wall, and surface drainage should be collected and discharged such that water is not permitted to pool or infiltrate any backfill of the wall.

## 6.0 Construction Considerations

### 6.1 Construction Activities

Construction activities should be performed in accordance with the current IDOT Standard Specifications for Road and Bridge Construction and any pertinent Special Provisions or Policies.

Should any MSE wall or embankment design considerations assumed by either ESCA, IDOT, or KEG change, KEG should be contacted to determine if the recommendations stated in this report still apply.

## 7.0 Computations

Computations and analyses for special circumstances, if any, are included as Exhibits. Please refer to each section of the report for reference to the Exhibit containing any such calculations or analysis used.

## 8.0 Geotechnical Data

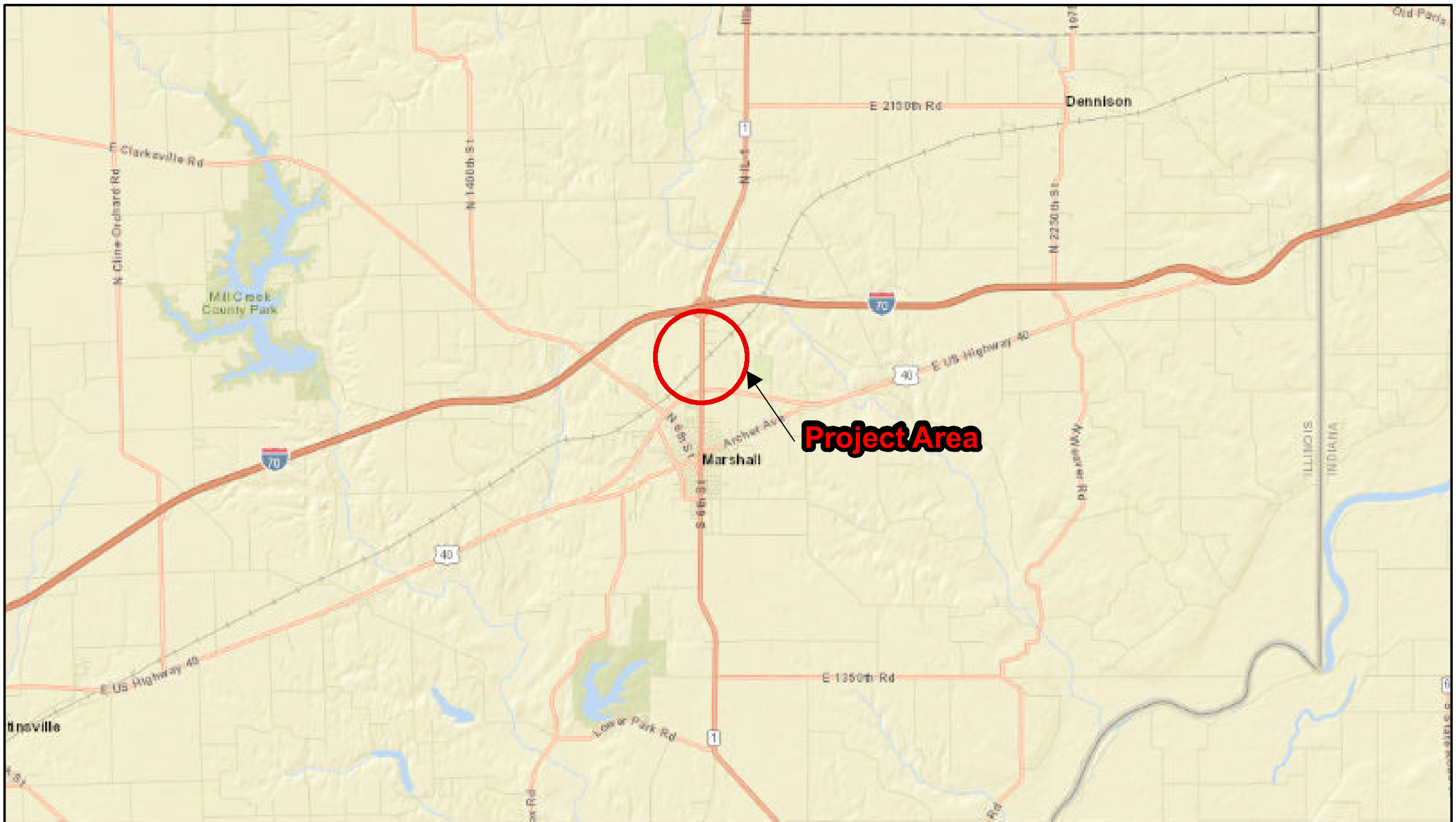
Soil borings can be found in Exhibit D. The Subsurface Profile can be found in Exhibit E.

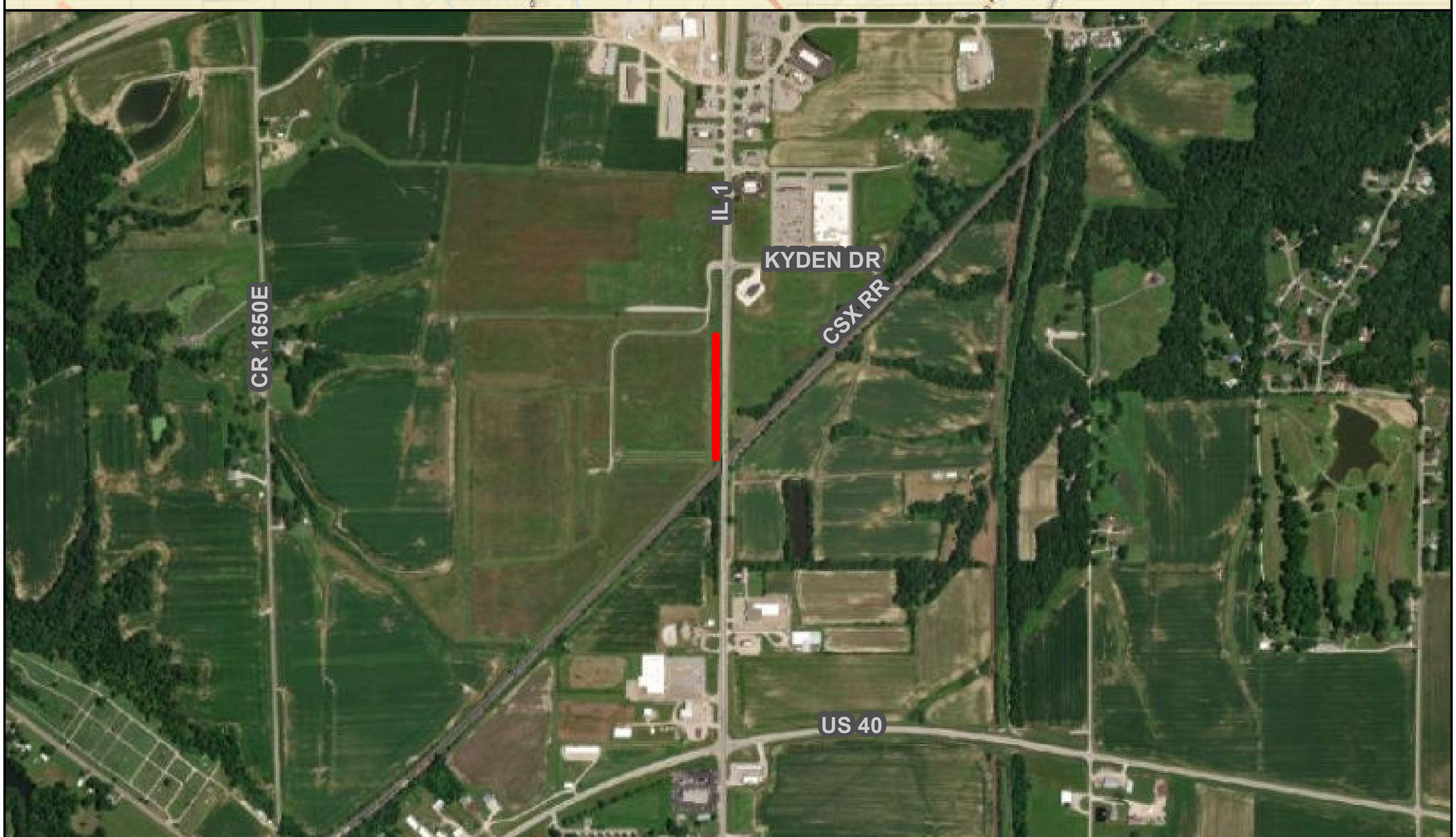
## 9.0 Limitations

The recommendations provided herein are for the exclusive use of ESCA Consultants, Inc. and IDOT. They are specific only to the project described and are based on subsurface information obtained by KEG at eight boring locations within the project area, KEG's understanding of the project as described herein, and geotechnical engineering practice consistent with the standard of care. No other warranty is expressed or implied. KEG should be contacted if conditions encountered during construction are not consistent with those described.

# EXHIBIT A

# LOCATION MAP




Kaskaskia
Engineering Group, LLC

**LOCATION MAP**

**IL 1 over CSX Retaining Wall**
**Marshall, Illinois**

**Exhibit No.**

**A**

KEG JOB #21-1009.01

# EXHIBIT B

# BORING PLAN


Kaskaskia Engineering Group, LLC

**BORING LOCATION MAP**

**IL 1 over CSX Retaining Wall**
**Marshall, Illinois**

**Exhibit No.**

**B**

KEG JOB #21-1009.01

# EXHIBIT C

# TYPE, SIZE, AND LOCATION PLAN (TS&L)

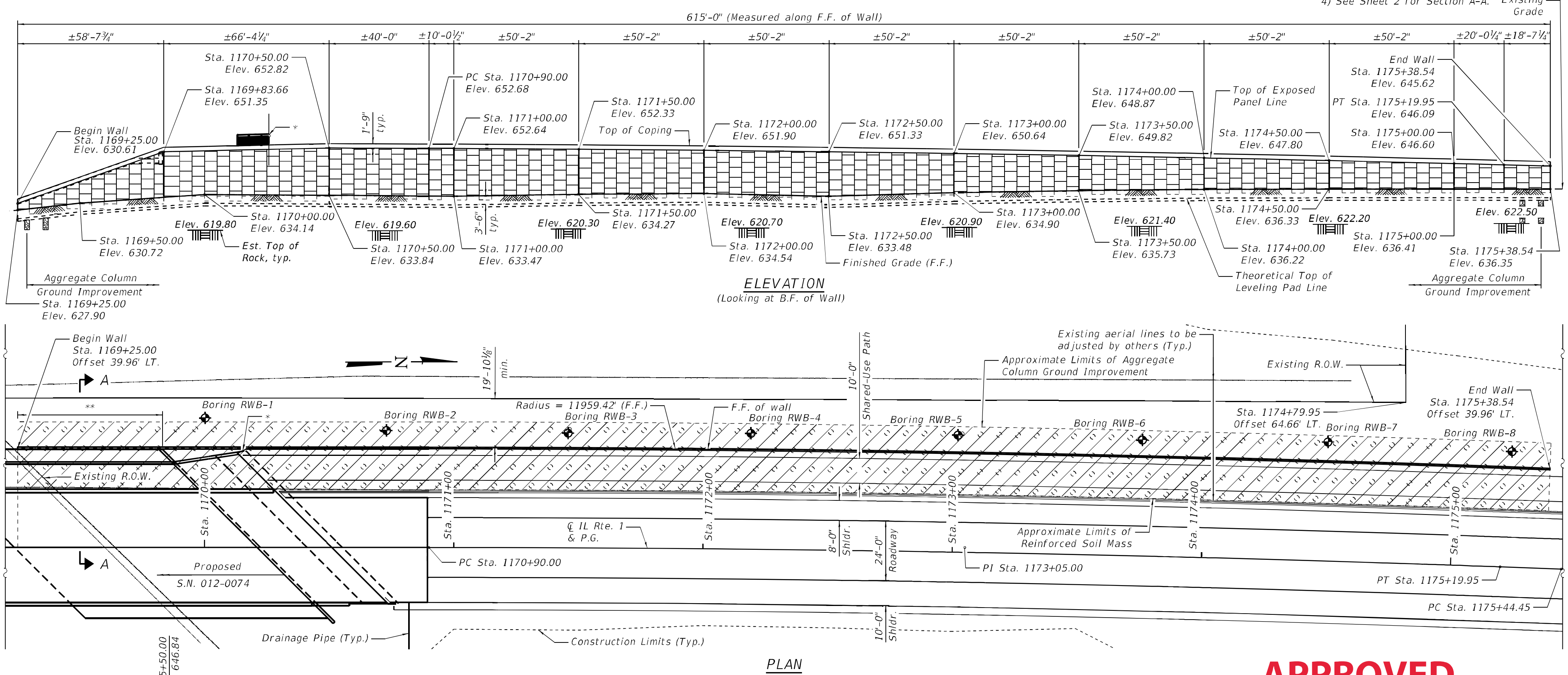
Bench Mark: BM#401 - Chiseled "□" on the top of curb at the S.E. corner of S.N. 012-0014. Elev. 650.96
BM#402 - Chiseled "□" on the top of curb at the N.W. corner of S.N. 012-0014. Elev. 651.65

Existing Structure: None

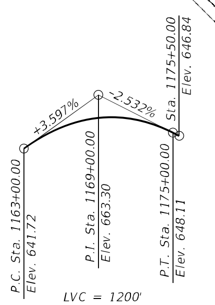
* Bicycle Railing, modified to attach to the north approach of Proposed S.N. 012-0074. Extend north along remainder of wall.

** 1" Joint Filler to be placed between both the northwest wing wall of S.N. 012-0074 and the slope wall, and the proposed retaining wall.

Notes:
1) Offsets are measured from the ℄ IL Rte. 1 to the front face of wall.
2) F.F. - Front Face
3) B.F. - Back Face
4) See Sheet 2 for Section A-A.




Aggregate Column Ground Improvement




PROFILE GRADE
(along ℄ IL Rte. 1)

## DESIGN SPECIFICATIONS

2020 AASHTO LRFD Bridge Design Specifications, 9th Edition

## DESIGN STRESSES

FIELD UNITS

f'c = 3,500 psi
fy = 60,000 psi (Reinforcement)

PRECAST UNITS

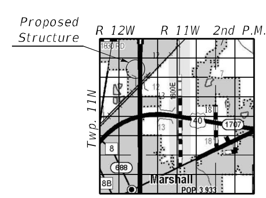
f'c = 4,500 psi (Precast Panels)

## HIGHWAY CLASSIFICATION

F.A.P. Rte. 332 - IL Rte. 1
Functional Class: Other Principal Arterial
ADT: 8,900 (2021); 11,000 (2041)
ADTT: 445 (2021); 550 (2041)
DHV: 1305 (2039)
Design Speed: 45 m.p.h.
Posted Speed: 45 m.p.h.
Two-Way Traffic
Directional Distribution: 51:49

## CURVE DATA

(IL Rte. 1)
P.I. Sta. = 1173+05.00
Δ = 2° 04' 00" (RT)
D = 0° 28' 51"
R = 11,919.13'
T = 215.00'
L = 429.95'
E = 1.94'
P.C. Sta. = 1170+90.00
P.T. Sta. = 1175+19.95




LOCATION SKETCH

APPROVED
DECEMBER 12, 2022
AS A BASIS FOR PREPARATION OF DETAILED PLANS

GENERAL PLAN & ELEVATION
IL ROUTE 1 OVER CSX RAILROAD RETAINING WALL
F.A.P. RT. 332 - SEC. (FX-VBR)B-1
CLARK COUNTY
STATION 1169+25.00 TO 1175+38.54
S.N. 012-W009

| Kaskaskia Engineering Group, LLC | USER NAME = | DESIGNED - MMC | REVISED 06/02/2022 - MMC | STATE OF ILLINOIS DEPARTMENT OF TRANSPORTATION | | F.A.P. RTE. | SECTION | COUNTY | TOTAL SHEETS | SHEET NO. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | CHECKED - JW | REVISED 10/12/2022 - MMC | | | 332 | (FX-VBR)B-1 | CLARK | | |
| | PLOT SCALE = | DRAWN - MMC | REVISED 10/20/2022 - MMC | | | | | CONTRACT NO. 74433 | | |
| | PLOT DATE = | CHECKED - JW | REVISED - | | SHEET 1 OF 2 SHEETS | | ILLINOIS FED. AID PROJECT | | | |

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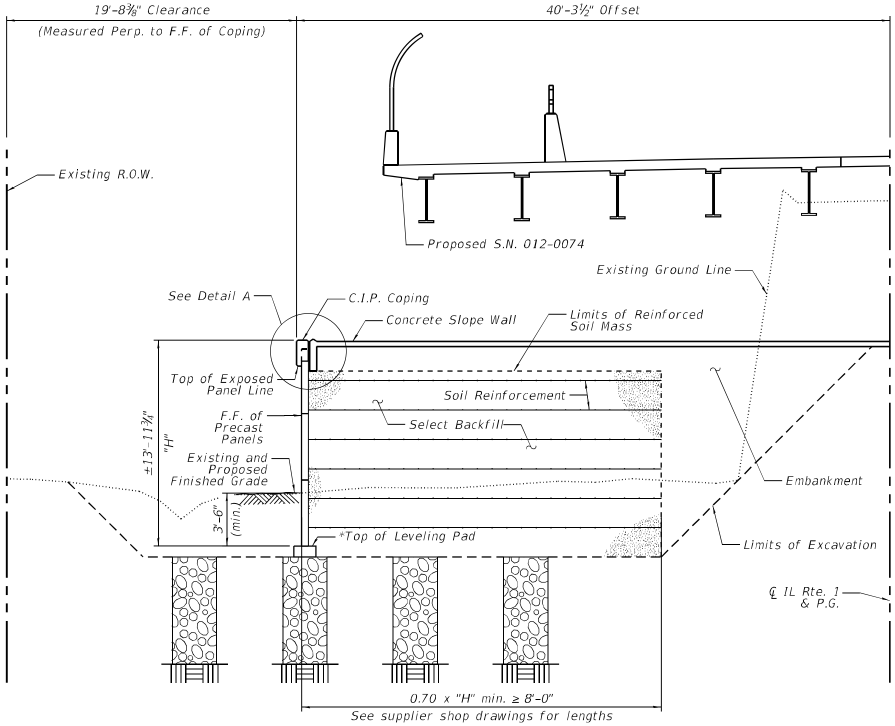
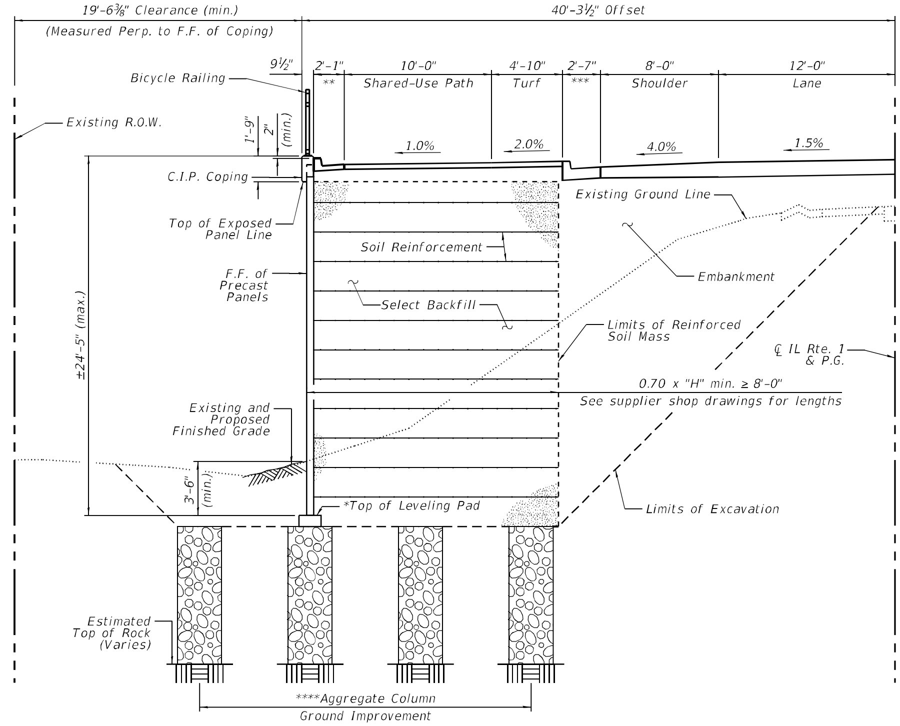
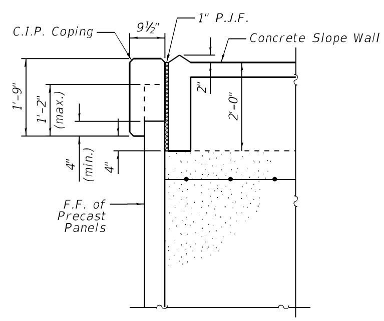



SECTION A-A
(Looking North)




TYPICAL WALL SECTION
(Looking North)




DETAIL A

* Dimensions of Leveling Pad to be determined during final design.
** Combination Concrete Curb and Gutter Type B-6.18
*** Curb & Gutter (See Roadway Plans)
**** Size, depth, and spacing of Aggregate Column Ground Improvement to be determined in design phase.

**APPROVED**
**DECEMBER 12, 2022**
AS A BASIS FOR
PREPARATION OF DETAILED PLANS

DETAILS
IL ROUTE 1 OVER CSX RAILROAD RETAINING WALL
F.A.P. RT. 332 - SEC. (FX-VBR)B-1
CLARK COUNTY
STATION 1169+25.00 TO 1175+38.54
S.N. 012-W009

MODEL: Default
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Kaskaskia Engineering Group, LLC

| | | | | | |
|---|---|---|---|---|---|
| USER NAME = | | DESIGNED - | MMC | REVISED | 10/12/2022 - MMC |
| | | CHECKED - | JW | REVISED | 10/20/2022 - MMC |
| PLOT SCALE = | | DRAWN - | MMC | REVISED | 12/09/2022 - MMC |
| PLOT DATE = | | CHECKED - | JW | REVISED | - |

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET 2 OF 2 SHEETS

| F.A.P. RTE. | SECTION | COUNTY | TOTAL SHEETS | SHEET NO. |
|---|---|---|---|---|
| 332 | (FX-VBR)B-1 | CLARK | | |
| | | CONTRACT NO. 74433 | | |
| | ILLINOIS | FED. AID PROJECT | | |

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# EXHIBIT D

# BORING LOGS

# Illinois Department of Transportation
Division of Highways

# SOIL BORING LOG



**Date** 6/28/21

**ROUTE** FAP 332 (IL-1) **DESCRIPTION** IL 1 Over CSX RR Retaining Wall **LOGGED BY** KEG

**SECTION** (FX-VBR)B-1 **LOCATION** Clark County, IL

**COUNTY** Clark **DRILLING METHOD** HSA **HAMMER TYPE** AUTO

**STRUCT. NO.** 012-0074
**Station** 1169+65.27

**BORING NO.** RWB-1
**Station** 1170+00.13
**Offset** 62.0 ft LT
**Ground Surface Elev.** 631.76 ft

**Surface Water Elev.** ____ ft
**Stream Bed Elev.** ____ ft

**Groundwater Elev.:**
**First Encounter** ____ ft
**Upon Completion** ____ ft
**After** ____ **Hrs.** ____ ft

| Description | Elev. (ft) | DEPTH (ft) | BLOWS (/6") | UCS Qu (tsf) | MOIST (%) |
|---|---|---|---|---|---|
| CLAY - Brown, medium-stiff, with trace organics | | | WH<br>1<br>1 | 1.7<br>B | 25 |
| 1" coarse sand seam at 2' | | | | | |
| with trace sand | | | 2<br>2<br>3 | 1.0<br>B | 20 |
| | | -5 | | | |
| Shelby Tube Pushed 6'-8'<br>Recovery 23" | | | | 1.8<br>P | |
| | 623.3 | | | | |
| CLAY LOAM - Brown, medium-stiff | | | 3<br>5<br>6 | 1.8<br>B | 18 |
| | | -10 | | | |
| | 621.3 | | | | |
| SANDY CLAY LOAM - Brown, medium-stiff, moist | | | 2<br>3 | 0.7<br>B | 19 |
| | 619.8 | | | | |
| SANDSTONE - Tan, highly weathered, dense | | | 14 | | |
| | 618.8 | | | | |
| SHALE - Brown, moderately hard | | | 13<br>16<br>22 | 4.5<br>P | 11 |
| | | -15 | | | |
| | | | 41<br>50/1"<br>- | 3.5<br>P | 9 |
| | | | 12<br>34<br>50/2" | 4.6<br>B | 7 |
| | 611.8 | -20 | | | |

End of Boring

**The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)**
**The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)**

**BBS, form 137 (Rev. 8-99)**

Illinois Department of Transportation
Division of Highways

# SOIL BORING LOG

Date 6/28/21

**ROUTE** FAP 332 (IL-1) **DESCRIPTION** IL 1 Over CSX RR Retaining Wall **LOGGED BY** KEG

**SECTION** (FX-VBR)B-1 **LOCATION** Clark County, IL

**COUNTY** Clark **DRILLING METHOD** HSA **HAMMER TYPE** AUTO

**STRUCT. NO.** 012-0074
**Station** 1169+65.27

**BORING NO.** RWB-2
**Station** 1170+72.26
**Offset** 57.1 ft LT
**Ground Surface Elev.** 632.57 ft

**Surface Water Elev.** ft
**Stream Bed Elev.** ft

**Groundwater Elev.:**
**First Encounter** 619.1 ft ▼
**Upon Completion** ft
**After** Hrs. ft

| Description | Elev. | DEPTH (ft) | BLOWS (/6") | UCS Qu (tsf) | MOIST (%) |
|---|---|---|---|---|---|
| CLAY - Brown and gray, medium-stiff | | | WH<br>2<br>2 | 0.8<br>B | 26 |
| | 629.6 | | | | |
| CLAY LOAM - Brown, medium-stiff | | | 1<br>2<br>3 | 1.0<br>B | 21 |
| | | -5 | | | |
| | | | 3<br>6<br>8 | 1.6<br>B | 20 |
| | 625.6 | | | | |
| SILTY CLAY LOAM TILL - Brown, medium-stiff | | | 3<br>5<br>6 | 2.4<br>B | 18 |
| | | -10 | | | |
| becomes moist at 11' | | | 1<br>2<br>3 | 0.9<br>B | 18 |
| | 619.6 | | | | |
| SANDSTONE - Brown and red, highly weathered, very dense, with clay seams less than 1/2" ▼ | | | 18<br>26<br>30 | - | 14 |
| Sampler Refusal on Sandstone Bedrock. Boring Terminated at 16.3'. | | -15 | | | |
| | 616.3 | | 50/3"<br>-<br>- | - | 19 |
| End of Boring | | | | | |
| | | -20 | | | |

**The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)**
**The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)**

**BBS, form 137 (Rev. 8-99)**

Illinois Department of Transportation
Division of Highways

# SOIL BORING LOG

Date 6/29/21

**ROUTE** FAP 332 (IL-1) **DESCRIPTION** IL 1 Over CSX RR Retaining Wall **LOGGED BY** KEG

**SECTION** (FX-VBR)B-1 **LOCATION** Clark County, IL

**COUNTY** Clark **DRILLING METHOD** HSA **HAMMER TYPE** AUTO

**STRUCT. NO.** 012-0074
**Station** 1169+65.27

**BORING NO.** RWB-3
**Station** 1171+45.60
**Offset** 56.2 ft LT
**Ground Surface Elev.** 633.31 ft

**Surface Water Elev.** ft
**Stream Bed Elev.** ft

**Groundwater Elev.:**
**First Encounter** ft
**Upon Completion** ft
**After** Hrs. ft

| Description | Elev. | DEPTH (ft) | BLOWS (/6") | UCS Qu (tsf) | MOIST (%) |
|---|---|---|---|---|---|
| CLAY - Brown and gray, medium-stiff, with trace sand | | | 1<br>2<br>3 | 0.8<br>B | 30 |
| CLAY LOAM - Brown, medium-stiff | 630.3 | | 2<br>3<br>3 | 1.2<br>B | 28 |
| | | -5 | 3<br>3<br>4 | 1.1<br>B | 17 |
| SILTY CLAY LOAM TILL - Brown, stiff | 625.3 | | 4<br>6<br>5 | 3.1<br>B | 18 |
| | | -10 | 3<br>9<br>12 | 3.3<br>B | 18 |
| SANDSTONE-Brown, highly weathered, medium-dense, moist | 620.3 | | 13<br>15<br>9 | - | 12 |
| becomes gray and brown, very dense, strong petroleum odor at 16' | | -15 | 50/4"<br>-<br>- | - | 13 |
| becomes brown | 613.3 | -20 | 50/4"<br>-<br>- | - | 13 |

End of Boring

**The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)**
**The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)**

Illinois Department of Transportation
Division of Highways

# SOIL BORING LOG

Date 6/29/21

| | | | | | |
|---|---|---|---|---|---|
| ROUTE | FAP 332 (IL-1) | DESCRIPTION | IL 1 Over CSX RR Retaining Wall | LOGGED BY | KEG |
| SECTION | (FX-VBR)B-1 | LOCATION | Clark County, IL | | |
| COUNTY | Clark | DRILLING METHOD | HSA | HAMMER TYPE | AUTO |

STRUCT. NO. 012-0074
Station 1169+65.27

BORING NO. RWB-4
Station 1172+18.90
Offset 56.3 ft LT
Ground Surface Elev. 633.69 ft

Surface Water Elev. ____ ft
Stream Bed Elev. ____ ft

Groundwater Elev.:
First Encounter ____ ft
Upon Completion ____ ft
After ____ Hrs. ____ ft

| Description | Elev. | DEPTH (ft) | BLOWS (/6") | UCS Qu (tsf) | MOIST (%) |
|---|---|---|---|---|---|
| CLAY - Brown and gray, medium-stiff, with trace sand | | | 1 | | |
| | | | 2 | 1.2 | 23 |
| | | | 2 | B | |
| | 630.7 | | | | |
| CLAY LOAM - Brown, medium-stiff | | | 3 | | |
| | | | 3 | 1.1 | 22 |
| | | | 3 | B | |
| | | -5 | | | |
| | | | 3 | | |
| | | | 3 | 1.3 | 31 |
| | | | 4 | B | |
| | 625.7 | | | | |
| SILTY CLAY LOAM TILL - Brown, medium-stiff | | | 4 | | |
| | | | 4 | 2.0 | 24 |
| | | | 5 | B | |
| | | -10 | | | |
| | | | 2 | | |
| | | | 2 | 0.7 | 20 |
| | | | 2 | B | |
| | 620.7 | | | | |
| SANDSTONE - Brown, highly weathered, very dense | | | 17 | | |
| | | | 31 | - | 15 |
| | | | 39 | | |
| | | -15 | | | |
| | | | 50/4" | | |
| becomes red | | | - | - | 12 |
| | | | - | | |
| | | | 50/3" | | |
| | | | - | - | 11 |
| | 613.7 | -20 | - | | |

End of Boring

**The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)**
**The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)**

Illinois Department of Transportation
Division of Highways

# SOIL BORING LOG

Date 6/29/21

**ROUTE** FAP 332 (IL-1) **DESCRIPTION** IL 1 Over CSX RR Retaining Wall **LOGGED BY** KEG

**SECTION** (FX-VBR)B-1 **LOCATION** Clark County, IL

**COUNTY** Clark **DRILLING METHOD** HSA **HAMMER TYPE** AUTO

**STRUCT. NO.** 012-0074
**Station** 1169+65.27

**BORING NO.** RWB-5
**Station** 1173+01.99
**Offset** 55.9 ft LT
**Ground Surface Elev.** 633.85 ft

**Surface Water Elev.** ft
**Stream Bed Elev.** ft

**Groundwater Elev.:**
**First Encounter** 617.9 ft ▼
**Upon Completion** ft
**After** Hrs. ft

| Description | Elev. | DEPTH (ft) | BLOWS (/6") | UCS Qu (tsf) | MOIST (%) |
|---|---|---|---|---|---|
| CLAY - Brown and gray, medium-stiff, with trace sand | | | WH | | |
| | | | WH<br>2 | 0.8<br>B | 32 |
| | 630.9 | | | | |
| SILTY CLAY LOAM - Brown, medium-stiff | | | 2 | | |
| | | | 2<br>3 | 1.0<br>B | 20 |
| | | -5 | | | |
| Shelby Tube Pushed 6-8' Recovery 24" | | | | 1.8<br>P | |
| | 625.9 | | | | |
| | 625.4 | | | | |
| SANDY CLAY LOAM - Brown, medium-stiff | | | 3 | | |
| | | | 4<br>4 | 2.6<br>B | 18 |
| | | -10 | | | |
| | | | WH | | |
| | | | WH<br>2 | 0.7<br>B | 19 |
| | 620.9 | | | | |
| SANDSTONE - Brown, highly weathered, very dense | | | 16 | | |
| | | | 30<br>46 | - | 16 |
| | | -15 | | | |
| becomes wet at 16' ▼ | | | 25 | | |
| | | | 25<br>26 | - | 16 |
| | | | 50/4" | | |
| | | | -<br>- | - | 19 |
| | 613.9 | -20 | | | |

End of Boring

**The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)**
**The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)**

**BBS, form 137 (Rev. 8-99)**

Illinois Department of Transportation
Division of Highways

# SOIL BORING LOG



Date 6/29/21

**ROUTE** FAP 332 (IL-1) **DESCRIPTION** IL 1 Over CSX RR Retaining Wall **LOGGED BY** KEG

**SECTION** (FX-VBR)B-1 **LOCATION** Clark County, IL

**COUNTY** Clark **DRILLING METHOD** HSA **HAMMER TYPE** AUTO

**STRUCT. NO.** 012-0074
**Station** 1169+65.27

**BORING NO.** RWB-6
**Station** 1173+75.89
**Offset** 54.3 ft LT
**Ground Surface Elev.** 634.38 ft

**Surface Water Elev.** ft
**Stream Bed Elev.** ft

**Groundwater Elev.:**
**First Encounter** ft
**Upon Completion** ft
**After** Hrs. ft

| Description | Elev. | DEPTH (ft) | BLOWS (/6") | UCS Qu (tsf) | MOIST (%) |
|---|---|---|---|---|---|
| CLAY - Brown and gray, medium-stiff, with trace sand | | | 2<br>3<br>3 | 1.0<br>B | 26 |
| | 631.4 | | | | |
| SILTY CLAY LOAM - Brown, medium-stiff | | | 3<br>4<br>3 | 1.2<br>B | 16 |
| | | -5 | | | |
| | | | 3<br>5<br>5 | 2.4<br>B | 17 |
| | 626.4 | | | | |
| SILTY CLAY LOAM TILL - Brown, medium-stiff | | | 3<br>4<br>3 | 1.8<br>B | 23 |
| | | -10 | | | |
| | 622.9 | | 2 | | |
| SANDY CLAY LOAM - Brown, medium-stiff, moist | | | 3<br>8 | 0.4<br>B | 14 |
| | 621.4 | | | | |
| SANDSTONE - Brown, highly weathered, very dense | | | 48<br>50/5"<br>- | - | 16 |
| | | -15 | | | |
| | | | 12<br>39<br>50/3" | - | 21 |
| | | | 50/4"<br>-<br>- | - | 15 |
| | 614.4 | -20 | | | |

End of Boring

**The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)**
**The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)**

**BBS, form 137 (Rev. 8-99)**

Illinois Department of Transportation
Division of Highways

# SOIL BORING LOG

Date 6/29/21

**ROUTE** FAP 332 (IL-1) **DESCRIPTION** IL 1 Over CSX RR Retaining Wall **LOGGED BY** KEG

**SECTION** (FX-VBR)B-1 **LOCATION** Clark County, IL

**COUNTY** Clark **DRILLING METHOD** HSA **HAMMER TYPE** AUTO

**STRUCT. NO.** 012-0074
**Station** 1169+65.27

**BORING NO.** RWB-7
**Station** 1174+50.33
**Offset** 53.9 ft LT
**Ground Surface Elev.** 635.17 ft

**Surface Water Elev.** ____ ft
**Stream Bed Elev.** ____ ft

**Groundwater Elev.:**
**First Encounter** 619.2 ft ▼
**Upon Completion** ____ ft
**After** ____ **Hrs.** ____ ft

| Description | Elev. (ft) | DEPTH (ft) | BLOWS (/6") | UCS Qu (tsf) | MOIST (%) |
|---|---|---|---|---|---|
| CLAY - Brown, medium-stiff, with trace sand | | | 2<br>3<br>3 | 1.7<br>B | 27 |
| | 632.2 | | | | |
| SILTY CLAY LOAM - Brown, medium-stiff | | -5 | 3<br>5<br>5 | 1.1<br>B | 14 |
| | 629.7 | | | | |
| SILTY CLAY LOAM TILL - Brown, medium-stiff | | | 4<br>5<br>7 | 2.1<br>B | 16 |
| | 626.2 | | 3 | | |
| SANDY CLAY LOAM TILL - Brown, medium-stiff | | -10 | 3<br>2 | 1.0<br>B | 17 |
| | | | 3<br>3<br>6 | 1.8<br>B | 14 |
| | 622.2 | | | | |
| SANDSTONE - Brown, highly weathered, very dense | | -15 | 26<br>50/5"<br>- | - | 13 |
| becomes wet at 16' ▼ | | | 6<br>30<br>50/3" | 4.0<br>P | 18 |
| | 615.2 | -20 | 50/5"<br>-<br>- | - | 17 |

End of Boring

**The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)**
**The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)**

**Illinois Department of Transportation**
Division of Highways

# SOIL BORING LOG



**Date** 6/30/21

**ROUTE** FAP 332 (IL-1) **DESCRIPTION** IL 1 Over CSX RR Retaining Wall **LOGGED BY** KEG

**SECTION** (FX-VBR)B-1 **LOCATION** Clark County, IL

**COUNTY** Clark **DRILLING METHOD** HSA **HAMMER TYPE** AUTO

**STRUCT. NO.** 012-0074
**Station** 1169+65.27

**BORING NO.** RWB-8
**Station** 1175+24.19
**Offset** 50.5 ft LT
**Ground Surface Elev.** 635.46 ft

**Surface Water Elev.** ft
**Stream Bed Elev.** ft

**Groundwater Elev.:**
**First Encounter** 619.0 ft ▼
**Upon Completion** ft
**After** Hrs. ft

| Description | Elev. | DEPTH (ft) | BLOWS (/6") | UCS Qu (tsf) | MOIST (%) |
|---|---|---|---|---|---|
| CLAY - Brown and gray, medium-stiff, with trace sand | | | 1 | | |
| | | | 2 | 1.4 | 27 |
| | | | 3 | B | |
| | 631.5 | | 3 | | |
| SILTY CLAY LOAM - Brown, medium-stiff | | | 4 | 0.9 | 13 |
| | | -5 | 4 | B | |
| Shelby Tube Pushed 6-8' Recovery 19" | | | | 3.0 | |
| | | | | P | |
| | 627.0 | | | | |
| SILTY CLAY LOAM TILL - Brown, medium-stiff | | | 3 | | |
| | | | 3 | 1.0 | 20 |
| | | -10 | 3 | B | |
| | | | 5 | | |
| becomes stiff at 11.5' | | | 10 | 4.8 | 12 |
| | | | 11 | B | |
| | 622.5 | | | | |
| SANDSTONE - Brown, highly weathered, very dense | | | 12 | | |
| | | | 19 | - | 15 |
| | | -15 | 50/3" | | |
| | | ▼ | 50/5" | | |
| becomes wet at 16.5' | | | - | - | 18 |
| | | | - | | |
| | | | 20 | | |
| | | | 50 | - | 12 |
| | 615.5 | -20 | 50/4" | | |

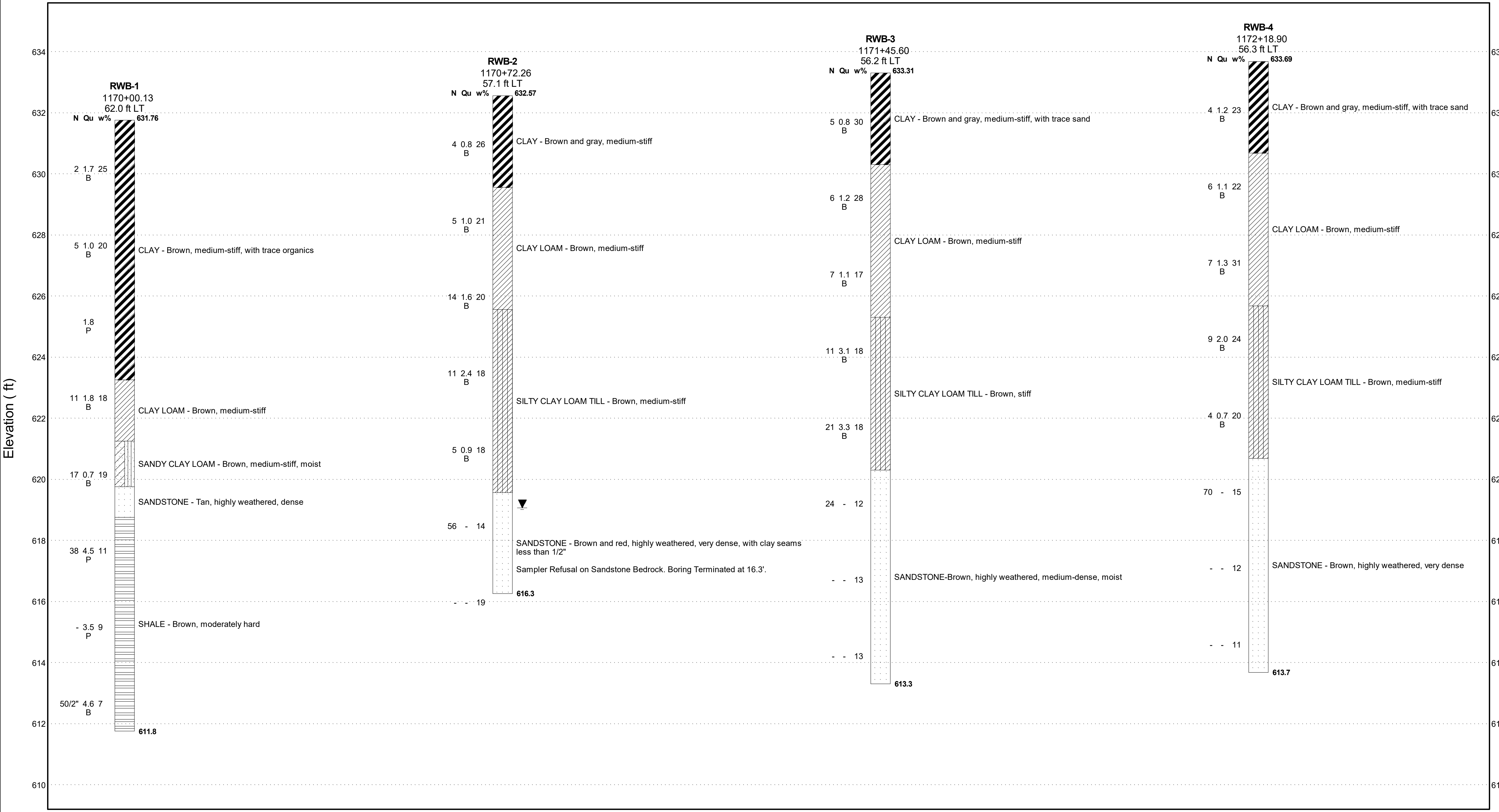
End of Boring

**The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)**
**The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)**

**BBS, form 137 (Rev. 8-99)**

# EXHIBIT E

# SUBSURFACE PROFILE



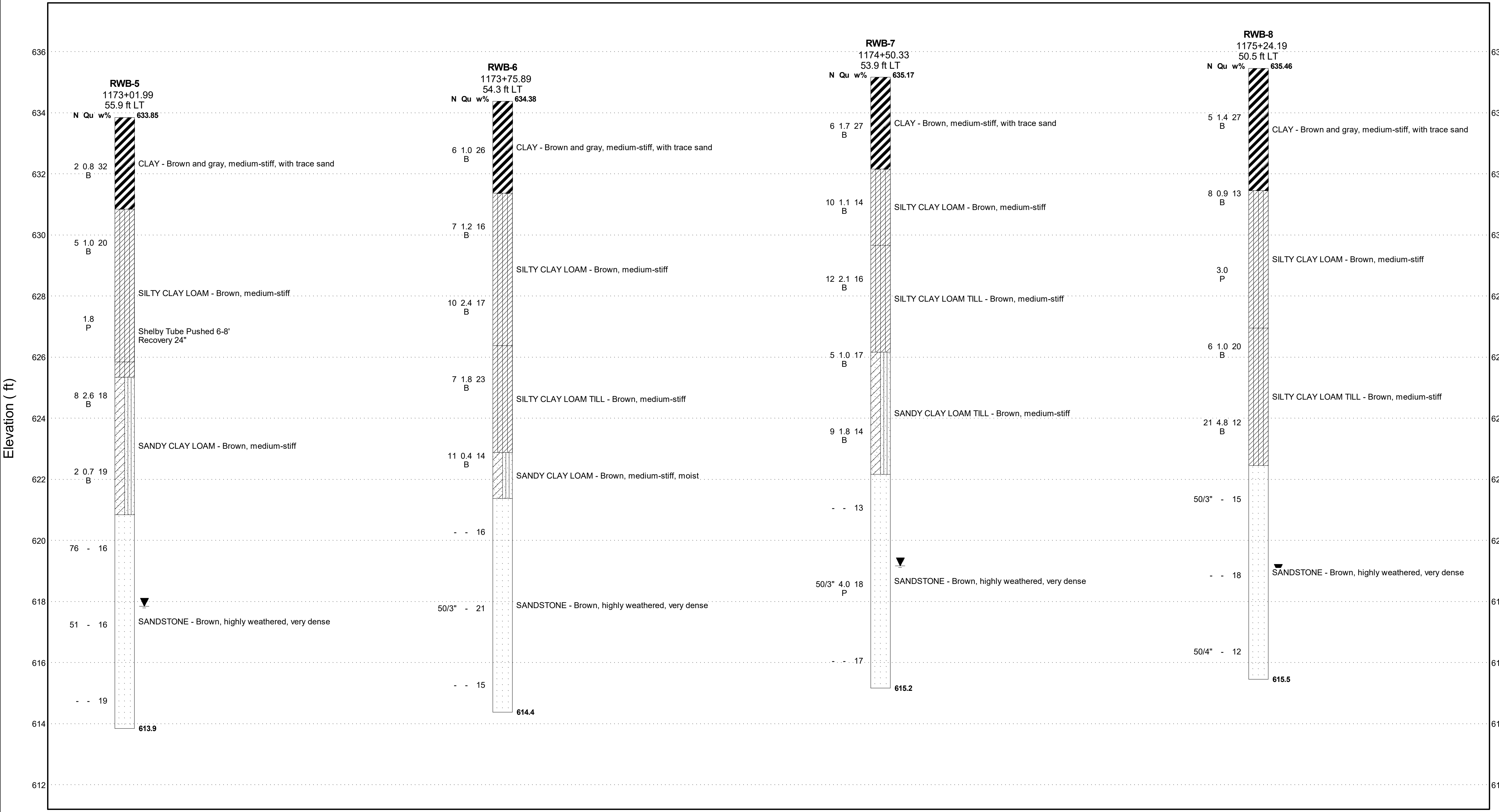

**Illinois Department of Transportation**
**Division of Highways**

**NOT TO HORIZONTAL SCALE**

## SUBSURFACE DATA PROFILE

Route: FAP 332 (IL-1)
Section: (FX-VBR)B-1
County: Clark

PRINTERMOD2 11X17 21-1009.01 IL 1 OVER CSX RETAINING WALL.GPJ IL_DOT.GDT 9/8/21




**Illinois Department of Transportation**
Division of Highways

**NOT TO HORIZONTAL SCALE**

## SUBSURFACE DATA PROFILE

Route: FAP 332 (IL-1)
Section: (FX-VBR)B-1
County: Clark

PRINTERMOD2 11X17 21-1009.01 IL 1 OVER CSX RETAINING WALL.GPJ IL_DOT.GDT 9/8/21

# EXHIBIT F

# SETTLEMENT CALCULATIONS

# IL OVER CSX RR RETAINING WALL - SETTLEMENT CALCULATIONS

**Boring RWB-3**

| | |
|---|---|
| **B (ft)=** | 52.00 |
| **L (ft)=** | 570.00 |
| **H (ft)=** | 22.00 |
| **γ (pcf)=** | 125.00 |
| **ΔP (psf)=** | 2750.00 |

| **0.02** | **Hc (ft)** | **zcl (ft)** | **Descriptions** | **γ (pcf)** | **w (%)** | **OCR** | **p'o (psf)** | **Δp (psf)** | **p'o + Δp (psf)** | **p'c (psf)** | **CASE** | **eo** | **Cc** | **δ(ft)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 1.5 | CLAY | 95 | 30 | 1 | 142.50 | 2665.88 | 2808.38 | 142.5 | NC | 0.81 | 0.249 | 0.53 |
| 2 | 5 | 5.5 | CLAY LOAM | 105 | 22.5 | 1 | 547.50 | 2463.19 | 3010.69 | 547.5 | NC | 0.61 | 0.249 | 0.57 |
| 3 | 5 | 10.5 | SILTY CLAY LOAM TILL | 115 | 18 | 1 | 1097.50 | 2246.61 | 3344.11 | 1097.5 | NC | 0.49 | 0.179 | 0.29 |
| | | | | | | | | | | | | | **Sp (ft)=** | 1.40 |
| | | | | | | | | | | | | | **Sp (in)=** | 16.79 |

**Boring RWB-5**

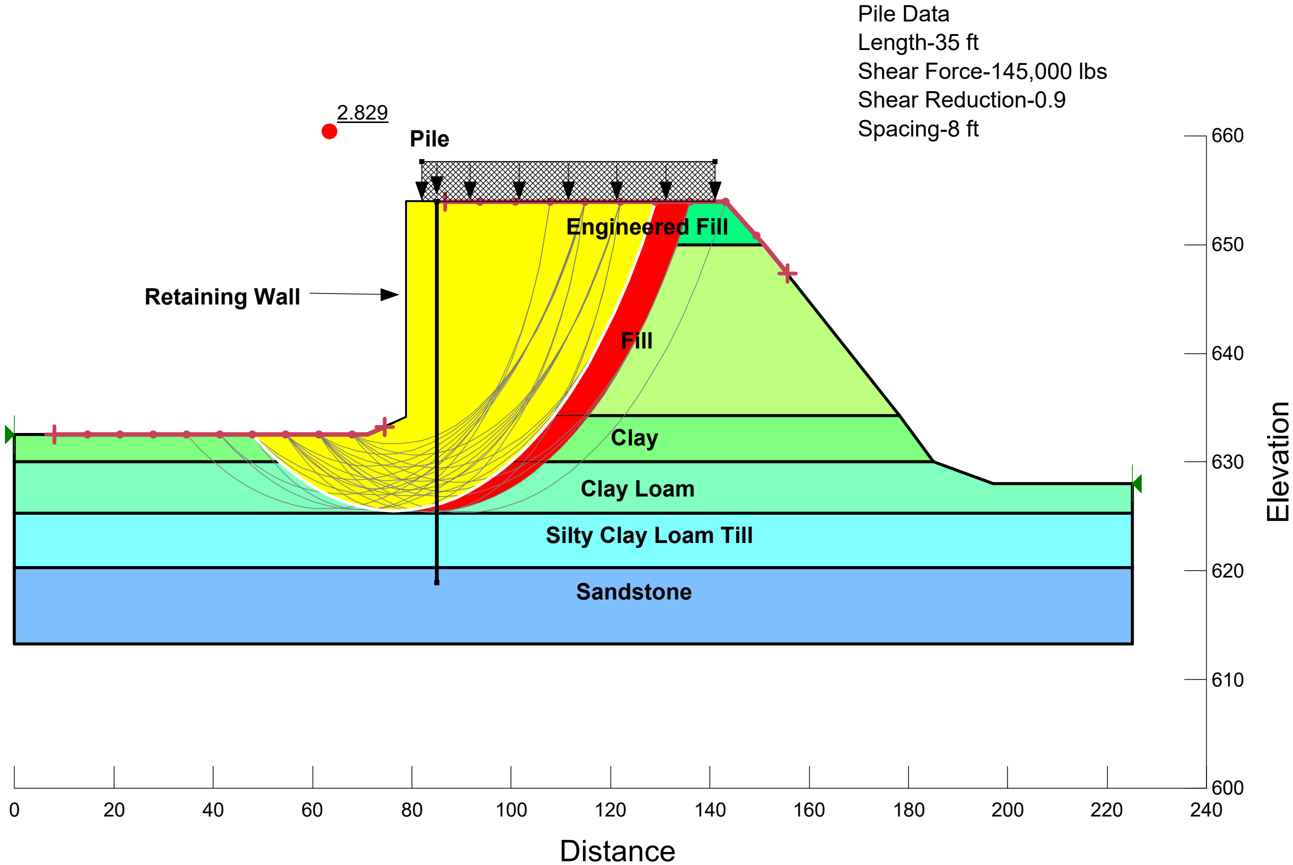
| | |
|---|---|
| **B (ft)=** | 52.00 |
| **L (ft)=** | 570.00 |
| **H (ft)=** | 17.83 |
| **γ (pcf)=** | 125.00 |
| **ΔP (psf)=** | 2228.75 |

| **Layer** | **Hc (ft)** | **zcl (ft)** | **Descriptions** | **γ (pcf)** | **w (%)** | **OCR** | **p'o (psf)** | **Δp (psf)** | **p'o + Δp (psf)** | **p'c (psf)** | **CASE** | **eo** | **Cc** | **δ(ft)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 1.5 | CLAY | 95 | 32 | 1 | 142.50 | 2160.58 | 2303.08 | 142.5 | NC | 0.86 | 0.1980 | 0.39 |
| 2 | 5.5 | 5.75 | SILTY CLAY LOAM | 110 | 20 | 1 | 587.50 | 1986.80 | 2574.30 | 587.5 | NC | 0.54 | 0.0900 | 0.21 |
| 3 | 4.5 | 10.75 | SANDY CLAY LOAM | 120 | 18.5 | 1 | 1160.00 | 1812.74 | 2972.74 | 1160 | NC | 0.50 | 0.0765 | 0.09 |
| | | | | | | | | | | | | | **Sp (ft)=** | 0.69 |
| | | | | | | | | | | | | | **Sp (in)=** | 8.22 |

# EXHIBIT G

# SLOPE/W SLOPE STABILITY ANALYSIS

**IL 1 CSX Retaining Wall**
**Cross Section of 1171+50 (Boring RWB-3)**
**End-of-Construction (Undrained Analysis)**




Name: Engineered Fill
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,500 psf
Phi': 0 °

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,500 psf
Phi': 0 °

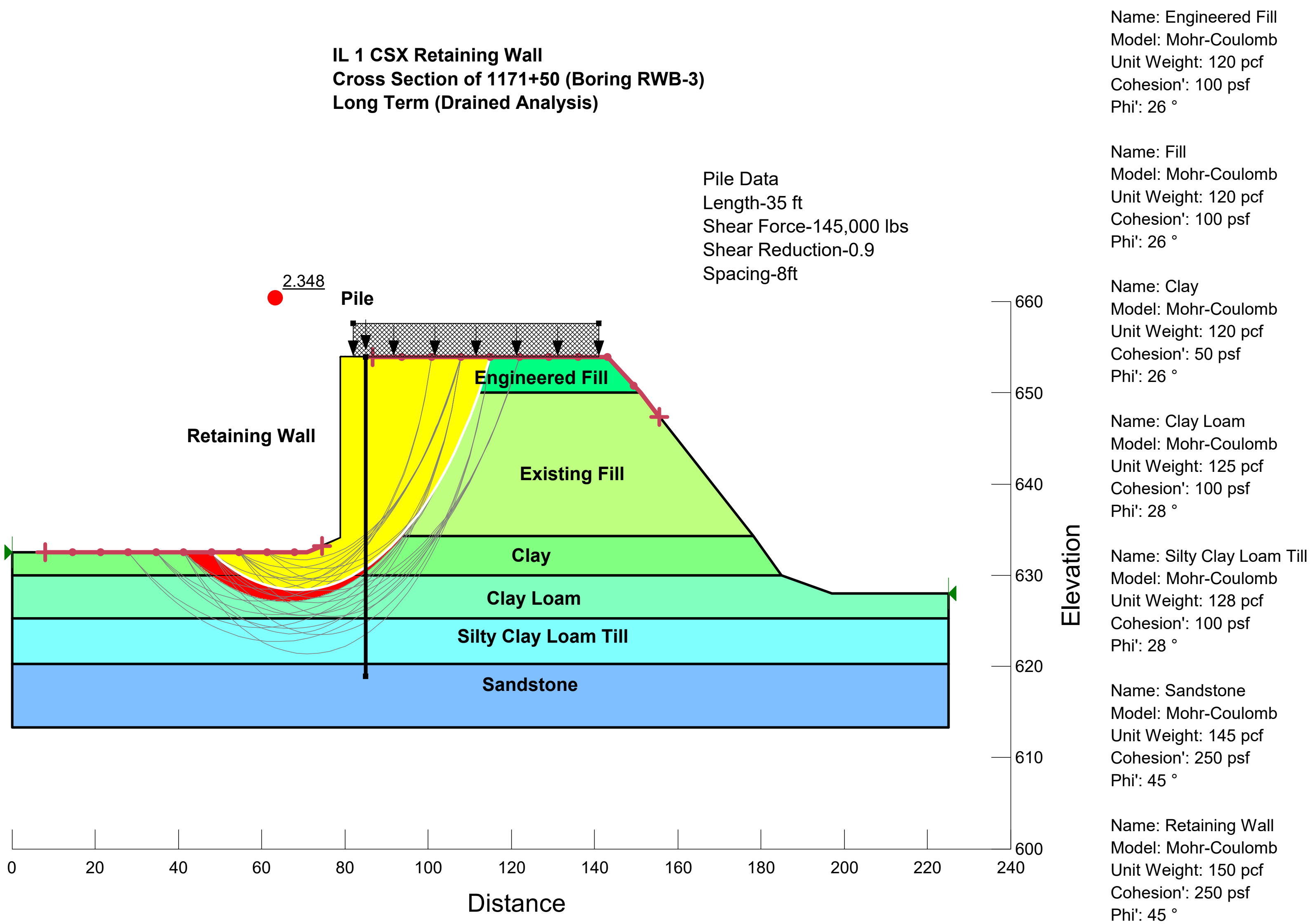
Name: Clay
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 800 psf
Phi': 0 °

Name: Clay Loam
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 1,100 psf
Phi': 0 °

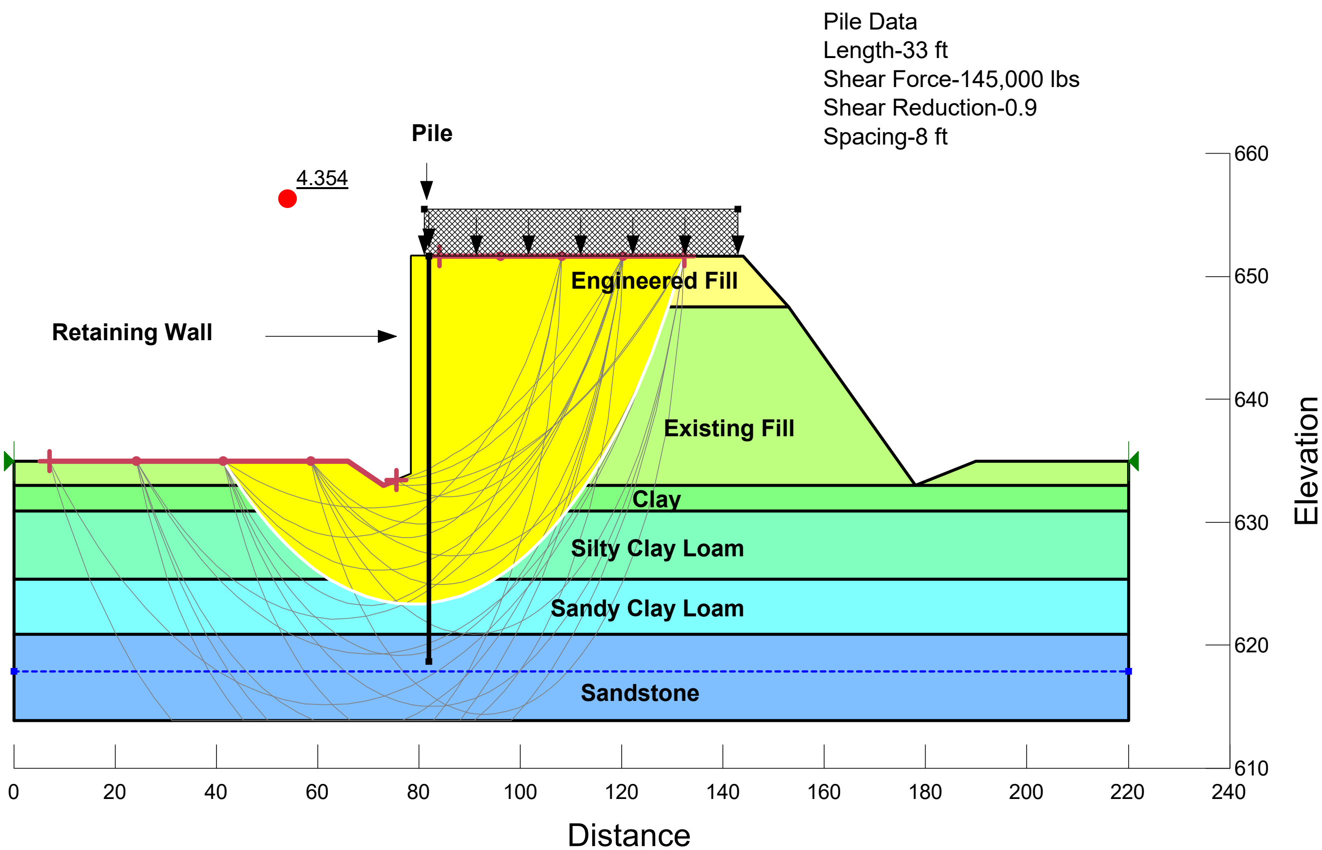
Name: Silty Clay Loam Till
Model: Mohr-Coulomb
Unit Weight: 128 pcf
Cohesion': 3,200 psf
Phi': 0 °

Name: Sandstone
Model: Mohr-Coulomb
Unit Weight: 145 pcf
Cohesion': 4,000 psf
Phi': 0 °

Name: Retaining Wall
Model: Mohr-Coulomb
Unit Weight: 150 pcf
Cohesion': 5,000 psf
Phi': 0 °


IL 1 CSX Retaining Wall
Cross Section of 1171+50 (Boring RWB-3)
Long Term (Drained Analysis)
Pile Data
Length-35 ft
Shear Force-145,000 lbs
Shear Reduction-0.9
Spacing-8ft
2.348
Pile
Retaining Wall
Engineered Fill
Existing Fill
Clay
Clay Loam
Silty Clay Loam Till
Sandstone
660
650
640
630
620
610
600
Elevation
0
20
40
60
80
100
120
140
160
180
200
220
240
Distance
Name: Engineered Fill
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 100 psf
Phi': 26 °
Name: Fill
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 100 psf
Phi': 26 °
Name: Clay
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 50 psf
Phi': 26 °
Name: Clay Loam
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 28 °
Name: Silty Clay Loam Till
Model: Mohr-Coulomb
Unit Weight: 128 pcf
Cohesion': 100 psf
Phi': 28 °
Name: Sandstone
Model: Mohr-Coulomb
Unit Weight: 145 pcf
Cohesion': 250 psf
Phi': 45 °
Name: Retaining Wall
Model: Mohr-Coulomb
Unit Weight: 150 pcf
Cohesion': 250 psf
Phi': 45 °

# IL 1 CSX Retaining Wall
## Cross Section of 1173+00 (Boring RWB-5)
## End-of-Construction (Undrained Analysis)




Name: Engineered Fill
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,500 psf
Phi': 0 °

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,500 psf
Phi': 0 °

Name: Clay
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 800 psf
Phi': 0 °

Name: Silty Clay Loam
Model: Mohr-Coulomb
Unit Weight: 128 pcf
Cohesion': 1,400 psf
Phi': 0 °

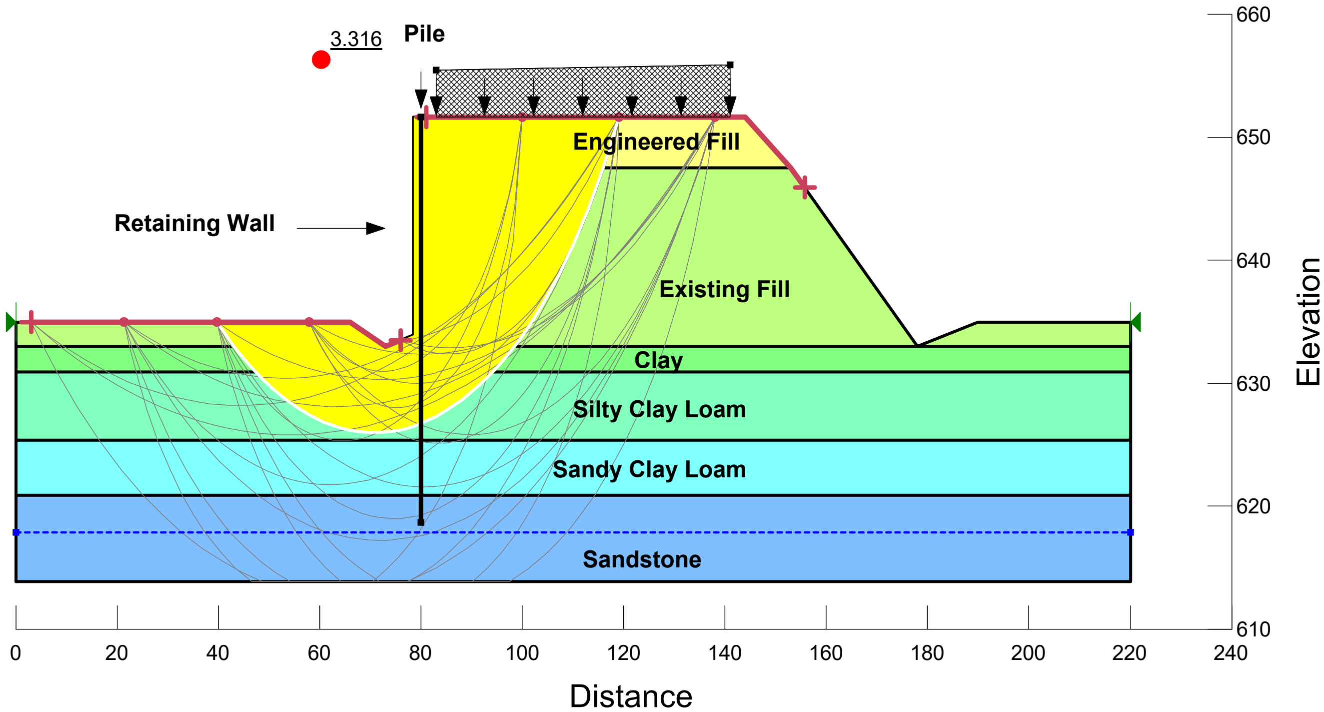
Name: Sandy Clay Loam
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,650 psf
Phi': 0 °

Name: Sandstone
Model: Mohr-Coulomb
Unit Weight: 145 pcf
Cohesion': 4,000 psf
Phi': 0 °

Name: Retaining Wall
Model: Mohr-Coulomb
Unit Weight: 150 pcf
Cohesion': 5,000 psf
Phi': 0 °

**IL 1 CSX Retaining Wall**
**Cross Section of 1173+00 (Boring RWB-5)**
**Long Term (Drained Analysis)**

Pile Data
Length-33 ft
Shear Force-145,000 lbs
Shear Reduction-0.9
Spacing-8 ft




Name: Engineered Fill
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 100 psf
Phi': 26 °

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 100 psf
Phi': 26 °

Name: Clay
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 50 psf
Phi': 26 °

Name: Silty Clay Loam
Model: Mohr-Coulomb
Unit Weight: 128 pcf
Cohesion': 100 psf
Phi': 28 °

Name: Sandy Clay Loam
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 100 psf
Phi': 30 °

Name: Sandstone
Model: Mohr-Coulomb
Unit Weight: 145 pcf
Cohesion': 250 psf
Phi': 45 °

Name: Retaining Wall
Model: Mohr-Coulomb
Unit Weight: 150 pcf
Cohesion': 250 psf
Phi': 45 °

# EXHIBIT H

# BEARING RESISTANCE CALCULATIONS

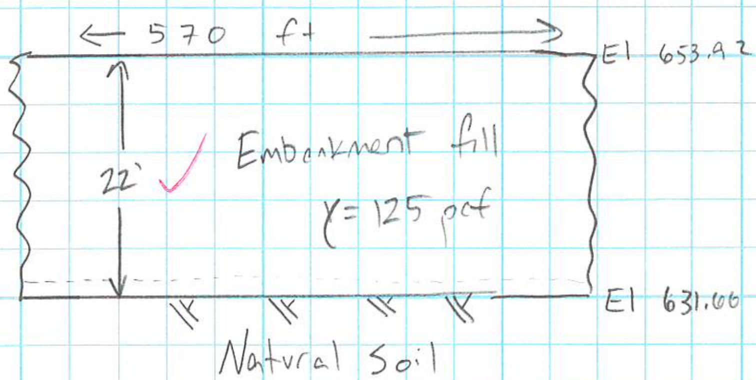
Kaskaskia
Engineering Group, LLC
208 E. Main Street
Suite 100
Belleville, Illinois 62220
618.233.5877 *phone*
618.233.5977 *fax*
www.kaskaskiaeng.com

Project Title: IL 1 over CSX RR Retaining Wall Sheet: 1 of 2
Project Number: 21-1009.01
Calculated By: CO Date: 09/09/2021
Checked By: MAM Date: 09/09/2021
Comments:

# Bearing Resistance Calcs

Assumptions: Embankment fill

$\gamma = 125$ pcf ✓
$L = 570$ ft ✓
$H = 22$ ft ✓




Width of Embankment
100 ft

Check at sta 1171 + 15.30 near Boring RWB-3

Weight of wall:

$V_w = L \times W \times H = (570\ ft)(100\ ft)(22\ ft) =$
$1{,}254{,}000\ ft^3$

$W_w = V_w \times \gamma = (1{,}254{,}000\ ft^3)(125\ pcf) =$
$156{,}750{,}000\ lbs$

Bearing pressure:

$$\frac{W_w}{A} = \frac{156{,}750{,}000\ lbs}{(570\ ft)(100\ ft)} = 2{,}750\ psf$$ ✓

Kaskaskia
Engineering Group, LLC
208 E. Main Street
Suite 100
Belleville, Illinois 62220
618.233.5877 phone
618.233.5977 fax
www.kaskaskiaeng.com

Project Title: IL 1 over CSX RR Retaining Wall Sheet: 2 of 2
Project Number: 21-1009.01
Calculated By: CO Date: 09/09/2021
Checked By: [signature] Date: 09/09/2021
Comments:

Bearing capacity for continuous foundations:

$$q_u = c' N_c + \gamma' D_f N_q + 0.5 \gamma B N_\gamma$$

Bearing in clay at EL 631.66 from boring RWB-3

Parameters:

$\Phi' = 0$
$D_f = 3.5$ ft
$N_c = 5.14$
$N_q = 1$
$N_\gamma = 0$
$c' = 1000$ psf (average cohesion in clay layers)
$\gamma' = 120$ pcf for clay

$$\Rightarrow q_u = c' N_c + \gamma' D_f N_q + 0.5 \gamma' B N_\gamma \; (\to 0)$$

$$q_u = (1000 \text{ psf})(5.14) + (120 \text{ pcf})(3.5 \text{ ft})(1) + 0$$

$$q_u = 5{,}560 \text{ psf}$$

$$q_a = q_u / 2 = 2{,}780 \text{ psf}$$

2,780 psf > 2,750 psf ✓ OK

# EXHIBIT I

# IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

# IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

Illinois Department of Transportation

SUBSTRUCTURE===================================== Retaining Wall
REFERENCE BORING ================================ RWB-05
LRFD or ASD or SEISMIC ============================== LRFD
PILE CUTOFF ELEV. ================================== 651.68 ft
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVING = 633.85 ft
GEOTECHNICAL LOSS TYPE (None, Scour, Liquef., DD) ====== None
BOTTOM ELEV. OF SCOUR, LIQUEF., or DD ================= ft
TOP ELEV. OF LIQUEF. (so layers above apply DD) =============== ft

***MAX. REQUIRED BEARING & RESISTANCE for Selected Pile, Soil Profile, & Losses***

| Maximum Nominal Req'd Bearing of Pile | Maximum Nominal Req.d Bearing of Boring | Maximum Factored Resistance Available in Boring | Maximum Pile Driveable Length in Boring |
|---|---|---|---|
| **335** KIPS | **325** KIPS | **179** KIPS | **33** FT. |

TOTAL FACTORED SUBSTRUCTURE LOAD ============== 2 kips
TOTAL LENGTH OF SUBSTRUCTURE (along skew)========= 52.00 ft
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE ======= 1
Approx. Factored Loading Applied per pile at 8 ft. Cts =========== 0.31 KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts =========== 0.12 KIPS

PILE TYPE AND SIZE ============= Steel HP 10 X 42
Plugged Pile Perimeter========================= 3.300 FT. Unplugged Pile Perimeter============== 4.858 FT.
Plugged Pile End Bearing Area=================== 0.680 SQFT. Unplugged Pile End Bearing Area======== 0.086 SQFT.

| BOT. OF LAYER ELEV. (FT.) | LAYER THICK. (FT.) | UNCONF. COMPR. STRENGTH (TSF.) | S.P.T. N VALUE (BLOWS) | GRANULAR OR ROCK LAYER DESCRIPTION | NOMINAL PLUGGED SIDE RESIST. (KIPS) | NOMINAL PLUGGED END BRG. RESIST. (KIPS) | NOMINAL PLUGGED TOTAL RESIST. (KIPS) | NOMINAL UNPLUG'D SIDE RESIST. (KIPS) | NOMINAL UNPLUG'D END BRG. RESIST. (KIPS) | NOMINAL UNPLUG'D TOTAL RESIST. (KIPS) | NOMINAL REQ'D BEARING (KIPS) | FACTORED GEOTECH. LOSS FROM SCOUR or DD (KIPS) | FACTORED GEOTECH. LOSS LOAD FROM DD (KIPS) | FACTORED RESISTANCE AVAILABLE (KIPS) | ESTIMATED PILE LENGTH (FT.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 632.85 | 1.00 | 0.80 | | | 1.9 | | 9.6 | 2.9 | | ***3.8*** | 4 | 0 | 0 | 2 | 19 |
| 630.85 | 2.00 | 0.80 | | | 3.9 | 7.6 | 15.4 | 5.7 | 1.0 | ***9.8*** | 10 | 0 | 0 | 5 | 21 |
| 628.35 | 2.50 | 1.00 | | | 5.9 | 9.5 | 28.9 | 8.6 | 1.2 | ***19.4*** | 19 | 0 | 0 | 11 | 23 |
| 625.35 | 3.00 | 1.80 | | | 10.8 | 17.2 | 47.3 | 15.9 | 2.2 | ***36.2*** | 36 | 0 | 0 | 20 | 26 |
| 622.85 | 2.50 | 2.60 | | | 11.4 | 24.8 | ***40.6*** | 16.8 | 3.1 | 50.7 | 41 | 0 | 0 | 22 | 29 |
| 620.85 | 2.00 | 0.70 | | | 3.5 | 6.7 | 175.1 | 5.1 | 0.8 | ***72.4*** | 72 | 0 | 0 | 40 | 31 |
| 620.35 | 0.50 | | | Sandstone | 34.3 | 137.7 | 209.3 | 50.4 | 17.4 | ***122.9*** | 123 | 0 | 0 | 68 | 31.3 |
| 619.85 | 0.50 | | | Sandstone | 34.3 | 137.7 | 243.6 | 50.4 | 17.4 | ***173.3*** | 173 | 0 | 0 | 95 | 31.8 |
| 619.35 | 0.50 | | | Sandstone | 34.3 | 137.7 | 277.9 | 50.4 | 17.4 | ***223.7*** | 224 | 0 | 0 | 123 | 32.3 |
| 618.85 | 0.50 | | | Sandstone | 34.3 | 137.7 | 312.1 | 50.4 | 17.4 | ***274.2*** | 274 | 0 | 0 | 151 | 32.8 |
| 618.35 | 0.50 | | | Sandstone | 34.3 | 137.7 | 346.4 | 50.4 | 17.4 | ***324.6*** | 325 | 0 | 0 | 179 | 33.3 |
| 617.85 | 0.50 | | | Sandstone | 34.3 | 137.7 | 380.6 | 50.4 | 17.4 | ***375.0*** | ~~375~~ | ~~0~~ | ~~0~~ | ~~206~~ | ~~33.8~~ |
| 617.35 | 0.50 | | | Sandstone | 34.3 | 137.7 | ***414.9*** | 50.4 | 17.4 | 425.5 | ~~415~~ | ~~0~~ | ~~0~~ | ~~228~~ | ~~34.3~~ |
| 616.85 | 0.50 | | | Sandstone | 34.3 | 137.7 | ***449.1*** | 50.4 | 17.4 | 475.9 | ~~449~~ | ~~0~~ | ~~0~~ | ~~247~~ | ~~34.8~~ |
| 616.35 | 0.50 | | | Sandstone | 34.3 | 137.7 | ***483.4*** | 50.4 | 17.4 | 526.3 | ~~483~~ | ~~0~~ | ~~0~~ | ~~266~~ | ~~35.3~~ |
| 615.85 | 0.50 | | | Sandstone | 34.3 | 137.7 | ***517.7*** | 50.4 | 17.4 | 576.8 | ~~518~~ | ~~0~~ | ~~0~~ | ~~285~~ | ~~35.8~~ |
| 615.35 | 0.50 | | | Sandstone | 34.3 | 137.7 | ***551.9*** | 50.4 | 17.4 | 627.2 | ~~552~~ | ~~0~~ | ~~0~~ | ~~304~~ | ~~36.3~~ |
| 614.85 | 0.50 | | | Sandstone | 34.3 | 137.7 | ***586.2*** | 50.4 | 17.4 | 677.6 | ~~586~~ | ~~0~~ | ~~0~~ | ~~322~~ | ~~36.8~~ |
| 614.35 | 0.50 | | | Sandstone | 34.3 | 137.7 | ***620.4*** | 50.4 | 17.4 | 728.1 | ~~620~~ | ~~0~~ | ~~0~~ | ~~341~~ | ~~37.3~~ |
| 613.85 | 0.50 | | | Sandstone | | 137.7 | | | 17.4 | | | | | | |

# EXHIBIT J

# IDOT DRILLED SHAFT SPREADSHEETS

Illinois Department of Transportation

# DRILLED SHAFT AXIAL CAPACITY IN ROCK -
# DOLOMITE, LIMESTONE, SANDSTONE, AND HARD SHALE

STRUCTURE =============================== SN 012-0074
SUBSTRUCTURE & REFERENCE BORING ======= Boring RWB-3
GROUND SURFACE ELEVATION =============== 633.31 FT
GROUND WATER ELEVATION ================= 619.31 FT
ESTIMATED TOP OF ROCK ELEVATION ======== 620.30 FT
DRILLED SHAFT DIAMETER IN ROCK ========== 18 IN.
FACTORED AXIAL LOAD ===================== 2 KIPS
DRILLED SHAFT CONCRETE STRENGTH, f'c ===== 3.5 KSI

FOUNDATION REDUNDANCY ==== REDUNDANT

***Drilled Shaft Dia.'s for Design Table***

18 IN.
24 IN,
30 IN.
IN.
IN.
IN.

| SOCKET DEPTH (FT) | TIP ELEV. (FT) | LAYER THICK. (FT) | UNCONFINED COMPRESSIVE STRENGTH ($q_u$) (KSF) | ROCK TYPE | GSI | ROCK CONDITION | RQD (%) | JOINT TYPE | ROCK INTACT OR TIGHTLY JOINTED? | SIDE RESISTANCE: NOM. RESIST. (KIPS) | SIDE RESISTANCE: Σ NOM. RESIST. (KIPS) | SIDE RESISTANCE: Σ FACT. RESIST. (KIPS) | SIDE RESISTANCE SETTLEMENT: $Q_{C1}$ (KIPS) | SIDE RESISTANCE SETTLEMENT: $w_{C1}$ (IN.) | SIDE RESISTANCE SETTLEMENT: $w_{Rn}$ (IN.) | AVG. $q_u$ W/IN 2 - SHAFT DIA. (KSF) | TIP RESISTANCE: NOM. RESIST. (KIPS) | TIP RESISTANCE: FACT. RESIST. (KIPS) | TIP RESISTANCE: SETTL. $w_{Rn}$ (IN.) | COMBINED: $R_P/R_n$ | COMBINED: NOM. RESIST. (KIPS) | COMBINED: FACT. RESIST. (KIPS) | COMBINED SETTLEMENT: $Q_{C1}$ (KIPS) | COMBINED SETTLEMENT: $w_{C1}$ (IN.) | COMBINED SETTLEMENT: $w_{Rn}$ (IN.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.00 | 618.30 | 2.00 | 417.0 | Sandstone | 35 | Fractured | 50 | Open | No | 100 | 100 | 55 | 68 | 0.038 | 0.200 | 626.0 | 434 | 217 | 0.411 | 0.66 | 291 | 151 | 110 | 0.040 | 0.183 |
| 4.00 | 616.30 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 210 | 116 | 162 | 0.058 | 0.158 | 626.0 | 538 | 269 | 0.529 | 0.41 | 354 | 188 | 223 | 0.061 | 0.146 |
| 6.00 | 614.30 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 320 | 176 | 259 | 0.072 | 0.153 | 626.0 | 560 | 280 | 0.566 | 0.29 | 450 | 241 | 332 | 0.077 | 0.144 |
| 8.00 | 612.30 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 431 | 237 | 360 | 0.086 | 0.154 | 626.0 | 580 | 290 | 0.602 | 0.22 | 550 | 297 | 441 | 0.093 | 0.147 |
| 10.00 | 610.30 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 541 | 297 | 465 | 0.101 | 0.159 | 626.0 | 598 | 299 | 0.638 | 0.17 | 652 | 353 | 552 | 0.109 | 0.154 |
| 12.00 | 608.30 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 651 | 358 | 574 | 0.116 | 0.166 | 626.0 | 616 | 308 | 0.683 | 0.14 | 753 | 409 | 663 | 0.125 | 0.163 |
| 14.00 | 606.30 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 761 | 419 | 686 | 0.133 | 0.175 | 626.0 | 633 | 316 | 0.710 | 0.11 | 854 | 465 | 775 | 0.142 | 0.173 |
| 16.00 | 604.30 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 871 | 479 | 800 | 0.150 | 0.186 | | | | | | | | | | |
| 18.00 | 602.30 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 981 | 540 | 917 | 0.168 | 0.198 | | | | | | | | | | |

**Drilled Shaft Design Table for Boring RWB-3**

*Estimated Top of Rock Elevation: 620.30*



| SOCKET DEPTH (FT) | TIP ELEV. (FT) | NOMINAL SHAFT RESIST. (KIPS) | FACTORED SHAFT RESIST. (KIPS) | RESIST. METHOD | SETTLEMENT DATA $Q_{C1}$ (KIPS) | $w_{C1}$ (IN.) | $w_{Rn}$ (IN.) |
|---|---|---|---|---|---|---|---|
| **18 in. Diameter Drilled Shaft** | | | | | | | |
| 2 | 618.3 | 434 | 217 | TIP | -- | -- | 0.411 |
| 4 | 616.3 | 538 | 269 | TIP | -- | -- | 0.529 |
| 6 | 614.3 | 560 | 280 | TIP | -- | -- | 0.566 |
| 8 | 612.3 | 580 | 290 | TIP | -- | -- | 0.602 |
| 10 | 610.3 | 652 | 353 | SIDE + TIP | 552 | 0.109 | 0.154 |
| 12 | 608.3 | 753 | 409 | SIDE + TIP | 663 | 0.125 | 0.163 |
| 14 | 606.3 | 854 | 465 | SIDE + TIP | 775 | 0.142 | 0.173 |
| 16 | 604.3 | 871 | 479 | SIDE | 800 | 0.150 | 0.186 |
| 18 | 602.3 | 981 | 540 | SIDE | 917 | 0.168 | 0.198 |
| **24 in. Diameter Drilled Shaft** | | | | | | | |
| 2 | 618.3 | 772 | 386 | TIP | -- | -- | 0.550 |
| 4 | 616.3 | 957 | 478 | TIP | -- | -- | 0.707 |
| 6 | 614.3 | 995 | 498 | TIP | -- | -- | 0.733 |
| 8 | 612.3 | 1031 | 515 | TIP | -- | -- | 0.782 |
| 10 | 610.3 | 1064 | 532 | TIP | -- | -- | 0.835 |
| 12 | 608.3 | 1095 | 548 | TIP | -- | -- | 0.865 |
| 14 | 606.3 | 1202 | 652 | SIDE + TIP | 1043 | 0.151 | 0.203 |
| 16 | 604.3 | 1162 | 639 | SIDE | 1033 | 0.156 | 0.217 |
| 18 | 602.3 | 1308 | 720 | SIDE | 1182 | 0.172 | 0.227 |
| **30 in. Diameter Drilled Shaft** | | | | | | | |
| 2 | 618.3 | 1207 | 603 | TIP | -- | -- | 0.670 |
| 4 | 616.3 | 1495 | 748 | TIP | -- | -- | 0.876 |
| 6 | 614.3 | 1555 | 777 | TIP | -- | -- | 0.912 |
| 8 | 612.3 | 1610 | 805 | TIP | -- | -- | 0.954 |
| 10 | 610.3 | 1662 | 831 | TIP | -- | -- | 1.008 |
| 12 | 608.3 | 1711 | 856 | TIP | -- | -- | 1.055 |
| 14 | 606.3 | 1268 | 698 | SIDE | 1087 | 0.150 | 0.246 |
| 16 | 604.3 | 1452 | 799 | SIDE | 1263 | 0.165 | 0.253 |
| 18 | 602.3 | 1635 | 899 | SIDE | 1443 | 0.180 | 0.260 |

Illinois Department of Transportation

# DRILLED SHAFT AXIAL CAPACITY IN ROCK - DOLOMITE, LIMESTONE, SANDSTONE, AND HARD SHALE

STRUCTURE ============================== SN 012-0074
SUBSTRUCTURE & REFERENCE BORING ======= Boring RWB-5
GROUND SURFACE ELEVATION =============== 633.85 FT
GROUND WATER ELEVATION ================= 617.90 FT
ESTIMATED TOP OF ROCK ELEVATION ======== 620.90 FT
DRILLED SHAFT DIAMETER IN ROCK ========== 18 IN.
FACTORED AXIAL LOAD ===================== 2 KIPS
DRILLED SHAFT CONCRETE STRENGTH, f'c ===== 3.5 KSI

FOUNDATION REDUNDANCY ==== REDUNDANT

***Drilled Shaft Dia.'s for Design Table***

18 IN.
24 IN,
30 IN.
IN.
IN.
IN.

| SOCKET DEPTH (FT) | TIP ELEV. (FT) | LAYER THICK. (FT) | UNCONFINED COMPRESSIVE STRENGTH ($q_u$) (KSF) | ROCK TYPE | GSI | ROCK CONDITION | RQD (%) | JOINT TYPE | ROCK INTACT OR TIGHTLY JOINTED? | SIDE RESISTANCE: NOM. RESIST. (KIPS) | Σ NOM. RESIST. (KIPS) | Σ FACT. RESIST. (KIPS) | SETTLEMENT: $Q_{C1}$ (KIPS) | $w_{C1}$ (IN.) | $w_{Rn}$ (IN.) | AVG. $q_u$ W/IN 2 - SHAFT DIA. (KSF) | TIP RESISTANCE: NOM. RESIST. (KIPS) | FACT. RESIST. (KIPS) | SETTL. $w_{Rn}$ (IN.) | $R_P/R_n$ | COMBINED SIDE & TIP RESISTANCE: NOM. RESIST. (KIPS) | FACT. RESIST. (KIPS) | SETTLEMENT: $Q_{C1}$ (KIPS) | $w_{C1}$ (IN.) | $w_{Rn}$ (IN.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.00 | 618.90 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 110 | 61 | 91 | 0.041 | 0.103 | 626.0 | 515 | 257 | 0.487 | 0.48 | 212 | 112 | 135 | 0.042 | 0.097 |
| 4.00 | 616.90 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 220 | 121 | 185 | 0.060 | 0.118 | 626.0 | 538 | 269 | 0.529 | 0.33 | 327 | 175 | 249 | 0.063 | 0.110 |
| 6.00 | 614.90 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 330 | 182 | 284 | 0.074 | 0.127 | 626.0 | 559 | 280 | 0.566 | 0.24 | 436 | 235 | 359 | 0.079 | 0.120 |
| 8.00 | 612.90 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 441 | 242 | 386 | 0.089 | 0.136 | 626.0 | 579 | 290 | 0.602 | 0.19 | 543 | 294 | 470 | 0.095 | 0.130 |
| 10.00 | 610.90 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 551 | 303 | 493 | 0.103 | 0.145 | 626.0 | 598 | 299 | 0.638 | 0.15 | 648 | 352 | 582 | 0.111 | 0.140 |
| 12.00 | 608.90 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 661 | 363 | 603 | 0.119 | 0.154 | 626.0 | 616 | 308 | 0.682 | 0.12 | 752 | 409 | 695 | 0.128 | 0.151 |
| 14.00 | 606.90 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 771 | 424 | 716 | 0.136 | 0.165 | 626.0 | 632 | 316 | 0.710 | 0.10 | 855 | 466 | 807 | 0.145 | 0.163 |
| 16.00 | 604.90 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 881 | 485 | 832 | 0.153 | 0.177 | | | | | | | | | | |
| 18.00 | 602.90 | 2.00 | 626.0 | Sandstone | 40 | Fractured | 50 | Open | No | 110 | 991 | 545 | 950 | 0.172 | 0.190 | | | | | | | | | | |

**Drilled Shaft Design Table for Boring RWB-5**

*Estimated Top of Rock Elevation: 620.90*



| SOCKET DEPTH (FT) | TIP ELEV. (FT) | NOMINAL SHAFT RESIST. (KIPS) | FACTORED SHAFT RESIST. (KIPS) | RESIST. METHOD | SETTLEMENT DATA $Q_{C1}$ (KIPS) | $w_{C1}$ (IN.) | $w_{Rn}$ (IN.) |
|---|---|---|---|---|---|---|---|
| **18 in. Diameter Drilled Shaft** | | | | | | | |
| 2 | 618.9 | 515 | 257 | TIP | -- | -- | 0.487 |
| 4 | 616.9 | 538 | 269 | TIP | -- | -- | 0.529 |
| 6 | 614.9 | 559 | 280 | TIP | -- | -- | 0.566 |
| 8 | 612.9 | 579 | 290 | TIP | -- | -- | 0.602 |
| 10 | 610.9 | 648 | 352 | SIDE + TIP | 582 | 0.111 | 0.140 |
| 12 | 608.9 | 752 | 409 | SIDE + TIP | 695 | 0.128 | 0.151 |
| 14 | 606.9 | 855 | 466 | SIDE + TIP | 807 | 0.145 | 0.163 |
| 16 | 604.9 | 881 | 485 | SIDE | 832 | 0.153 | 0.177 |
| 18 | 602.9 | 991 | 545 | SIDE | 950 | 0.172 | 0.190 |
| **24 in. Diameter Drilled Shaft** | | | | | | | |
| 2 | 618.9 | 915 | 457 | TIP | -- | -- | 0.651 |
| 4 | 616.9 | 956 | 478 | TIP | -- | -- | 0.707 |
| 6 | 614.9 | 994 | 497 | TIP | -- | -- | 0.733 |
| 8 | 612.9 | 1030 | 515 | TIP | -- | -- | 0.781 |
| 10 | 610.9 | 1063 | 532 | TIP | -- | -- | 0.834 |
| 12 | 608.9 | 1095 | 547 | TIP | -- | -- | 0.864 |
| 14 | 606.9 | 1198 | 650 | SIDE + TIP | 1084 | 0.154 | 0.190 |
| 16 | 604.9 | 1175 | 646 | SIDE | 1072 | 0.159 | 0.205 |
| 18 | 602.9 | 1322 | 727 | SIDE | 1223 | 0.175 | 0.216 |
| **30 in. Diameter Drilled Shaft** | | | | | | | |
| 2 | 618.9 | 1429 | 715 | TIP | -- | -- | 0.796 |
| 4 | 616.9 | 1494 | 747 | TIP | -- | -- | 0.876 |
| 6 | 614.9 | 1554 | 777 | TIP | -- | -- | 0.912 |
| 8 | 612.9 | 1609 | 805 | TIP | -- | -- | 0.953 |
| 10 | 610.9 | 1661 | 831 | TIP | -- | -- | 1.008 |
| 12 | 608.9 | 1710 | 855 | TIP | -- | -- | 1.055 |
| 14 | 606.9 | 1285 | 707 | SIDE | 1131 | 0.153 | 0.229 |
| 16 | 604.9 | 1468 | 808 | SIDE | 1309 | 0.167 | 0.238 |
| 18 | 602.9 | 1652 | 909 | SIDE | 1490 | 0.183 | 0.247 |