Wang Engineering

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Geotechnical Design Memorandum

To:	Dan Manojlovski, PE, Project Manager, AECOM
From:	Met Seyhun, PE, Sr. Geotechnical Engineer
Date:	November 22, 2017
Subject:	Ramp EN (016-1712) East Abutment Drilled HP Pile Foundations
Project:	Circle Interchange Reconstruction
	IDOT Job No. D-91-227-13, IDOT PTB 163, Item 01
	Wang Project No. 1100-04-01

Introduction

Following the approval of Ramp EN (016-1712) Bridge SGR by IDOT on September 1, 2017, Wang Engineering, Inc. (Wang) understands that the east abutment foundations for the bridge have been changed to drilled or vibrated HP piles into bedrock, as per TSL dated September 13, 2017 (Appendix A). The micropile option is also discussed. The memorandum provides estimated pile lengths and tip elevations for various HP piles, and provides downdrag induced on the piles by the construction of Wall 20 (016-1811).

Drilled HP Piles Set in Rock

The east abutment will be supported HP piles drilled into rock. Based on borings 1705-B-6A and 20-RWB-01, the top of bedrock is at 487.6 to 490.0 feet elevation. An estimated top of bedrock elevation of 488.0 feet was used for our analysis. We recommend the pile be drilled through the soil with casing stopping on the top of bedrock and the top 4 feet of the bedrock should be cored to provide bearing into fresh bedrock. The coring depth may vary depending on the bedrock condition encountered during construction. The space between the pile and the casing will be concreted. The geotechnical factored resistances of rock socketed HP piles based on the socket diameter and end bearing is shown in Table 1. The downdrag loads on drilled HP piles resulting from the construction of wall 20 are included in Table 3 under “Downdrag Loads” section and should be applied for final resistance determination.

Table 1: Estimated Pile Lengths and Tip Elevations for Drilled HP Steel Piles Encased 4-foot in Bedrock

Structure Unit (Reference Boring)	Drilled Steel HP Socket Diameter (feet)	Pile Cap Base Elevation (feet)	Top of Bedrock Elevation (feet)	Nominal Unit Socket Base Resistance (ksf)	Factored Resistance Available[2] R_F (kips)	Total Estimated Pile Length[1] (feet)	Estimated Pile Tip Elevation (feet)
East Abutment (1705-B-06A and 20-RWB-01)	2.0	589.33	486.0	650	1000	108	482

[1] Includes 1-foot embedment in to pile cap and 4-foot of rock socketing.
[2] For HP pile end bearing in rock, resistance factor (ϕ_{stat}) of 0.50 was used in accordance with Table 10.5.5.2.4-1, AASHTO 2014. Does not include DD.

Vibrated HP Piles

The HP piles may be vibrated to top of bedrock with taking precautions against excessive pore pressure build up and excessive vibration to nearby main drain. Upon reaching the top of bedrock, the driven bearing must be verified through the use of an impact hammer. The design values are based on the maximum nominal required as established on Table 6.13.2.1-1 of IDOT Geotechnical Manual 2015. Design information for various HP pile sizes are in Table 2. The downdrag loads on vibrated HP piles resulted from the construction of wall 20 are included in Table 4 under "Downdrag Loads" section and should be applied for final resistance determination.

Table 2: Estimated Pile Lengths and Tip Elevations for Vibrated HP Steel Piles

Structure Unit (Reference Boring)	Steel HP Size	Pile Cap Base Elevation (feet)	Top of Bedrock Elevation (feet)	Nominal Required Bearing[1] R_N (kips)	Factored Resistance Available[2] R_F (kips)	Total Estimated Pile Length[3] (feet)	Estimated Pile Tip Elevation (feet)
East Abutment (1705-B-06A and 20-RWB-01)	HP 12×53	589.33	488.0	419	230	103	487
	HP 12×63	589.33	488.0	497	273	103	487
	HP 14×73	589.33	488.0	578	318	103	487
	HP 14×89	589.33	488.0	705	388	103	487

[1] Maximum Nominal Required Bearing as per Table 6.13.2.1-1, IDOT Geotechnical Manual 2015.
[2] For end bearing in rock, resistance factor (ϕ_{stat}) of 0.55 was used in accordance with IDOT Standard. Does not include DD.
[3] Includes 1-foot embedment in to pile cap and 1-foot into rock.

Downdrag Loads for drilled and vibrated HP piles

Downdrag (DD) will be acting on the drilled and vibrated HP piles by the construction of wall 20 where the settlement is expected to exceed 0.4 inches.

The estimated DD loads to be used for the design of drilled piles are provided in Table 3.

Table 3: Estimated Downdrag (DD) Loads on Drilled HP Steel Piles with Casing

Drilled HP Pile Diameter (feet)	Nominal Downdrag Load[1] (Kips)	Factored Downdrag Load with Load Factor of 1.25[2] (Kips)
2.0	61	76

[1] Based on a factor of 0.55x S_u (undrained shear strength) as per AASHTO 2014
[2] Load factor of 1.25 as per in accordance with Table 3.4.1-2, AASHTO 2014.

The estimated DD loads to be used for the design of vibrated piles are provided in Table 4. The DD loads are calculated using IDOT's *AGMU Memorandum 10.2 – Geotechnical Pile Design* (IDOT, 2011).

Table 4: Estimated Downdrag (DD) Loads on Vibrated HP Steel Piles

Structure Unit (Reference Boring)	Steel HP Size	Factored Geotechnical Loss Load From DD (kips)
East Abutment (1705-B-06A and 20-RWB-01)	HP (12×53)	52
	HP (12×63)	53
	HP (14×73)	62
	HP (14×89)	62

Micropiles

Micropiles can also be an option for the east abutment foundations like for Pier 1. Micropiles cause minimal vibrations and noise, and can be installed in low headroom conditions. The contractor shall design, furnish, install and test micropiles in accordance with FHWA-SA-97-070 (2000), "Micropile Design and Construction Guidelines."

Based on our evaluation of the dolostone, we recommend a unit grout-to-ground (rock) nominal bond resistance of 30 ksf to be used for the design of micropiles which corresponds to factored resistance of 16.5 ksf, using a resistance factor of 0.55 (AASHTO 2014). Alternatively, it can be designed with an allowable of 200 ksf when the base of the micropile is one foot or more below the surface of solid rock. The capacity can be increased by 40 ksf for each additional foot to a maximum of 400 ksf (CBC 2016).

Final foundation selection shall be made by performing a cost benefit analyses.

Attachments:
Appendix A, TSL dated September 13, 2017

Exp. 11/30/2019

Copy To: Amish Bhatt, PE, SE, AECOM
Corina Farez, PE, PG, Wang Engineering, Inc.

Benchmark: Cut square on center of door entrance to 707 W. Harrison St. (south side of Harrison St., approx. 90' west of west line of Des Plaines St.). Elevation 597.47.

Existing Structure: S.N. 016-2453 was originally constructed in 1960 as an eight-span structure carrying one lane of traffic from eastbound I-290 to northbound I-90/94 (FAI Route No. 94; Section 0101.6-1P). Rehabilitation was performed under various contracts including removal and replacement of the Spans 1 thru 3 superstructure (from existing Bent 26 to Abutment 29), Piers 27 and 28, and the Abutment 29 backwall in 1987. The bridge has an overall length of approximately 429'-0" (41'-8 3/8" / 70'-5 3/16" / 53'-11 1/2" / 49'-0 5/8" / 54'-2 5/16" / 79'-5 13/16" / 40'-9 1/2" / 40'-0" spans), an overall width of 29'-0" (out-to-out superstructure) and consists of a minimum 7 1/2"-thick reinforced concrete deck with overlay supported on five (5) steel girders. The existing substructure consists of reinforced concrete piers and abutments on drilled shafts. This structure will be removed and replaced. Traffic shall be maintained on the existing structure during the construction of the proposed MSE walls, abutments, and pier 1 and 2. Subsequently, traffic shall be detoured to allow for the removal of the existing structure and the construction of the remaining portions of the proposed bridge and approaches.

HIGHWAY CLASSIFICATION

Ramp EN
Functional Class: Interstate
ADT: 26,600 (2012); 31,000 (2040)
ADTT: 1,032 (2012); 1,203 (2040)
DHV: 1,910 (2040)
Design Speed: 30 m.p.h.
Posted Speed: 30 m.p.h.
One-Way Traffic
Directional Distribution: 100%

I-90/94 SB at Van Buren
Functional Class: Interstate
ADT: 100,100 (2012); 98,000 (2040)
ADTT: 11,351 (2012); 11,113 (2040)
DHV: 6,340 (2040)
Design Speed: 60 m.p.h.
Posted Speed: 45 m.p.h.
One-Way Traffic
Directional Distribution: 100%

DESIGN SPECIFICATIONS

2014 AASHTO LRFD Bridge Design Specifications, 7th Edition with 2015 and 2016 Interim Revisions

LOADING HL-93

Allow 50#/sq. ft. for future wearing surface.

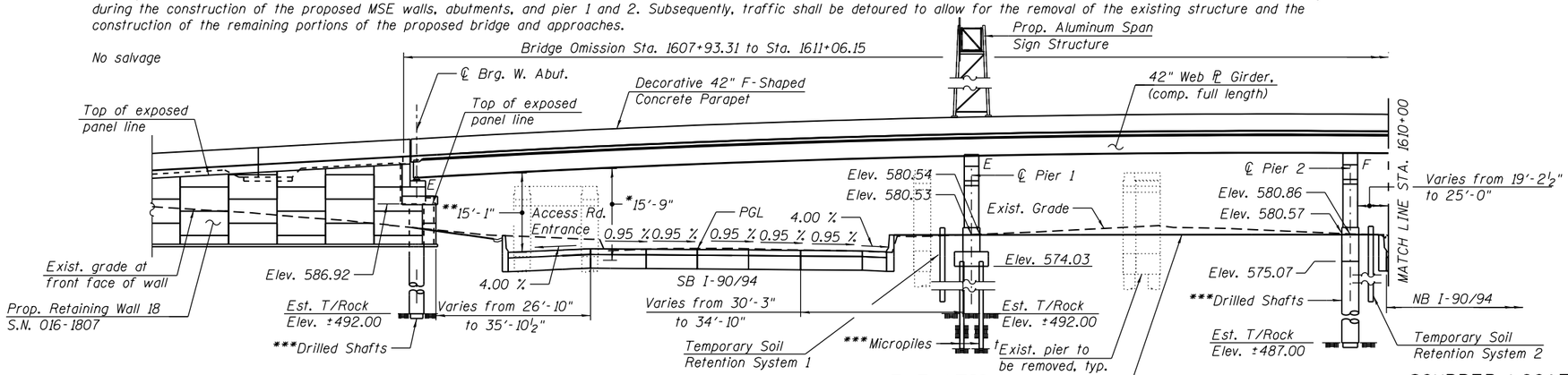
DESIGN STRESSES

FIELD UNITS

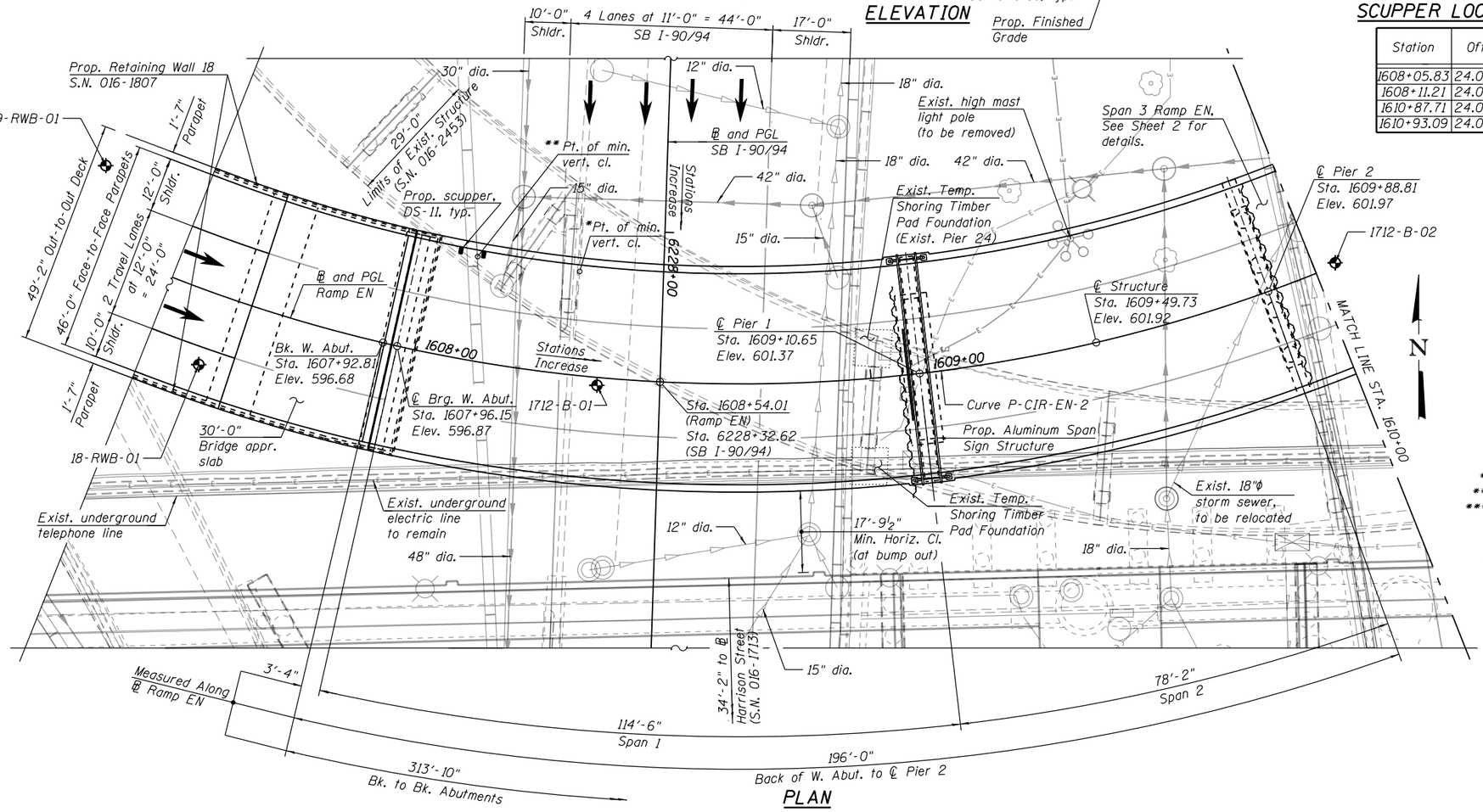
f'c = 3,500 psi
f'c = 4,000 psi (Superstructure Concrete)
fy = 60,000 psi (Reinforcement)
fy = 50,000 psi (M270 Grade 50)

SEISMIC DATA

Seismic Performance Zone (SPZ) = 1
Design Spectral Acceleration at 1.0 sec. (SD1) = 0.085g
Design Spectral Acceleration at 0.2 sec. (SDS) = 0.144g
Soil Site Class = D



ELEVATION



PLAN

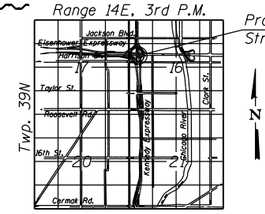
SCUPPER LOCATION

Station	Offset
1608+05.83	24.00' Lt.
1608+11.21	24.00' Lt.
1610+87.71	24.00' Lt.
1610+93.09	24.00' Lt.

LEGEND:

Soil Boring
Exist. High Mast Light Pole (to be removed)
Exist. Traffic Signal/ Light Pole (to be removed)
Fire Hydrant
Junction Box
Manhole
Temporary Soil Retention System
Combined Sewer
Electric
Fiber Optic
Exist. Storm Sewer
Prop. Storm Sewer
Water Line
Telephone

* Interim Min. Vert. Cl.
** Final Min. Vert. Cl.
*** Spacing, tip elevation, and drilled shaft/micropile diameter to be determined during final design.
t Only exist. piers interfering with proposed superstructure have been presented for clarity



LOCATION SKETCH

GENERAL PLAN & ELEVATION - 1
RAMP EN OVER F.A.I. RTE. 90/94
(DAN RYAN EXPRESSWAY)
F.A.I. RTE. 90/94/290 - SECTION 2014-005R&B
COOK COUNTY
STATION 1609+49.73
STRUCTURE NO. 016-1712

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FAX: (708) 236-0901

USER NAME = Kendrabant	DESIGNED - MI, JJS	REVISED -	
	DRAWN - JJS, KJD	REVISED -	
PLOT SCALE = 28.0 '1' / in.	CHECKED - MAI, MI	REVISED -	
PLOT DATE = 9/13/2017	DATE - 09/13/2017	REVISED -	

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

STRUCTURE NO. 016-1712

SCALE: | SHEET 1 OF 4 SHEETS | STA. | TO STA.

F.A.I. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
90/94/290	2014-005R&B	COOK	4	1
		CONTRACT NO. 60X79		
		ILLINOIS FED. AID PROJECT		

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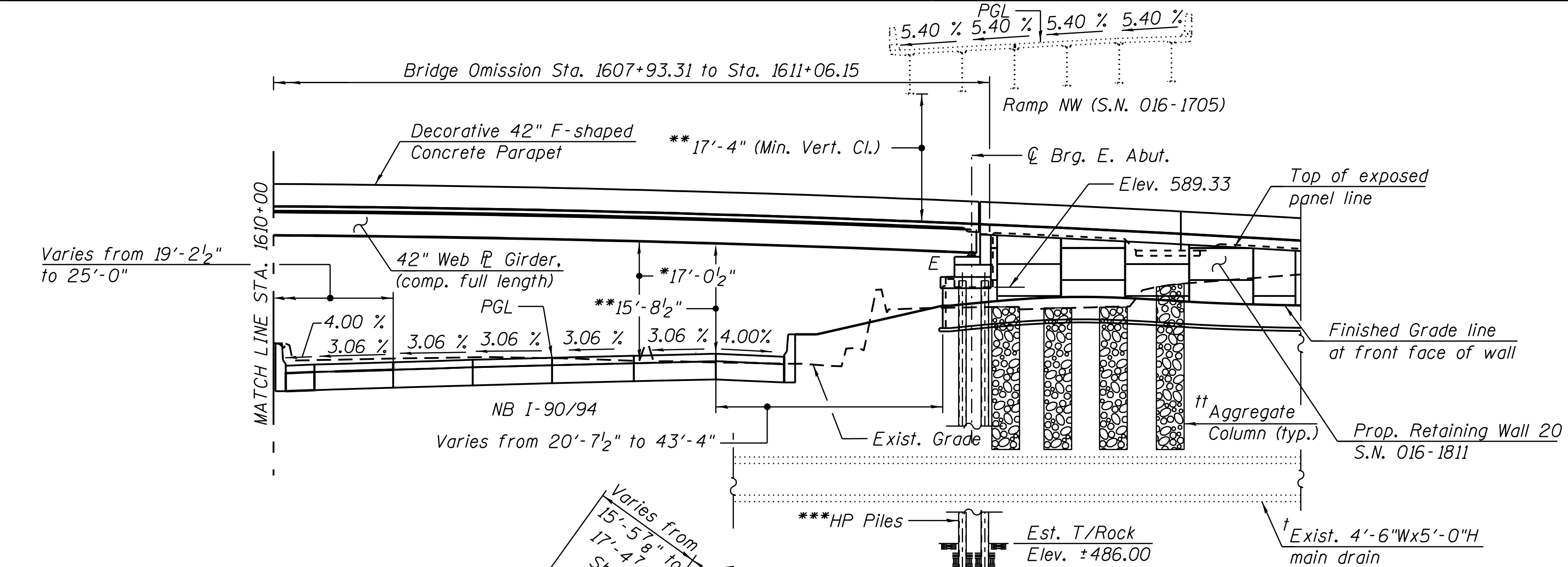
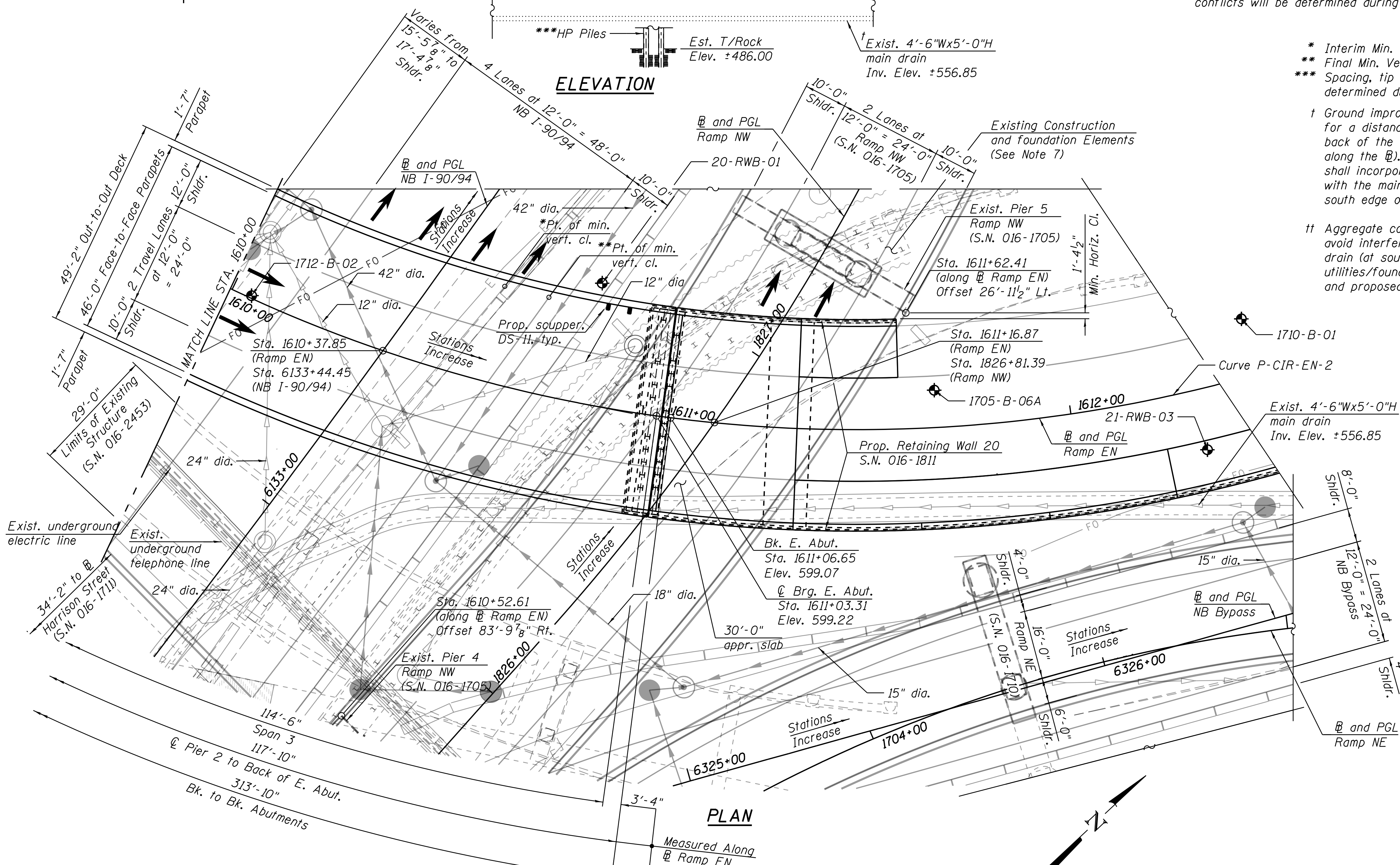


ELEVATION



PLAN

NOTES:

1. For Profile Grade Lines and Offset Sketch, see Sheet 4 of 4.
2. Drainage scuppers shall be attached to a closed drainage system.
3. All structural steel shall be metalized (thermal spraying).
4. All substructure units are radial to ℄ unless noted otherwise.
5. Lightweight Cellular Concrete fill (Class III - 42pcf) shall be used for all MSE retaining wall fill.
6. Aggregate Column ground improvement is shown here for information only, it is included with Prop. Retaining Wall 20 (S.N. 016-1811) design plans.
7. Existing construction and foundation elements (sheet piles, drilled shafts, steel piles, etc.) are present at the proposed location of the East Abutment. Methods for resolving potential conflicts will be determined during the design phase.

* Interim Min. Vert. Cl.
** Final Min. Vert. Cl.
*** Spacing, tip elevation and Size to be determined during final design.
† Ground improvement shall be required for a distance of 30'-0" from the back of the E. Abutment (measured along the ℄). The stone Column design shall incorporate the overlapping areas with the main drain located along the south edge of proposed retaining wall.
†† Aggregate columns shall be spaced to avoid interfering with existing main drain (at south side of wall), existing utilities/foundation elements to remain and proposed utilities to be installed.

HIGHWAY CLASSIFICATION

Ramp NW
Functional Class: Interstate
ADT: 32,500 (2012); 36,000 (2040)
ADTT: 2,483 (2012); 2,730 (2040)
DHV: 2,790 (2040)
Design Speed: 35 m.p.h.
Posted Speed: 35 m.p.h.
One-Way Traffic
Directional Distribution: N/A

I-90/94 NB at Van Buren
Functional Class: Interstate
ADT: 96,700 (2012); 81,000 (2040)
ADTT: 11,217 (2012); 9,396 (2040)
DHV: 4,780 (2040)
Design Speed: 60 m.p.h.
Posted Speed: 45 m.p.h.
One-Way Traffic
Directional Distribution: 100%

Ramp NE
Functional Class: Interstate
ADT: 3,100 (2012); 4,000 (2040)
ADTT: 42 (2012); 55 (2040)
DHV: 280 (2040)
Design Speed: 30 m.p.h.
Posted Speed: 30 m.p.h.
One-Way Traffic
Directional Distribution: NA

NB Bypass
Functional Class: Interstate
ADT: NA (2012); 17,000 (2040)
ADTT: NA (2012); 440 (2040)
DHV: 1,680 (2040)
Design Speed: 30 m.p.h.
Posted Speed: 30 m.p.h.
One-Way Traffic
Directional Distribution: NA

LEGEND:

Soil Boring
Exist. High Mast Light Pole (to be removed)
Exist. Traffic Signal/ Light Pole (to be removed)
Fire Hydrant
Junction Box
Manhole
Combined Sewer
Electric — E —
Fiber Optic — FO —
Exist. Storm Sewer
Prop. Storm Sewer
Water Line — W —
Telephone — T —

GENERAL PLAN & ELEVATION - 2
RAMP EN OVER F.A.I. RTE. 90/94
(DAN RYAN EXPRESSWAY)
F.A.I. RTE. 90/94/290 - SECTION 2014-005R&B
COOK COUNTY
STATION 1609+49.73
STRUCTURE NO. 016-1712

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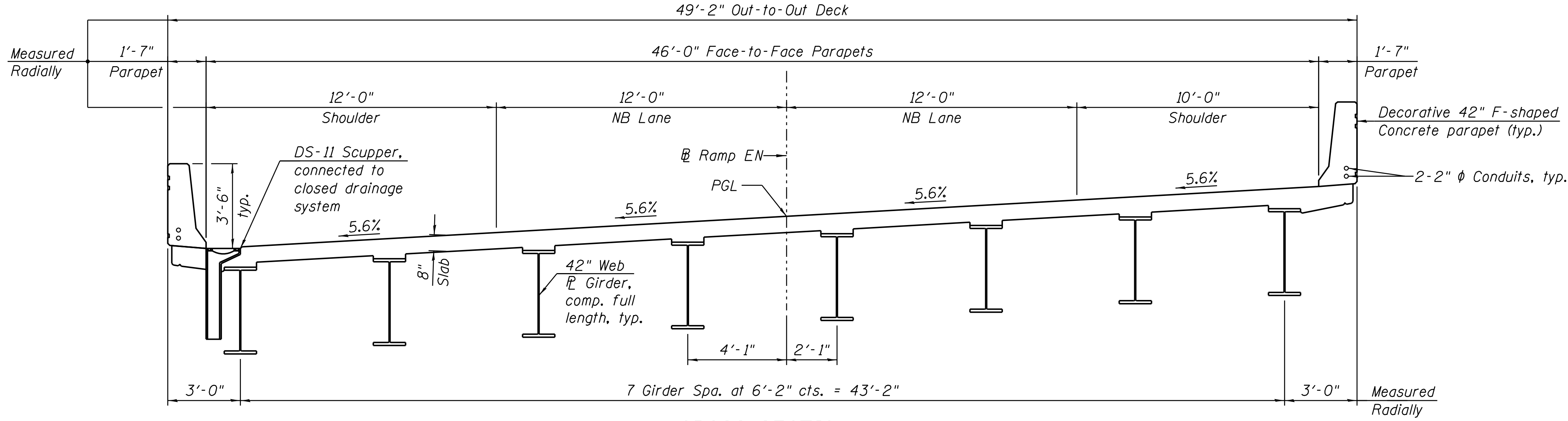
	DRAWN - JJS, KJD	REVISED -	
PLOT SCALE = 28.0 ' / in.	CHECKED - MAI, MI	REVISED -	
PLOT DATE = 9/13/2017	DATE - 09/13/2017	REVISED -	

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

STRUCTURE NO. 016-1712

SCALE: SHEET 2 OF 4 SHEETS STA. TO STA.

F.A.I. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
90/94/290	2014-005R&B	COOK	4	2
		CONTRACT NO. 60X79		
		ILLINOIS FED. AID PROJECT		



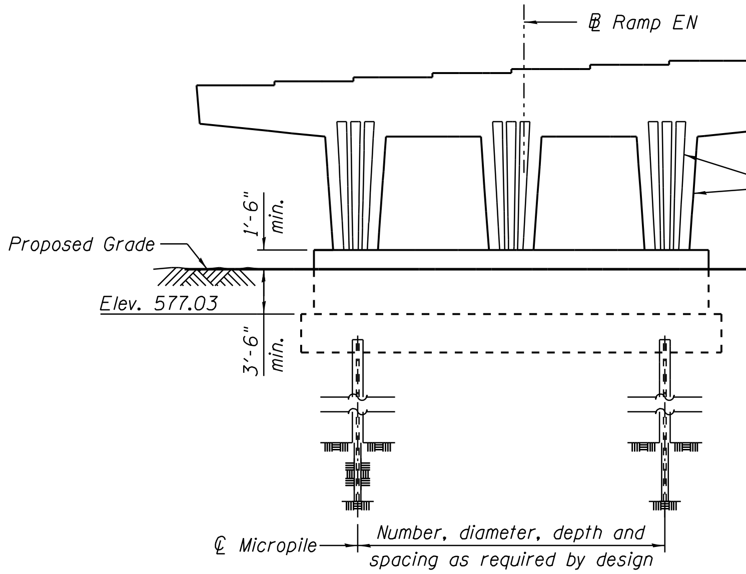
CROSS SECTION
(Looking Up-station)

NOTES:

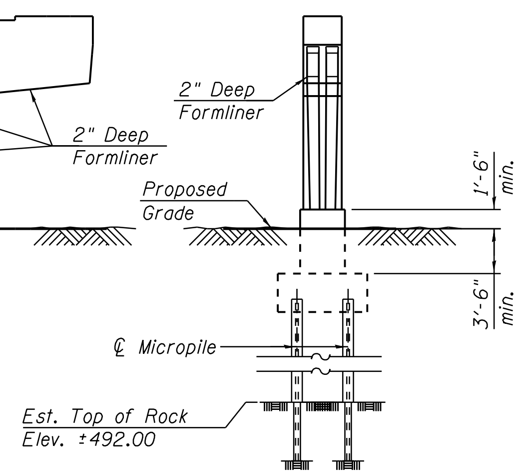
1. For Notes, See Sheet 2.

* Number, diameter/size, depth and spacing as required by design

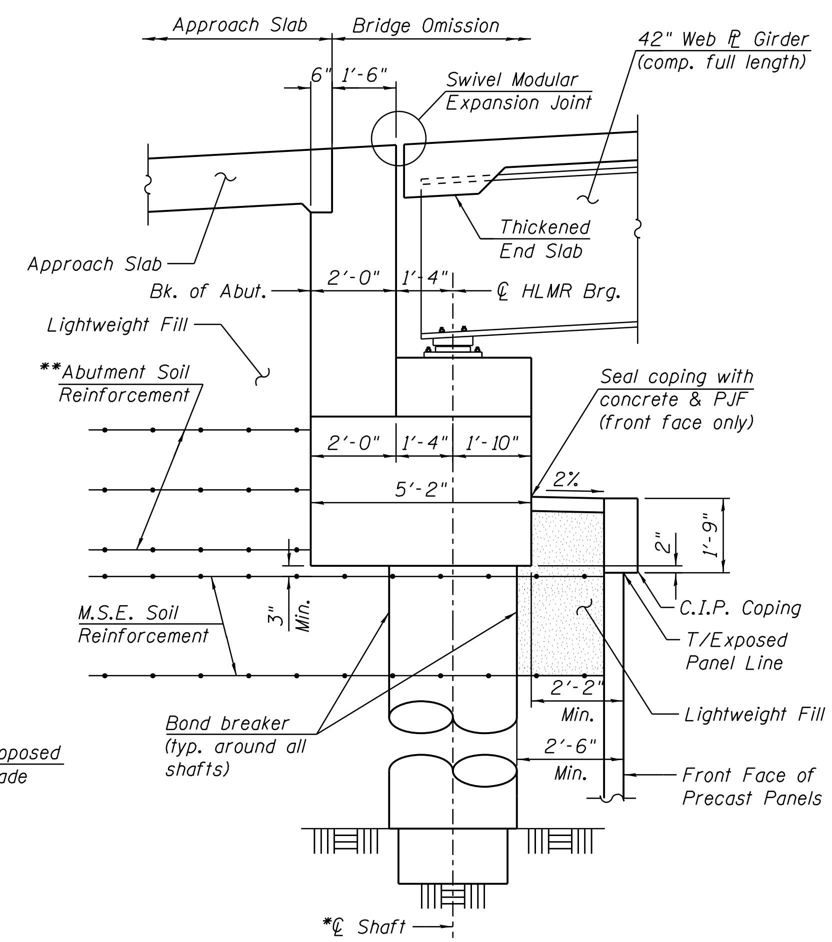
** Abutment Soil Reinforcement to resist lateral loads in lieu of drilled shafts. The MSE wall supplier shall design the abutment soil reinforcement to resist a horizontal force to be determined in final design.



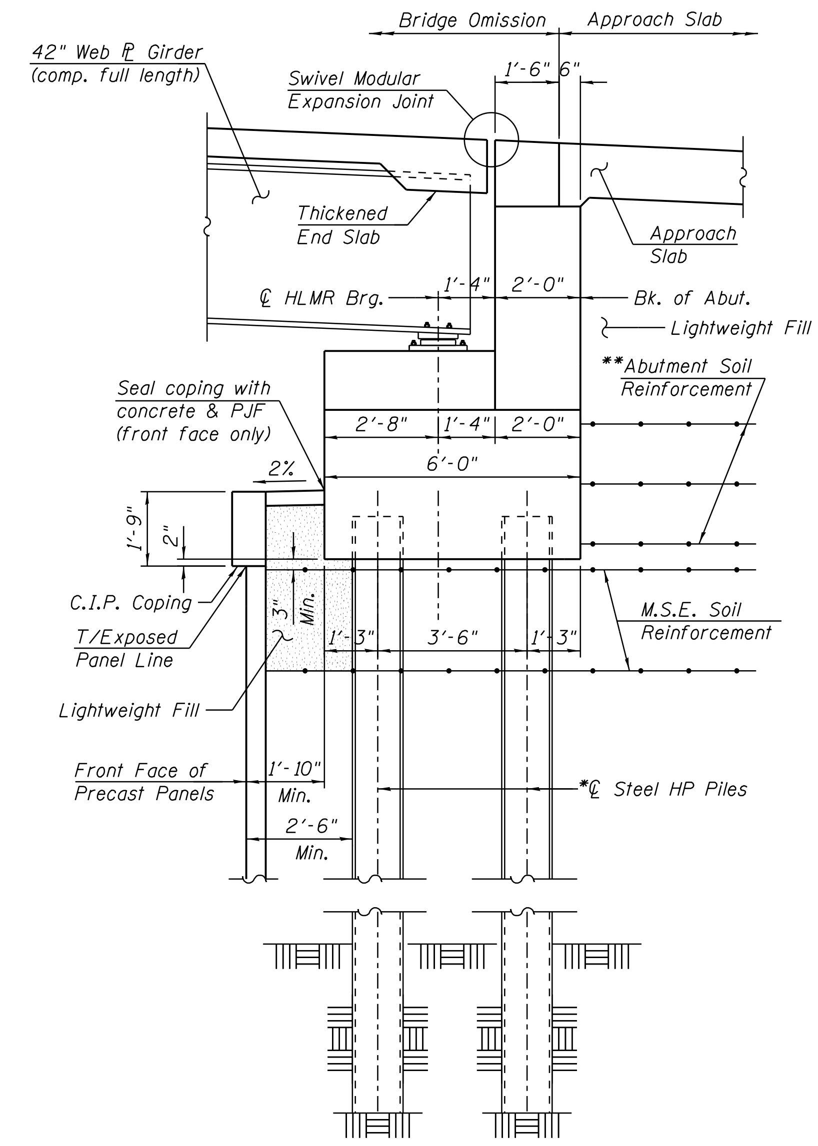
PIER 1 SKETCH
(Looking Up-station)



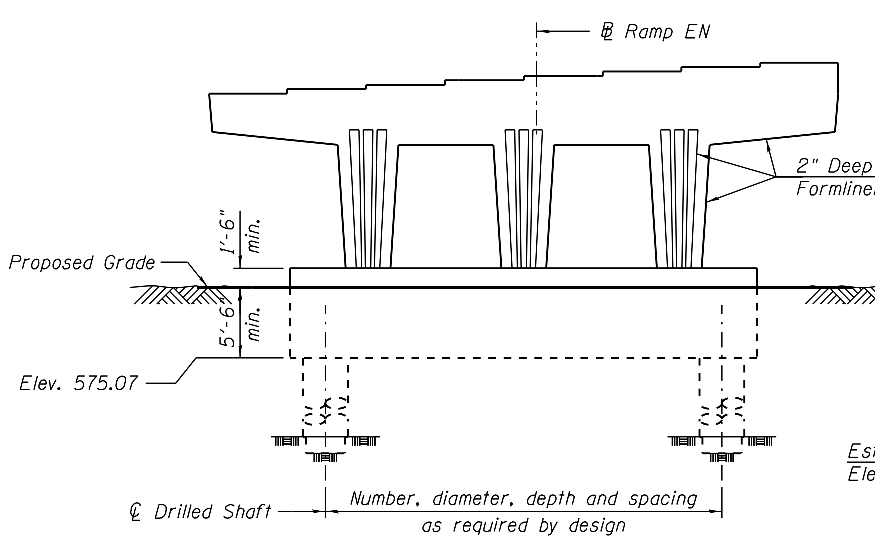
END VIEW



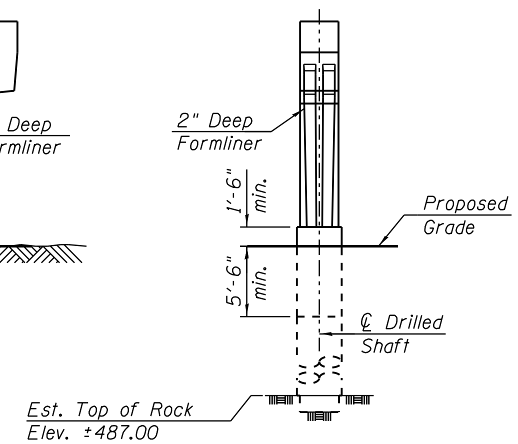
SECTION THRU WEST ABUTMENT
(Horiz. Dims. @ Rt. L's to ℄ Brg.)



SECTION THRU EAST ABUTMENT
(Horiz. Dims. @ Rt. L's to ℄ Brg.)



PIER 2 SKETCH
(Looking Up-station)



END VIEW

SECTIONS & DETAILS
RAMP EN OVER F.A.I. RTE. 90/94
(DAN RYAN EXPRESSWAY)
F.A.I. RTE. 90/94/290 - SECTION 2014-005R&B
COOK COUNTY
STATION 1609+49.73
STRUCTURE NO. 016-1712

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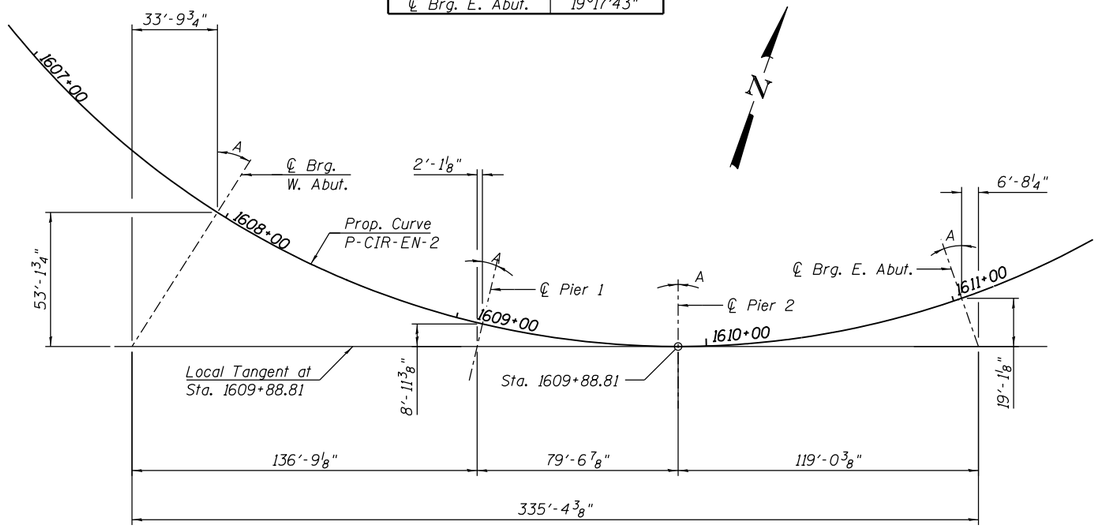
PLOT SCALE = 6:0.0000 ' / in.	CHECKED - MAI, MI	REVISED -	
PLOT DATE = 9/13/2017	DATE - 09/13/2017	REVISED -	

STRUCTURE NO. 016-1712

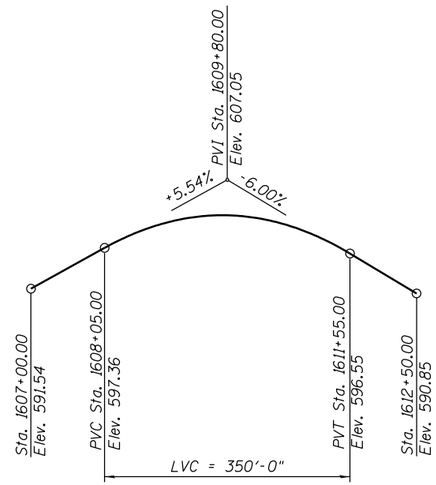
SCALE: | SHEET 3 OF 4 SHEETS | STA. | TO STA.

F.A.I. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
90/94/290	2014-005R&B	COOK	4	3
		CONTRACT NO. 60X79		
		ILLINOIS FED. AID PROJECT		

Location	A
℄ Brg. W. Abut.	32°28'03"
℄ Pier 1	13°10'21"
℄ Pier 2	00°00'00"
℄ Brg. E. Abut.	19°17'43"



OFFSET SKETCH



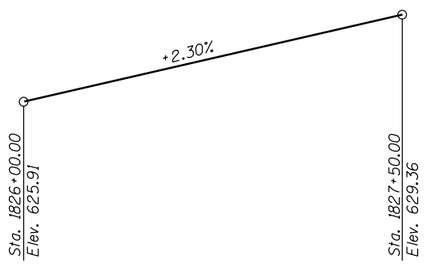
PROFILE GRADE

(Along ℄ Ramp EN)

CURVE DATA

(RAMP EN)
(PROP. CURVE P-CIR-EN-2)

PI STA. = 1624+41.43
Δ = 158° 32' 09" (LT)
D = 16° 51' 06"
R = 340.00'
T = 1,793.89'
L = 940.77'
E = 1,485.82'
e = 5.60%
T.R. = 36'
S.E. RUN = 102'
P.C. STA. = 1606+47.54
P.T. STA. = 1615+88.31
DS = 30
PS = 30



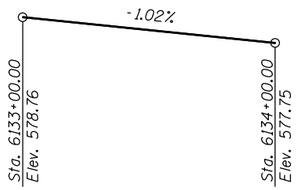
PROFILE GRADE

(Along ℄ Ramp NW)

CURVE DATA

(RAMP NW)
(Prop. Curve P-CIR-NW-6)

P.I. Sta. = 1831+44.22
Δ = 88° 30' 25" (LT)
D = 10° 36' 37"
R = 540.00'
T = 526.11'
L = 834.16'
E = 213.92'
e = 5.40%
T.R. = 39'
S.E. Run = 105'
P.C. Sta. = 1826+18.11
P.T. Sta. = 1834+52.27
DS = 35
PS = 35



PROFILE GRADE

(Along ℄ NB I-90/94)

CURVE DATA

(NB I-90/94)
(PROP. CURVE P-KDR-NB-3)

PI STA. = 6129+99.47
Δ = 11° 38' 44" (LT)
D = 1° 33' 16"
R = 3,686.00'
T = 375.89'
L = 749.19'
E = 19.12'
e = 3.80%
T.R. = 107'
S.E. RUN = 204'
P.C. STA. = 6126+23.58
P.T. STA. = 6133+72.77
DS = 60
PS = 45

PROFILE GRADE

(Along ℄ SB I-90/94)

CURVE DATA

(SB I-90/94)
(PROP. CURVE P-KDR-SB-4)

PI STA. = 6231+84.46
Δ = 13° 18' 21" (LT)
D = 2° 44' 34"
R = 2,089.00'
T = 243.66'
L = 485.13'
E = 14.16'
e = 4.40%
T.R. = NA
S.E. RUN = 164'
P.C. STA. = 6229+40.80
P.T. STA. = 6234+25.93
DS = 60
PS = 45

OFFSET SKETCH, PROFILE GRADE LINES AND CURVE DATA
RAMP EN OVER F.A.I. RTE. 90/94
(DAN RYAN EXPRESSWAY)
F.A.I. RTE. 90/94/290 - SECTION 2014-005R&B
COOK COUNTY
STATION 1609+49.73
STRUCTURE NO. 016-1712

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FAX: (708) 236-0901

USER NAME = Ken.drabant	DESIGNED - MI, JJS	REVISED -	
	DRAWN - KJD, MA	REVISED -	
PLOT SCALE = 60.0000 ' / in.	CHECKED - MAI, MI	REVISED -	
PLOT DATE = 9/13/2017	DATE - 09/13/2017	REVISED -	

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

STRUCTURE NO. 016-1712

SCALE: | SHEET 4 OF 4 SHEETS | STA. | TO STA.

F.A.I. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
90/94/290	2014-005R&B	COOK	4	4
		CONTRACT NO. 60X79		
	ILLINOIS FED. AID PROJECT			

FILE PATH = pw:\61479-PWINT.aecomonline.local:AECOM.DSO2.NA\Documents\01 Americas\Transportation\60269938 Circle\Phase 1\000 CAD\008 Structural\Bridge_016-1712\016712-60W00-0002-TSL-004