STRUCTURE GEOTECHNICAL REPORT

Proposed SN 091-0075 (NB)
Proposed SN 091-0076 (SB)

Existing SNs 091-0001 & 091-0002

I-57 & US 51 over Shake Rag Road
FAI Route 57
Section (91-4)B-1
Union County

PTB 178 - Item 19
Contract No. 78522
Job No. D-99-024-16

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Project Description and Scope

This project involves the complete replacement of dual bridges carrying I-57 and US 51 over Shake Rag Road in Union County. The project site is located in Section 30, Range 1E, Township 13S, in the 3rd Principal Meridian about 2 miles north of the Pulaski County line. A *Location Map* is presented in Exhibit A.

There are existing dual bridges at this location, SN 091-0001 and SN 091-0002, which were constructed in 1957. They are three span structures with concrete T-beam superstructure supported on wall piers and open abutments. The piers and north abutments are supported on spread footings while the south abutments are supported on steel piles. The existing plans call for 30 ton capacity of the steel piles at an estimated 51 foot length. See *Existing Structure Pile Data* in Exhibit E for as-built information. Concrete slope walls are present within the outer spans of the bridges. The bridges measure 121'-2" back to back abutments and 43'-4" out to out, with a 30 degree left ahead skew.

Per the preliminary Type, Size & Location Plan (TSL), the proposed dual structures are 3 span bridges with W27 rolled beams supported on integral abutments and encased pile bent piers. The proposed structures will have a back-to-back abutment length of 127'-0", out-to-out width of 45'-2" and 30 degree left ahead skew. The roadway will be on a horizontal tangent alignment and on a tangent vertical profile. The proposed abutments will be constructed on existing embankments, but the profile will be raised by over one foot at the bridge location. Traffic will be maintained utilizing cross overs during construction. The new south abutment foundations will be located to avoid conflict with the existing piles. The new structures are to be designed following LRFD Bridge Design Specifications.

See *Preliminary TSL* attached in Exhibit B for further information about the proposed structures.

Field Exploration

Subsurface Exploration and Testing

The site is located in a rural area east of Dongola with woods located immediately to the east and to the west of the bridges. The structures cross over Shake Rag Road, which is approximately 22 feet wide. A grassy median separates the two structures. There are no known utilities near the bridge.

The subsurface investigation consisted of five borings (1-S, 2-S, 3-S, 4-S and 5-S) drilled by IDOT District 9 personnel in November of 2008 and April of 2009. 1-S was drilled along the east edge of SN 091-0001 in the south span; 2-S was drilled in the east shoulder of the north approach of SN 091-0001; 3-S was drilled along the west edge of SN 091-0002 in the north span; 4-S was drilled along the west edge of SN-091-0002 in the south approach; 5-S was drilled at the intersection of the I-57 and Shake Rag Road centerlines. Boring locations can be found in Exhibit B.

Beginning at the ground surface, standard penetration tests (SPT) were conducted every 2.5 feet according to AASHTO T 206, using a Hollow Stem Auger. All borings except 2-S were drilled until auger refusal, where rock cores into the refusal materials were then

retrieved. Boring 2-S was terminated prior to reaching rock due to the auger kicking out of plumb, not allowing any further drilling.

Subsurface Conditions

While drilling, groundwater was encountered at an elevation between 376.1 and 396.4 for the borings within the existing bridge embankments, while groundwater was encountered at an elevation of 324.6 for the boring taken at the centerline of Shake Rag Road.

Boring 1-S: Starting at ground surface, the boring data depicts stiff to very stiff red brown and brown clay and silty clay to an elevation of 406.4, with Q_u values from 1.4 to 2.3 tsf, SPT (N) values ranging from 7 to 10 blows per foot, and moisture contents ranging between 19% and 21%. Very soft to medium grey silty clay is present down to elevation 398.9, with Q_u values from 0.2 to 0.5 tsf, SPT (N) values ranging from 2 to 6 blows per foot, and moisture contents ranging between 25% and 29%. Medium to very stiff grey and red brown clay is present down to elevation 352.4, with Q_u values from 0.8 to 2.3 tsf, SPT (N) values ranging from 5 to 20 blows per foot, and moisture contents ranging between 17% and 41%. Two layers of medium dense chert gravel fall within the medium to very stiff clay, centered at 387.65 and 381.40, with friction angles of 35 and 34 degrees respectively, and a moisture content of 13%. Limestone was encountered at elevation 352.4 and the rock cores displayed RQD values between 0% and 24% with sample recovery varying from 5% to 33%.

Boring 2-S: Starting at ground surface, the boring data depicts medium to very stiff red brown clay, clay loam and silty clay with broken chert gravel to an elevation of 356.1, with Q_u values from 0.8 to 2.1 tsf, SPT (N) values ranging from 1 to 37 blows per foot, and moisture contents ranging between 12% and 44%. Very soft to soft grey, red and red brown clay and clay loam with gravel is present down to elevation 344.6, with Q_u values from 0.2 to 0.4 tsf, SPT (N) values ranging from 2 to 9 blows per foot, and moisture contents ranging between 48% and 53%.

Boring 3-S: Starting at ground surface, the boring data depicts stiff to very stiff red brown clay and silty clay to an elevation of 388.1, with Q_u values from 1.2 to 3.0 tsf, SPT (N) values ranging from 5 to 22 blows per foot, and moisture contents ranging between 20% and 36%. Very soft grey loam to elevation 387.1, with a Qu of 0.1 tsf, SPT (N) value of 5 blows per foot, and a moisture content of 33%. Medium to stiff red brown clay is present down to elevation 367.6, with Q_u values from 0.7 to 1.9 tsf, SPT (N) values ranging from 2 to 7 blows per foot, and moisture contents ranging between 34% and 57%. Limestone was encountered at elevation 367.6 and the rock cores displayed RQD values between 70% and 72% with sample recovery varying from 93% to 100%.

Boring 4-S: Starting at ground surface, the boring data depicts medium to very stiff red brown and grey clay and silty clay loam to an elevation of 414.0, with Q_u values from 0.7 to 2.5 tsf, SPT (N) values ranging from 5 to 9 blows per foot, and moisture contents ranging between 19% and 31%. Soft red brown clay is present down to elevation 411.5, with a Q_u value of 0.3 tsf, SPT (N) value of 3 blows per foot, and a moisture content of 22%. Medium to stiff grey and red brown clay, silty clay and silty clay loam with broken chert gravel is present down to elevation 346.0, with Q_u values from 0.7 to 1.9 tsf, SPT (N) values ranging from 3 to 26 blows per foot, and moisture contents ranging between 19% and 37%. Three layers of medium dense chert gravel fall within the medium to stiff

clay, centered at 392.75, 387.75, and 376.25; with friction angles between 32 and 35 degrees, and a moisture content of 20%. Very soft to soft brown and red brown clay and loam with gravel is present down to elevation 319.5, with Q_u values from 0.2 to 0.5 tsf, SPT (N) values ranging from 1 to 2 blows per foot, and moisture contents ranging between 32% and 48%. Limestone was encountered at elevation 319.5 and the rock core displayed an RQD value of 53% with sample recovery of 72%.

Boring 5-S: Starting at ground surface, the boring data depicts medium to stiff red brown clay with broken chert gravel to an elevation of 322.6, with Q_u values from 0.5 to 1.4 tsf, SPT (N) values ranging from 2 to 11 blows per foot, and moisture contents ranging between 15% and 47%. Limestone was encountered at elevation 322.6 and the rock cores displayed RQD values between 0% and 66% with sample recovery varying from 0% to 100%.

Further descriptions of the soil conditions encountered in the borings are presented in the *Soil Borings* attached in Exhibit D and the *Subsurface Data Profile* in Exhibit C.

Geotechnical Evaluations

Settlement

Per the preliminary TSL, it is estimated the profile will be raised between 0.5 to 1.4 feet at the abutments. The proposed abutments will be located behind the existing abutments on existing embankments, resulting in calculated settlement of less than 0.4 inches. Since the settlement is negligible, downdrag forces are not significant and no pre-coring will be required.

Slope Stability

Preliminary stability analyses using Bishop's method were performed for both abutments on SN 091-0075 and SN 091-0076. According to AASHTO LRFD 11.6.2.3, the required resistance factor for slope stability is 0.65 which is equivalent to factor of safety of 1.54. For SN 091-0075, the south abutment is 18'-3" high 2H:1V (at right angles) end slope model with rendered factor of safety 2.11. The north abutment used 17'-8" high 2H:1V (at right angles) end slope model which rendered factor of safety of 3.28. The Seismic slope stability was also analyzed and yielded factors of safety of 1.10 and 1.53 at south and north abutments respectively. For SN 091-0076, the south abutment is 18'-9" high 2H:1V (at right angles) end slope model with rendered factor of safety 2.58. The north abutment used 17'-11" high 2H:1V (at right angles) end slope model which rendered factor of safety of 3.48. The Seismic slope stability was also analyzed and yielded factors of safety of 1.16 and 1.63 at south and north abutments respectively. As per AASHTO LRFD 11.6.5.3, minimum required factor of safety under the effect of seismic loads is 1. The horizontal coefficient was calculated according to FHWA-NHI-11-032. The horizontal coefficient for all of the abutments is 0.32g. Slope stability analyses are presented in Exhibit H. No stability problems are expected.

Seismic Considerations

Based on the method described in the IDOT Design Guide LRFD Soil Site Class Definition, Soil Site Class E controls. The Design Spectral Acceleration at 1.0 sec (S_{D1}) is 0.898g and at 0.2 sec (S_{Ds}) is 1.214g. These values are based on a 1000 year design

return period earthquake. According to AASHTO LRFD 3.10.6 the Seismic Performance Zone is 4 based on the 1.0 second Design Spectral Acceleration.

Liquefaction analysis was performed using the IDOT Liquefaction Analysis spreadsheet for each boring at the proposed bridge location. Borings 1-S and 4-S near the south abutments of both structures were found to contain potentially liquefiable Chert Gravel layers. In boring 1-S, the layers of concern are between elevations 376.4 and 386.4. In boring 4-S, the layers of concern are between elevations 371.0 and 389.0. Similar potentially liquefiable Chert Gravel layers are absent from the other three borings, making it difficult to determine more precisely the extents over which this soil type occurs. It is assumed that the effects of liquefaction would be limited to both of the south abutments. See Exhibit F.

Approach Slab

Due to the profile raise, the approach slabs will rest on fill material where bearing capacities above the required 2 ksf should be expected.

Mining Activity

A review of the Illinois State Geological Survey (ISGS) "Directory of Coal Mines in Illinois" for Union County indicates that no mining activity has been present at the project location. The nearest underground coal mine is located 6.8 miles southwest of the bridge location.

Foundation Recommendations

Following is the summary of preliminary factored vertical loads for the AASHTO LRFD Strength I load combination provided by ESCA Consultants, Inc., for both bridges. The Extreme Event I load combination was estimated to be 75% of Strength I.

Strength I Load Combination

North Abutment	800 kips
Pier 1	1500 kips
Pier 2	1500 kips
South Abutment	800 kips

Abutments

Due to IDOT's strong desire for a jointless structure, integral abutments will be provided for both of these bridges. Per IDOT ABD Memoranda 12.3, there are no restrictions on the pile types that are permissible for an effective expansion length of 74.20' determined for northbound SN 091-0075, or for an effective expansion length of 76.62' determined for southbound SN 091-0076. Unless the abutment type is changed, spread footings and drilled shafts are not allowed for integral abutments as per the IDOT Bridge Manual.

Driven pile foundation design includes seismic design, which accounts for the effects of liquefiable soil layers at the south abutments for each bridge. Analyses have been performed using the Modified IDOT Static Method for estimating nominal pile resistance. Pile size calculations are presented in Exhibit G and summarized in Tables 1 thru 6. Tables include strength limit state and extreme event including liquefaction. The

estimated lengths include a 2 foot embedment into the abutment cap and are based on top of pile elevations of 417.51 at the south abutment and 416.88 at the north abutment for SN 091-0075, and 417.86 at the south abutment and 417.05 at the north abutment for SN 091-0076. R_n values in tables represent the maximum nominal required bearing. Results from the seismic case show the piles need to be driven to rock to achieve required capacity. For this reason, the following tables only include pile data for H-piles driven to rock, and assume an additional 2 ft penetration into the limestone for determining pile length and tip elevations. Per IDOT Bridge Manual 3.10.1.6, the suggested upper limit for pile length is 50 ft for HP 8's, 75 ft for HP 10's and 100 ft for HP 12's. Due to the highly variable location of bedrock found in borings 3-S and 4-S, and the failure of the other borings to reach bedrock, it is anticipated that the piles could extend beyond 100 ft in length prior to reaching refusal. Since required lengths exceed the recommended limits, H-piles smaller than HP 12 have not been included in the following tables. Metal shell piles are not feasible, as they do not provide sufficient resistance during a seismic event.

Location	Pile Size	R_n Nominal Required Bearing (kips)	R_F Factored Resistance Available (kips)	Estimated Pile Length (ft)	Pile Tip Elev.	Estimated Embedment into rock (ft)
South Abutment SN 091-0075 Strength Limit State	HP 12x53	419	230	99	318	2
	HP 12x63	497	273	99	318	2
	HP 14x73	578	318	99	318	2
	HP 14x89	705	388	99	318	2

Table 1

Location	Pile Size	R_n Nominal Required Bearing (kips)	R_F Factored Resistance Available (kips)	Estimated Pile Length (ft)	Pile Tip Elev.	Estimated Embedment into rock (ft)
South Abutment SN 091-0075 Extreme Event (Liquefaction)	HP 12x53	419	213	99	318	2
	HP 12x63	497	289	99	318	2
	HP 14x73	578	334	99	318	2
	HP 14x89	705	458	99	318	2

Table 2

Location	Pile Size	R_n Nominal Required Bearing (kips)	R_F Factored Resistance Available (kips)	Estimated Pile Length (ft)	Pile Tip Elev.	Estimated Embedment into rock (ft)
North Abutment SN 091-0075 Strength Limit State	HP 12x53	419	230	99	318	2
	HP 12x63	497	273	99	318	2
	HP 14x73	578	318	99	318	2
	HP 14x89	705	388	99	318	2

Table 3

Location	Pile Size	R_n Nominal Required Bearing (kips)	R_F Factored Resistance Available (kips)	Estimated Pile Length (ft)	Pile Tip Elev.	Estimated Embedment into rock (ft)
South Abutment SN 091-0076 Strength Limit State	HP 12x53	419	230	100	318	2
	HP 12x63	497	273	100	318	2
	HP 14x73	578	318	100	318	2
	HP 14x89	705	388	100	318	2

Table 4

Location	Pile Size	R_n Nominal Required Bearing (kips)	R_F Factored Resistance Available (kips)	Estimated Pile Length (ft)	Pile Tip Elev.	Estimated Embedment into rock (ft)
South Abutment SN 091-0076 Extreme Event (Liquefaction)	HP 12x53	419	213	100	318	2
	HP 12x63	497	289	100	318	2
	HP 14x73	578	334	100	318	2
	HP 14x89	705	458	100	318	2

Table 5

Location	Pile Size	R_n Nominal Required Bearing (kips)	R_F Factored Resistance Available (kips)	Estimated Pile Length (ft)	Pile Tip Elev.	Estimated Embedment into rock (ft)
North Abutment SN 091-0076 Strength Limit State	HP 12x53	419	230	51	366	2
	HP 12x63	497	273	51	366	2
	HP 14x73	578	318	51	366	2
	HP 14x89	705	388	51	366	2

Table 6

Piers

There are several options for the type of foundation at the piers: Spread footing bearing on soil, pile-supported footings, encased pile bent, or drilled shaft foundation.

Spread Footing on Soil: Due to the weak soil layers less than 2.0 tsf for all piers, an uncertain and relatively deep bedrock elevation, and the potentially liquefiable soil layers, it is not recommended to use spread footings.

Pile Supported: Per the preliminary TSL, pile bent piers with a single row of piles are anticipated for each pier. Pile size calculations are presented in Exhibit G and summarized in Table 7. The estimated lengths include 2 ft encasement into the pier cap, are based on top of pile elevations of 418.48, and assume an additional 2 ft penetration into the limestone. Analyses have been performed using the Modified IDOT Static Method for estimating nominal pile resistance. Tables include strength limit state. R_n values in tables represent the maximum nominal required bearing.

Location	Pile Size	R_n Nominal Required Bearing (kips)	R_F Factored Resistance Available (kips)	Estimated Pile Length (ft)	Pile Tip Elev.	Estimated Embedment into rock (ft)
Piers SN 091-0075, -0076 Strength Limit State	HP 12x53	419	230	100	318	2
	HP 12x63	497	273	100	318	2
	HP 14x73	578	318	100	318	2
	HP 14x89	705	388	100	318	2

Table 7

Drilled Shafts: With the rock layers being very deep and highly variable, drilled shafts would be uneconomical at this location. If it is determined in the final design that the proposed piles do not develop sufficient resistance, drilled shafts set into rock are feasible, but will require rock cores for more accurate calculations.

Lateral Loading Analysis

Tables 8 thru 12 provide soil parameters for the LPile program (or other approved programs) for the structural engineer to perform the lateral analysis of the foundations.

Preliminary analysis has determined that adequate lateral resistance can be provided for the piles before they reach the rock strata. Per Bridge Manual 3.10.1.10, if the lateral load on a pile exceeds 3 kips then a detailed soil structure interaction analysis shall be performed.

Soil Type	Elev. At Bottom of Layer	Effective Unit Wt. (pci)	Friction Angle (deg)	k (pci)	c (psi)	E50
Stiff to Very Stiff Silty Clay	406.4	0.038	-	500	13	0.007
Soft to Very Soft Silty Clay	398.9	0.027	-	30	3	0.020
Stiff Silty Clay	393.9	0.036	-	500	9	0.007
Medium Dense Chert Gravel	388.9	0.040	35	60	-	-
Very Stiff Clay	386.4	0.040	-	1000	16	0.005
Medium Dense Chert Gravel	376.4	0.038	34	60	-	-
Stiff Clay	366.4	0.036	-	500	9	0.007
Medium to Stiff Clay	342.4	0.033	-	100	6	0.010
Limestone	332.4	0.048	44	-	-	-

Table 8 – Northbound, South Abutment

Soil Type	Elev. At Bottom of Layer	Effective Unit Wt. (pci)	Friction Angle (deg)	k (pci)	c (psi)	E50
Stiff to Very Stiff Clay	398.6	0.038	-	500	12	0.007
Medium Clay Loam	395.6	0.033	-	100	6	0.010
Stiff Clay	361.1	0.036	-	500	9	0.007
Medium Clay	356.1	0.033	-	100	6	0.010
Soft to Very Soft Clay	344.6	0.027	-	30	2	0.020
Limestone	334.6	0.048	44	-	-	-

Table 9 – Northbound, North Abutment

Soil Type	Elev. At Bottom of Layer	Effective Unit Wt. (pci)	Friction Angle (deg)	k (pci)	c (psi)	E50
Medium Clay	416.5	0.032	-	100	5	0.010
Very Stiff Silty Clay	414.0	0.041	-	1000	17	0.005
Soft Clay	411.5	0.027	-	30	2	0.020
Stiff Silty Clay	401.5	0.036	-	500	9	0.007
Medium Silty Clay	399.0	0.032	-	100	5	0.010
Stiff Silty Clay	394.0	0.038	-	500	12	0.007
Medium Dense Chert Gravel	391.5	0.035	32	90	-	-
Medium Clay	389.0	0.033	-	100	5	0.010
Medium Dense Chert Gravel	386.5	0.036	32	60	-	-
Medium to Stiff Clay	381.5	0.035	-	100	7	0.010
Medium Dense Chert Gravel	371.0	0.038	33	60	-	-
Medium Clay	346.0	0.032	-	100	5	0.010
Soft to Very Soft Clay	319.5	0.027	-	30	2	0.020
Limestone	309.5	0.048	44	-	-	-

Table 10 – Southbound, South Abutment

Soil Type	Elev. At Bottom of Layer	Effective Unit Wt. (pci)	Friction Angle (deg)	k (pci)	c (psi)	E50
Stiff Silty Clay	416.1	0.035	-	500	8	0.007
Very Stiff Clay	403.6	0.041	-	1000	18	0.005
Stiff to Very Stiff Clay	388.1	0.038	-	500	12	0.007
Very Soft Loam	387.1	0.020	-	30	1	0.020
Medium to Stiff Clay	367.6	0.035	-	100	8	0.010
Limestone	357.6	0.048	44	-	-	-

Table 11 – Southbound, North Abutment

Soil Type	Elev. At Bottom of Layer	Effective Unit Wt. (pci)	Friction Angle (deg)	k (pci)	c (psi)	E50
Stiff Clay	389.6	0.035	-	500	8	0.007
Medium Clay	377.1	0.032	-	100	5	0.010
Stiff Clay	374.6	0.036	-	500	10	0.007
Medium to Stiff Clay	354.1	0.034	-	100	7	0.010
Medium Clay	322.6	0.031	-	100	4	0.010
Limestone	312.6	0.048	44	-	-	-

Table 12 – Piers

Construction Considerations

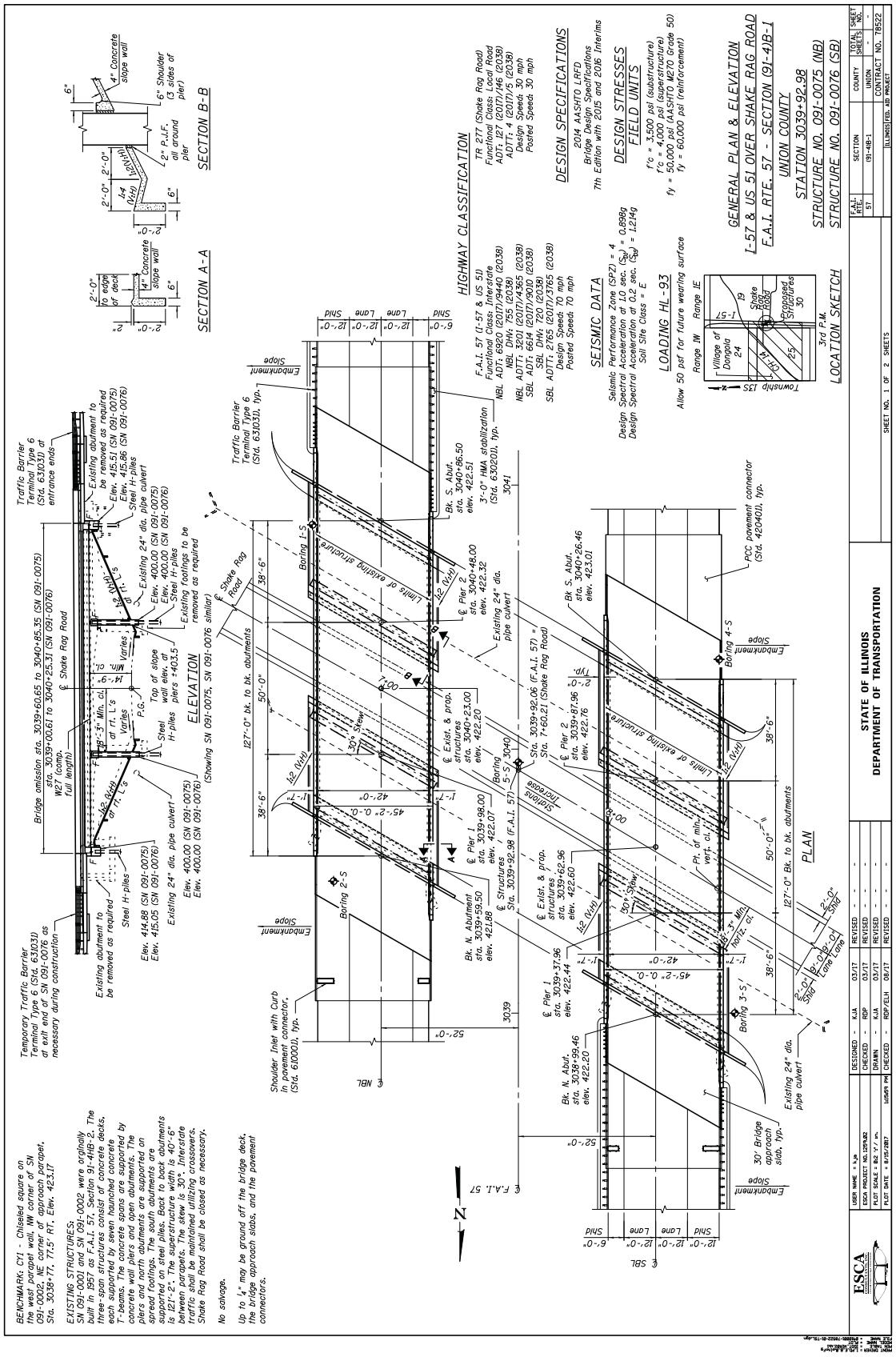
Stage Construction: Traffic is expected to be maintained on I-57 & US 51 utilizing cross overs for the construction of both structures, while Shake Rag Road will be closed as necessary. No temporary soil support system will be required as each of the proposed bridges will be constructed in a single stage and there is adequate space between the structures to excavate without cutting into the other structure. It has been determined that the soil will generally be adequate for a 1V:1H excavation slope. However, if the intermittent very soft soil layers shown in the borings are encountered in the field, a 1V:1.5H excavation slope may be more appropriate.

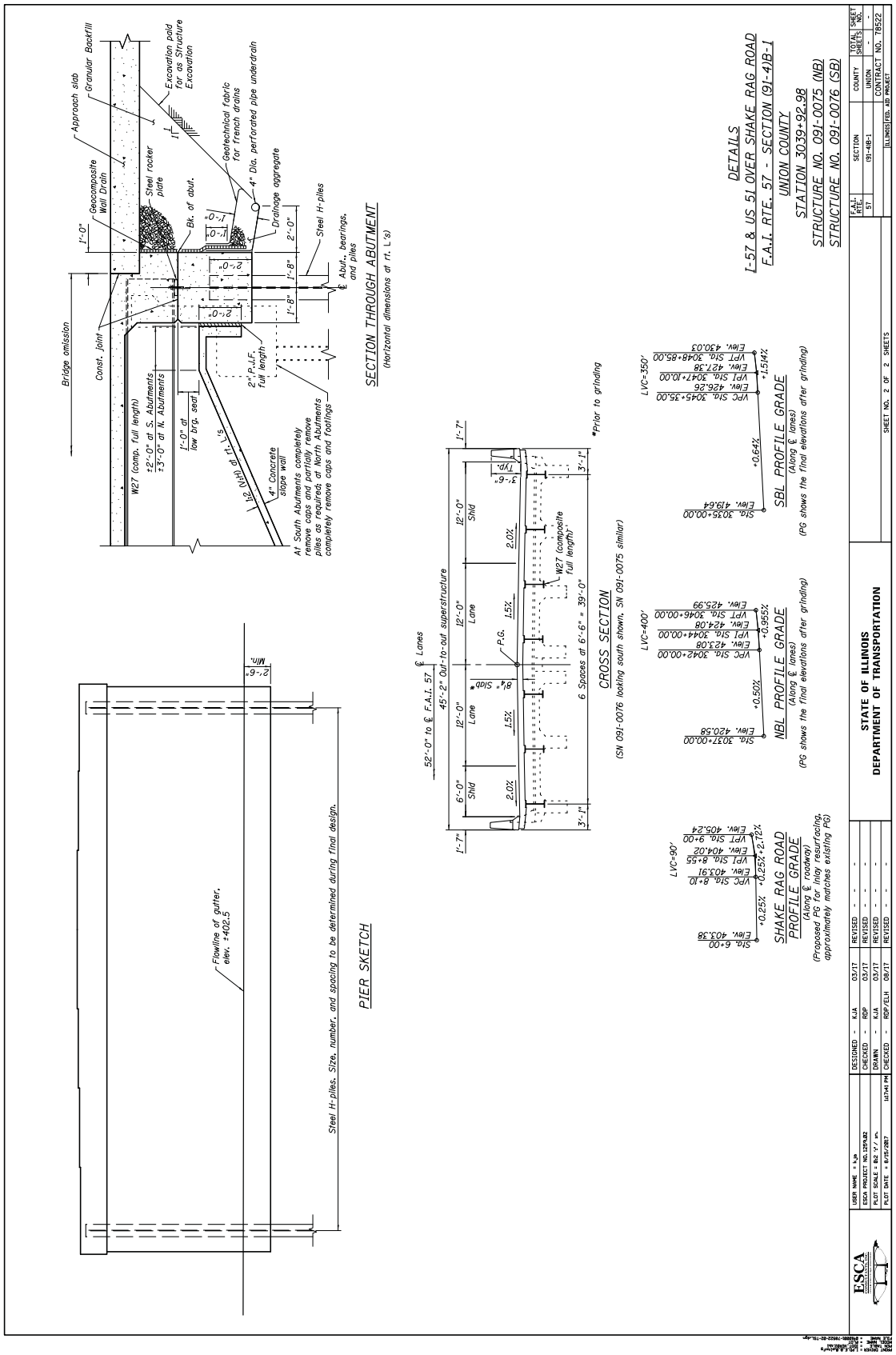
Foundation Construction: One test pile at each driven pile foundation should be provided due to the uncertain depth to bedrock. Pile shoes are recommended due to the presence of boulders.

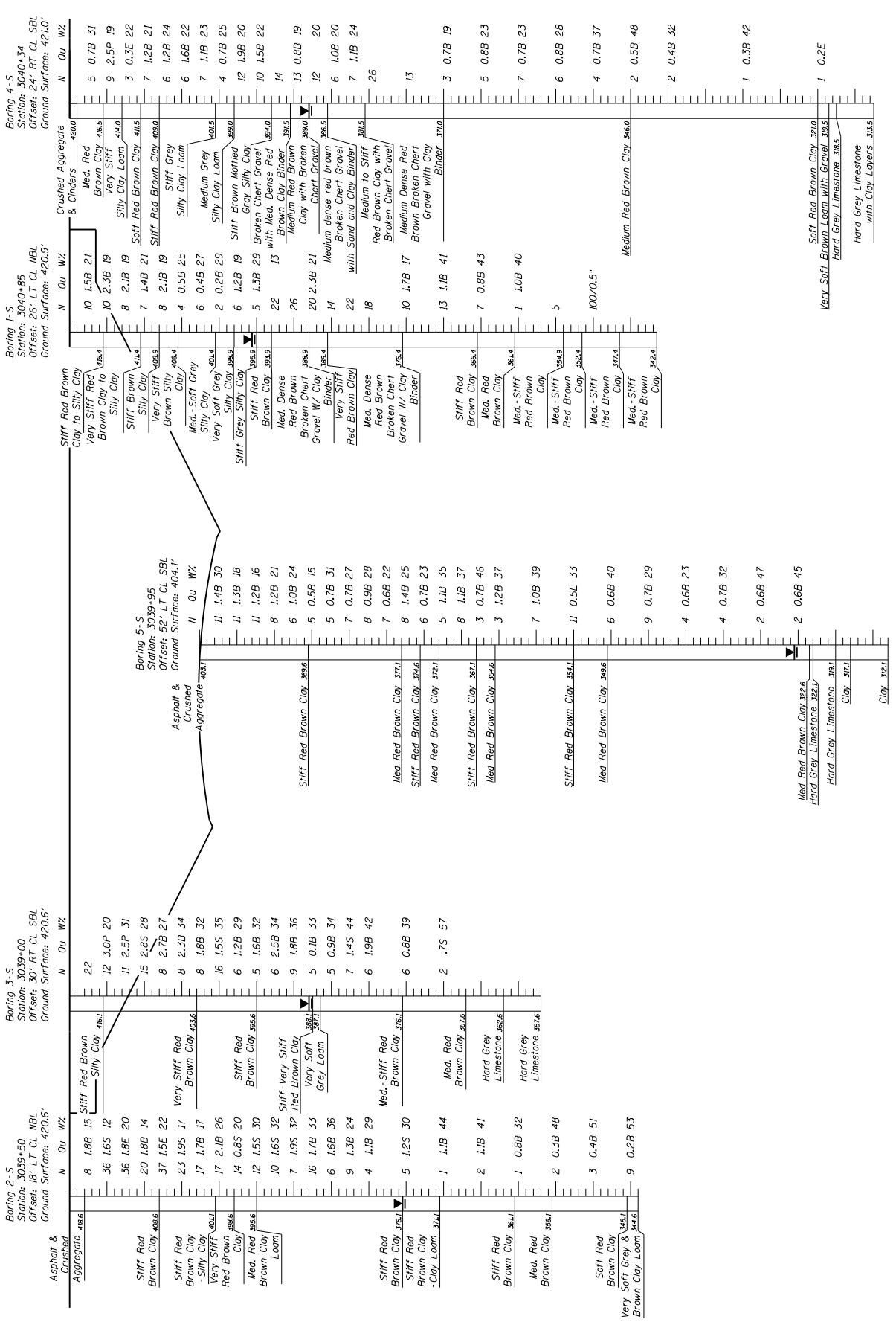
Limitations

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


Pomona
Makanda
Creal Spring
Pulleys Mill
Alto Pass
Goreville
Cobden
Lick Creek
Elvira
Buncombe
Anna
Ware
Bloomfield
Structure Location
Balcom
Vienna
Cypress
Mill Creek
Belknap
McClure
Elco
Karnak
Cypress Creek National Wildlife Refuge
Ullin
Mermet
New Grand Chain
Ohio River
Pulaski
Joppa
Olmsted
Olive Branch
Bandana
Miller City
Mounds
Mound City
Barlow
Price Landing
Future City
Cairo
N
S.N. 091-0075 &
S.N. 091-0076
I-57 & US 51 Over
Shake Rag Road
Union County


GENERAL PLAN & ELEVATION
I-57 & US 51 OVER SHAKE RAG ROAD
F.A.I. RTE. 57 - SECTION (91-4)B-1
UNION COUNTY
STATION 3039+92.98
STRUCTURE NO. 091-0075 (NB)
STRUCTURE NO. 091-0076 (SB)
LOCATION SKETCH
PLAN
ELEVATION
SECTION A-A
SECTION B-B
HIGHWAY CLASSIFICATION
DESIGN SPECIFICATIONS
2014 AASHTO LRFD Bridge Design Specifications
7th Edition with 2015 and 2016 Interims
DESIGN STRESSES
FIELD UNITS
SEISMIC DATA
LOADING HL-93
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION
SHEET NO. 1 OF 2 SHEETS
CONTRACT NO. 78522


SECTION THROUGH ABUTMENT
(Horizontal dimensions at rt. L's)
Approach slab
Granular Backfill
Geocomposite Wall Drain
Steel rocker plate
Excavation paid for as Structure Excavation
Geotechnical fabric for french drains
4" Dia. perforated pipe underdrain
Drainage aggregate
Steel H-piles
Abut. bearings and piles
Bridge omission
Const. Joint
W27 (comp. full length)
±2'-0" at S. Abutments
±3'-0" at N. Abutments
1'-0" at low brg. seat
2" P.J.F. full length
4" Concrete Slope wall
At South Abutments completely remove caps and partially remove piles as required, at North Abutments completely remove caps and footings
PIER SKETCH
Flowline of gutter, elev. ±402.5
Steel H-piles. Size, number, and spacing to be determined during final design.
CROSS SECTION
(SN 091-0076 looking south shown, SN 091-0075 similar)
6 Spaces at 6'-6" = 39'-0"
W27 (composite full length)
*Prior to grinding
SHAKE RAG ROAD
PROFILE GRADE
(Proposed PG for inlay resurfacing, approximately matches existing PG)
NBL PROFILE GRADE
(PG shows the final elevations after grinding)
SBL PROFILE GRADE
(PG shows the final elevations after grinding)
DETAILS
I-57 & US 51 OVER SHAKE RAG ROAD
F.A.I. RTE. 57 - SECTION (91-4)B-1
UNION COUNTY
STATION 3039+92.98
STRUCTURE NO. 091-0075 (NB)
STRUCTURE NO. 091-0076 (SB)
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION
SHEET NO. 2 OF 2 SHEETS


SUBSURFACE DATA PROFILE
I-57 & US 51 OVER SHAKE RAG ROAD
F.A.I. RTE. 57 - SEC. (9I-4)B-1
STATION 3039+92.98
SN 091-0075 & SN 091-0076
Boring 1-S
Station: 3040+85
Offset: 26' LT CL NBL
Ground Surface: 420.9'
Boring 2-S
Station: 3039+50
Offset: 18' LT CL NBL
Ground Surface: 420.6'
Boring 3-S
Station: 3039+00
Offset: 30' RT CL SBL
Ground Surface: 420.6'
Boring 4-S
Station: 3040+34
Offset: 24' RT CL SBL
Ground Surface: 421.0'
Boring 5-S
Station: 3039+95
Offset: 52' LT CL SBL
Ground Surface: 404.1'
N Qu W%

Illinois Department of Transportation

Memorandum

To:	Carrie Nelsen	Attn: Dave Piche
From:	Greg Smothers	By: Rob Graeff
Subject:	*Boring Logs & Liquefaction Analysis	
Date:	April 29, 2009	

FAI 57/US 51 over TR 277 (Shake Rag Road)
Structures 091-0001/0002(E)
Union County

Foundation boring logs have been obtained for the above listed structure and are attached.

Liquefaction Analysis
Liquefaction calculations indicate no liquefiable soils at this structure location.

Slope Stability
At the time of this report, a preliminary TSL is not available. Therefore, we are unable to provide any slope stability calculations for the proposed endslope configuration. This office should be contacted to complete the slope stability calculations when a proposed endslope configuration is determined.

Structure Geotechnical Report
Due to a current shortage of staffing, the District Nine Geotechnical Unit is unable to complete the required Structure Geotechnical Report. Any additional foundation recommendations should be evaluated by a competent consultant.

Miscellaneous
Our borings indicate a fairly large elevation difference to locate competent bedrock at this location. We encountered difficult drilling conditions due to the presence of boulders and clay seams throughout. Below average recovery and RQD percentages were common in most borings.

Attachments
RG:rg
cc: Soils File

ILLINOIS DEPARTMENT OF TRANSPORTATION
District Nine Materials

Bridge Foundation Boring Log
Sheet 1 of 2

FAI 57/ US 51 Over TR 277 (Shake Rag Road)
Route: FAI 57/ US 51 Structure Number: 091-0001/0002 Date: 11/5/2008
Section 91-4HB-2 Bored By: Rich Moberly
County: Union Location: 1.2 miles North of Pulaski County Checked By: Rob Graeff

Boring No 1-S
Station 3040+85
Offset 26' Lt CL NBL
Ground Surface 420.9 Ft

Surf Wat Elev:
Ground Water Elevation
when Drilling 24.5
At Completion
At: Hrs:

DEPTH	BLOWS	Qu tsf	W%	Description
				Stiff, moist, red brown, Clay to Silty Clay A7-6 with Chert gravel
	2			
	4	1.5B	21	
	6			
416.4				
5.0	2			Very stiff, moist, red brown, Clay to Silty Clay A7-6 with Chert gravel
	5	2.3B	19	
	5			
	2			
	4	2.1B	19	
	4			
411.4				
10.0	1			Stiff, moist to very moist, brown, Silty Clay A7-6
	4	1.4B	21	
	3			
408.9				
	2			Very stiff, moist, brown, Silty Clay A-6
	4	2.1B	19	
	4			
406.4				
15.0	2			Medium to soft, very moist, grey, Silty Clay A-6
	2	0.5B	25	
	2			
	1			
	2	0.4B	27	
	4			
401.4				
20.0	1			Very soft, very moist, grey, Silty Clay A-6
	1	0.2B	29	
	1			
398.9				
	1			Stiff, moist, grey, Silty Clay A-6
	2	1.2B	19	
	4			
395.9				
25.0	1			

DEPTH	BLOWS	Qu tsf	W%	Description
	3	1.3B	29	Stiff, moist, red brown, Clay A7-6
	2			
393.9				
	4			Medium dense, very moist, red brown, broken Chert Gravel with Clay binder
	10		13	
	12			
30.0	2			
	8			
	18			
388.9				
	3			Very stiff, moist, red brown, Clay A7-6 with broken Chert gravel
	9	2.3B	21	
	11			
386.4				
35.0	1			Medium dense, very moist, red brown, broken Chert Gravel with Clay binder
	5			
	9			
	5			
	11			
	11			
40.0	2			
	8			
	10			
376.4				
45.0	3			Stiff, moist, red brown, Clay A7-6 with broken Chert gravel
	6	1.7B	17	
	4			
50.0	4			

N-Std Pentr Test: 2" OD Sampler,140# Hammer, 30" Fall (Type Fail. B-Bulge S-Shear E-Estimated P-Penetrometer)

Sheet 2 of 2

te: FAI 57/ US 51 Date: 11/5/2008

Section: 91-4NB-2

County: Union

Boring No: 1-S
Station: 3040+85
Offset: 26' Lt CL NBL
Ground Surface: 420.9 Ft

	DEPTH	BLOWS	Qu tsf	W%
		7	1.1B	41
		6		
366.4				
Medium, very moist, red brown, Clay A7-6	55.0	1		
		4	0.8B	43
		3		
361.4				
Medium to stiff, moist to very moist, red brown, Clay A7-6	60.0	WH		
		WH	1.0B	40
		1		
	65.0	WH		
		4	Recovery	
354.9		1		
Medium to stiff, moist to very moist, red brown, Clay A7-6 with Limestone boulders				
352.4		100/0.5" per Refusal		
Cored 68.5 to 73.5 feet 33% Recovery; 24% RQD	70.0			
Medium to stiff, moist to very moist, red brown, Clay A7-6 with Limestone boulders (10" & 8" thick boulders)				
347.4				
Cored 73.5 to 78.5 feet 5% Recovery; 0% RQD				
	75.0			

	DEPTH	BLOWS	Qu tsf	W%
Cored 73.5 to 78.5 feet 5% Recovery; 0% RQD				
Medium to stiff, moist to very moist, red brown, Clay A7-6				
342.4				
Bottom of hole = 78.5 feet				
	80.0			
Free water observed at 24.5 ft				
Elevation referenced to BM at NW corner of 091-0002; Elevation = 423.0				
To convert "N" values to "N60" multiply by 1.25				
	85.0			
	90.0			
	95.0			
	100.0			

N-Std Pentr Test: 2" OD Sampler,140# Hammer, 30" Fall (Type Fail. B-Bulge S-Shear E-Estimated P-Penetrometer)

ILLINOIS DEPARTMENT OF TRANSPORTATION
District Nine Materials

Bridge Foundation Boring Log
Sheet 1 of 2

FAI 57/ US 51 Over TR 277 (Shake Rag Road)
te: FAI 57/ US 51 Structure Number: 091-0001/0002 Date: 4/23/2009
Section 91-4HB-2 Bored By: Rich Moberly
County: Union Location: 1.2 miles North of Pulaski County Checked By: Rob Graeff

Boring No 2-S
Station 3039+50
Offset 18' Lt CL NBL
Ground Surface 420.6 Ft

Surf Wat Elev:
Ground Water Elevation
when Drilling 376.1
At Completion
At: Hrs:

DEPTH	BLOWS	Qu tsf	W%
Asphalt and Crushed aggregate			
418.6			
Stiff, moist, red brown, Clay A7-6 with broken Chert Gravel	2		
	3 5	1.8B	15
5.0	3		
	11 25	1.6S	12
	6		
	18 18	1.8E	20
10.0	4		
	9 11	1.8B	14
408.6			
Stiff, moist, red brown, Clay to Silty Clay A7-6 with broken Chert Gravel	4		
	18 19	1.5E	22
15.0	3		
	8 15	1.9S	17
	2		
	7 10	1.7B	17
401.1			
Very stiff, moist, red brown, Clay A7-6 with some gravel 20.0	1		
	7 10	2.1B	26
398.6			
Medium, very moist, red brown, Clay Loam A-6 with broken Chert Gravel	2		
	5 9	0.8S	20
395.6	25.0 2		

DEPTH	BLOWS	Qu tsf	W%
Stiff, moist, red brown, Clay A7-6 with some gravel	6 6	1.5S	30
	1		
	5 5	1.6S	32
30.0	1		
	3 4	1.9S	32
	1		
	5 11	1.7B	33
35.0	1		
	3 3	1.6B	36
	1		
	4 5	1.3B	24
40.0	1		
	2 2	1.1B	29
376.1			
Stiff, moist to very moist, red brown, Clay to Clay Loam A7-6 with broken chert gravel and some sand 45.0	1		
	3 2	1.2S	30
371.1			
50.0	WH		

N-Std Pentr Test: 2" OD Sampler,140# Hammer, 30" Fall (Type Fail, B-Bulge S-Shear E-Estimated P-Penetrometer)

Sheet 2 of 2

te: FAI 57/ US 51
Section: 91-4HB-2
County: Union
Date: 4/23/2009

Boring No: 2-S
Station: 3039+50
Offset: 18' Lt CL NBL
Ground Surface: 420.6 Ft

	DEPTH	BLOWS	Qu tsf	W%
Stiff, moist to very moist, red brown, Clay A7-6		WH	1.1B	44
		WH		
	55.0	1		
		1	1.1B	41
		1		
	361.1			
Medium, very moist, red brown, Clay A7-6	60.0	WH		
		WH	0.8B	32
		WH		
	356.1			
Soft, very moist, red brown, Clay A7-6 with some gravel	65.0	WH		
		1	0.3B	48
		1		
	70.0	WH		
		1	0.4B	51
		2		
	346.1			
	75.0	1		

	DEPTH	BLOWS	Qu tsf	W%
V. soft, v moist, grey and brown, Clay Loam A-6 with gravel 344.6		7	0.2B	53
		2		
Bottom of hole = 76.0 feet				
Free water observed at 44.5 feet				
Elevation refernced to BM @ 091-0002; Elev.= 423.0 feet				
	80.0			
To convert "N" values to "N60" multiply by 1.25				
Note: Augers kicked out of plumb sufficiently that the bit would not go through the augers. Hole abandoned after several attempts to overcome were unsuccessful.				
	85.0			
	90.0			
	95.0			
	100.0			

N-Std Pentr Test: 2" OD Sampler,140# Hammer, 30" Fall (Type Fail, B-Bulge S-Shear E-Estimated P-Penetrometer)

ILLINOIS DEPARTMENT OF TRANSPORTATION
District Nine Materials

Bridge Foundation Boring Log
Sheet 1 of 2

FAI 57/ US 51 Over TR 277 (Shake Rag Road)

Route: FAI 57/ US 51 Structure Number: 091-0001/0002 Date: 11/7/2008

Section 91-4HB-2 Bored By: Rich Moberly

County: Union Location: 1.2 miles North of Pulaski County Checked By: Rob Graeff

Boring No 3-S
Station 3039+00
Offset 30' Rt CL SBL
Ground Surface 420.6 Ft

Surf Wat Elev:
Ground Water Elevation
when Drilling 388.6
At Completion
At: Hrs:

DEPTH	BLOWS	Qu tsf	W%	DEPTH	BLOWS	Qu tsf	W%
Stiff, moist, red brown, Silty Clay A7-6 with broken concrete blocks				Stiff to very stiff, moist, red brown Clay A7-6 with broken Chert gravel	2	1.6B	32
	2				3		
	12				1		
	10				3	2.5B	34
416.1					3		
Very stiff, moist, red brown, Clay A7-6 with broken Chert gravel 5.0	2			30.0	2		
	6	3.0P	20		4	1.8B	36
	6				5		
	1			388.1	1		
	6	2.5P	31	Very soft, wet, grey, Loam A-4	2	0.1B	33
	5			387.1	3		
10.0	1			Medium to stiff, moist, red brown, Clay A7-6 35.0	1		
	8	2.8S	28		2	0.9B	34
	7				3		
	1				1		
	4	2.7B	27		2	1.4S	44
	4				5		
15.0	1			40.0	1		
	3	2.3B	34		3	1.9B	42
	5				3		
403.6							
Stiff, moist, red brown, Clay A7-6 with broken Chert gravel	1						
	4	1.8B	32				
	4						
				376.1			
20.0	1			Medium, very moist, red brown, Clay A7-6 45.0	1		
	6	1.5S	35		3	0.8B	39
	10				3		
	1						
	3	1.2B	29				
	3						
395.6 25.0	1			50.0	1		

N-Std Pentr Test: 2" OD Sampler,140# Hammer, 30" Fall (Type Fail, B-Bulge S-Shear E-Estimated P-Penetrometer)

Sheet 2 of 2

Route: FAI 57/ US 51
Section: 91-4HB-2
County: Union
Date: 11/7/2008

Boring No: 3-S
Station: 3039+00
Offset: 30' Rt CL SBL
Ground Surface: 420.6 Ft

DEPTH	BLOWS	Qu tsf	W%
Medium, very moist, red brown, Clay A7-6	1 1	0.7S	57
367.6	Auger Refusal		
Cored 53.0 to 58.0 feet 93% Recovery; 72% RQD			
55.0			
Hard, dry, grey, Limestone			
362.6			
Cored 58.0 to 63.0 feet 100% Recovery; 70% RQD			
60.0			
Hard, dry, grey, Limestone			
357.6			
Bottom of hole = 63.0 feet			
Free water observed at 32.0 feet			
65.0			
Elevation referenced to BM at NW corner of SN 091-0002; Elevation = 423.0 feet			
To convert "N" values to "N60" multiply by 1.25			
70.0			
75.0			
80.0			
85.0			
90.0			
95.0			
100.0			

N-Std Pentr Test: 2" OD Sampler,140# Hammer, 30" Fall (Type Fail, B-Bulge S-Shear E-Estimated P-Penetrometer)

ILLINOIS DEPARTMENT OF TRANSPORTATION
District Nine Materials

Bridge Foundation Boring Log
Sheet 1 of 3

FAI 57/ US 51 Over TR 277 (Shake Rag Road)

Route: FAI 57/ US 51 Structure Number: 091-0001/0002 Date: 11/18/2008

Section 91-4HB-2 Bored By: Rich Moberly

County: Union Location: 1.2 miles North of Pulaski County Checked By: Rob Graeff

Boring No 4-S
Station 3040+34
Offset 24' Rt CL SBL
Ground Surface 421.0 Ft

Surf Wat Elev:
Ground Water Elevation
when Drilling 389
At Completion
At: Hrs:

DEPTH	BLOWS	Qu tsf	W%	Material
				Crushed aggregate and Cinders
420.0				
				Medium, very moist, red brown, Clay A7-6
	1			
	2	0.7B	31	
	3			
416.5				
5.0	1			Very stiff, moist, grey, Silty Clay Loam A-6
	4	2.5P	19	
	5			
414.0				
	1			Soft, very moist, red brown, Clay A7-6
	1	0.3E	22	
	2			
411.5				
10.0	2			
	3	1.2B	21	Stiff, moist, red brown, Clay A7-6
	4			
409.0				
	1			Stiff, moist, grey, Silty Clay Loam A-6
	3	1.2B	24	
	3			
15.0	1			
	2	1.6B	22	
	4			
	1			
	3	1.1B	23	
	4			
401.6				
20.0	1			Medium, very moist, grey, Silty Clay Loam A-6
	2	0.7B	25	
	2			
399.0				
	2			Stiff, moist, brown mottled grey, Silty Clay A7-6
	5	1.9B	20	
	7			
25.0	2			

DEPTH	BLOWS	Qu tsf	W%	Material
	5	1.5B	22	Stiff, moist, brown mottled grey, Silty Clay A7-6
	5			
394.0				
	3			Medium dense, very moist, red brown, Broken Chert Gravel with Clay binder
	8			
	6			
391.5				
30.0	3			Medium, very moist, red brown, Clay A7-6 with broken Chert gravel
	6	0.8B	19	
	7			
389.0				
	1			Medium dense, wet, red brown, Broken Chert Gravel with sand and clay binder
	4		20	
	8			
386.5				
35.0	1			Medium to stiff, very moist, red brown, Clay A7-6 with broken Chert gravel
	2	1.0B	20	
	4			
	1			
	2	1.1B	24	
	5			
381.5				
40.0	1			Medium dense, very moist, red brown, Broken Chert Gravel with Clay binder
	14			
	12			
45.0	1			
	7			
	6			
371.0	50.0	1		

N-Std Pentr Test: 2" OD Sampler,140# Hammer, 30" Fall (Type Fail, B-Bulge S-Shear E-Estimated P-Penetrometer)

Sheet 2 of 3

te: FAI 57/ US 51 Date: 11/18/2008

Section: 91-4HB-2

County: Union

Boring No: 4-S
Station: 3040+34
Offset: 24' Rt CL SBL
Ground Surface: 421.0 Ft

DEPTH	BLOWS	Qu tsf	W%		DEPTH	BLOWS	Qu tsf	W%
	Medium, very moist, red brown, Clay A7-6 with some gravel					Soft, very moist, red brown, Clay A7-6 with some gravel		
	1 2	0.7B	19			1 1	0.5B	48
55.0	1				80.0	WH		
	2 3	0.8B	23			1 1	0.4B	32
60.0	1				85.0			
	3 4	0.7B	23					
65.0	1				90.0	WH		
	3 3	0.8B	28			WH 1	0.3B	42
70.0	1				95.0			
	2 2	0.7B	37					
346.0	75.0 WH				321.0	100.0 WH		

N-Std Pentr Test: 2" OD Sampler,140# Hammer, 30" Fall (Type Fail, B-Bulge S-Shear E-Estimated P-Penetrometer)

Sheet 3 of 3

te: FAI 57/ US 51 Date: 11/18/2008

Section: 91-4HB-2

County: Union

Boring No: 4-S
Station: 3040+34
Offset: 24' Rt CL SBL
Ground Surface: 421.0 Ft

DEPTH	BLOWS	Qu tsf	W%
Very soft, wet, brown, Loam A-4 with gravel	WH 1	0.2E	
319.5			
Hard, dry, grey, Limestone	Auger Refusal		
318.5			
Cored 102.5 to 107.5 feet 72% Recovery; 53% RQD			
Hard, dry, grey, Limestone with Clay layers			
105.0			
313.5			
Bottom of hole = 107.5 feet			
Free water observed at 32.0 feet			
110.0			
Elevation referenced to BM @ NW corner SN 091-0002; Elevation = 423.0 feet			
To convert "N" values to "N60" multiply by 1.25			
++++++++++++++++++++++++			
Note: Attempted to core 107.5 to 112.5 feet but lost 25' of rods and the core barrel, reamer and bit when a weld on an old rod broke.			
115.0			
++++++++++++++++++++++++			
120.0			
125.0			

DEPTH	BLOWS	Qu tsf	W%
130.0			
135.0			
140.0			
145.0			
150.0			

N-Std Pentr Test: 2" OD Sampler,140# Hammer, 30" Fall (Type Fail. B-Bulge S-Shear E-Estimated P-Penetrometer)

ILLINOIS DEPARTMENT OF TRANSPORTATION
District Nine Materials

Bridge Foundation Boring Log
Sheet 1 of 2

FAI 57/ US 51 Over TR 277 (Shake Rag Road)

Route: FAI 57/ US 51 Structure Number: 091-0001/0002 Date: 11/17/2008

Section 91-4HB-2 Bored By: Rich Moberly

County: Union Location: 1.2 miles North of Pulaski County Checked By: Rob Graeff

Boring No 5-S
Station 3039+95
Offset 52' Lt CL SBL
Ground Surface 404.1 Ft

Surf Wat Elev:
Ground Water Elevation
when Drilling 324.6
At Completion
At: Hrs:

DEPTH	BLOWS	Qu tsf	W%	DEPTH	BLOWS	Qu tsf	W%
Multi A-1 and Crushed Aggregate 403.1				Medium, very moist, red brown, Clay A7-6 with broken Chert gravel 377.1	3 4	0.6B	22
Stiff, moist to very moist, red brown, Clay A7-6 with broken Chert gravel	2 5 6	1.4B	30	Stiff, moist to very moist, red brown, Clay A7-6 with broken Chert gravel 374.6	1 4 4	1.4B	25
5.0	1 6 5	1.3B	18	Medium, very moist, red brown, Clay A7-6 with broken Chert gravel 372.1	1 2 4	0.7B	23
	1 5 6	1.2B	16	Stiff, moist to very moist, red brown, Clay A7-6	1 2 3	1.1B	35
10.0	1 4 4	1.2B	21	35.0	1 3 5	1.1B	37
	1 3 3	1.0B	24	367.1 Medium, very moist, red brown, Clay A7-6	1 1 2	0.7B	46
389.6				364.6			
Medium, very moist, red brown, Clay A7-6 with broken Chert gravel 15.0	1 2 3	0.5B	15	Stiff, moist to very moist, red brown, Clay A7-6 40.0	1 1 2	1.2B	37
	1 2 3	0.7B	31				
20.0	1 3 4	0.7B	27	45.0	1 3 4	1.0B	39
	1 3 5	0.9B	28				
25.0	1			354.1 50.0	1		

N-Std Pentr Test: 2" OD Sampler,140# Hammer, 30" Fall (Type Fail. B-Bulge S-Shear E-Estimated P-Penetrometer)

Sheet 2 of 2

Route: FAI 57/ US 51
Section: 91-4HB-2
County: Union
Date: 11/17/2008

Boring No: 5-S
Station: 3039+95
Offset: 52' Lt CL SBL
Ground Surface: 404.1 Ft

DEPTH	BLOWS	Qu tsf	W%		DEPTH	BLOWS	Qu tsf	W%
	8	0.5E	33	Medium, very moist, red brown, Clay A7-6		1	0.6B	47
	3					1		
Medium, very moist to wet, red brown, Clay and broken Chert and Limestone gravel								
349.6								
55.0	1				80.0	WH		
Medium, very moist, red brown, Clay A7-6	3	0.6B	40			1	0.6B	45
	3					1		
					322.6			
				Hard, dry, grey, Limestone 322.1			Auger Refusal	
				Cored 82.0 to 85.0 feet 100% Recovery; 66% RQD				
				Hard, dry, grey Limestone Boulder				
60.0	1				319.1 85.0			
	3	0.7B	29	Cored 85.0 to 87.0 feet 0% Recovery; 0% RQD Clay?				
	6				317.1			
				Cored 87.0 to 92.0 feet 0% Recovery; 0% RQD Clay?				
65.0	1				90.0			
	2	0.6B	23					
	2				312.1			
				Bottom of hole = 92.0 feet				
				Free water observed at 79.5 feet				
				Elevation referenced to BM @				
70.0	1			NW corner SN 091-0002;	95.0			
	2	0.7B	32	Elevation = 423.0 feet				
	2							
				To convert "N" values to "N60" multiply by 1.25				
75.0	WH				100.0			

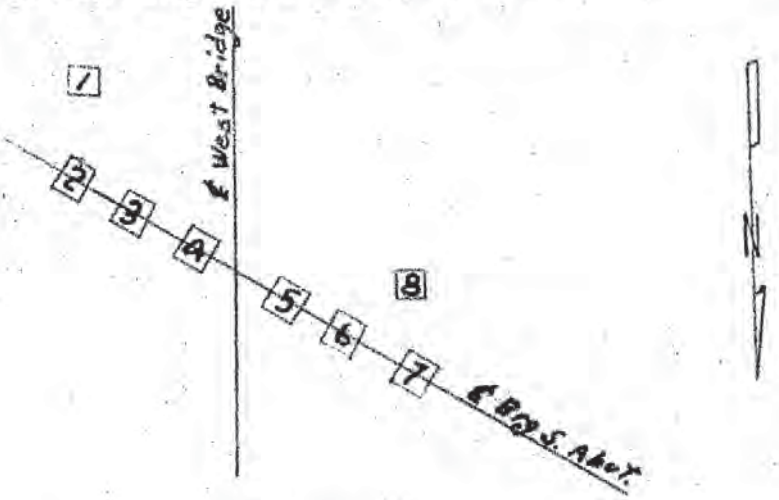
N-Std Pentr Test: 2" OD Sampler,140# Hammer, 30" Fall (Type Fail. B-Bulge S-Shear E-Estimated P-Penetrometer)

Pile Data

Dongola
F.A.I. Rte 8
Proj I-09-1(26)

Sta 3039+92.98 West
Sec. 91-7HB-2, HB-3
Union County

30 Ton bearing Specified on plans for 51' 8B P36 steel pile.
All dimensions and spacing as shown on plans.



Pile No	Plan Lgth.	Order Lgth.	Accepted + Form Actual length	Driven Lgth	Bearing Tons
1	51	70	70	56.1	70
2	51	70	70	66.0	80
3	51	70	70	60.0	60
4	51	70	70	58.3	75
5	51	70	70	68.5	66
6	51	70	70	67.6	70
7	Test	(Test pile 61' specified)	71*	71 (68.3 in place)	Refusal
8	51	70	70	69.1	60
Total		490	497.3	452.2	

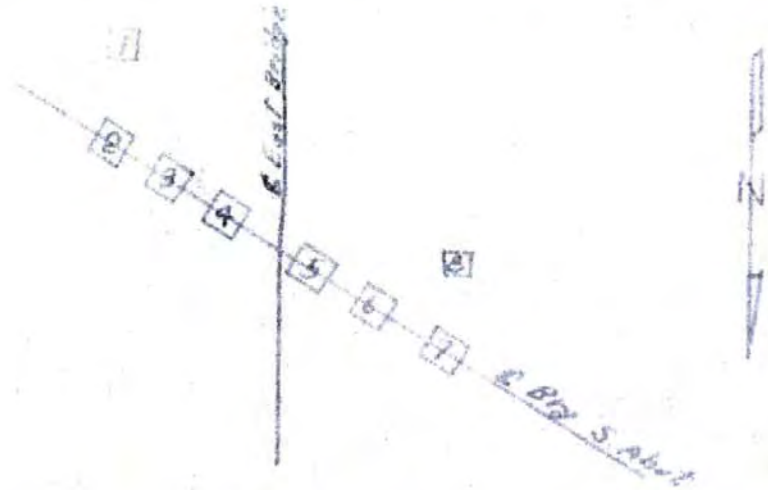
* This amout of splice on test pile needed to obtain required bearing. Contractor welded required splice without charge.

Pile Data

[illegible]

Sta [illegible] East
Sec [illegible]
Union County

3? ton bearing specified on plans for 51' 8 BP 36 steel pile.
All dimensions and spacing as shown on plans.



Pile No	Plan Length	Order Length	Accepted + Furn. Actual Lengths	Driven Length	Bearing Tons
1	51	98	59.9	59.9	56
2	51	98	36.9	36.8	60
3	51	98	65.6	65.6	35
4	51	98	69.5	69.5	29
5	51	98	83.3	83.3	22
6	51	98	60.6	60.6	80
7	test	(test 61' specified)		(46.3 Driven)	Refusal
8	51	98	60.0	60.0	19
Total		386	925.1	926.7	

LIQUEFACTION ANALYSIS

I.D.O.T. Bureau of Bridges and Structures FOUNDATIONS AND GEOTECHNICAL UNIT — Modified 5/24/10

REFERENCE BORING NUMBER ==========: 1-S, NB, S Abut
ELEVATION OF BORING GROUND SURFACE ==========: 420.90 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ==========: 24.50 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ==========: 26.13 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ====: 0.815
EARTHQUAKE MOMENT MAGNITUDE ==========: 7.7
FINISHED GRADE FILL OR CUT FROM BORING SURFACE ==========: 1.63 FT. (Fill Height)
HAMMER EFFICIENCY==========: 73 %
BOREHOLE DIAMETER==========: 8 IN.
SAMPLING METHOD==========: Sampler w/out Liners

EQ MAGNITUDE SCALING FACTOR
(MSF) = **0.959**

AVG. SHEAR WAVE VELOCITY (top 40')
$V^{*}_{s,40'}$ = **495** FT./SEC.

PGA CALCULATOR
Earthquake Moment Magnitude = 7.66
Source-To-Site Distance, R (km) = 20.32
Ground Motion Prediction Equations = NMSZ
PGA = **0.905**

IF(P22="","",IF(B22>=(K$7+K$12-K$9),"N.L. (1)",IF(OR(G22>=12,AND(H22>0,I22

	BORING DATA							CONDITIONS DURING DRILLING					CONDITIONS DURING EARTHQUAKE							
ELEV. OF SAMPLE (FT.)	BORING SAMPLE DEPTH (FT.)	SPT N VALUE (BLOWS)	UNCONF. COMPR. STR., Q_u (TSF.)	% FINES < #200 (%)	PLAST. INDEX PI	LIQUID LIMIT LL	MOIST. CONTENT w_c (%)	EFFECTIVE UNIT WT. (KCF.)	EFFECTIVE VERT. STRESS (KSF.)	CORR. SPT N VALUE $(N_1)_{60}$	EQUIV. CLN. SAND SPT N VALUE $(N_1)_{60cs}$	CRR RESIST. MAG 7.5 $CRR_{7.5}$	EFFECTIVE UNIT WT. (KCF.)	EFFECTIVE VERT. STRESS (KSF.)	TOTAL VERT. STRESS (KSF.)	OVER-BURDEN CORR. FACT. (Ks)	CORR. RESIST. $CRR_{7.5}$ CRR	SOIL MASS PART. FACTOR (r_d)	EQ INDUCED CSR	FACTOR OF SAFETY * CRR/CSR
416.4	4.5	10	1.5				21	0.126	0.567	18.091	18.091	0.193	0.126	0.763	0.763	1.334	**0.247**	0.954	**0.505**	**N.L. (1)**
414.4	6.5	10	2.3				19	0.132	0.831	16.506	16.506	0.176	0.132	1.027	1.027	1.218	**0.205**	0.934	**0.495**	**N.L. (1)**
411.4	9.5	8	2.1				19	0.130	1.221	12.268	12.268	0.134	0.130	1.417	1.417	1.104	**0.142**	0.899	**0.476**	**N.L. (1)**
408.9	12	7	1.4				21	0.125	1.534	10.499	10.499	0.118	0.125	1.729	1.729	1.049	**0.118**	0.866	**0.459**	**N.L. (1)**
406.4	14.5	8	2.1				19	0.130	1.859	11.574	11.574	0.127	0.130	2.054	2.054	1.008	**0.123**	0.829	**0.439**	**N.L. (1)**
404.4	16.5	4	0.5				25	0.114	2.087	5.634	5.634	0.077	0.114	2.282	2.282	0.985	**0.073**	0.797	**0.422**	**N.L. (1)**
401.4	19.5	6	0.4				27	0.111	2.420	8.083	8.083	0.097	0.111	2.615	2.615	0.955	**0.089**	0.747	**0.396**	**N.L. (1)**
398.9	22	2	0.2				29	0.104	2.680	2.597	2.597	0.056	0.104	2.875	2.875	0.941	**0.051**	0.706	**0.374**	**N.L. (1)**
396.9	24	6	1.2				19	0.124	2.928	7.500	7.500	0.092	0.124	3.123	3.123	0.920	**0.081**	0.673	**0.357**	**N.L. (1)**
393.9	27	5	1.3	80	12	41	29	0.062	3.114	6.099	12.319	0.134	0.062	3.309	3.465	0.896	**0.115**	0.627	**0.348**	**N.L. (2)**
391.9	29	22					13	0.068	3.250	28.168	28.168	0.376	0.068	3.445	3.726	0.846	**0.305**	0.599	**0.343**	**N.L. (3)**
388.9	32	26					13	0.069	3.457	32.998	32.998	1.237	0.069	3.652	4.120	0.815	**0.968**	0.562	**0.336**	**N.L. (3)**
386.4	34.5	20	2.3	80	12	41	21	0.069	3.629	23.714	33.456	2.083	0.069	3.825	4.449	0.800	**1.599**	0.535	**0.330**	**N.L. (2)**
384.4	36.5	14					13	0.064	3.757	15.633	15.633	0.166	0.064	3.953	4.701	0.847	**0.135**	0.517	**0.325**	**0.415** (D)
381.9	39	22					13	0.068	3.927	25.190	25.190	0.296	0.068	4.123	5.027	0.805	**0.228**	0.497	**0.321**	**N.L. (3)**
376.4	44.5	18					13	0.066	4.290	19.033	19.033	0.204	0.066	4.486	5.734	0.806	**0.157**	0.466	**0.315**	**0.498** (D)
373.15	47.75	10	1.7	80	12	41	17	0.065	4.501	10.081	17.097	0.182	0.065	4.697	6.148	0.803	**0.140**	0.453	**0.314**	**N.L. (2)**
366.4	54.5	13	1.1	80	12	41	41	0.060	4.906	12.457	19.948	0.215	0.060	5.102	6.974	0.773	**0.159**	0.437	**0.316**	**N.L. (2)**
361.4	59.5	7	0.8	80	12	41	43	0.057	5.191	6.474	12.769	0.138	0.057	5.387	7.571	0.793	**0.105**	0.430	**0.320**	**N.L. (2)**
360.9	60	1	1	80	12	41	40	0.059	5.221	0.921	6.106	0.081	0.059	5.416	7.632	0.823	**0.064**	0.429	**0.320**	**N.L. (2)**

* FACTOR OF SAFETY DESCRIPTIONS
N.L. (1) = NOT LIQUEFIABLE, ABOVE EQ GROUND WATER ELEVATIC
N.L. (2) = NOT LIQUEFIABLE, PI $\geq$ 12 OR $w_c/LL \leq 0.85$
N.L. (3) = NOT LIQUEFIABLE, $(N_1)_{60} > 25$
(C) = CONTRACTIVE SOIL TYPES
(D) = DILATIVE SOIL TYPES

6/1/2017 — 04 1-S Liquefaction.xls

L I Q U E F A C T I O N A N A L Y S I S

I.D.O.T. Bureau of Bridges and Structures FOUNDATIONS AND GEOTECHNICAL UNIT — Modified 5/24/10

REFERENCE BORING NUMBER ========== 2-S, NB, N Abut
ELEVATION OF BORING GROUND SURFACE ========== 418.60 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ========== 42.50 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ========== 45.76 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ===== 0.815
EARTHQUAKE MOMENT MAGNITUDE ========== 7.7
FINISHED GRADE FILL OR CUT FROM BORING SURFACE ========== 3.26 FT. (Fill Height)
HAMMER EFFICIENCY========== 73 %
BOREHOLE DIAMETER========== 8 IN.
SAMPLING METHOD========== Sampler w/out Liners

EQ MAGNITUDE SCALING FACTOR
(MSF) = **0.959**

AVG. SHEAR WAVE VELOCITY (top 40')
$\bar{V}_{s,40'}$ = **657** FT./SEC.

PGA CALCULATOR
Earthquake Moment Magnitude = 7.66
Source-To-Site Distance, R (km) = 20.32
Ground Motion Prediction Equations = NMSZ
PGA = **0.905**

IF(P22="","",IF(B22>=(K$7+K$12-K$9),"N.L. (1)",IF(OR(G22>=12,AND(H22>0,I22>(

	BORING DATA							CONDITIONS DURING DRILLING					CONDITIONS DURING EARTHQUAKE							
ELEV. OF SAMPLE (FT.)	BORING SAMPLE DEPTH (FT.)	SPT N VALUE (BLOWS)	UNCONF. COMPR. STR., Q_u (TSF.)	% FINES < #200 (%)	PLAST. INDEX PI	LIQUID LIMIT LL	MOIST. CONTENT w_c (%)	EFFECTIVE UNIT WT. (KCF.)	EFFECTIVE VERT. STRESS (KSF.)	CORR. SPT N VALUE $(N_1)_{60}$	EQUIV. CLN. SAND SPT N VALUE $(N_1)_{60cs}$	CRR RESIST. MAG 7.5 $CRR_{7.5}$	EFFECTIVE UNIT WT. (KCF.)	EFFECTIVE VERT. STRESS (KSF.)	TOTAL VERT. STRESS (KSF.)	OVER-BURDEN CORR. FACT. (K_S)	CORR. RESIST. $CRR_{7.5}$ CRR	SOIL MASS PART. FACTOR (r_d)	EQ INDUCED CSR	FACTOR OF SAFETY * CRR/CSR
416.6	2	8	1.8				15	0.128	0.256	15.847	15.847	0.169	0.128	0.647	0.647	1.374	**0.222**	0.991	**0.525**	**N.L. (1)**
414.1	4.5	36	1.6				12	0.127	0.574	73.473	73.473	0.514	0.127	0.965	0.965	1.370	**0.676**	0.985	**0.522**	**N.L. (1)**
411.6	7	36	1.8				20	0.128	0.894	66.633	66.633	0.458	0.128	1.285	1.285	1.222	**0.537**	0.978	**0.518**	**N.L. (1)**
408.6	10	20	1.8				14	0.128	1.278	34.628	34.628	-1.341	0.128	1.669	1.669	1.097	**-1.411**	0.967	**0.512**	**N.L. (1)**
406.6	12	37	1.5				22	0.126	1.530	65.651	65.651	0.450	0.126	1.921	1.921	1.040	**0.449**	0.957	**0.507**	**N.L. (1)**
404.1	14.5	23	1.9				17	0.129	1.852	37.686	37.686	0.003	0.129	2.243	2.243	0.978	**0.003**	0.944	**0.500**	**N.L. (1)**
401.1	17.5	17	1.7				17	0.128	2.236	24.819	24.819	0.288	0.128	2.627	2.627	0.933	**0.258**	0.923	**0.489**	**N.L. (1)**
398.6	20	17	2.1				26	0.130	2.561	23.464	23.464	0.264	0.130	2.952	2.952	0.901	**0.228**	0.903	**0.478**	**N.L. (1)**
395.6	23	14	0.8				20	0.119	2.918	17.772	17.772	0.189	0.119	3.309	3.309	0.883	**0.160**	0.876	**0.464**	**N.L. (1)**
394.1	24.5	12	1.5				30	0.126	3.107	14.548	14.548	0.156	0.126	3.498	3.498	0.878	**0.131**	0.860	**0.456**	**N.L. (1)**
391.6	27	10	1.6				32	0.127	3.425	11.562	11.562	0.127	0.127	3.816	3.816	0.868	**0.106**	0.833	**0.441**	**N.L. (1)**
389.1	29.5	7	1.9				32	0.129	3.747	7.721	7.721	0.094	0.129	4.138	4.138	0.865	**0.078**	0.804	**0.426**	**N.L. (1)**
386.6	32	16	1.7				33	0.128	4.067	17.063	17.063	0.182	0.128	4.458	4.458	0.815	**0.142**	0.775	**0.410**	**N.L. (1)**
384.1	34.5	6	1.6				36	0.127	4.385	6.057	6.057	0.080	0.127	4.776	4.776	0.845	**0.065**	0.746	**0.395**	**N.L. (1)**
381.6	37	9	1.3				24	0.125	4.697	8.722	8.722	0.102	0.125	5.088	5.088	0.822	**0.080**	0.719	**0.381**	**N.L. (1)**
376.1	42.5	4	1.1				29	0.123	5.374	3.569	3.569	0.062	0.123	5.765	5.765	0.819	**0.049**	0.666	**0.353**	**N.L. (1)**
372.85	45.75	5	1.2	80	12	41	30	0.061	5.572	4.367	10.240	0.115	0.061	5.963	6.166	0.786	**0.087**	0.641	**0.351**	**N.L. (2)**
367.85	50.75	1	1.1	80	12	41	44	0.060	5.872	0.846	6.015	0.080	0.060	6.263	6.778	0.799	**0.061**	0.613	**0.351**	**N.L. (2)**
361.1	57.5	2	1.1	80	12	41	41	0.060	6.277	1.621	6.945	0.087	0.060	6.668	7.604	0.784	**0.066**	0.588	**0.355**	**N.L. (2)**
358.6	60	1	0.8	80	12	41	32	0.057	6.419	0.798	5.958	0.079	0.057	6.810	7.902	0.786	**0.060**	0.582	**0.358**	**N.L. (2)**

* FACTOR OF SAFETY DESCRIPTIONS
N.L. (1) = NOT LIQUEFIABLE, ABOVE EQ GROUND WATER ELEVATION
N.L. (2) = NOT LIQUEFIABLE, PI $\geq$ 12 OR w_c/LL $\leq$ 0.85
N.L. (3) = NOT LIQUEFIABLE, $(N_1)_{60} > 25$
(C) = CONTRACTIVE SOIL TYPES
(D) = DILATIVE SOIL TYPES

LIQUEFACTION ANALYSIS

I.D.O.T. Bureau of Bridges and Structures FOUNDATIONS AND GEOTECHNICAL UNIT — Modified 5/24/10

REFERENCE BORING NUMBER ==========: 3-S, SB, N Abut
ELEVATION OF BORING GROUND SURFACE ==========: 420.60 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ==========: 32.00 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ==========: 33.57 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) =====: 0.815
EARTHQUAKE MOMENT MAGNITUDE ==========: 7.7
FINISHED GRADE FILL OR CUT FROM BORING SURFACE ==========: 1.57 FT. (Fill Height)
HAMMER EFFICIENCY==========: 73 %
BOREHOLE DIAMETER==========: 8 IN.
SAMPLING METHOD==========: Sampler w/out Liners

EQ MAGNITUDE SCALING FACTOR
(MSF) = **0.959**

AVG. SHEAR WAVE VELOCITY (top 40')
$\bar{V}_{s,40'}$ = **517** FT./SEC.

PGA CALCULATOR
Earthquake Moment Magnitude = 7.66
Source-To-Site Distance, R (km) = 20.32
Ground Motion Prediction Equations = NMSZ
PGA = **0.905**

IF(P22="","",IF(B22>=(K$7+K$12-K$9),"N.L. (1)",IF(OR(G22>=12,AND(H22>0,I22>(

	BORING DATA							CONDITIONS DURING DRILLING					CONDITIONS DURING EARTHQUAKE							
ELEV. OF SAMPLE (FT.)	BORING SAMPLE DEPTH (FT.)	SPT N VALUE (BLOWS)	UNCONF. COMPR. STR., Q_u (TSF.)	% FINES < #200 (%)	PLAST. INDEX PI	LIQUID LIMIT LL	MOIST. CONTENT w_c (%)	EFFECTIVE UNIT WT. (KCF.)	EFFECTIVE VERT. STRESS (KSF.)	CORR. SPT N VALUE $(N_1)_{60}$	EQUIV. CLN. SAND SPT N VALUE $(N_1)_{60cs}$	CRR RESIST. MAG 7.5 $CRR_{7.5}$	EFFECTIVE UNIT WT. (KCF.)	EFFECTIVE VERT. STRESS (KSF.)	TOTAL VERT. STRESS (KSF.)	OVER-BURDEN CORR. FACT. (K_S)	CORR. RESIST. $CRR_{7.5}$ CRR	SOIL MASS PART. FACTOR (r_d)	EQ INDUCED CSR	FACTOR OF SAFETY * CRR/CSR
416.1	4.5	22	1.2				29	0.124	0.558	45.125	45.125	0.240	0.124	0.746	0.746	1.500	**0.345**	0.962	**0.510**	**N.L. (1)**
414.1	6.5	12	3				20	0.135	0.828	20.308	20.308	0.219	0.135	1.016	1.016	1.243	**0.261**	0.945	**0.501**	**N.L. (1)**
411.6	9	11	2.5				31	0.133	1.161	17.493	17.493	0.186	0.133	1.349	1.349	1.134	**0.203**	0.921	**0.488**	**N.L. (1)**
409.1	11.5	15	2.8				28	0.134	1.496	23.981	23.981	0.273	0.134	1.684	1.684	1.076	**0.282**	0.892	**0.473**	**N.L. (1)**
406.6	14	8	2.7				27	0.134	1.831	11.566	11.566	0.127	0.134	2.019	2.019	1.012	**0.123**	0.860	**0.456**	**N.L. (1)**
403.6	17	8	2.3				34	0.132	2.227	10.991	10.991	0.122	0.132	2.415	2.415	0.970	**0.113**	0.817	**0.433**	**N.L. (1)**
401.6	19	8	1.8				32	0.128	2.483	10.606	10.606	0.118	0.128	2.671	2.671	0.947	**0.108**	0.786	**0.416**	**N.L. (1)**
399.1	21.5	16	1.5				35	0.126	2.798	20.998	20.998	0.228	0.126	2.986	2.986	0.902	**0.198**	0.747	**0.395**	**N.L. (1)**
396.6	24	6	1.2				29	0.124	3.108	7.261	7.261	0.090	0.124	3.296	3.296	0.910	**0.078**	0.707	**0.374**	**N.L. (1)**
394.1	26.5	5	1.6				32	0.127	3.425	5.773	5.773	0.078	0.127	3.613	3.613	0.896	**0.067**	0.669	**0.354**	**N.L. (1)**
391.6	29	6	2.5				34	0.133	3.758	6.600	6.600	0.084	0.133	3.946	3.946	0.878	**0.071**	0.633	**0.335**	**N.L. (1)**
388.1	32.5	9	1.8	80	12	41	36	0.066	3.989	9.608	16.530	0.176	0.066	4.177	4.208	0.831	**0.140**	0.588	**0.314**	**N.L. (2)**
387.1	33.5	5	0.1	80	10	40	33	0.035	4.024	5.317	11.381	0.125	0.035	4.212	4.306	0.848	**0.102**	0.576	**0.312**	**N.L. (2)**
384.1	36.5	5	0.9	80	12	41	34	0.058	4.198	5.201	11.241	0.124	0.058	4.386	4.667	0.840	**0.100**	0.546	**0.307**	**N.L. (2)**
381.6	39	7	1.4	80	12	41	44	0.063	4.355	7.138	13.565	0.146	0.063	4.543	4.980	0.824	**0.115**	0.524	**0.304**	**N.L. (2)**
376.1	44.5	6	1.9	80	12	41	42	0.067	4.724	5.844	12.013	0.131	0.067	4.912	5.692	0.815	**0.103**	0.490	**0.301**	**N.L. (2)**
372.85	47.75	6	0.8	80	12	41	39	0.057	4.909	5.718	11.861	0.130	0.057	5.097	6.080	0.808	**0.101**	0.476	**0.300**	**N.L. (2)**
367.6	53	2	0.7	80	12	41	57	0.055	5.198	1.843	7.211	0.089	0.055	5.386	6.696	0.819	**0.070**	0.460	**0.303**	**N.L. (2)**
360.6	60	100					10	0.083	5.779	######	101.599	0.733	0.083	5.967	7.714	0.661	**0.465**	0.449	**0.307**	**N.L. (3)**

* FACTOR OF SAFETY DESCRIPTIONS
N.L. (1) = NOT LIQUEFIABLE, ABOVE EQ GROUND WATER ELEVATION
N.L. (2) = NOT LIQUEFIABLE, PI $\geq$ 12 OR w_c/LL $\leq$ 0.85
N.L. (3) = NOT LIQUEFIABLE, $(N_1)_{60} > 25$
(C) = CONTRACTIVE SOIL TYPES
(D) = DILATIVE SOIL TYPES

LIQUEFACTION ANALYSIS

I.D.O.T. Bureau of Bridges and Structures FOUNDATIONS AND GEOTECHNICAL UNIT — Modified 5/24/10

REFERENCE BORING NUMBER ========== 4-S, SB, S Abut
ELEVATION OF BORING GROUND SURFACE ========== 420.00 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ========== 31.00 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ========== 34.03 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ===== 0.815
EARTHQUAKE MOMENT MAGNITUDE ========== 7.7
FINISHED GRADE FILL OR CUT FROM BORING SURFACE ========== 3.03 FT. (Fill Height)
HAMMER EFFICIENCY========== 73 %
BOREHOLE DIAMETER========== 8 IN.
SAMPLING METHOD========== Sampler w/out Liners

EQ MAGNITUDE SCALING FACTOR
(MSF) = **0.959**

AVG. SHEAR WAVE VELOCITY (top 40')
$\bar{V}_{s,40'}$ = **468** FT./SEC.

PGA CALCULATOR
Earthquake Moment Magnitude = 7.66
Source-To-Site Distance, R (km) = 20.32
Ground Motion Prediction Equations = NMSZ
PGA = **0.905**

IF(P22="","",IF(B22>=(K$7+K$12-K$9),"N.L. (1)",IF(OR(G22>=12,AND(H22>0,I22>(

	BORING DATA							CONDITIONS DURING DRILLING					CONDITIONS DURING EARTHQUAKE							
ELEV. OF SAMPLE (FT.)	BORING SAMPLE DEPTH (FT.)	SPT N VALUE (BLOWS)	UNCONF. COMPR. STR., Q_u (TSF.)	% FINES < #200 (%)	PLAST. INDEX PI	LIQUID LIMIT LL	MOIST. CONTENT w_c (%)	EFFECTIVE UNIT WT. (KCF.)	EFFECTIVE VERT. STRESS (KSF.)	CORR. SPT N VALUE $(N_1)_{60}$	EQUIV. CLN. SAND SPT N VALUE $(N_1)_{60cs}$	CRR RESIST. MAG 7.5 $CRR_{7.5}$	EFFECTIVE UNIT WT. (KCF.)	EFFECTIVE VERT. STRESS (KSF.)	TOTAL VERT. STRESS (KSF.)	OVER-BURDEN CORR. FACT. (K_S)	CORR. RESIST. $CRR_{7.5}$ CRR	SOIL MASS PART. FACTOR (r_d)	EQ INDUCED CSR	FACTOR OF SAFETY * CRR/CSR
416.5	3.5	5	0.7				31	0.117	0.410	9.114	9.114	0.105	0.117	0.773	0.773	1.256	**0.127**	0.938	**0.497**	**N.L. (1)**
414	6	9	2.5				19	0.133	0.742	15.117	15.117	0.161	0.133	1.106	1.106	1.187	**0.184**	0.907	**0.480**	**N.L. (1)**
411.5	8.5	3	0.3				22	0.108	1.012	4.730	4.730	0.070	0.108	1.376	1.376	1.090	**0.073**	0.871	**0.461**	**N.L. (1)**
409.5	10.5	7	1.2				21	0.124	1.260	10.899	10.899	0.121	0.124	1.624	1.624	1.065	**0.124**	0.840	**0.445**	**N.L. (1)**
407	13	6	1.2				24	0.124	1.570	9.081	9.081	0.105	0.124	1.934	1.934	1.021	**0.103**	0.798	**0.423**	**N.L. (1)**
404.5	15.5	6	1.6				22	0.127	1.888	8.733	8.733	0.102	0.127	2.251	2.251	0.987	**0.097**	0.754	**0.399**	**N.L. (1)**
401.5	18.5	7	1.1				23	0.123	2.257	9.681	9.681	0.110	0.123	2.620	2.620	0.953	**0.101**	0.701	**0.371**	**N.L. (1)**
399	21	4	0.7				25	0.117	2.549	5.300	5.300	0.074	0.117	2.913	2.913	0.938	**0.067**	0.658	**0.349**	**N.L. (1)**
397	23	12	1.9				20	0.129	2.807	15.341	15.341	0.164	0.129	3.171	3.171	0.899	**0.141**	0.626	**0.331**	**N.L. (1)**
394	26	10	1.5				22	0.126	3.185	12.014	12.014	0.131	0.126	3.549	3.549	0.882	**0.111**	0.581	**0.308**	**N.L. (1)**
391.5	28.5	14					20	0.122	3.490	16.186	16.186	0.172	0.122	3.854	3.854	0.851	**0.141**	0.548	**0.290**	**N.L. (1)**
389	31	13	0.8				19	0.119	3.788	14.285	14.285	0.153	0.119	4.151	4.151	0.841	**0.123**	0.520	**0.275**	**N.L. (1)**
386.5	33.5	12					20	0.063	3.945	12.916	12.916	0.140	0.063	4.309	4.465	0.838	**0.112**	0.496	**0.272**	0.412 **(C)**
384.5	35.5	6	1	80	12	41	20	0.059	4.063	6.360	12.632	0.137	0.059	4.427	4.707	0.833	**0.110**	0.480	**0.270**	**N.L. (2)**
381.5	38.5	7	1.1	80	12	41	24	0.060	4.243	7.251	13.701	0.147	0.060	4.607	5.075	0.821	**0.116**	0.460	**0.268**	**N.L. (2)**
378.25	41.75	26					20	0.069	4.467	27.907	27.907	0.366	0.069	4.831	5.502	0.754	**0.265**	0.443	**0.267**	**N.L. (3)**
371	49	13					20	0.063	4.924	12.377	12.377	0.135	0.063	5.288	6.411	0.798	**0.103**	0.420	**0.270**	0.381 **(C)**
368.25	51.75	3	0.7	80	12	41	19	0.055	5.075	2.806	8.367	0.099	0.055	5.439	6.734	0.812	**0.077**	0.414	**0.272**	**N.L. (2)**
363.25	56.75	5	0.8	80	12	41	23	0.057	5.360	4.521	10.425	0.117	0.057	5.724	7.331	0.792	**0.089**	0.408	**0.277**	**N.L. (2)**
360	60	7	0.7	80	12	41	23	0.055	5.539	6.196	12.435	0.135	0.055	5.903	7.712	0.777	**0.101**	0.405	**0.280**	**N.L. (2)**

* FACTOR OF SAFETY DESCRIPTIONS
N.L. (1) = NOT LIQUEFIABLE, ABOVE EQ GROUND WATER ELEVATION
N.L. (2) = NOT LIQUEFIABLE, PI $\geq$ 12 OR w_c/LL $\leq$ 0.85
N.L. (3) = NOT LIQUEFIABLE, $(N_1)_{60} > 25$
(C) = CONTRACTIVE SOIL TYPES
(D) = DILATIVE SOIL TYPES

5/25/2017 — 04 4-S Liquefaction.xls

L I Q U E F A C T I O N A N A L Y S I S

I.D.O.T. Bureau of Bridges and Structures FOUNDATIONS AND GEOTECHNICAL UNIT — Modified 5/24/10

REFERENCE BORING NUMBER ========== 5-S, Piers
ELEVATION OF BORING GROUND SURFACE ========== 403.10 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ========== 78.50 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ========== 79.29 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ===== 0.815
EARTHQUAKE MOMENT MAGNITUDE ========== 7.7
FINISHED GRADE FILL OR CUT FROM BORING SURFACE ========== 0.79 FT. (Fill Height)
HAMMER EFFICIENCY========== 73 %
BOREHOLE DIAMETER========== 8 IN.
SAMPLING METHOD========== Sampler w/out Liners

EQ MAGNITUDE SCALING FACTOR
(MSF) = **0.959**

AVG. SHEAR WAVE VELOCITY (top 40')
$\bar{V}_{s,40'}$ = **451** FT./SEC.

PGA CALCULATOR
Earthquake Moment Magnitude = 7.66
Source-To-Site Distance, R (km) = 20.32
Ground Motion Prediction Equations = NMSZ
PGA = **0.905**

IF(P22="","",IF(B22>=(K$7+K$12-K$9),"N.L. (1)",IF(OR(G22>=12,AND(H22>0,I22>(

	BORING DATA							CONDITIONS DURING DRILLING					CONDITIONS DURING EARTHQUAKE							
ELEV. OF SAMPLE (FT.)	BORING SAMPLE DEPTH (FT.)	SPT N VALUE (BLOWS)	UNCONF. COMPR. STR., Q_u (TSF.)	% FINES < #200 (%)	PLAST. INDEX PI	LIQUID LIMIT LL	MOIST. CONTENT w_c (%)	EFFECTIVE UNIT WT. (KCF.)	EFFECTIVE VERT. STRESS (KSF.)	CORR. SPT N VALUE $(N_1)_{60}$	EQUIV. CLN. SAND SPT N VALUE $(N_1)_{60cs}$	CRR RESIST. MAG 7.5 $CRR_{7.5}$	EFFECTIVE UNIT WT. (KCF.)	EFFECTIVE VERT. STRESS (KSF.)	TOTAL VERT. STRESS (KSF.)	OVER-BURDEN CORR. FACT. (K_S)	CORR. RESIST. $CRR_{7.5}$ CRR	SOIL MASS PART. FACTOR (r_d)	EQ INDUCED CSR	FACTOR OF SAFETY * CRR/CSR
400.1	3	11	1.4				30	0.125	0.375	21.685	21.685	0.238	0.125	0.470	0.470	1.500	**0.342**	0.963	**0.510**	**N.L. (1)**
397.6	5.5	11	1.3				18	0.125	0.688	19.305	19.305	0.207	0.125	0.782	0.782	1.335	**0.265**	0.933	**0.494**	**N.L. (1)**
395.1	8	11	1.2				16	0.124	0.998	17.828	17.828	0.190	0.124	1.092	1.092	1.204	**0.219**	0.898	**0.476**	**N.L. (1)**
392.6	10.5	8	1.2				21	0.124	1.308	12.302	12.302	0.134	0.124	1.402	1.402	1.107	**0.142**	0.859	**0.455**	**N.L. (1)**
389.6	13.5	6	1				24	0.122	1.674	8.930	8.930	0.104	0.122	1.768	1.768	1.042	**0.104**	0.808	**0.428**	**N.L. (1)**
387.6	15.5	5	0.5				15	0.114	1.902	7.255	7.255	0.090	0.114	1.996	1.996	1.013	**0.087**	0.772	**0.409**	**N.L. (1)**
385.1	18	5	0.7				31	0.117	2.194	6.978	6.978	0.087	0.117	2.289	2.289	0.984	**0.083**	0.726	**0.384**	**N.L. (1)**
382.6	20.5	7	0.7				27	0.117	2.487	9.364	9.364	0.108	0.117	2.581	2.581	0.956	**0.099**	0.680	**0.360**	**N.L. (1)**
380.1	23	8	0.9				28	0.120	2.787	10.224	10.224	0.115	0.120	2.881	2.881	0.931	**0.103**	0.637	**0.337**	**N.L. (1)**
377.1	26	7	0.6				22	0.116	3.135	8.484	8.484	0.100	0.116	3.229	3.229	0.911	**0.087**	0.588	**0.312**	**N.L. (1)**
374.6	28.5	8	1.4				25	0.125	3.447	9.247	9.247	0.107	0.125	3.542	3.542	0.890	**0.091**	0.553	**0.293**	**N.L. (1)**
372.1	31	6	0.7				23	0.117	3.740	6.643	6.643	0.085	0.117	3.834	3.834	0.883	**0.072**	0.522	**0.276**	**N.L. (1)**
370.1	33	5	1.1				35	0.123	3.986	5.344	5.344	0.075	0.123	4.080	4.080	0.876	**0.063**	0.500	**0.265**	**N.L. (1)**
367.1	36	8	1.1				37	0.123	4.355	8.127	8.127	0.097	0.123	4.449	4.449	0.850	**0.079**	0.473	**0.250**	**N.L. (1)**
364.6	38.5	3	0.7				46	0.117	4.647	2.933	2.933	0.058	0.117	4.742	4.742	0.851	**0.047**	0.455	**0.241**	**N.L. (1)**
361.35	41.75	3	1.2				37	0.124	5.050	2.788	2.788	0.057	0.124	5.145	5.145	0.838	**0.046**	0.436	**0.231**	**N.L. (1)**
354.1	49	7	1				39	0.122	5.935	5.870	5.870	0.079	0.122	6.029	6.029	0.807	**0.061**	0.410	**0.217**	**N.L. (1)**
349.6	53.5	11	0.5				33	0.114	6.448	8.729	8.729	0.102	0.114	6.542	6.542	0.777	**0.076**	0.400	**0.212**	**N.L. (1)**
346.35	56.75	6	0.6				40	0.116	6.825	4.577	4.577	0.069	0.116	6.919	6.919	0.789	**0.052**	0.396	**0.210**	**N.L. (1)**
343.1	60	9	0.7				29	0.117	7.205	6.605	6.605	0.084	0.117	7.300	7.300	0.771	**0.062**	0.393	**0.208**	**N.L. (1)**

* FACTOR OF SAFETY DESCRIPTIONS
N.L. (1) = NOT LIQUEFIABLE, ABOVE EQ GROUND WATER ELEVATION
N.L. (2) = NOT LIQUEFIABLE, PI $\geq$ 12 OR w_c/LL $\leq$ 0.85
N.L. (3) = NOT LIQUEFIABLE, $(N_1)_{60} > 25$
(C) = CONTRACTIVE SOIL TYPES
(D) = DILATIVE SOIL TYPES

Illinois Department of Transportation

IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

SUBSTRUCTURE========== NB, S Abut
REFERENCE BORING ========== 1-S
LRFD or ASD or SEISMIC ========== LRFD
PILE CUTOFF ELEV. ========== 417.38 ft
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVING = 415.38 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

TOTAL FACTORED SUBSTRUCTURE LOAD ========== 800 kips
TOTAL LENGTH OF SUBSTRUCTURE (along skew)========== 52.16 ft
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE ======= 1
Approx. Factored Loading Applied per pile at 8 ft. Cts ========== 122.70 KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts ========== 46.01 KIPS

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
418 KIPS	**418** KIPS	**230** KIPS	**98** FT.

PILE TYPE AND SIZE ========== Steel HP 12 X 53
Plugged Pile Perimeter========== 3.967 FT. Unplugged Pile Perimeter========== 5.800 FT.
Plugged Pile End Bearing Area========== 0.983 SQFT. Unplugged Pile End Bearing Area========= 0.108 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.)
414.40	0.98	2.30			5.0		33.9	7.2		***10.4***	10	0	0	6	3
411.40	3.00	2.10			14.3	28.9	38.5	20.9	3.2	***30.2***	30	0	0	17	6
408.90	2.50	1.40			9.1	19.3	57.3	13.3	2.1	***44.6***	45	0	0	25	8
406.40	2.50	2.10			11.9	28.9	***47.1***	17.4	3.2	59.6	47	0	0	26	11
404.40	2.00	0.50			3.1	6.9	***48.8***	4.5	0.8	64.0	49	0	0	27	13
401.40	3.00	0.40			3.8	5.5	***49.9***	5.5	0.6	69.2	50	0	0	27	16
398.90	2.50	0.20			1.6	2.8	***65.3***	2.4	0.3	73.1	65	0	0	36	18
396.90	2.00	1.20			6.5	16.5	***73.2***	9.5	1.8	82.7	73	0	0	40	20
393.90	3.00	1.30			10.3	17.9	119.5	15.1	2.0	***101.8***	102	0	0	56	23
391.90	2.00		22	Sandy Gravel	4.1	53.9	133.4	6.0	5.9	***108.8***	109	0	0	60	25
388.90	3.00		26	Sandy Gravel	7.6	63.7	***108.9***	11.1	7.0	116.4	109	0	0	60	28
386.40	2.50	2.30			12.6	31.7	***124.2***	18.5	3.5	135.2	124	0	0	68	31
384.40	2.00		14	Sandy Gravel	2.6	34.3	146.4	3.8	3.8	***141.1***	141	0	0	78	33
381.90	2.50		22	Sandy Gravel	5.1	53.9	***141.7***	7.5	5.9	147.5	142	0	0	78	35
376.40	5.50		18	Sandy Gravel	9.2	44.1	***130.2***	13.4	4.8	158.6	130	0	0	72	41
373.15	3.25	1.70			13.5	23.4	***135.4***	19.7	2.6	177.5	135	0	0	74	44
366.40	6.75	1.10			20.5	15.2	***151.8***	30.0	1.7	207.0	152	0	0	83	51
361.40	5.00	0.80			11.7	11.0	***166.3***	17.1	1.2	224.5	166	0	0	91	56
358.15	3.25	1.00			9.2	13.8	***172.7***	13.4	1.5	237.5	173	0	0	95	59
354.90	3.25	0.80			7.6	11.0	***180.3***	11.1	1.2	248.7	180	0	0	99	62
352.40	2.50	0.80			5.9	11.0	***186.1***	8.6	1.2	257.2	186	0	0	102	65
347.40	5.00	0.80			11.7	11.0	***197.8***	17.1	1.2	274.4	198	0	0	109	70
342.40	5.00	0.80			11.7	11.0	***209.6***	17.1	1.2	291.5	210	0	0	115	75
337.40	5.00	0.80			11.7	11.0	***221.3***	17.1	1.2	308.6	221	0	0	122	80
332.40	5.00	0.80			11.7	11.0	***233.0***	17.1	1.2	325.7	233	0	0	128	85
327.40	5.00	0.80			11.7	11.0	***244.7***	17.1	1.2	342.9	245	0	0	135	90
322.40	5.00	0.80			11.7	11.0	***256.4***	17.1	1.2	360.0	256	0	0	141	95
320.00	2.40	0.80			5.6	11.0	496.0	8.2	1.2	***393.8***	394	0	0	217	97
319.00	1.00			Limestone	98.8	245.0	594.8	144.5	26.8	***538.3***	~~538~~	~~0~~	~~0~~	~~296~~	~~98.4~~
318.00	1.00			Limestone	98.8	245.0	693.6	144.5	26.8	***682.8***	~~683~~	~~0~~	~~0~~	~~376~~	~~99.4~~
317.00	1.00			Limestone	98.8	245.0	***792.5***	144.5	26.8	827.3	~~792~~	~~0~~	~~0~~	~~436~~	~~100.4~~
316.00	1.00			Limestone	98.8	245.0	***891.3***	144.5	26.8	971.8	~~891~~	~~0~~	~~0~~	~~490~~	~~101.4~~
315.00	1.00			Limestone		245.0			26.8						

Illinois Department of Transportation

IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

SUBSTRUCTURE========== NB, N Abut
REFERENCE BORING ========== 2-S
LRFD or ASD or SEISMIC ========== LRFD
PILE CUTOFF ELEV. ========== 416.73 ft
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVING = 414.73 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

TOTAL FACTORED SUBSTRUCTURE LOAD ========== 800 kips
TOTAL LENGTH OF SUBSTRUCTURE (along skew)========== 52.16 ft
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE ======= 1
Approx. Factored Loading Applied per pile at 8 ft. Cts ========== 122.70 KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts ========== 46.01 KIPS

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
418 KIPS	**418** KIPS	**230** KIPS	**98** FT.

PILE TYPE AND SIZE ========== Steel HP 12 X 53
Plugged Pile Perimeter========== 3.967 FT. Unplugged Pile Perimeter========== 5.800 FT.
Plugged Pile End Bearing Area========== 0.983 SQFT. Unplugged Pile End Bearing Area========= 0.108 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.)
414.10	0.63	1.60			2.5		27.3	3.7		***6.4***	6	0	0	4	3
411.60	2.50	1.80			10.8	24.8	38.1	15.8	2.7	***22.2***	22	0	0	12	5
408.60	3.00	1.80			12.9	24.8	46.9	18.9	2.7	***40.6***	41	0	0	22	8
406.60	2.00	1.50			7.6	20.7	60.1	11.2	2.3	***52.4***	52	0	0	29	10
404.10	2.50	1.90			11.2	26.2	68.5	16.3	2.9	***68.4***	68	0	0	38	13
401.10	3.00	1.70			12.5	23.4	***86.4***	18.2	2.6	87.2	86	0	0	48	16
398.60	2.50	2.10			11.9	28.9	***80.4***	17.4	3.2	102.7	80	0	0	44	18
395.60	3.00	0.80			7.0	11.0	***97.1***	10.3	1.2	114.0	97	0	0	53	21
394.10	1.50	1.50			5.7	20.7	***104.2***	8.4	2.3	122.5	104	0	0	57	23
391.60	2.50	1.60			10.0	22.0	***118.3***	14.6	2.4	137.6	118	0	0	65	25
389.10	2.50	1.90			11.2	26.2	***126.7***	16.3	2.9	153.6	127	0	0	70	28
386.60	2.50	1.70			10.4	23.4	***135.7***	15.2	2.6	168.6	136	0	0	75	30
384.10	2.50	1.60			10.0	22.0	***141.6***	14.6	2.4	182.8	142	0	0	78	33
381.60	2.50	1.30			8.6	17.9	***147.4***	12.6	2.0	195.1	147	0	0	81	35
376.10	5.50	1.10			16.7	15.2	***165.5***	24.4	1.7	219.7	166	0	0	91	41
372.85	3.25	1.20			10.6	16.5	***174.7***	15.4	1.8	235.0	175	0	0	96	44
367.85	5.00	1.10			15.2	15.2	***189.9***	22.2	1.7	257.2	190	0	0	104	49
361.10	6.75	1.10			20.5	15.2	***206.3***	30.0	1.7	286.7	206	0	0	113	56
356.10	5.00	0.80			11.7	11.0	***211.1***	17.1	1.2	303.1	211	0	0	116	61
352.85	3.25	0.30			3.1	4.1	***215.6***	4.6	0.5	307.8	216	0	0	119	64
347.85	5.00	0.40			6.3	5.5	***219.2***	9.2	0.6	316.7	219	0	0	121	69
344.60	3.25	0.20			2.1	2.8	***222.9***	3.1	0.3	320.0	223	0	0	123	72
339.60	5.00	0.32			5.0	4.3	***227.9***	7.4	0.5	327.4	228	0	0	125	77
334.60	5.00	0.32			5.0	4.3	***232.9***	7.4	0.5	334.7	233	0	0	128	82
329.60	5.00	0.32			5.0	4.3	***238.0***	7.4	0.5	342.1	238	0	0	131	87
324.60	5.00	0.32			5.0	4.3	***243.0***	7.4	0.5	349.4	243	0	0	134	92
320.00	4.60	0.32			4.6	4.3	488.3	6.8	0.5	***382.5***	383	0	0	210	97
319.00	1.00			Limestone	98.8	245.0	587.1	144.5	26.8	***527.0***	~~527~~	~~0~~	~~0~~	~~290~~	~~97.7~~
318.00	1.00			Limestone	98.8	245.0	685.9	144.5	26.8	***671.5***	~~672~~	~~0~~	~~0~~	~~369~~	~~98.7~~
317.00	1.00			Limestone	98.8	245.0	***784.7***	144.5	26.8	816.0	~~785~~	~~0~~	~~0~~	~~432~~	~~99.7~~
316.00	1.00			Limestone	98.8	245.0	***883.6***	144.5	26.8	960.5	~~884~~	~~0~~	~~0~~	~~486~~	~~100.7~~
315.00	1.00			Limestone		245.0			26.8						

Illinois Department of Transportation

IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

SUBSTRUCTURE========== SB, N Abut
REFERENCE BORING ========== 3-S
LRFD or ASD or SEISMIC ========== LRFD
PILE CUTOFF ELEV. ========== 417.04 ft
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVING = 415.04 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
418 KIPS	**418** KIPS	**230** KIPS	**50** FT.

TOTAL FACTORED SUBSTRUCTURE LOAD ========== 800 kips
TOTAL LENGTH OF SUBSTRUCTURE (along skew)========== 52.16 ft
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE ======= 1
Approx. Factored Loading Applied per pile at 8 ft. Cts ========== 122.70 KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts ========== 46.01 KIPS

PILE TYPE AND SIZE ========== Steel HP 12 X 53
Plugged Pile Perimeter========== 3.967 FT. Unplugged Pile Perimeter========== 5.800 FT.
Plugged Pile End Bearing Area========== 0.983 SQFT. Unplugged Pile End Bearing Area========= 0.108 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.)
414.10	0.94	3.00			5.7		40.2	8.3		***12.1***	12	0	0	7	3
411.60	2.50	2.50			13.4	34.5	57.6	19.5	3.8	***32.1***	32	0	0	18	5
409.10	2.50	2.80			14.4	38.6	70.7	21.1	4.2	***53.1***	53	0	0	29	8
406.60	2.50	2.70			14.1	37.2	79.3	20.6	4.1	***73.1***	73	0	0	40	10
403.60	3.00	2.30			15.2	31.7	***87.6***	22.2	3.5	94.5	88	0	0	48	13
401.60	2.00	1.80			8.6	24.8	***92.0***	12.6	2.7	106.6	92	0	0	51	15
399.10	2.50	1.50			9.5	20.7	***97.5***	13.9	2.3	120.1	97	0	0	54	18
396.60	2.50	1.20			8.1	16.5	***111.1***	11.9	1.8	132.6	111	0	0	61	20
394.10	2.50	1.60			10.0	22.0	***133.5***	14.6	2.4	148.5	133	0	0	73	23
391.60	2.50	2.50			13.4	34.5	***137.2***	19.5	3.8	167.0	137	0	0	75	25
388.10	3.50	1.80			15.1	24.8	***128.8***	22.1	2.7	186.5	129	0	0	71	29
387.10	1.00	0.10			0.3	1.4	***140.2***	0.5	0.2	188.2	140	0	0	77	30
384.10	3.00	0.90			7.8	12.4	***154.8***	11.3	1.4	200.3	155	0	0	85	33
381.60	2.50	1.40			9.1	19.3	***170.8***	13.3	2.1	214.4	171	0	0	94	35
376.10	5.50	1.90			24.6	26.2	***180.3***	35.9	2.9	248.6	180	0	0	99	41
372.85	3.25	0.80			7.6	11.0	***186.5***	11.1	1.2	259.6	186	0	0	103	44
367.60	5.25	0.70			11.0	9.6	432.8	16.0	1.1	***301.4***	301	0	0	166	49
366.60	1.00			Limestone	98.8	245.0	531.6	144.5	26.8	***445.9***	~~446~~	~~0~~	~~0~~	~~245~~	~~50.4~~
365.60	1.00			Limestone	98.8	245.0	630.4	144.5	26.8	***590.4***	~~590~~	~~0~~	~~0~~	~~325~~	~~51.4~~
364.60	1.00			Limestone	98.8	245.0	***729.3***	144.5	26.8	734.9	~~729~~	~~0~~	~~0~~	~~401~~	~~52.4~~
363.60	1.00			Limestone	98.8	245.0	***828.1***	144.5	26.8	879.4	~~828~~	~~0~~	~~0~~	~~455~~	~~53.4~~
362.60	1.00			Limestone		245.0			26.8						

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Illinois Department of Transportation

IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

SUBSTRUCTURE========== SB, S Abut
REFERENCE BORING ========== 4-S
LRFD or ASD or SEISMIC ========== LRFD
PILE CUTOFF ELEV. ========== 418.02 ft
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVING = 416.02 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

TOTAL FACTORED SUBSTRUCTURE LOAD ========== 800 kips
TOTAL LENGTH OF SUBSTRUCTURE (along skew)========== 52.16 ft
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE ======= 1
Approx. Factored Loading Applied per pile at 8 ft. Cts ========== 122.70 KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts ========== 46.01 KIPS

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
418 KIPS	**418** KIPS	**230** KIPS	**100** FT.

PILE TYPE AND SIZE ========== Steel HP 12 X 53
Plugged Pile Perimeter========== 3.967 FT. Unplugged Pile Perimeter========== 5.800 FT.
Plugged Pile End Bearing Area========== 0.983 SQFT. Unplugged Pile End Bearing Area========= 0.108 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.)
414.00	2.02	2.50			10.8		***14.9***	15.8		16.2	15	0	0	8	4
411.50	2.50	0.30			2.4	4.1	29.7	3.5	0.5	***21.1***	21	0	0	12	7
409.50	2.00	1.20			6.5	16.5	36.2	9.5	1.8	***30.6***	31	0	0	17	9
407.00	2.50	1.20			8.1	16.5	49.9	11.9	1.8	***43.1***	43	0	0	24	11
404.50	2.50	1.60			10.0	22.0	***52.9***	14.6	2.4	56.9	53	0	0	29	14
401.50	3.00	1.10			9.1	15.2	***56.6***	13.3	1.7	69.6	57	0	0	31	17
399.00	2.50	0.70			5.2	9.6	***78.3***	7.6	1.1	79.1	78	0	0	43	19
397.00	2.00	1.90			8.9	26.2	***81.7***	13.1	2.9	91.6	82	0	0	45	21
394.00	3.00	1.50			11.4	20.7	***106.8***	16.7	2.3	109.8	107	0	0	59	24
391.50	2.50		14	Sandy Gravel	3.2	34.3	***86.8***	4.7	3.8	112.0	87	0	0	48	27
389.00	2.50	0.80			5.9	11.0	***111.0***	8.6	1.2	122.5	111	0	0	61	29
386.50	2.50		12	Sandy Gravel	2.8	29.4	***98.2***	4.1	3.2	124.9	98	0	0	54	32
384.50	2.00	1.00			5.6	13.8	***105.2***	8.2	1.5	133.3	105	0	0	58	34
381.50	3.00	1.10			9.1	15.2	162.8	13.3	1.7	***151.9***	152	0	0	84	37
378.25	3.25		26	Sandy Gravel	8.2	63.7	***139.2***	12.0	7.0	160.5	139	0	0	77	40
371.00	7.25		13	Sandy Gravel	8.7	31.8	***125.7***	12.8	3.5	170.8	126	0	0	69	47
368.25	2.75	0.70			5.7	9.6	***132.9***	8.4	1.1	179.3	133	0	0	73	50
363.25	5.00	0.80			11.7	11.0	***143.2***	17.1	1.2	196.3	143	0	0	79	55
358.25	5.00	0.70			10.4	9.6	***155.0***	15.3	1.1	211.7	155	0	0	85	60
353.25	5.00	0.80			11.7	11.0	***165.3***	17.1	1.2	228.7	165	0	0	91	65
346.00	7.25	0.70			15.1	9.6	***177.7***	22.1	1.1	250.5	178	0	0	98	72
343.25	2.75	0.50			4.3	6.9	***180.6***	6.2	0.8	256.6	181	0	0	99	75
335.75	7.50	0.40			9.4	5.5	***188.7***	13.8	0.6	270.3	189	0	0	104	82
325.75	10.00	0.30			9.6	4.1	***196.9***	14.0	0.5	284.2	197	0	0	108	92
319.50	6.25	0.20			4.1	2.8	443.2	6.0	0.3	***316.6***	317	0	0	174	99
318.50	1.00			Limestone	98.8	245.0	542.0	144.5	26.8	***461.1***	~~461~~	~~0~~	~~0~~	~~254~~	~~99.5~~
317.50	1.00			Limestone	98.8	245.0	640.9	144.5	26.8	***605.6***	~~606~~	~~0~~	~~0~~	~~333~~	~~100.5~~
316.50	1.00			Limestone	98.8	245.0	***739.7***	144.5	26.8	750.1	~~740~~	~~0~~	~~0~~	~~407~~	~~101.5~~
315.50	1.00			Limestone	98.8	245.0	***838.5***	144.5	26.8	894.6	~~839~~	~~0~~	~~0~~	~~461~~	~~102.5~~
314.50	1.00			Limestone		245.0			26.8						

Illinois Department of Transportation

IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

SUBSTRUCTURE========== Piers
REFERENCE BORING ========== 5-S
LRFD or ASD or SEISMIC ========== LRFD
PILE CUTOFF ELEV. ========== 418.48 ft
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVING = 400.00 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

TOTAL FACTORED SUBSTRUCTURE LOAD ========== 1500 kips
TOTAL LENGTH OF SUBSTRUCTURE (along skew)========== 52.16 ft
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE ======= 1
Approx. Factored Loading Applied per pile at 8 ft. Cts ========== 230.07 KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts ========== 86.28 KIPS

PILE TYPE AND SIZE ========== Steel HP 12 X 53
Plugged Pile Perimeter========== 3.967 FT. Unplugged Pile Perimeter========== 5.800 FT.
Plugged Pile End Bearing Area========== 0.983 SQFT. Unplugged Pile End Bearing Area========= 0.108 SQFT.

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
418 KIPS	**418** KIPS	**230** KIPS	**99** FT.

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.)
397.60	2.40	1.30			8.3		24.8	12.1		***13.9***	14	0	0	8	21
395.10	2.50	1.20			8.1	16.5	32.9	11.9	1.8	***25.8***	26	0	0	14	23
392.60	2.50	1.20			8.1	16.5	38.3	11.9	1.8	***37.4***	37	0	0	21	26
389.60	3.00	1.00			8.5	13.8	***39.9***	12.4	1.5	49.0	40	0	0	22	29
387.60	2.00	0.50			3.1	6.9	***45.7***	4.5	0.8	53.8	46	0	0	25	31
385.10	2.50	0.70			5.2	9.6	***50.9***	7.6	1.1	61.4	51	0	0	28	33
382.60	2.50	0.70			5.2	9.6	***58.9***	7.6	1.1	69.4	59	0	0	32	36
380.10	2.50	0.90			6.5	12.4	***61.3***	9.5	1.4	78.4	61	0	0	34	38
377.10	3.00	0.60			5.5	8.3	***77.7***	8.0	0.9	87.6	78	0	0	43	41
374.60	2.50	1.40			9.1	19.3	***77.2***	13.3	2.1	99.8	77	0	0	42	44
372.10	2.50	0.70			5.2	9.6	***87.9***	7.6	1.1	108.1	88	0	0	48	46
370.10	2.00	1.10			6.1	15.2	***94.0***	8.9	1.7	116.9	94	0	0	52	48
367.10	3.00	1.10			9.1	15.2	***97.6***	13.3	1.7	129.7	98	0	0	54	51
364.60	2.50	0.70			5.2	9.6	***109.7***	7.6	1.1	138.1	110	0	0	60	54
361.35	3.25	1.20			10.6	16.5	***117.5***	15.4	1.8	153.2	118	0	0	65	57
354.10	7.25	1.00			20.4	13.8	***131.1***	29.9	1.5	182.3	131	0	0	72	64
349.60	4.50	0.50			7.0	6.9	***139.4***	10.2	0.8	192.7	139	0	0	77	69
346.35	3.25	0.60			5.9	8.3	***146.7***	8.7	0.9	201.5	147	0	0	81	72
341.35	5.00	0.70			10.4	9.6	***155.8***	15.3	1.1	216.6	156	0	0	86	77
336.35	5.00	0.60			9.1	8.3	***166.3***	13.3	0.9	230.1	166	0	0	91	82
331.35	5.00	0.70			10.4	9.6	***175.3***	15.3	1.1	245.2	175	0	0	96	87
326.35	5.00	0.60			9.1	8.3	***184.4***	13.3	0.9	258.5	184	0	0	101	92
322.60	3.75	0.60			6.8	8.3	***191.3***	10.0	0.9	268.5	191	0	0	105	96
320.00	2.60	0.60			4.7	8.3	432.7	6.9	0.9	***301.3***	301	0	0	166	98
319.00	1.00			Limestone	98.8	245.0	531.6	144.5	26.8	***445.8***	~~446~~	~~0~~	~~0~~	~~245~~	~~99.5~~
318.00	1.00			Limestone	98.8	245.0	630.4	144.5	26.8	***590.3***	~~590~~	~~0~~	~~0~~	~~325~~	~~100.5~~
317.00	1.00			Limestone	98.8	245.0	***729.2***	144.5	26.8	734.8	~~729~~	~~0~~	~~0~~	~~401~~	~~101.5~~
316.00	1.00			Limestone	98.8	245.0	***828.0***	144.5	26.8	879.3	~~828~~	~~0~~	~~0~~	~~455~~	~~102.5~~
315.00	1.00			Limestone		245.0			26.8						

Illinois Department of Transportation

IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

SUBSTRUCTURE========== NB, S Abut
REFERENCE BORING ========== 1-S
LRFD or ASD or SEISMIC ========== SEISMIC
PILE CUTOFF ELEV. ========== 417.38 ft
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVING = 415.38 ft
GEOTECHNICAL LOSS TYPE (None, Scour, Liquef., DD) ====== Liquef.
BOTTOM ELEV. OF SCOUR, LIQUEF., or DD ========== 376.40 ft
TOP ELEV. OF LIQUEF. (so layers above apply DD) ========== 386.40 ft

TOTAL SEISMIC SUBSTRUCTURE LOAD ========== 600 kips
TOTAL LENGTH OF SUBSTRUCTURE (along skew)========== 52.16 ft
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE ======= 1
Approx. Seismic Loading Applied per pile spaced at 8 ft. Cts ======= 92.03 KIPS
Approx. Seismic Loading Applied per pile spaced at 3 ft. Cts ======= 34.51 KIPS

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 Seismic Resistance Available in Boring	Maximum Pile Driveable Length in Boring
418 KIPS	**418** KIPS	**213** KIPS	**98** FT.

PILE TYPE AND SIZE ========== Steel HP 12 X 53
Plugged Pile Perimeter========== 3.967 FT. Unplugged Pile Perimeter========== 5.800 FT.
Plugged Pile End Bearing Area========== 0.983 SQFT. Unplugged Pile End Bearing Area========= 0.108 SQFT.

BOT. OF LAYER ELEV. (FT.)	LAYER THICK. (FT.)	UNCONF. COMPR. STRENGTH (TSF.)	S.P.T. N VALUE (BLOWS)	GRANULAR OR ROCK LAYER DESCRIPTION	ULTIMATE PLUGGED SIDE RESIST. (KIPS)	ULTIMATE PLUGGED END BRG. RESIST. (KIPS)	ULTIMATE PLUGGED TOTAL RESIST. (KIPS)	ULTIMATE UNPLUGGED SIDE RESIST. (KIPS)	ULTIMATE UNPLUGGED END BRG. RESIST. (KIPS)	ULTIMATE UNPLUGGED TOTAL RESIST. (KIPS)	NOMINAL REQ'D BEARING (KIPS)	NOMINAL GEOTECH. LOSS FROM LIQUEF. & DD (KIPS)	FACTORED GEOTECH. LOSS LOAD FROM DD (KIPS)	SEISMIC RESISTANCE AVAILABLE (KIPS)	ESTIMATED PILE LENGTH (FT.)
414.40	0.98	2.30			5.0		33.9	7.2		***10.4***	10	5	5	0	3
411.40	3.00	2.10			14.3	28.9	38.5	20.9	3.2	***30.2***	30	19	21	-10	6
408.90	2.50	1.40			9.1	19.3	57.3	13.3	2.1	***44.6***	45	28	31	-15	8
406.40	2.50	2.10			11.9	28.9	***47.1***	17.4	3.2	59.6	47	40	44	-37	11
404.40	2.00	0.50			3.1	6.9	***48.8***	4.5	0.8	64.0	49	43	48	-42	13
401.40	3.00	0.40			3.8	5.5	***49.9***	5.5	0.6	69.2	50	47	52	-49	16
398.90	2.50	0.20			1.6	2.8	***65.3***	2.4	0.3	73.1	65	49	54	-37	18
396.90	2.00	1.20			6.5	16.5	***73.2***	9.5	1.8	82.7	73	55	61	-43	20
393.90	3.00	1.30			10.3	17.9	119.5	15.1	2.0	***101.8***	102	66	72	-36	23
391.90	2.00		22	Sandy Gravel	4.1	53.9	133.4	6.0	5.9	***108.8***	109	70	77	-38	25
388.90	3.00		26	Sandy Gravel	7.6	63.7	***108.9***	11.1	7.0	116.4	109	77	85	-53	28
386.40	2.50	2.30			12.6	31.7	***124.2***	18.5	3.5	135.2	124	90	99	-65	31
384.40	2.00		14	Sandy Gravel	2.6	34.3	146.4	3.8	3.8	***141.1***	141	92	99	-50	33
381.90	2.50		22	Sandy Gravel	5.1	53.9	***141.7***	7.5	5.9	147.5	142	98	99	-55	35
376.40	5.50		18	Sandy Gravel	9.2	44.1	***130.2***	13.4	4.8	158.6	130	107	99	-76	41
373.15	3.25	1.70			13.5	23.4	***135.4***	19.7	2.6	177.5	135	107	99	-70	44
366.40	6.75	1.10			20.5	15.2	***151.8***	30.0	1.7	207.0	152	107	99	-54	51
361.40	5.00	0.80			11.7	11.0	***166.3***	17.1	1.2	224.5	166	107	99	-40	56
358.15	3.25	1.00			9.2	13.8	***172.7***	13.4	1.5	237.5	173	107	99	-33	59
354.90	3.25	0.80			7.6	11.0	***180.3***	11.1	1.2	248.7	180	107	99	-26	62
352.40	2.50	0.80			5.9	11.0	***186.1***	8.6	1.2	257.2	186	107	99	-20	65
347.40	5.00	0.80			11.7	11.0	***197.8***	17.1	1.2	274.4	198	107	99	-8	70
342.40	5.00	0.80			11.7	11.0	***209.6***	17.1	1.2	291.5	210	107	99	4	75
337.40	5.00	0.80			11.7	11.0	***221.3***	17.1	1.2	308.6	221	107	99	15	80
332.40	5.00	0.80			11.7	11.0	***233.0***	17.1	1.2	325.7	233	107	99	27	85
327.40	5.00	0.80			11.7	11.0	***244.7***	17.1	1.2	342.9	245	107	99	39	90
322.40	5.00	0.80			11.7	11.0	***256.4***	17.1	1.2	360.0	256	107	99	51	95
320.00	2.40	0.80			5.6	11.0	496.0	8.2	1.2	***393.8***	394	107	99	188	97
319.00	1.00			Limestone	98.8	245.0	594.8	144.5	26.8	***538.3***	~~538~~	~~107~~	~~99~~	~~332~~	~~98.4~~
318.00	1.00			Limestone	98.8	245.0	693.6	144.5	26.8	***682.8***	~~683~~	~~107~~	~~99~~	~~477~~	~~99.4~~
317.00	1.00			Limestone	98.8	245.0	***792.5***	144.5	26.8	827.3	~~792~~	~~107~~	~~99~~	~~587~~	~~100.4~~
316.00	1.00			Limestone	98.8	245.0	***891.3***	144.5	26.8	971.8	~~891~~	~~107~~	~~99~~	~~685~~	~~101.4~~
315.00	1.00			Limestone		245.0			26.8						

Illinois Department of Transportation

IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

SUBSTRUCTURE========== SB, S Abut
REFERENCE BORING ========== 4-S
LRFD or ASD or SEISMIC ========== SEISMIC
PILE CUTOFF ELEV. ========== 418.02 ft
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVING = 416.02 ft
GEOTECHNICAL LOSS TYPE (None, Scour, Liquef., DD) ====== Liquef.
BOTTOM ELEV. OF SCOUR, LIQUEF., or DD ========== 371.00 ft
TOP ELEV. OF LIQUEF. (so layers above apply DD) ========== 389.00 ft

TOTAL SEISMIC SUBSTRUCTURE LOAD ========== 600 kips
TOTAL LENGTH OF SUBSTRUCTURE (along skew)========== 52.16 ft
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE ======= 1
Approx. Seismic Loading Applied per pile spaced at 8 ft. Cts ======= 92.03 KIPS
Approx. Seismic Loading Applied per pile spaced at 3 ft. Cts ======= 34.51 KIPS

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 Seismic Resistance Available in Boring	Maximum Pile Driveable Length in Boring
418 KIPS	**418** KIPS	**212** KIPS	**100** FT.

PILE TYPE AND SIZE ========== Steel HP 12 X 53
Plugged Pile Perimeter========== 3.967 FT. Unplugged Pile Perimeter========== 5.800 FT.
Plugged Pile End Bearing Area========== 0.983 SQFT. Unplugged Pile End Bearing Area========= 0.108 SQFT.

BOT. OF LAYER ELEV. (FT.)	LAYER THICK. (FT.)	UNCONF. COMPR. STRENGTH (TSF.)	S.P.T. N VALUE (BLOWS)	GRANULAR OR ROCK LAYER DESCRIPTION	ULTIMATE PLUGGED SIDE RESIST. (KIPS)	ULTIMATE PLUGGED END BRG. RESIST. (KIPS)	ULTIMATE PLUGGED TOTAL RESIST. (KIPS)	ULTIMATE UNPLUGGED SIDE RESIST. (KIPS)	ULTIMATE UNPLUGGED END BRG. RESIST. (KIPS)	ULTIMATE UNPLUGGED TOTAL RESIST. (KIPS)	NOMINAL REQ'D BEARING (KIPS)	NOMINAL GEOTECH. LOSS FROM LIQUEF. & DD (KIPS)	FACTORED GEOTECH. LOSS LOAD FROM DD (KIPS)	SEISMIC RESISTANCE AVAILABLE (KIPS)	ESTIMATED PILE LENGTH (FT.)
414.00	2.02	2.50			10.8		***14.9***	15.8		16.2	15	11	12	-8	4
411.50	2.50	0.30			2.4	4.1	29.7	3.5	0.5	***21.1***	21	13	15	-7	7
409.50	2.00	1.20			6.5	16.5	36.2	9.5	1.8	***30.6***	31	20	22	-11	9
407.00	2.50	1.20			8.1	16.5	49.9	11.9	1.8	***43.1***	43	28	31	-15	11
404.50	2.50	1.60			10.0	22.0	***52.9***	14.6	2.4	56.9	53	38	42	-27	14
401.50	3.00	1.10			9.1	15.2	***56.6***	13.3	1.7	69.6	57	47	52	-42	17
399.00	2.50	0.70			5.2	9.6	***78.3***	7.6	1.1	79.1	78	52	57	-31	19
397.00	2.00	1.90			8.9	26.2	***81.7***	13.1	2.9	91.6	82	61	67	-47	21
394.00	3.00	1.50			11.4	20.7	***106.8***	16.7	2.3	109.8	107	73	80	-46	24
391.50	2.50		14	Sandy Gravel	3.2	34.3	***86.8***	4.7	3.8	112.0	87	76	84	-72	27
389.00	2.50	0.80			5.9	11.0	***111.0***	8.6	1.2	122.5	111	82	90	-61	29
386.50	2.50		12	Sandy Gravel	2.8	29.4	***98.2***	4.1	3.2	124.9	98	84	90	-76	32
384.50	2.00	1.00			5.6	13.8	***105.2***	8.2	1.5	133.3	105	90	90	-75	34
381.50	3.00	1.10			9.1	15.2	162.8	13.3	1.7	***151.9***	152	99	90	-37	37
378.25	3.25		26	Sandy Gravel	8.2	63.7	***139.2***	12.0	7.0	160.5	139	107	90	-58	40
371.00	7.25		13	Sandy Gravel	8.7	31.8	***125.7***	12.8	3.5	170.8	126	116	90	-80	47
368.25	2.75	0.70			5.7	9.6	***132.9***	8.4	1.1	179.3	133	116	90	-73	50
363.25	5.00	0.80			11.7	11.0	***143.2***	17.1	1.2	196.3	143	116	90	-63	55
358.25	5.00	0.70			10.4	9.6	***155.0***	15.3	1.1	211.7	155	116	90	-51	60
353.25	5.00	0.80			11.7	11.0	***165.3***	17.1	1.2	228.7	165	116	90	-41	65
346.00	7.25	0.70			15.1	9.6	***177.7***	22.1	1.1	250.5	178	116	90	-28	72
343.25	2.75	0.50			4.3	6.9	***180.6***	6.2	0.8	256.6	181	116	90	-25	75
335.75	7.50	0.40			9.4	5.5	***188.7***	13.8	0.6	270.3	189	116	90	-17	82
325.75	10.00	0.30			9.6	4.1	***196.9***	14.0	0.5	284.2	197	116	90	-9	92
319.50	6.25	0.20			4.1	2.8	443.2	6.0	0.3	***316.6***	317	116	90	111	99
318.50	1.00			Limestone	98.8	245.0	542.0	144.5	26.8	***461.1***	~~461~~	~~116~~	~~90~~	~~255~~	~~99.5~~
317.50	1.00			Limestone	98.8	245.0	640.9	144.5	26.8	***605.6***	~~606~~	~~116~~	~~90~~	~~400~~	~~100.5~~
316.50	1.00			Limestone	98.8	245.0	***739.7***	144.5	26.8	750.1	~~740~~	~~116~~	~~90~~	~~534~~	~~101.5~~
315.50	1.00			Limestone	98.8	245.0	***838.5***	144.5	26.8	894.6	~~839~~	~~116~~	~~90~~	~~632~~	~~102.5~~
314.50	1.00			Limestone		245.0			26.8						

Slope Stability Soil Parameters SN 091-0075

Northbound, South Abutment (LRFD)			
Layer Number	Unit Weight (lbs/ft^3)	Cohesion (lbs/ft^2)	Friction Angle (deg.)
1	128	1821	-
2	110	360	-
3	124	1260	-
4	131	-	35
5	131	2300	-
6	129	-	34
7	124	1295	-
8	119	827	-

Northbound, South Abutment (Seismic)			
Layer Number	Unit Weight (lbs/ft^3)	Cohesion (lbs/ft^2)	Friction Angle (deg.)
1	128	1821	-
2	110	360	-
3	124	1260	-
4	131	-	35
5	131	2300	-
6	129	-	13
7	124	1295	-
8	119	827	-

Northbound, North Abutment (LRFD)			
Layer Number	Unit Weight (lbs/ft^3)	Cohesion (lbs/ft^2)	Friction Angle (deg.)
1	128	1780	-
2	119	800	-
3	124	1315	-
4	119	800	-
5	109	315	-

Northbound, North Abutment (Seismic)			
Layer Number	Unit Weight (lbs/ft^3)	Cohesion (lbs/ft^2)	Friction Angle (deg.)
1	128	1780	-
2	119	800	-
3	124	1315	-
4	119	800	-
5	109	315	-

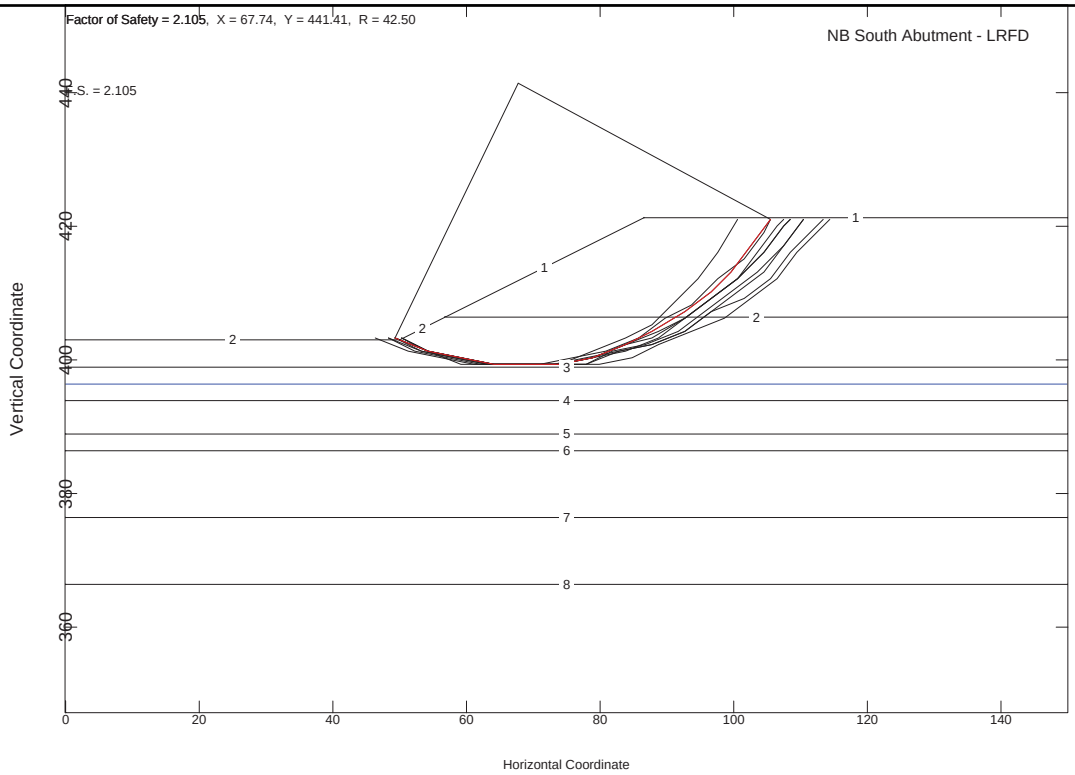
Slope Stability Soil Parameters SN 091-0076

Southbound, North Abutment (LRFD)			
Layer Number	Unit Weight (lbs/ft^3)	Cohesion (lbs/ft^2)	Friction Angle (deg.)
1	123	1200	-
2	133	2632	-
3	128	1735	-
4	98	100	-
5	122	1176	-

Southbound, North Abutment (Seismic)			
Layer Number	Unit Weight (lbs/ft^3)	Cohesion (lbs/ft^2)	Friction Angle (deg.)
1	123	1200	-
2	133	2632	-
3	128	1735	-
4	98	100	-
5	122	1176	-

Southbound, South Abutment (LRFD)			
Layer Number	Unit Weight (lbs/ft^3)	Cohesion (lbs/ft^2)	Friction Angle (deg.)
1	118	700	-
2	133	2500	-
3	108	300	-
4	124	1270	-
5	118	700	-
6	127	1660	-
7	122	-	32
8	119	800	-
9	125	-	32
10	122	1060	-
11	128	-	33
12	118	740	-

Southbound, South Abutment (Seismic)			
Layer Number	Unit Weight (lbs/ft^3)	Cohesion (lbs/ft^2)	Friction Angle (deg.)
1	118	700	-
2	133	2500	-
3	108	300	-
4	124	1270	-
5	118	700	-
6	127	1660	-
7	122	-	32
8	119	800	-
9	125	-	12
10	122	1060	-
11	128	-	13
12	118	740	-


Factor of Safety = 2.105, X = 67.74, Y = 441.41, R = 42.50
NB South Abutment - LRFD
F.S. = 2.105
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Horizontal Coordinate
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100
120
140
1
2
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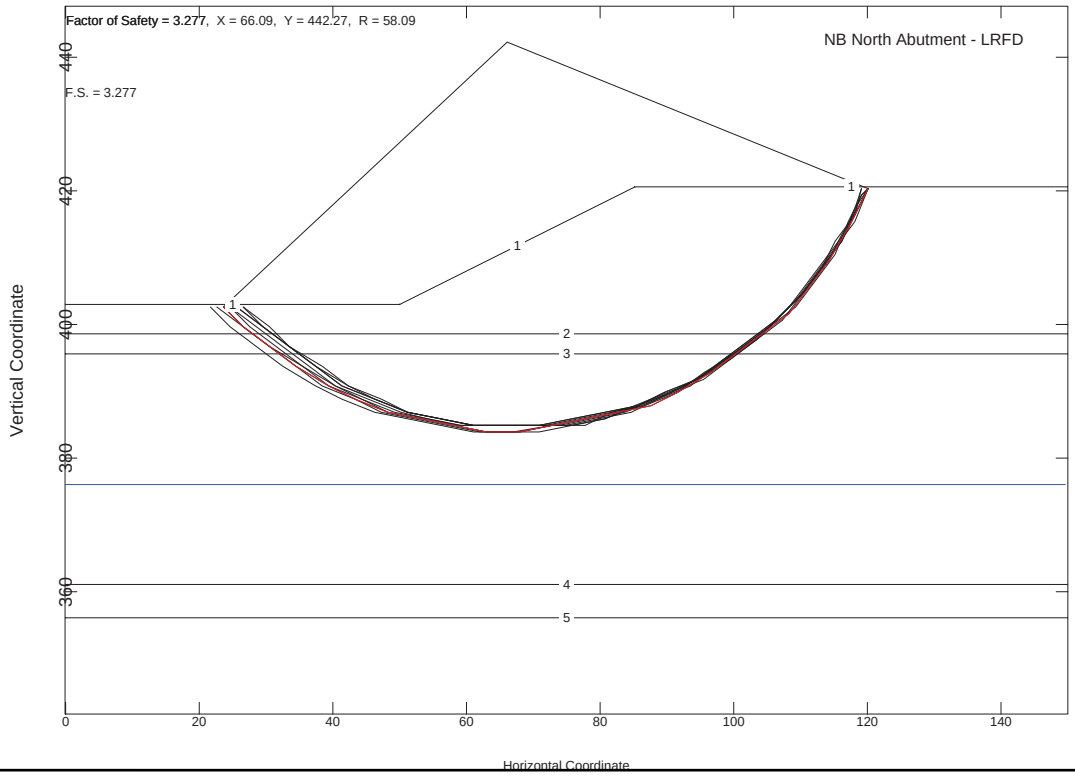
5
6
7
8


Factor of Safety = 3.277, X = 66.09, Y = 442.27, R = 58.09
NB North Abutment - LRFD
F.S. = 3.277
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Horizontal Coordinate
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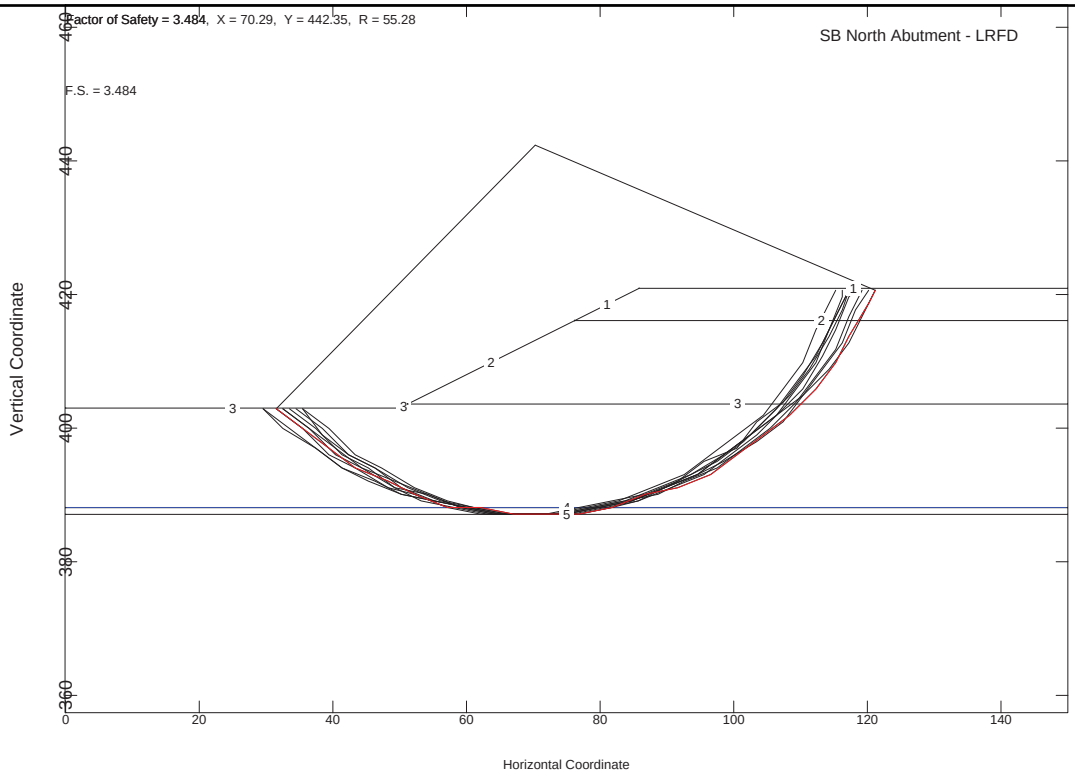
Factor of Safety = 3.484, X = 70.29, Y = 442.35, R = 55.28
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F.S. = 3.484
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Horizontal Coordinate
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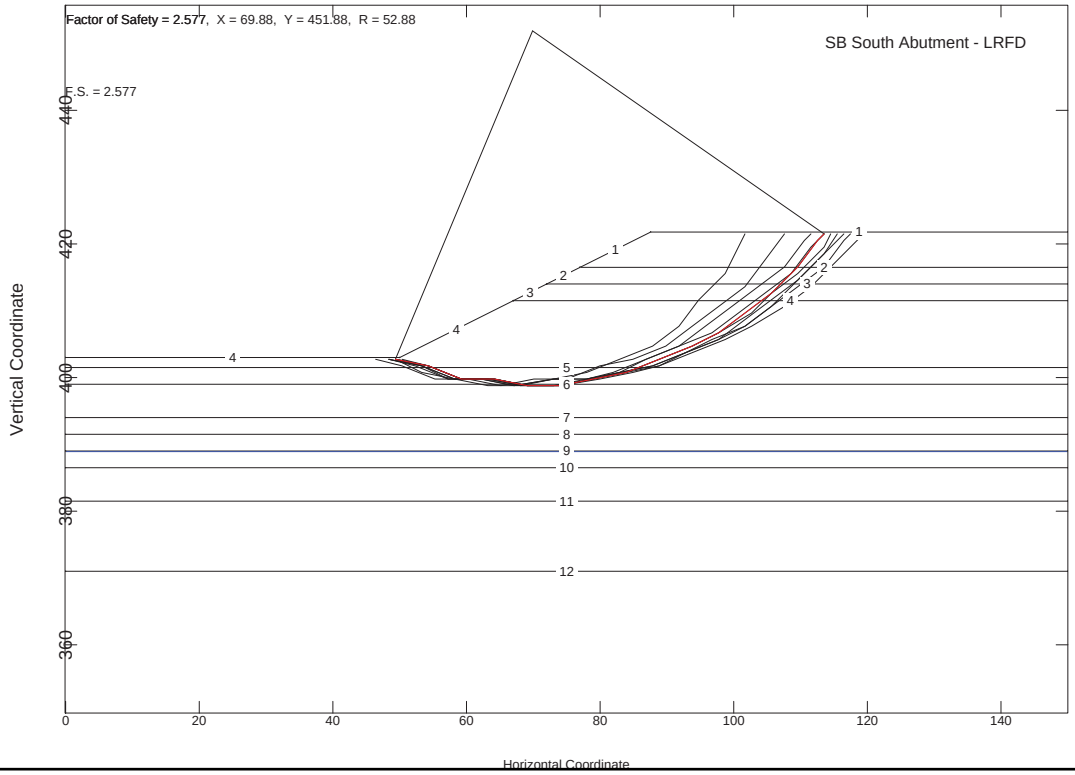
Factor of Safety = 2.577, X = 69.88, Y = 451.88, R = 52.88
SB South Abutment - LRFD
F.S. = 2.577
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Horizontal Coordinate
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360
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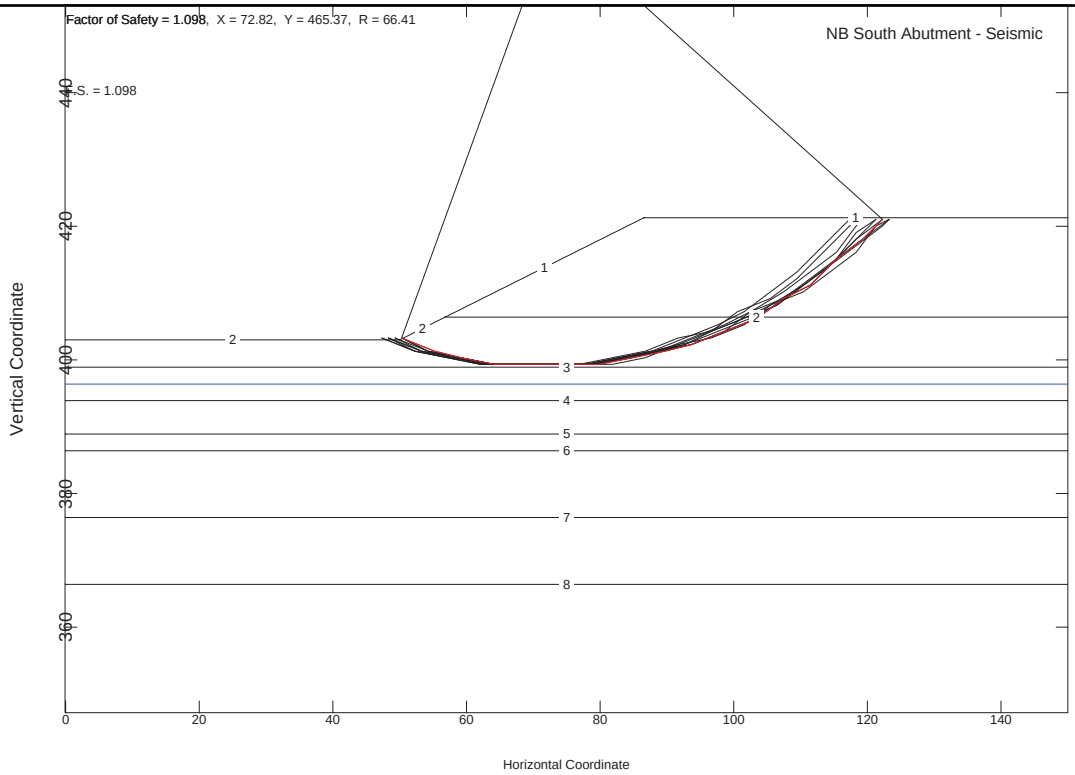
100
120
140


Factor of Safety = 1.098, X = 72.82, Y = 465.37, R = 66.41
NB South Abutment - Seismic
F.S. = 1.098
Vertical Coordinate
Horizontal Coordinate
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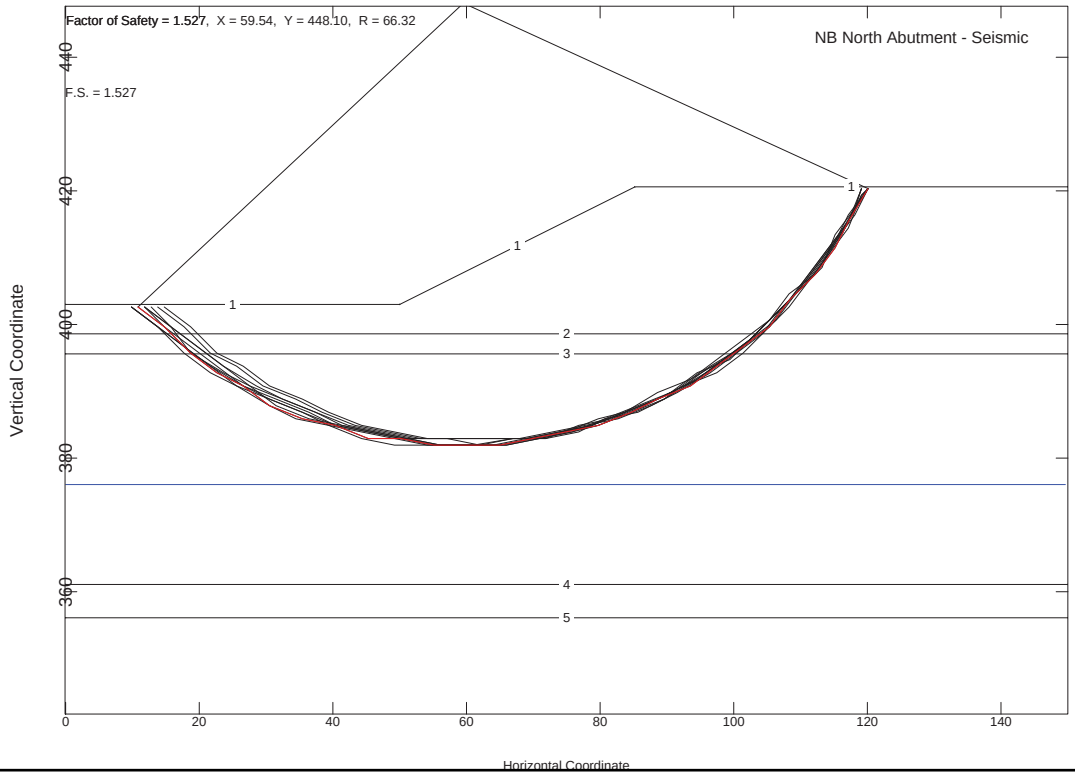
Factor of Safety = 1.527, X = 59.54, Y = 448.10, R = 66.32
NB North Abutment - Seismic
F.S. = 1.527
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Horizontal Coordinate
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100
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140
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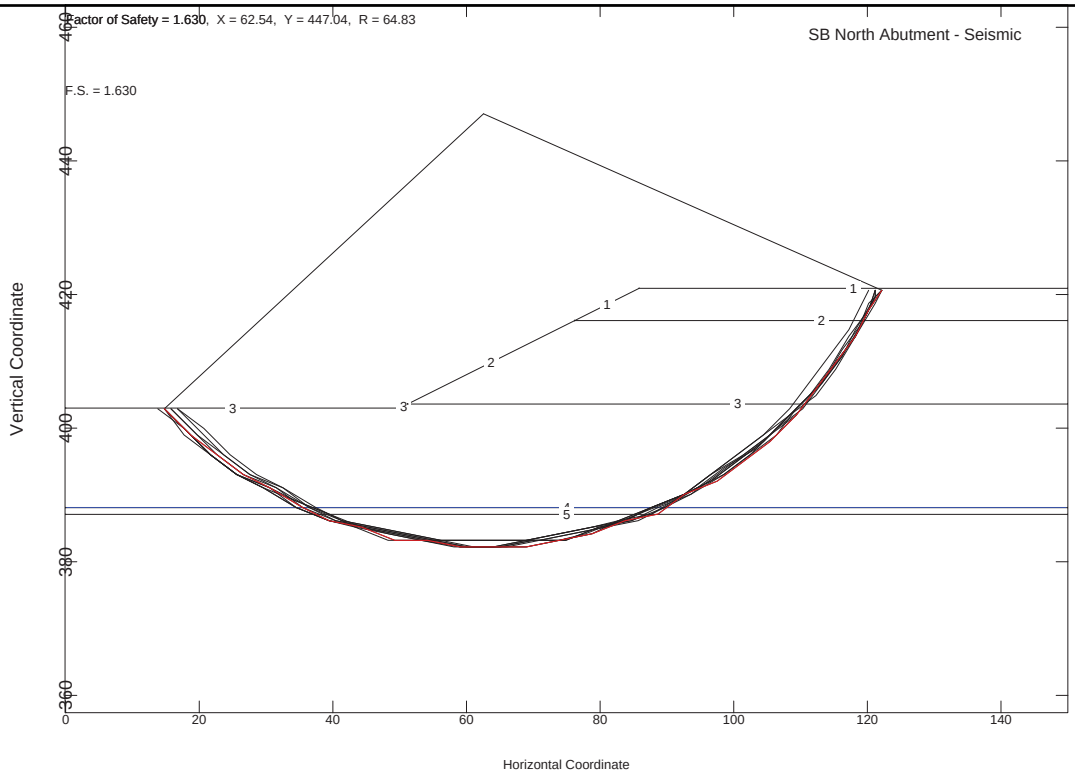
2
3
4
5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SB North Abutment - Seismic
F.S. = 1.630
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Horizontal Coordinate
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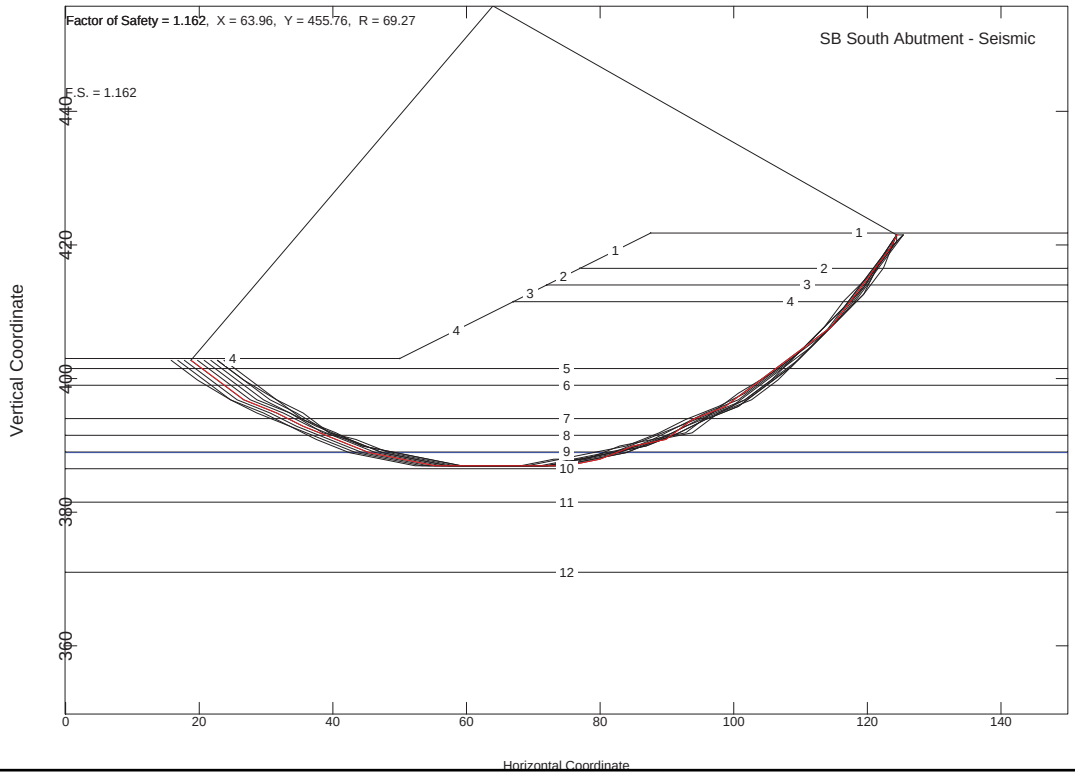
420
400
380
360
0
20
40
60
80
100
120
140


Factor of Safety = 1.162, X = 63.96, Y = 455.76, R = 69.27
SB South Abutment - Seismic
F.S. = 1.162
Vertical Coordinate
Horizontal Coordinate
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420
400
380
360
0
20
40
60
80
100
120
140