

CALCULATIONS

FOR

PROPOSED NORFOLK SOUTHERN RAILWAY COMPANY SHOOFLY BRIDGE

part of

**PROPOSED WIDENING OF I-70 AND ASSOCIATED REPLACEMENT OF THE NORFOLK
SOUTHERN RAILWAY COMPANY UNDERPASS BRIDGE**

MIDWEST DIVISION, MP S-45.25

WENTZVILLE

ST. CHARLES COUNTY, MO

MoDOT Job No. JST0020

Bridge No. A5801T



09-18-2025

Submitted By

HNTB Corporation

September 18, 2025

LONGITUDINAL FORCE DISTRIBUTION CALCULATIONS

HNTB	Prepared by: M. Ellis (M. Briggs)	Approved by: D. Evans	Document number: QF 06
Calculation Cover Sheet	Revision Number: 0 (KCO_2)	Revision Date: 01/22/16 (05/12/2017)	Page 1 of _____ (includes attachments)

Project: NSRR Shoofly over I-70	Job No: 71886	Design Criteria Document: (See Below)
Client: NSRR / MoDOT	Discipline: Bridge	Calculation No:

Name or Description of Calculation: Longitudinal Force Distribution Calculation

Calc. Rev. No.	Originator	Checker	Senior Technical Reviewer (if required)	Confirmation Required (Y/N)

Calculation Objective:

Determine longitudinal force distribution to substructure elements and respective substructure deflections

Calculation Methodology/List of Assumptions:

References/Inputs:

AREMA 2024

Attachments: (List each attachment following the subject calculation)

Conclusions:

See calculations

Document Check:	Name	Initials	Date
Originator:	Todd Kelley	TSK	7-17-2025
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Verifier:			

Applies to all pages unless noted otherwise (), attachments excluded.

**LONGITUDINAL FORCE
DISTRIBUTION
HAND CALCULATIONS**

Design Criteria

A. Design Code & References

1. AREMA 2024 - Chapters 8 and 15
2. Geotechnical parameters per Geotechnology Report number J032438.03 dated 4/6/2022

B. Materials

1. Drilled Shaft Concrete - $f'_c = 4500$ psi
2. Bent Cap and Abutment Concrete - $f'_c = 4500$ psi
3. Rebar - Gr 60
4. Piles are HP14x117

C. Design Software

1. CSI Bridge
2. SPcolumn

D. Design Assumptions

1. Assume final grade elevations from preliminary grading
2. Ignore stiffness of drilled shaft steel casing
3. Ground elevation for all locations below low chord listed in calcs below
4. Fixity is assumed as 8(diameters) for the steel pile, 6(diameters) for the drilled shaft below grade.
Abutment fixity set at 11.33' from cap centerline to account for top layer frost considerations.
5. One abutment is removed and excluded from the model, expansion bearing location
6. Soil assumptions are based on B-11 and B-16

Longitudinal Force Distribution and Deflection

Assumptions:

- Assume abutment backfill soil parameters for passive resistance
- Assume an uncracked drilled shaft section (use gross moment of inertia)

Substructure Element Section Info

All Piles are HP14x117

- Bents 1-5 and 8-9 are 4 pile bents
- Bents 6 and 7 have (2) 48" dia drilled shaft/columns
- Assume clearance to low chord is 23' at all locations except bent 2+8 and abutment

Drilled Shaft Diameter $D_{ds} := 48 \text{ in}$

Drilled shaft cap depth $D_{dsc} := 5 \text{ ft}$

Bent Fixity for the model

Abutments - 1/2 cap depth plus 8xdia pile

$$H_{abut} := \frac{2 \text{ ft}}{2} + 8 \cdot 14 \text{ in} = 10.3 \text{ ft}$$

Bents 2,8 - 1/2 cap depth plus height to GL plus 8xdia pile - assume 8 ft to GL

$$H_{bent28} := \frac{2.67 \text{ ft}}{2} + 8 \text{ ft} + 8 \cdot 14 \text{ in} = 18.7 \text{ ft}$$

Bents 3,4,5 - 1/2 cap depth plus height to GL plus 8xdia pile - assume 23 ft to GL

$$H_{bent345} := \frac{2.67 \text{ ft}}{2} + 23 \text{ ft} + 8 \cdot 14 \text{ in} = 33.7 \text{ ft}$$

Bents 6+7 - 1/2 cap depth plus height to GL plus 6xdia pile - assume 23 ft to GL

$$H_{bent67} := \frac{5 \text{ ft}}{2} + 23 \text{ ft} + 6 \cdot 48 \text{ in} = 49.5 \text{ ft}$$

For bents 6 and 7 top of rock will control over the 6D depth, top of rock

$$H_{bent67Rock} := 636.97 \text{ ft} - 607 \text{ ft} + \frac{5 \text{ ft}}{2} = 32.5 \text{ ft}$$

Longitudinal Force (LF) - AREMA 8-2.2.3.j(1)

Bridge Length (ft)	$L_{br} := 390$	
Braking Force (kip)	$F_{br} := 4.5 + 1.2 \cdot L_{br} = 472.5$	
Traction Force (kip)	$F_{tr} := 25 \cdot \sqrt{L_{br}} = 493.7$	
Total Longitudinal Force	$V_{LF.tot} := \max(F_{br}, F_{tr}) \cdot 1 \text{ kip} = 494 \text{ kip}$	
Soil Unit Weight	$\gamma_s := 125 \text{ pcf}$	assumed
Passive Soil Coeff.	$k_p := 2.77$	
Depth from Top of Tie to 3ft - assume top 3' not included due to frost	$d_1 := 3 \text{ ft}$	assume 8" ballast and 7" tie
Depth from T/T to Bottom of Abutment Cap	$d_2 := 6.75 \text{ ft}$	
Length of Abutment	$L_A := 16.75 \text{ ft}$	
Passive Soil Pressure at Top of Abutment Backwall	$w_{p1} := \gamma_s \cdot k_p \cdot d_1 \cdot L_A = 17.4 \text{ klf}$	
Passive Soil Pressure at Bottom of Abutment Cap	$w_{p2} := \gamma_s \cdot k_p \cdot d_2 \cdot L_A = 39.1 \text{ klf}$	
Total Passive Force Acting Behind Abutment	$F_p := w_{p1} \cdot (d_2 - d_1) + (w_{p2} - w_{p1}) \cdot \frac{(d_2 - d_1)}{2} = 106 \text{ kip}$	
Reduced LF	$V_{LF.tot.red} := V_{LF.tot} - F_p = 387.7 \text{ kip}$	

LF Distribution

CSI model

CSI MODEL OUTPUT

Table: Case - Static 1 - Load Assignments

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Case	LoadType	LoadName	LoadSF
Long	Load pattern	Long	1.

Table: Connectivity - Frame, Part 1 of 2

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Frame	JointI	JointJ	IsCurved	Length ft	CentroidX ft	CentroidY ft	CentroidZ ft
1	1	2	No	10.3	0.	-6.	14.85
2	3	4	No	10.3	0.	-2.	14.85
3	46	56	No	48.	234.33	0.	20.
4	7	8	No	10.3	0.	2.	14.85
5	9	10	No	10.3	0.	6.	14.85
6	11	12	No	18.7	37.33	-5.2	10.65
7	13	14	No	18.7	35.33	-1.73	10.65
8	56	66	No	48.	282.33	0.	20.
9	17	18	No	18.7	33.33	1.73	10.65
10	19	20	No	18.7	31.33	5.2	10.65
12	23	24	No	33.	84.96	-4.55	3.5
14	27	28	No	33.	79.71	4.55	3.5
17	33	34	No	33.	188.38	-4.55	3.5
19	37	38	No	33.	183.13	4.55	3.5
21	41	42	No	32.	213.33	-5.2	4.
22	43	44	No	32.	211.33	-1.73	4.
24	47	48	No	32.	209.33	1.73	4.
25	49	50	No	32.	207.33	5.2	4.
26	51	52	No	32.	261.33	-5.2	4.
27	53	54	No	32.	259.33	-1.73	4.
29	57	58	No	32.	257.33	1.73	4.
30	59	60	No	32.	255.33	5.2	4.
31	61	62	No	32.	309.33	-5.2	4.
32	63	64	No	32.	307.33	-1.73	4.
34	67	68	No	32.	305.33	1.73	4.
35	69	70	No	32.	303.33	5.2	4.
36	71	72	No	18.7	357.33	-5.2	10.65
37	73	74	No	18.7	355.33	-1.73	10.65
39	77	78	No	18.7	353.33	1.73	10.65
40	79	80	No	18.7	351.33	5.2	10.65
62	6	16	No	34.33	17.165	0.	20.
63	16	26	No	48.	58.33	0.	20.
64	26	36	No	103.42	134.04	0.	20.
65	36	46	No	24.58	198.04	0.	20.
68	66	76	No	48.	330.33	0.	20.
86	2	4	No	4.	0.	-4.	20.
87	4	6	No	2.	0.	-1.	20.
88	6	8	No	2.	0.	1.	20.
89	8	10	No	4.	0.	4.	20.
90	12	14	No	4.0051	36.33	-3.465	20.
91	14	16	No	1.9982	34.83	-0.865	20.
92	16	18	No	1.9982	33.83	0.865	20.

Table: Connectivity - Frame, Part 1 of 2

Frame	JointI	JointJ	IsCurved	Length ft	CentroidX ft	CentroidY ft	CentroidZ ft
93	18	20	No	4.0051	32.33	3.465	20.
94	22	24	No	3.0017	85.71	-5.85	20.
95	24	26	No	5.2554	83.645	-2.275	20.
96	26	28	No	5.2504	81.02	2.275	20.
97	28	30	No	3.0017	78.96	5.85	20.
98	32	34	No	3.0017	189.13	-5.85	20.
99	34	36	No	5.2554	187.065	-2.275	20.
100	36	38	No	5.2504	184.44	2.275	20.
101	38	40	No	3.0017	182.38	5.85	20.
102	42	44	No	4.0051	212.33	-3.465	20.
103	44	46	No	1.9982	210.83	-0.865	20.
104	46	48	No	1.9982	209.83	0.865	20.
105	48	50	No	4.0051	208.33	3.465	20.
106	52	54	No	4.0051	260.33	-3.465	20.
107	54	56	No	1.9982	258.83	-0.865	20.
108	56	58	No	1.9982	257.83	0.865	20.
109	58	60	No	4.0051	256.33	3.465	20.
110	62	64	No	4.0051	308.33	-3.465	20.
111	64	66	No	1.9982	306.83	-0.865	20.
112	66	68	No	1.9982	305.83	0.865	20.
113	68	70	No	4.0051	304.33	3.465	20.
114	72	74	No	4.0051	356.33	-3.465	20.
115	74	76	No	1.9982	354.83	-0.865	20.
116	76	78	No	1.9982	353.83	0.865	20.
117	78	80	No	4.0051	352.33	3.465	20.

Table: Connectivity - Frame, Part 2 of 2

Table: Connectivity - Frame, Part 2 of 2

Frame	GUID
1	688cad7b-5cf3-4c9e-8760-305322e94d1e
2	fc4f2515-c3ac-4765-81af-8a977e051f27
3	f2a08c08-5726-4a9c-92e-b-d917b72c9c1a
4	6bef8725-feca-49cc-905d-5e18ec24ba27
5	21fbef05-c2f9-41c7-99d1-048ef83a3ea5
6	ac7b4bea-595d-4f65-a684-e4aff47ec303
7	a8659b02-6ca0-44b2-a0dd-6ff9e02d95fd
8	618d4abd-b277-452d-8ad9-4a1a8686e2dc
9	1af5a104-c7ef-4f34-9e90-a309e6d95e29
10	ee47a514-53ae-4daf-b4fc-71118f7f8452
12	2b58b1b7-edee-4863-a22f-f97f88d66de6
14	c469b669-e395-411a-adb8-9defd165345f

Table: Connectivity - Frame, Part 2 of 2

Frame	GUID
17	06b06b40-af30-4c06-8268-176eb0b06336
19	70e0c492-0200-4655-8f81-fc36765dd9c1
21	744d5c7d-1a7a-4f34-a4ea-7b3908dd8b87
22	159097b5-7c12-41f1-b9be-9f62779c80bd
24	0115949a-09a3-4ebc-94c6-9f13621e69b2
25	2af2ce39-d4fe-4b4b-992e-e01ed0583fe3
26	09b9305a-3475-4a2a-bea6-2e3d5dff32a0
27	d4c7b1e8-2f50-4321-86e2-a854a110004a
29	bbdfbe2c-1668-4c69-9334-de0efe66df62
30	ddfe060e-4ed8-4676-a9fa-a53f1dbc9c40
31	c3bc1c13-6f6a-4031-a810-5b2481752ce8
32	df337291-7978-4293-880d-4ca9527c9b91
34	73648eaf-c08a-41fb-8734-07b29bbf947c
35	3b26f126-4f83-42a4-a4f6-9e5658a805ef
36	02a857b0-ac2e-403a-b407-546528a9cca1
37	08d8cd53-ee87-4b7b-b12c-b6139dbe2b0b
39	30f41c05-2d9d-4f77-ab22-7ee2740132c1
40	b1816ad9-9369-4cf5-a921-cfd84e53fd4b
62	5cdbe076-9de4-410b-a291-3229ff351d1e
63	fa560ef2-acf4-4277-860d-c1731f35a34a
64	1cd9d482-6748-4ce5-b856-5e5515709a81
65	69be5a98-98be-4931-aff4-40498b1ac926
68	d31b7a6f-e96a-4292-90e9-8de60e192d7f
86	9c011e44-e6cc-4efc-9d1b-b5aaa4672571
87	e44a0cb7-d339-491d-9899-cf1dc2c6436b
88	eea0562a-0d0c-44b8-85a5-a61d278fa5a8
89	c147a013-444b-47ba-9f71-fcd880aadaa7
90	ab60e17b-2687-40d1-bc76-fb8b62940751
91	c1eba3d9-97d0-4087-8a53-827d96c989c3
92	cc7219ff-6e6a-4da6-b339-a21ec786b0ee

Table: Connectivity - Frame, Part 2 of 2

Frame	GUID
93	f47115bc-25e3-45cc-8668-ed8f9f70cce4
94	2eb9f58f-7500-4b1e-80c6-244ead72e0c7
95	c8bbc182-14ae-485e-b098-fff137ed908b
96	0359f918-98e8-494e-b789-b05a0121b12b
97	8677d033-7e33-4319-9461-335344152926
98	fc53831d-b6d4-4fcc-8254-921efd2197d4
99	21a9c245-40e6-40e4-9dcc-0f472ec5a4cf
100	50ed4542-8512-4617-9c91-d9fa0950e411
101	5cbf367e-b34a-4784-bd61-958e92336da0
102	046cf17d-c13a-42e7-883f-d4ed2195d159
103	4044a69c-3245-4220-b662-00256e10eef1
104	62e2630d-2ed5-4041-ac96-ac68cf72d8ec
105	acc904dc-9dc1-4fe3-8da4-72da1bd697e2
106	b64bc330-8af7-4bed-942f-f358a9456183
107	d15f1221-79fa-45a6-93b6-507decdae8bd
108	e1dc9db3-89a1-4e6f-b3d3-07c249109062
109	2e4c9d13-a0d9-4ddd-b0b5-fa69bc2a5682
110	e5f03aa0-a396-410c-a639-63dbc6c7eb37
111	76e4bd63-f95c-4c69-bef8-5fe5eab218d2
112	a6cd74db-1f72-41a5-8ca4-a61b2142d46a4
113	ca80f4db-8673-4980-be6d-f501d292fc4c
114	c2d9716c-598f-4ab3-90c4-f3a948bbdfc3
115	21ab93cb-c66d-4e77-8342-89678aace83d
116	f83ce018-8820-4f5b-bba9-25c624bcfe54
117	2818bfd2-4a8a-4dae-9c37-94058e0162ec

Table: Element Forces - Frames, Part 1 of 2**Table: Element Forces - Frames, Part 1 of 2**

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
1	0.	Long	LinStatic	24.809	28.556	0.19	-0.0098	1.0101
1	5.15	Long	LinStatic	24.809	28.556	0.19	-0.0098	0.0331

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
1	10.3	Long	LinStatic	24.809	28.556	0.19	-0.0098	-0.944
1	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
1	5.15	Wind Long	LinStatic	0.	0.	0.	0.	0.
1	10.3	Wind Long	LinStatic	0.	0.	0.	0.	0.
2	0.	Long	LinStatic	19.959	30.037	-0.19	-0.0059	-0.2628
2	5.15	Long	LinStatic	19.959	30.037	-0.19	-0.0059	0.7142
2	10.3	Long	LinStatic	19.959	30.037	-0.19	-0.0059	1.6913
2	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
2	5.15	Wind Long	LinStatic	0.	0.	0.	0.	0.
2	10.3	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	0.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	0.
3	2.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-6.519E-07
3	4.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-1.304E-06
3	6.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-1.956E-06
3	8.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-2.608E-06
3	10.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-3.260E-06
3	12.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-3.912E-06
3	14.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-4.563E-06
3	16.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-5.215E-06
3	18.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-5.867E-06
3	20.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-6.519E-06
3	22.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-7.171E-06
3	24.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-7.823E-06
3	26.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-8.475E-06
3	28.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-9.127E-06
3	30.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-9.779E-06
3	32.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-1.043E-05
3	34.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-1.108E-05
3	36.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-1.173E-05
3	38.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-1.239E-05
3	40.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-1.304E-05
3	42.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-1.369E-05
3	44.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-1.434E-05
3	46.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-1.499E-05
3	48.	Long	LinStatic	-33.352	-1.826E-19	3.260E-07	-36.4319	-1.565E-05
3	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	2.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	4.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	6.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	8.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	10.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	12.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	14.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	16.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	18.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	20.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	22.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	24.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	26.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	28.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	30.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	32.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	34.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	36.	Wind Long	LinStatic	0.	0.	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
3	38.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	40.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	42.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	44.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	46.	Wind Long	LinStatic	0.	0.	0.	0.	0.
3	48.	Wind Long	LinStatic	0.	0.	0.	0.	0.
4	0.	Long	LinStatic	-19.959	30.037	-0.19	0.0059	-0.2628
4	5.15	Long	LinStatic	-19.959	30.037	-0.19	0.0059	0.7142
4	10.3	Long	LinStatic	-19.959	30.037	-0.19	0.0059	1.6913
4	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
4	5.15	Wind Long	LinStatic	0.	0.	0.	0.	0.
4	10.3	Wind Long	LinStatic	0.	0.	0.	0.	0.
5	0.	Long	LinStatic	-24.809	28.556	0.19	0.0098	1.0101
5	5.15	Long	LinStatic	-24.809	28.556	0.19	0.0098	0.0331
5	10.3	Long	LinStatic	-24.809	28.556	0.19	0.0098	-0.944
5	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
5	5.15	Wind Long	LinStatic	0.	0.	0.	0.	0.
5	10.3	Wind Long	LinStatic	0.	0.	0.	0.	0.
6	0.	Long	LinStatic	-30.709	7.1	-4.234	-0.0013	-40.055
6	9.35	Long	LinStatic	-30.709	7.1	-4.234	-0.0013	-0.4714
6	18.7	Long	LinStatic	-30.709	7.1	-4.234	-0.0013	39.1123
6	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
6	9.35	Wind Long	LinStatic	0.	0.	0.	0.	0.
6	18.7	Wind Long	LinStatic	0.	0.	0.	0.	0.
7	0.	Long	LinStatic	-14.31	7.472	-4.18	-8.065E-04	-39.723
7	9.35	Long	LinStatic	-14.31	7.472	-4.18	-8.065E-04	-0.6441
7	18.7	Long	LinStatic	-14.31	7.472	-4.18	-8.065E-04	38.4348
7	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
7	9.35	Wind Long	LinStatic	0.	0.	0.	0.	0.
7	18.7	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	0.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	0.
8	2.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	3.909E-07
8	4.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	7.817E-07
8	6.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	1.173E-06
8	8.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	1.563E-06
8	10.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	1.954E-06
8	12.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	2.345E-06
8	14.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	2.736E-06
8	16.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	3.127E-06
8	18.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	3.518E-06
8	20.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	3.909E-06
8	22.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	4.299E-06
8	24.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	4.690E-06
8	26.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	5.081E-06
8	28.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	5.472E-06
8	30.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	5.863E-06
8	32.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	6.254E-06
8	34.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	6.645E-06
8	36.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	7.035E-06
8	38.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	7.426E-06
8	40.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	7.817E-06
8	42.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	8.208E-06
8	44.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	8.599E-06
8	46.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	8.990E-06

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
8	48.	Long	LinStatic	-28.648	0.	-1.954E-07	-28.71	9.381E-06
8	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	2.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	4.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	6.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	8.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	10.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	12.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	14.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	16.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	18.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	20.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	22.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	24.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	26.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	28.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	30.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	32.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	34.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	36.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	38.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	40.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	42.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	44.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	46.	Wind Long	LinStatic	0.	0.	0.	0.	0.
8	48.	Wind Long	LinStatic	0.	0.	0.	0.	0.
9	0.	Long	LinStatic	14.31	7.472	-4.18	8.065E-04	-39.723
9	9.35	Long	LinStatic	14.31	7.472	-4.18	8.065E-04	-0.6441
9	18.7	Long	LinStatic	14.31	7.472	-4.18	8.065E-04	38.4348
9	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
9	9.35	Wind Long	LinStatic	0.	0.	0.	0.	0.
9	18.7	Wind Long	LinStatic	0.	0.	0.	0.	0.
10	0.	Long	LinStatic	30.709	7.1	-4.234	0.0013	-40.055
10	9.35	Long	LinStatic	30.709	7.1	-4.234	0.0013	-0.4714
10	18.7	Long	LinStatic	30.709	7.1	-4.234	0.0013	39.1123
10	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
10	9.35	Wind Long	LinStatic	0.	0.	0.	0.	0.
10	18.7	Wind Long	LinStatic	0.	0.	0.	0.	0.
12	0.	Long	LinStatic	-51.669	27.302	-15.763	-2.2282	-275.2902
12	16.5	Long	LinStatic	-51.669	27.302	-15.763	-2.2282	-15.2066
12	33.	Long	LinStatic	-51.669	27.302	-15.763	-2.2282	244.877
12	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
12	16.5	Wind Long	LinStatic	0.	0.	0.	0.	0.
12	33.	Wind Long	LinStatic	0.	0.	0.	0.	0.
14	0.	Long	LinStatic	51.669	27.301	-15.762	2.2201	-275.2845
14	16.5	Long	LinStatic	51.669	27.301	-15.762	2.2201	-15.2077
14	33.	Long	LinStatic	51.669	27.301	-15.762	2.2201	244.8691
14	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
14	16.5	Wind Long	LinStatic	0.	0.	0.	0.	0.
14	33.	Wind Long	LinStatic	0.	0.	0.	0.	0.
17	0.	Long	LinStatic	-44.637	26.582	-15.347	-2.1694	-266.9153
17	16.5	Long	LinStatic	-44.637	26.582	-15.347	-2.1694	-13.6961
17	33.	Long	LinStatic	-44.637	26.582	-15.347	-2.1694	239.523
17	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
17	16.5	Wind Long	LinStatic	0.	0.	0.	0.	0.
17	33.	Wind Long	LinStatic	0.	0.	0.	0.	0.
19	0.	Long	LinStatic	44.637	26.58	-15.346	2.1616	-266.9123
19	16.5	Long	LinStatic	44.637	26.58	-15.346	2.1616	-13.6958
19	33.	Long	LinStatic	44.637	26.58	-15.346	2.1616	239.5207
19	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
19	16.5	Wind Long	LinStatic	0.	0.	0.	0.	0.
19	33.	Wind Long	LinStatic	0.	0.	0.	0.	0.
21	0.	Long	LinStatic	-1.214	0.882	-0.506	-9.684E-05	-8.1338
21	16.	Long	LinStatic	-1.214	0.882	-0.506	-9.684E-05	-0.0446
21	32.	Long	LinStatic	-1.214	0.882	-0.506	-9.684E-05	8.0445
21	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
21	16.	Wind Long	LinStatic	0.	0.	0.	0.	0.
21	32.	Wind Long	LinStatic	0.	0.	0.	0.	0.
22	0.	Long	LinStatic	-0.178	0.877	-0.51	-5.801E-05	-8.1843
22	16.	Long	LinStatic	-0.178	0.877	-0.51	-5.801E-05	-0.0193
22	32.	Long	LinStatic	-0.178	0.877	-0.51	-5.801E-05	8.1457
22	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
22	16.	Wind Long	LinStatic	0.	0.	0.	0.	0.
22	32.	Wind Long	LinStatic	0.	0.	0.	0.	0.
24	0.	Long	LinStatic	0.178	0.877	-0.51	5.801E-05	-8.1843
24	16.	Long	LinStatic	0.178	0.877	-0.51	5.801E-05	-0.0193
24	32.	Long	LinStatic	0.178	0.877	-0.51	5.801E-05	8.1457
24	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
24	16.	Wind Long	LinStatic	0.	0.	0.	0.	0.
24	32.	Wind Long	LinStatic	0.	0.	0.	0.	0.
25	0.	Long	LinStatic	1.214	0.882	-0.506	9.684E-05	-8.1338
25	16.	Long	LinStatic	1.214	0.882	-0.506	9.684E-05	-0.0446
25	32.	Long	LinStatic	1.214	0.882	-0.506	9.684E-05	8.0445
25	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
25	16.	Wind Long	LinStatic	0.	0.	0.	0.	0.
25	32.	Wind Long	LinStatic	0.	0.	0.	0.	0.
26	0.	Long	LinStatic	-1.782	1.175	-1.569E-04	-1.117E-04	3.3154
26	16.	Long	LinStatic	-1.782	1.175	-1.569E-04	-1.117E-04	3.3179
26	32.	Long	LinStatic	-1.782	1.175	-1.569E-04	-1.117E-04	3.3204
26	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
26	16.	Wind Long	LinStatic	0.	0.	0.	0.	0.
26	32.	Wind Long	LinStatic	0.	0.	0.	0.	0.
27	0.	Long	LinStatic	-0.71	1.18	1.572E-04	-6.698E-05	3.3209
27	16.	Long	LinStatic	-0.71	1.18	1.572E-04	-6.698E-05	3.3184
27	32.	Long	LinStatic	-0.71	1.18	1.572E-04	-6.698E-05	3.3159
27	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
27	16.	Wind Long	LinStatic	0.	0.	0.	0.	0.
27	32.	Wind Long	LinStatic	0.	0.	0.	0.	0.
29	0.	Long	LinStatic	0.71	1.18	1.572E-04	6.698E-05	3.3209
29	16.	Long	LinStatic	0.71	1.18	1.572E-04	6.698E-05	3.3184
29	32.	Long	LinStatic	0.71	1.18	1.572E-04	6.698E-05	3.3159
29	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
29	16.	Wind Long	LinStatic	0.	0.	0.	0.	0.
29	32.	Wind Long	LinStatic	0.	0.	0.	0.	0.
30	0.	Long	LinStatic	1.782	1.175	-1.569E-04	1.117E-04	3.3154
30	16.	Long	LinStatic	1.782	1.175	-1.569E-04	1.117E-04	3.3179
30	32.	Long	LinStatic	1.782	1.175	-1.569E-04	1.117E-04	3.3204
30	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
30	16.	Wind Long	LinStatic	0.	0.	0.	0.	0.
30	32.	Wind Long	LinStatic	0.	0.	0.	0.	0.
31	0.	Long	LinStatic	1.735	0.705	-0.398	-7.724E-05	-6.3685
31	16.	Long	LinStatic	1.735	0.705	-0.398	-7.724E-05	-0.008
31	32.	Long	LinStatic	1.735	0.705	-0.398	-7.724E-05	6.3526
31	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
31	16.	Wind Long	LinStatic	0.	0.	0.	0.	0.
31	32.	Wind Long	LinStatic	0.	0.	0.	0.	0.
32	0.	Long	LinStatic	1.146	0.686	-0.406	-4.620E-05	-6.4567
32	16.	Long	LinStatic	1.146	0.686	-0.406	-4.620E-05	0.0363
32	32.	Long	LinStatic	1.146	0.686	-0.406	-4.620E-05	6.5294
32	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
32	16.	Wind Long	LinStatic	0.	0.	0.	0.	0.
32	32.	Wind Long	LinStatic	0.	0.	0.	0.	0.
34	0.	Long	LinStatic	-1.146	0.686	-0.406	4.620E-05	-6.4567
34	16.	Long	LinStatic	-1.146	0.686	-0.406	4.620E-05	0.0363
34	32.	Long	LinStatic	-1.146	0.686	-0.406	4.620E-05	6.5294
34	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
34	16.	Wind Long	LinStatic	0.	0.	0.	0.	0.
34	32.	Wind Long	LinStatic	0.	0.	0.	0.	0.
35	0.	Long	LinStatic	-1.735	0.705	-0.398	7.724E-05	-6.3685
35	16.	Long	LinStatic	-1.735	0.705	-0.398	7.724E-05	-0.008
35	32.	Long	LinStatic	-1.735	0.705	-0.398	7.724E-05	6.3526
35	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
35	16.	Wind Long	LinStatic	0.	0.	0.	0.	0.
35	32.	Wind Long	LinStatic	0.	0.	0.	0.	0.
36	0.	Long	LinStatic	-14.281	5.437	-3.178	-0.001	-30.0079
36	9.35	Long	LinStatic	-14.281	5.437	-3.178	-0.001	-0.294
36	18.7	Long	LinStatic	-14.281	5.437	-3.178	-0.001	29.4198
36	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
36	9.35	Wind Long	LinStatic	0.	0.	0.	0.	0.
36	18.7	Wind Long	LinStatic	0.	0.	0.	0.	0.
37	0.	Long	LinStatic	-5.581	5.576	-3.18	-6.149E-04	-30.0251
37	9.35	Long	LinStatic	-5.581	5.576	-3.18	-6.149E-04	-0.2877
37	18.7	Long	LinStatic	-5.581	5.576	-3.18	-6.149E-04	29.4497
37	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
37	9.35	Wind Long	LinStatic	0.	0.	0.	0.	0.
37	18.7	Wind Long	LinStatic	0.	0.	0.	0.	0.
39	0.	Long	LinStatic	5.581	5.576	-3.18	6.149E-04	-30.0251
39	9.35	Long	LinStatic	5.581	5.576	-3.18	6.149E-04	-0.2877
39	18.7	Long	LinStatic	5.581	5.576	-3.18	6.149E-04	29.4497
39	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
39	9.35	Wind Long	LinStatic	0.	0.	0.	0.	0.
39	18.7	Wind Long	LinStatic	0.	0.	0.	0.	0.
40	0.	Long	LinStatic	14.281	5.437	-3.178	0.001	-30.0079
40	9.35	Long	LinStatic	14.281	5.437	-3.178	0.001	-0.294
40	18.7	Long	LinStatic	14.281	5.437	-3.178	0.001	29.4198
40	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
40	9.35	Wind Long	LinStatic	0.	0.	0.	0.	0.
40	18.7	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	0.	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	0.
62	1.9072	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	2.295E-07
62	3.8144	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	4.590E-07
62	5.7217	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	6.884E-07

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
62	7.6289	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	9.179E-07
62	9.5361	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	1.147E-06
62	11.4433	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	1.377E-06
62	13.3506	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	1.606E-06
62	15.2578	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	1.836E-06
62	17.165	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	2.065E-06
62	19.0722	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	2.295E-06
62	20.9794	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	2.524E-06
62	22.8867	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	2.754E-06
62	24.7939	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	2.983E-06
62	26.7011	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	3.213E-06
62	28.6083	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	3.442E-06
62	30.5156	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	3.672E-06
62	32.4228	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	3.901E-06
62	34.33	Long	LinStatic	-195.516	7.212E-20	-1.203E-07	-379.0322	4.131E-06
62	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	1.9072	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	3.8144	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	5.7217	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	7.6289	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	9.5361	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	11.4433	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	13.3506	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	15.2578	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	17.165	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	19.0722	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	20.9794	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	22.8867	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	24.7939	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	26.7011	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	28.6083	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	30.5156	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	32.4228	Wind Long	LinStatic	0.	0.	0.	0.	0.
62	34.33	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	0.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	0.
63	2.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-1.363E-06
63	4.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-2.725E-06
63	6.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-4.088E-06
63	8.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-5.451E-06
63	10.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-6.813E-06
63	12.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-8.176E-06
63	14.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-9.539E-06
63	16.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-1.090E-05
63	18.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-1.226E-05
63	20.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-1.363E-05
63	22.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-1.499E-05
63	24.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-1.635E-05
63	26.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-1.771E-05
63	28.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-1.908E-05
63	30.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-2.044E-05
63	32.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-2.180E-05
63	34.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-2.317E-05
63	36.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-2.453E-05
63	38.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-2.589E-05

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
63	40.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-2.725E-05
63	42.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-2.862E-05
63	44.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-2.998E-05
63	46.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-3.134E-05
63	48.	Long	LinStatic	-161.859	-3.072E-10	6.813E-07	-66.3245	-3.270E-05
63	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	2.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	4.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	6.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	8.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	10.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	12.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	14.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	16.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	18.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	20.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	22.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	24.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	26.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	28.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	30.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	32.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	34.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	36.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	38.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	40.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	42.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	44.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	46.	Wind Long	LinStatic	0.	0.	0.	0.	0.
63	48.	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	0.	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	0.
64	1.9888	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-2.095E-10
64	3.9777	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-4.190E-10
64	5.9665	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-6.285E-10
64	7.9554	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-8.380E-10
64	9.9442	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-1.048E-09
64	11.9331	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-1.257E-09
64	13.9219	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-1.467E-09
64	15.9108	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-1.676E-09
64	17.8996	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-1.886E-09
64	19.8885	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-2.095E-09
64	21.8773	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-2.305E-09
64	23.8662	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-2.514E-09
64	25.855	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-2.724E-09
64	27.8438	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-2.933E-09
64	29.8327	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-3.143E-09
64	31.8215	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-3.352E-09
64	33.8104	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-3.562E-09
64	35.7992	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-3.771E-09
64	37.7881	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-3.981E-09
64	39.7769	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-4.190E-09
64	41.7658	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-4.400E-09
64	43.7546	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-4.609E-09
64	45.7435	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-4.819E-09

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
64	47.7323	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-5.028E-09
64	49.7212	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-5.238E-09
64	51.71	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-5.447E-09
64	53.6988	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-5.657E-09
64	55.6877	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-5.866E-09
64	57.6765	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-6.076E-09
64	59.6654	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-6.285E-09
64	61.6542	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-6.495E-09
64	63.6431	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-6.704E-09
64	65.6319	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-6.914E-09
64	67.6208	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-7.123E-09
64	69.6096	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-7.333E-09
64	71.5985	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-7.542E-09
64	73.5873	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-7.752E-09
64	75.5762	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-7.961E-09
64	77.565	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-8.171E-09
64	79.5538	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-8.380E-09
64	81.5427	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-8.590E-09
64	83.5315	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-8.799E-09
64	85.5204	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-9.009E-09
64	87.5092	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-9.218E-09
64	89.4981	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-9.428E-09
64	91.4869	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-9.637E-09
64	93.4758	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-9.847E-09
64	95.4646	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-1.006E-08
64	97.4535	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-1.027E-08
64	99.4423	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-1.048E-08
64	101.4312	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-1.068E-08
64	103.42	Long	LinStatic	-98.815	-4.103E-14	1.053E-10	-5.0384	-1.089E-08
64	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	1.9888	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	3.9777	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	5.9665	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	7.9554	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	9.9442	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	11.9331	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	13.9219	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	15.9108	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	17.8996	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	19.8885	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	21.8773	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	23.8662	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	25.855	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	27.8438	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	29.8327	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	31.8215	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	33.8104	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	35.7992	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	37.7881	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	39.7769	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	41.7658	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	43.7546	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	45.7435	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	47.7323	Wind Long	LinStatic	0.	0.	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
64	49.7212	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	51.71	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	53.6988	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	55.6877	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	57.6765	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	59.6654	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	61.6542	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	63.6431	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	65.6319	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	67.6208	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	69.6096	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	71.5985	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	73.5873	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	75.5762	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	77.565	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	79.5538	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	81.5427	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	83.5315	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	85.5204	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	87.5092	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	89.4981	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	91.4869	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	93.4758	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	95.4646	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	97.4535	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	99.4423	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	101.4312	Wind Long	LinStatic	0.	0.	0.	0.	0.
64	103.42	Wind Long	LinStatic	0.	0.	0.	0.	0.
65	0.	Long	LinStatic	-37.414	4.566E-10	-4.014E-07	-16.6898	0.
65	1.8908	Long	LinStatic	-37.414	4.566E-10	-4.014E-07	-16.6898	7.590E-07
65	3.7815	Long	LinStatic	-37.414	4.566E-10	-4.014E-07	-16.6898	1.518E-06
65	5.6723	Long	LinStatic	-37.414	4.566E-10	-4.014E-07	-16.6898	2.277E-06
65	7.5631	Long	LinStatic	-37.414	4.566E-10	-4.014E-07	-16.6898	3.036E-06
65	9.4538	Long	LinStatic	-37.414	4.566E-10	-4.014E-07	-16.6898	3.795E-06
65	11.3446	Long	LinStatic	-37.414	4.566E-10	-4.014E-07	-16.6898	4.554E-06
65	13.2354	Long	LinStatic	-37.414	4.566E-10	-4.014E-07	-16.6898	5.313E-06
65	15.1262	Long	LinStatic	-37.414	4.566E-10	-4.014E-07	-16.6898	6.072E-06
65	17.0169	Long	LinStatic	-37.414	4.566E-10	-4.014E-07	-16.6898	6.831E-06
65	18.9077	Long	LinStatic	-37.414	4.566E-10	-4.014E-07	-16.6898	7.590E-06
65	20.7985	Long	LinStatic	-37.414	4.566E-10	-4.014E-07	-16.6898	8.349E-06
65	22.6892	Long	LinStatic	-37.414	4.566E-10	-4.014E-07	-16.6898	9.108E-06
65	24.58	Long	LinStatic	-37.414	4.566E-10	-4.014E-07	-16.6898	9.867E-06
65	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
65	1.8908	Wind Long	LinStatic	0.	0.	0.	0.	0.
65	3.7815	Wind Long	LinStatic	0.	0.	0.	0.	0.
65	5.6723	Wind Long	LinStatic	0.	0.	0.	0.	0.
65	7.5631	Wind Long	LinStatic	0.	0.	0.	0.	0.
65	9.4538	Wind Long	LinStatic	0.	0.	0.	0.	0.
65	11.3446	Wind Long	LinStatic	0.	0.	0.	0.	0.
65	13.2354	Wind Long	LinStatic	0.	0.	0.	0.	0.
65	15.1262	Wind Long	LinStatic	0.	0.	0.	0.	0.
65	17.0169	Wind Long	LinStatic	0.	0.	0.	0.	0.
65	18.9077	Wind Long	LinStatic	0.	0.	0.	0.	0.
65	20.7985	Wind Long	LinStatic	0.	0.	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
65	22.6892	Wind Long	LinStatic	0.	0.	0.	0.	0.
65	24.58	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	0.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	0.
68	2.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	5.903E-07
68	4.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	1.181E-06
68	6.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	1.771E-06
68	8.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	2.361E-06
68	10.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	2.952E-06
68	12.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	3.542E-06
68	14.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	4.132E-06
68	16.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	4.723E-06
68	18.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	5.313E-06
68	20.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	5.903E-06
68	22.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	6.494E-06
68	24.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	7.084E-06
68	26.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	7.675E-06
68	28.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	8.265E-06
68	30.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	8.855E-06
68	32.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	9.446E-06
68	34.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	1.004E-05
68	36.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	1.063E-05
68	38.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	1.122E-05
68	40.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	1.181E-05
68	42.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	1.240E-05
68	44.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	1.299E-05
68	46.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	1.358E-05
68	48.	Long	LinStatic	-25.432	0.	-2.952E-07	-87.7955	1.417E-05
68	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	2.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	4.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	6.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	8.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	10.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	12.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	14.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	16.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	18.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	20.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	22.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	24.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	26.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	28.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	30.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	32.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	34.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	36.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	38.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	40.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	42.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	44.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	46.	Wind Long	LinStatic	0.	0.	0.	0.	0.
68	48.	Wind Long	LinStatic	0.	0.	0.	0.	0.
86	0.	Long	LinStatic	0.19	24.809	28.556	3.7239	0.0098
86	2.	Long	LinStatic	0.19	24.809	28.556	3.7239	-57.1025

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
86	4.	Long	LinStatic	0.19	24.809	28.556	3.7239	-114.2147
86	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
86	2.	Wind Long	LinStatic	0.	0.	0.	0.	0.
86	4.	Wind Long	LinStatic	0.	0.	0.	0.	0.
87	0.	Long	LinStatic	6.016E-08	44.767	58.594	7.276E-12	-114.2088
87	2.	Long	LinStatic	6.016E-08	44.767	58.594	7.276E-12	-231.396
87	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
87	2.	Wind Long	LinStatic	0.	0.	0.	0.	0.
88	0.	Long	LinStatic	-6.016E-08	44.767	-58.594	9.095E-12	-231.396
88	2.	Long	LinStatic	-6.016E-08	44.767	-58.594	9.095E-12	-114.2088
88	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
88	2.	Wind Long	LinStatic	0.	0.	0.	0.	0.
89	0.	Long	LinStatic	-0.19	24.809	-28.556	-3.7239	-114.2147
89	2.	Long	LinStatic	-0.19	24.809	-28.556	-3.7239	-57.1025
89	4.	Long	LinStatic	-0.19	24.809	-28.556	-3.7239	0.0098
89	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
89	2.	Wind Long	LinStatic	0.	0.	0.	0.	0.
89	4.	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	0.	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	0.0013
90	0.4005	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-2.8434
90	0.4005	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-2.8434
90	0.801	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-5.6881
90	0.801	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-5.6881
90	1.2015	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-8.5329
90	1.2015	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-8.5329
90	1.602	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-11.3776
90	1.602	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-11.3776
90	2.0026	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-14.2224
90	2.0026	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-14.2224
90	2.4031	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-17.0671
90	2.4031	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-17.0671
90	2.8036	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-19.9118
90	2.8036	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-19.9118
90	3.2041	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-22.7566
90	3.2041	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-22.7566
90	3.6046	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-25.6013
90	3.6046	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-25.6013
90	4.0051	Long	LinStatic	-4.228	-30.709	7.103	-36.8582	-28.4461
90	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	0.4005	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	0.4005	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	0.801	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	0.801	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	1.2015	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	1.2015	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	1.602	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	1.602	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	2.0026	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	2.0026	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	2.4031	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	2.4031	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	2.8036	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	2.8036	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	3.2041	Wind Long	LinStatic	0.	0.	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
90	3.2041	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	3.6046	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	3.6046	Wind Long	LinStatic	0.	0.	0.	0.	0.
90	4.0051	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	0.	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-28.4453
91	0.1998	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-31.3562
91	0.1998	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-31.3562
91	0.3996	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-34.2671
91	0.3996	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-34.2671
91	0.5995	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-37.1781
91	0.5995	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-37.1781
91	0.7993	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-40.089
91	0.7993	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-40.089
91	0.9991	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-43.
91	0.9991	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-43.
91	1.1989	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-45.9109
91	1.1989	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-45.9109
91	1.3988	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-48.8218
91	1.3988	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-48.8218
91	1.5986	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-51.7328
91	1.5986	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-51.7328
91	1.7984	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-54.6437
91	1.7984	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-54.6437
91	1.9982	Long	LinStatic	-8.421	-45.019	14.568	-78.2464	-57.5546
91	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	0.1998	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	0.1998	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	0.3996	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	0.3996	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	0.5995	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	0.5995	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	0.7993	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	0.7993	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	0.9991	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	0.9991	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	1.1989	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	1.1989	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	1.3988	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	1.3988	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	1.5986	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	1.5986	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	1.7984	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	1.7984	Wind Long	LinStatic	0.	0.	0.	0.	0.
91	1.9982	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	0.	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-57.5546
92	0.1998	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-54.6437
92	0.1998	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-54.6437
92	0.3996	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-51.7328
92	0.3996	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-51.7328
92	0.5995	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-48.8218
92	0.5995	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-48.8218
92	0.7993	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-45.9109
92	0.7993	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-45.9109
92	0.9991	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-43.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
92	0.9991	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-43.
92	1.1989	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-40.089
92	1.1989	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-40.089
92	1.3988	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-37.1781
92	1.3988	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-37.1781
92	1.5986	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-34.2671
92	1.5986	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-34.2671
92	1.7984	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-31.3562
92	1.7984	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-31.3562
92	1.9982	Long	LinStatic	8.421	-45.019	-14.568	78.2464	-28.4453
92	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	0.1998	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	0.1998	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	0.3996	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	0.3996	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	0.5995	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	0.5995	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	0.7993	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	0.7993	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	0.9991	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	0.9991	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	1.1989	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	1.1989	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	1.3988	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	1.3988	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	1.5986	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	1.5986	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	1.7984	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	1.7984	Wind Long	LinStatic	0.	0.	0.	0.	0.
92	1.9982	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	0.	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-28.4461
93	0.4005	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-25.6013
93	0.4005	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-25.6013
93	0.801	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-22.7566
93	0.801	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-22.7566
93	1.2015	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-19.9118
93	1.2015	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-19.9118
93	1.602	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-17.0671
93	1.602	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-17.0671
93	2.0026	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-14.2224
93	2.0026	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-14.2224
93	2.4031	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-11.3776
93	2.4031	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-11.3776
93	2.8036	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-8.5329
93	2.8036	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-8.5329
93	3.2041	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-5.6881
93	3.2041	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-5.6881
93	3.6046	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-2.8434
93	3.6046	Long	LinStatic	4.228	-30.709	-7.103	36.8582	-2.8434
93	4.0051	Long	LinStatic	4.228	-30.709	-7.103	36.8582	0.0013
93	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	0.4005	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	0.4005	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	0.801	Wind Long	LinStatic	0.	0.	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
93	0.801	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	1.2015	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	1.2015	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	1.602	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	1.602	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	2.0026	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	2.0026	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	2.4031	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	2.4031	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	2.8036	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	2.8036	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	3.2041	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	3.2041	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	3.6046	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	3.6046	Wind Long	LinStatic	0.	0.	0.	0.	0.
93	4.0051	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	0.	Long	LinStatic	0.	-2.728E-12	2.328E-10	2.910E-11	0.
94	0.3002	Long	LinStatic	0.	-2.728E-12	2.328E-10	2.910E-11	-6.989E-11
94	0.3002	Long	LinStatic	1.746E-10	-4.547E-12	0.	2.910E-11	-2.910E-11
94	0.6003	Long	LinStatic	1.746E-10	-4.547E-12	0.	2.910E-11	-2.910E-11
94	0.6003	Long	LinStatic	-5.821E-11	-6.366E-12	1.164E-10	0.	2.910E-11
94	0.9005	Long	LinStatic	-5.821E-11	-6.366E-12	1.164E-10	0.	-5.840E-12
94	0.9005	Long	LinStatic	5.821E-10	-5.457E-12	0.	0.	-1.455E-11
94	1.2007	Long	LinStatic	5.821E-10	-5.457E-12	0.	0.	-1.455E-11
94	1.2007	Long	LinStatic	4.657E-10	-6.366E-12	1.164E-10	2.910E-11	4.366E-11
94	1.5008	Long	LinStatic	4.657E-10	-6.366E-12	1.164E-10	2.910E-11	8.712E-12
94	1.5008	Long	LinStatic	1.164E-10	-5.457E-12	0.	8.731E-11	1.455E-11
94	1.801	Long	LinStatic	1.164E-10	-5.457E-12	0.	8.731E-11	1.455E-11
94	1.801	Long	LinStatic	5.239E-10	-5.457E-12	-2.328E-10	2.910E-11	1.455E-11
94	2.1012	Long	LinStatic	5.239E-10	-5.457E-12	-2.328E-10	2.910E-11	8.444E-11
94	2.1012	Long	LinStatic	2.328E-10	-4.547E-12	-6.985E-10	2.910E-11	2.910E-11
94	2.4013	Long	LinStatic	2.328E-10	-4.547E-12	-6.985E-10	2.910E-11	2.388E-10
94	2.4013	Long	LinStatic	5.239E-10	-2.728E-12	-3.492E-10	0.	1.892E-10
94	2.7015	Long	LinStatic	5.239E-10	-2.728E-12	-3.492E-10	0.	2.940E-10
94	2.7015	Long	LinStatic	4.657E-10	-5.002E-12	-2.328E-10	5.821E-11	2.765E-10
94	3.0017	Long	LinStatic	4.657E-10	-5.002E-12	-2.328E-10	5.821E-11	3.464E-10
94	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	0.3002	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	0.3002	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	0.6003	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	0.6003	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	0.9005	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	0.9005	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	1.2007	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	1.2007	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	1.5008	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	1.5008	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	1.801	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	1.801	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	2.1012	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	2.1012	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	2.4013	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	2.4013	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	2.7015	Wind Long	LinStatic	0.	0.	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
94	2.7015	Wind Long	LinStatic	0.	0.	0.	0.	0.
94	3.0017	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	0.	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	2.2282
95	0.5255	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-12.116
95	0.5255	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-12.116
95	1.0511	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-26.4602
95	1.0511	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-26.4602
95	1.5766	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-40.8044
95	1.5766	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-40.8044
95	2.1022	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-55.1487
95	2.1022	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-55.1487
95	2.6277	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-69.4929
95	2.6277	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-69.4929
95	3.1532	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-83.8371
95	3.1532	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-83.8371
95	3.6788	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-98.1813
95	3.6788	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-98.1813
95	4.2043	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-112.5256
95	4.2043	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-112.5256
95	4.7299	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-126.8698
95	4.7299	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-126.8698
95	5.2554	Long	LinStatic	-15.776	-51.669	27.294	-15.1301	-141.214
95	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	0.5255	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	0.5255	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	1.0511	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	1.0511	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	1.5766	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	1.5766	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	2.1022	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	2.1022	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	2.6277	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	2.6277	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	3.1532	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	3.1532	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	3.6788	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	3.6788	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	4.2043	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	4.2043	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	4.7299	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	4.7299	Wind Long	LinStatic	0.	0.	0.	0.	0.
95	5.2554	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	0.	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-141.214
96	0.525	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-126.8706
96	0.525	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-126.8706
96	1.0501	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-112.5272
96	1.0501	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-112.5272
96	1.5751	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-98.1838
96	1.5751	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-98.1838
96	2.1002	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-83.8403
96	2.1002	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-83.8403
96	2.6252	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-69.4969
96	2.6252	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-69.4969
96	3.1503	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-55.1535

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
96	3.1503	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-55.1535
96	3.6753	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-40.8101
96	3.6753	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-40.8101
96	4.2003	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-26.4667
96	4.2003	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-26.4667
96	4.7254	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-12.1233
96	4.7254	Long	LinStatic	15.731	-51.669	-27.319	15.4962	-12.1233
96	5.2504	Long	LinStatic	15.731	-51.669	-27.319	15.4962	2.2201
96	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	0.525	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	0.525	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	1.0501	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	1.0501	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	1.5751	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	1.5751	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	2.1002	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	2.1002	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	2.6252	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	2.6252	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	3.1503	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	3.1503	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	3.6753	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	3.6753	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	4.2003	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	4.2003	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	4.7254	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	4.7254	Wind Long	LinStatic	0.	0.	0.	0.	0.
96	5.2504	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	0.	Long	LinStatic	-2.328E-10	4.547E-13	-1.630E-09	2.910E-11	-1.979E-09
97	0.3002	Long	LinStatic	-2.328E-10	4.547E-13	-1.630E-09	2.910E-11	-1.490E-09
97	0.3002	Long	LinStatic	0.	-9.095E-13	-1.164E-09	8.731E-11	-1.513E-09
97	0.6003	Long	LinStatic	0.	-9.095E-13	-1.164E-09	8.731E-11	-1.164E-09
97	0.6003	Long	LinStatic	-5.821E-11	9.095E-13	-8.149E-10	8.731E-11	-1.135E-09
97	0.9005	Long	LinStatic	-5.821E-11	9.095E-13	-8.149E-10	8.731E-11	-8.904E-10
97	0.9005	Long	LinStatic	-5.821E-11	9.095E-13	-6.985E-10	5.821E-11	-8.877E-10
97	1.2007	Long	LinStatic	-5.821E-11	9.095E-13	-6.985E-10	5.821E-11	-6.780E-10
97	1.2007	Long	LinStatic	5.821E-11	1.819E-12	-8.149E-10	5.821E-11	-6.548E-10
97	1.5008	Long	LinStatic	5.821E-11	1.819E-12	-8.149E-10	5.821E-11	-4.102E-10
97	1.5008	Long	LinStatic	-2.328E-10	1.819E-12	-6.985E-10	5.821E-11	-3.638E-10
97	1.801	Long	LinStatic	-2.328E-10	1.819E-12	-6.985E-10	5.821E-11	-1.541E-10
97	1.801	Long	LinStatic	1.164E-10	9.095E-13	-4.657E-10	5.821E-11	-1.746E-10
97	2.1012	Long	LinStatic	1.164E-10	9.095E-13	-4.657E-10	5.821E-11	-3.485E-11
97	2.1012	Long	LinStatic	5.821E-11	9.095E-13	-1.164E-10	2.910E-11	-2.910E-11
97	2.4013	Long	LinStatic	5.821E-11	9.095E-13	-1.164E-10	2.910E-11	5.840E-12
97	2.4013	Long	LinStatic	-5.821E-11	-2.728E-12	2.328E-10	2.910E-11	4.366E-11
97	2.7015	Long	LinStatic	-5.821E-11	-2.728E-12	2.328E-10	2.910E-11	-2.623E-11
97	2.7015	Long	LinStatic	5.821E-11	-1.819E-12	0.	0.	0.
97	3.0017	Long	LinStatic	5.821E-11	-1.819E-12	0.	0.	0.
97	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	0.3002	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	0.3002	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	0.6003	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	0.6003	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	0.9005	Wind Long	LinStatic	0.	0.	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
97	0.9005	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	1.2007	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	1.2007	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	1.5008	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	1.5008	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	1.801	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	1.801	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	2.1012	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	2.1012	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	2.4013	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	2.4013	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	2.7015	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	2.7015	Wind Long	LinStatic	0.	0.	0.	0.	0.
97	3.0017	Wind Long	LinStatic	0.	0.	0.	0.	0.
98	0.	Long	LinStatic	-7.276E-12	-5.684E-14	0.	5.457E-12	1.455E-11
98	1.5008	Long	LinStatic	-7.276E-12	-5.684E-14	0.	5.457E-12	1.455E-11
98	3.0017	Long	LinStatic	-7.276E-12	-5.684E-14	0.	5.457E-12	1.455E-11
98	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
98	1.5008	Wind Long	LinStatic	0.	0.	0.	0.	0.
98	3.0017	Wind Long	LinStatic	0.	0.	0.	0.	0.
99	0.	Long	LinStatic	-15.36	-44.637	26.574	3.0903	2.1694
99	1.7518	Long	LinStatic	-15.36	-44.637	26.574	3.0903	-44.383
99	3.5036	Long	LinStatic	-15.36	-44.637	26.574	3.0903	-90.9355
99	5.2554	Long	LinStatic	-15.36	-44.637	26.574	3.0903	-137.488
99	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
99	1.7518	Wind Long	LinStatic	0.	0.	0.	0.	0.
99	3.5036	Wind Long	LinStatic	0.	0.	0.	0.	0.
99	5.2554	Wind Long	LinStatic	0.	0.	0.	0.	0.
100	0.	Long	LinStatic	15.316	-44.637	-26.598	-2.732	-137.488
100	1.7501	Long	LinStatic	15.316	-44.637	-26.598	-2.732	-90.9381
100	3.5003	Long	LinStatic	15.316	-44.637	-26.598	-2.732	-44.3883
100	5.2504	Long	LinStatic	15.316	-44.637	-26.598	-2.732	2.1616
100	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
100	1.7501	Wind Long	LinStatic	0.	0.	0.	0.	0.
100	3.5003	Wind Long	LinStatic	0.	0.	0.	0.	0.
100	5.2504	Wind Long	LinStatic	0.	0.	0.	0.	0.
101	0.	Long	LinStatic	-1.455E-11	1.705E-13	1.455E-11	0.	1.455E-11
101	1.5008	Long	LinStatic	-1.455E-11	1.705E-13	1.455E-11	0.	-7.288E-12
101	3.0017	Long	LinStatic	-1.455E-11	1.705E-13	1.455E-11	0.	-2.913E-11
101	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
101	1.5008	Wind Long	LinStatic	0.	0.	0.	0.	0.
101	3.0017	Wind Long	LinStatic	0.	0.	0.	0.	0.
102	0.	Long	LinStatic	-0.505	-1.214	0.883	2.4039	9.684E-05
102	1.335	Long	LinStatic	-0.505	-1.214	0.883	2.4039	-1.1783
102	2.6701	Long	LinStatic	-0.505	-1.214	0.883	2.4039	-2.3567
102	4.0051	Long	LinStatic	-0.505	-1.214	0.883	2.4039	-3.5351
102	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
102	1.335	Wind Long	LinStatic	0.	0.	0.	0.	0.
102	2.6701	Wind Long	LinStatic	0.	0.	0.	0.	0.
102	4.0051	Wind Long	LinStatic	0.	0.	0.	0.	0.
103	0.	Long	LinStatic	-1.017	-1.392	1.759	4.9399	-3.535
103	1.9982	Long	LinStatic	-1.017	-1.392	1.759	4.9399	-7.05
103	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
103	1.9982	Wind Long	LinStatic	0.	0.	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
104	0.	Long	LinStatic	1.017	-1.392	-1.759	-4.9399	-7.05
104	1.9982	Long	LinStatic	1.017	-1.392	-1.759	-4.9399	-3.535
104	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
104	1.9982	Wind Long	LinStatic	0.	0.	0.	0.	0.
105	0.	Long	LinStatic	0.505	-1.214	-0.883	-2.4039	-3.5351
105	1.335	Long	LinStatic	0.505	-1.214	-0.883	-2.4039	-2.3567
105	2.6701	Long	LinStatic	0.505	-1.214	-0.883	-2.4039	-1.1783
105	4.0051	Long	LinStatic	0.505	-1.214	-0.883	-2.4039	9.684E-05
105	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
105	1.335	Wind Long	LinStatic	0.	0.	0.	0.	0.
105	2.6701	Wind Long	LinStatic	0.	0.	0.	0.	0.
105	4.0051	Wind Long	LinStatic	0.	0.	0.	0.	0.
106	0.	Long	LinStatic	-0.587	-1.782	1.018	-0.9229	1.117E-04
106	1.335	Long	LinStatic	-0.587	-1.782	1.018	-0.9229	-1.3583
106	2.6701	Long	LinStatic	-0.587	-1.782	1.018	-0.9229	-2.7167
106	4.0051	Long	LinStatic	-0.587	-1.782	1.018	-0.9229	-4.0751
106	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
106	1.335	Wind Long	LinStatic	0.	0.	0.	0.	0.
106	2.6701	Wind Long	LinStatic	0.	0.	0.	0.	0.
106	4.0051	Wind Long	LinStatic	0.	0.	0.	0.	0.
107	0.	Long	LinStatic	-1.178	-2.493	2.038	-1.9322	-4.075
107	1.9982	Long	LinStatic	-1.178	-2.493	2.038	-1.9322	-8.1477
107	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
107	1.9982	Wind Long	LinStatic	0.	0.	0.	0.	0.
108	0.	Long	LinStatic	1.178	-2.493	-2.038	1.9322	-8.1477
108	1.9982	Long	LinStatic	1.178	-2.493	-2.038	1.9322	-4.075
108	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
108	1.9982	Wind Long	LinStatic	0.	0.	0.	0.	0.
109	0.	Long	LinStatic	0.587	-1.782	-1.018	0.9229	-4.0751
109	1.335	Long	LinStatic	0.587	-1.782	-1.018	0.9229	-2.7167
109	2.6701	Long	LinStatic	0.587	-1.782	-1.018	0.9229	-1.3583
109	4.0051	Long	LinStatic	0.587	-1.782	-1.018	0.9229	1.117E-04
109	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
109	1.335	Wind Long	LinStatic	0.	0.	0.	0.	0.
109	2.6701	Wind Long	LinStatic	0.	0.	0.	0.	0.
109	4.0051	Wind Long	LinStatic	0.	0.	0.	0.	0.
110	0.	Long	LinStatic	-0.397	1.735	0.706	7.1707	7.724E-05
110	1.335	Long	LinStatic	-0.397	1.735	0.706	7.1707	-0.9419
110	2.6701	Long	LinStatic	-0.397	1.735	0.706	7.1707	-1.8839
110	4.0051	Long	LinStatic	-0.397	1.735	0.706	7.1707	-2.8258
110	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
110	1.335	Wind Long	LinStatic	0.	0.	0.	0.	0.
110	2.6701	Wind Long	LinStatic	0.	0.	0.	0.	0.
110	4.0051	Wind Long	LinStatic	0.	0.	0.	0.	0.
111	0.	Long	LinStatic	-0.804	2.881	1.391	14.7845	-2.8258
111	1.9982	Long	LinStatic	-0.804	2.881	1.391	14.7845	-5.6054
111	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
111	1.9982	Wind Long	LinStatic	0.	0.	0.	0.	0.
112	0.	Long	LinStatic	0.804	2.881	-1.391	-14.7845	-5.6054
112	1.9982	Long	LinStatic	0.804	2.881	-1.391	-14.7845	-2.8258
112	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
112	1.9982	Wind Long	LinStatic	0.	0.	0.	0.	0.
113	0.	Long	LinStatic	0.397	1.735	-0.706	-7.1707	-2.8258
113	1.335	Long	LinStatic	0.397	1.735	-0.706	-7.1707	-1.8839

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
113	2.6701	Long	LinStatic	0.397	1.735	-0.706	-7.1707	-0.9419
113	4.0051	Long	LinStatic	0.397	1.735	-0.706	-7.1707	7.724E-05
113	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
113	1.335	Wind Long	LinStatic	0.	0.	0.	0.	0.
113	2.6701	Wind Long	LinStatic	0.	0.	0.	0.	0.
113	4.0051	Wind Long	LinStatic	0.	0.	0.	0.	0.
114	0.	Long	LinStatic	-3.174	-14.281	5.439	-10.197	0.001
114	1.335	Long	LinStatic	-3.174	-14.281	5.439	-10.197	-7.2605
114	2.6701	Long	LinStatic	-3.174	-14.281	5.439	-10.197	-14.5221
114	4.0051	Long	LinStatic	-3.174	-14.281	5.439	-10.197	-21.7837
114	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
114	1.335	Wind Long	LinStatic	0.	0.	0.	0.	0.
114	2.6701	Wind Long	LinStatic	0.	0.	0.	0.	0.
114	4.0051	Wind Long	LinStatic	0.	0.	0.	0.	0.
115	0.	Long	LinStatic	-6.364	-19.862	11.01	-21.9684	-21.7831
115	1.9982	Long	LinStatic	-6.364	-19.862	11.01	-21.9684	-43.7832
115	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
115	1.9982	Wind Long	LinStatic	0.	0.	0.	0.	0.
116	0.	Long	LinStatic	6.364	-19.862	-11.01	21.9684	-43.7832
116	1.9982	Long	LinStatic	6.364	-19.862	-11.01	21.9684	-21.7831
116	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
116	1.9982	Wind Long	LinStatic	0.	0.	0.	0.	0.
117	0.	Long	LinStatic	3.174	-14.281	-5.439	10.197	-21.7837
117	1.335	Long	LinStatic	3.174	-14.281	-5.439	10.197	-14.5221
117	2.6701	Long	LinStatic	3.174	-14.281	-5.439	10.197	-7.2605
117	4.0051	Long	LinStatic	3.174	-14.281	-5.439	10.197	0.001
117	0.	Wind Long	LinStatic	0.	0.	0.	0.	0.
117	1.335	Wind Long	LinStatic	0.	0.	0.	0.	0.
117	2.6701	Wind Long	LinStatic	0.	0.	0.	0.	0.
117	4.0051	Wind Long	LinStatic	0.	0.	0.	0.	0.

Table: Element Forces - Frames, Part 2 of 2

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
1	0.	Long	297.8519	1-1	0.
1	5.15	Long	150.7879	1-1	5.15
1	10.3	Long	3.7239	1-1	10.3
1	0.	Wind Long	0.	1-1	0.
1	5.15	Wind Long	0.	1-1	5.15
1	10.3	Wind Long	0.	1-1	10.3
2	0.	Long	305.6622	2-1	0.
2	5.15	Long	150.9692	2-1	5.15
2	10.3	Long	-3.7239	2-1	10.3
2	0.	Wind Long	0.	2-1	0.
2	5.15	Wind Long	0.	2-1	5.15
2	10.3	Wind Long	0.	2-1	10.3
3	0.	Long	0.	3-1	0.
3	2.	Long	3.653E-19	3-1	2.
3	4.	Long	7.305E-19	3-1	4.
3	6.	Long	1.096E-18	3-1	6.
3	8.	Long	1.461E-18	3-1	8.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
3	10.	Long	1.826E-18	3-1	10.
3	12.	Long	2.192E-18	3-1	12.
3	14.	Long	2.557E-18	3-1	14.
3	16.	Long	2.922E-18	3-1	16.
3	18.	Long	3.287E-18	3-1	18.
3	20.	Long	3.653E-18	3-1	20.
3	22.	Long	4.018E-18	3-1	22.
3	24.	Long	4.383E-18	3-1	24.
3	26.	Long	4.748E-18	3-1	26.
3	28.	Long	5.114E-18	3-1	28.
3	30.	Long	5.479E-18	3-1	30.
3	32.	Long	5.844E-18	3-1	32.
3	34.	Long	6.209E-18	3-1	34.
3	36.	Long	6.575E-18	3-1	36.
3	38.	Long	6.940E-18	3-1	38.
3	40.	Long	7.305E-18	3-1	40.
3	42.	Long	7.671E-18	3-1	42.
3	44.	Long	8.036E-18	3-1	44.
3	46.	Long	8.401E-18	3-1	46.
3	48.	Long	8.766E-18	3-1	48.
3	0.	Wind Long	0.	3-1	0.
3	2.	Wind Long	0.	3-1	2.
3	4.	Wind Long	0.	3-1	4.
3	6.	Wind Long	0.	3-1	6.
3	8.	Wind Long	0.	3-1	8.
3	10.	Wind Long	0.	3-1	10.
3	12.	Wind Long	0.	3-1	12.
3	14.	Wind Long	0.	3-1	14.
3	16.	Wind Long	0.	3-1	16.
3	18.	Wind Long	0.	3-1	18.
3	20.	Wind Long	0.	3-1	20.
3	22.	Wind Long	0.	3-1	22.
3	24.	Wind Long	0.	3-1	24.
3	26.	Wind Long	0.	3-1	26.
3	28.	Wind Long	0.	3-1	28.
3	30.	Wind Long	0.	3-1	30.
3	32.	Wind Long	0.	3-1	32.
3	34.	Wind Long	0.	3-1	34.
3	36.	Wind Long	0.	3-1	36.
3	38.	Wind Long	0.	3-1	38.
3	40.	Wind Long	0.	3-1	40.
3	42.	Wind Long	0.	3-1	42.
3	44.	Wind Long	0.	3-1	44.
3	46.	Wind Long	0.	3-1	46.
3	48.	Wind Long	0.	3-1	48.
4	0.	Long	305.6622	4-1	0.
4	5.15	Long	150.9692	4-1	5.15
4	10.3	Long	-3.7239	4-1	10.3
4	0.	Wind Long	0.	4-1	0.
4	5.15	Wind Long	0.	4-1	5.15
4	10.3	Wind Long	0.	4-1	10.3
5	0.	Long	297.8519	5-1	0.
5	5.15	Long	150.7879	5-1	5.15
5	10.3	Long	3.7239	5-1	10.3

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
5	0.	Wind Long	0.	5-1	0.
5	5.15	Wind Long	0.	5-1	5.15
5	10.3	Wind Long	0.	5-1	10.3
6	0.	Long	95.9344	6-1	0.
6	9.35	Long	29.5525	6-1	9.35
6	18.7	Long	-36.8294	6-1	18.7
6	0.	Wind Long	0.	6-1	0.
6	9.35	Wind Long	0.	6-1	9.35
6	18.7	Wind Long	0.	6-1	18.7
7	0.	Long	98.4284	7-1	0.
7	9.35	Long	28.5626	7-1	9.35
7	18.7	Long	-41.3031	7-1	18.7
7	0.	Wind Long	0.	7-1	0.
7	9.35	Wind Long	0.	7-1	9.35
7	18.7	Wind Long	0.	7-1	18.7
8	0.	Long	0.	8-1	0.
8	2.	Long	0.	8-1	2.
8	4.	Long	0.	8-1	4.
8	6.	Long	0.	8-1	6.
8	8.	Long	0.	8-1	8.
8	10.	Long	1.150E-20	8-1	10.
8	12.	Long	1.379E-20	8-1	12.
8	14.	Long	1.609E-20	8-1	14.
8	16.	Long	1.839E-20	8-1	16.
8	18.	Long	2.069E-20	8-1	18.
8	20.	Long	2.299E-20	8-1	20.
8	22.	Long	2.529E-20	8-1	22.
8	24.	Long	2.759E-20	8-1	24.
8	26.	Long	2.989E-20	8-1	26.
8	28.	Long	3.219E-20	8-1	28.
8	30.	Long	3.449E-20	8-1	30.
8	32.	Long	3.678E-20	8-1	32.
8	34.	Long	3.908E-20	8-1	34.
8	36.	Long	4.138E-20	8-1	36.
8	38.	Long	4.368E-20	8-1	38.
8	40.	Long	4.598E-20	8-1	40.
8	42.	Long	4.828E-20	8-1	42.
8	44.	Long	5.058E-20	8-1	44.
8	46.	Long	5.288E-20	8-1	46.
8	48.	Long	5.518E-20	8-1	48.
8	0.	Wind Long	0.	8-1	0.
8	2.	Wind Long	0.	8-1	2.
8	4.	Wind Long	0.	8-1	4.
8	6.	Wind Long	0.	8-1	6.
8	8.	Wind Long	0.	8-1	8.
8	10.	Wind Long	0.	8-1	10.
8	12.	Wind Long	0.	8-1	12.
8	14.	Wind Long	0.	8-1	14.
8	16.	Wind Long	0.	8-1	16.
8	18.	Wind Long	0.	8-1	18.
8	20.	Wind Long	0.	8-1	20.
8	22.	Wind Long	0.	8-1	22.
8	24.	Wind Long	0.	8-1	24.
8	26.	Wind Long	0.	8-1	26.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
8	28.	Wind Long	0.	8-1	28.
8	30.	Wind Long	0.	8-1	30.
8	32.	Wind Long	0.	8-1	32.
8	34.	Wind Long	0.	8-1	34.
8	36.	Wind Long	0.	8-1	36.
8	38.	Wind Long	0.	8-1	38.
8	40.	Wind Long	0.	8-1	40.
8	42.	Wind Long	0.	8-1	42.
8	44.	Wind Long	0.	8-1	44.
8	46.	Wind Long	0.	8-1	46.
8	48.	Wind Long	0.	8-1	48.
9	0.	Long	98.4284	9-1	0.
9	9.35	Long	28.5626	9-1	9.35
9	18.7	Long	-41.3031	9-1	18.7
9	0.	Wind Long	0.	9-1	0.
9	9.35	Wind Long	0.	9-1	9.35
9	18.7	Wind Long	0.	9-1	18.7
10	0.	Long	95.9344	10-1	0.
10	9.35	Long	29.5525	10-1	9.35
10	18.7	Long	-36.8294	10-1	18.7
10	0.	Wind Long	0.	10-1	0.
10	9.35	Wind Long	0.	10-1	9.35
10	18.7	Wind Long	0.	10-1	18.7
12	0.	Long	885.7162	12-1	0.
12	16.5	Long	435.2314	12-1	16.5
12	33.	Long	-15.2534	12-1	33.
12	0.	Wind Long	0.	12-1	0.
12	16.5	Wind Long	0.	12-1	16.5
12	33.	Wind Long	0.	12-1	33.
14	0.	Long	885.7031	14-1	0.
14	16.5	Long	435.2437	14-1	16.5
14	33.	Long	-15.2157	14-1	33.
14	0.	Wind Long	0.	14-1	0.
14	16.5	Wind Long	0.	14-1	16.5
14	33.	Wind Long	0.	14-1	33.
17	0.	Long	880.1668	17-1	0.
17	16.5	Long	441.5682	17-1	16.5
17	33.	Long	2.9696	17-1	33.
17	0.	Wind Long	0.	17-1	0.
17	16.5	Wind Long	0.	17-1	16.5
17	33.	Wind Long	0.	17-1	33.
19	0.	Long	880.154	19-1	0.
19	16.5	Long	441.5802	19-1	16.5
19	33.	Long	3.0063	19-1	33.
19	0.	Wind Long	0.	19-1	0.
19	16.5	Wind Long	0.	19-1	16.5
19	33.	Wind Long	0.	19-1	33.
21	0.	Long	30.6431	21-1	0.
21	16.	Long	16.5265	21-1	16.
21	32.	Long	2.4099	21-1	32.
21	0.	Wind Long	0.	21-1	0.
21	16.	Wind Long	0.	21-1	16.
21	32.	Wind Long	0.	21-1	32.
22	0.	Long	30.6007	22-1	0.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
22	16.	Long	16.5642	22-1	16.
22	32.	Long	2.5278	22-1	32.
22	0.	Wind Long	0.	22-1	0.
22	16.	Wind Long	0.	22-1	16.
22	32.	Wind Long	0.	22-1	32.
24	0.	Long	30.6007	24-1	0.
24	16.	Long	16.5642	24-1	16.
24	32.	Long	2.5278	24-1	32.
24	0.	Wind Long	0.	24-1	0.
24	16.	Wind Long	0.	24-1	16.
24	32.	Wind Long	0.	24-1	32.
25	0.	Long	30.6431	25-1	0.
25	16.	Long	16.5265	25-1	16.
25	32.	Long	2.4099	25-1	32.
25	0.	Wind Long	0.	25-1	0.
25	16.	Wind Long	0.	25-1	16.
25	32.	Wind Long	0.	25-1	32.
26	0.	Long	34.6052	26-1	0.
26	16.	Long	15.8131	26-1	16.
26	32.	Long	-2.979	26-1	32.
26	0.	Wind Long	0.	26-1	0.
26	16.	Wind Long	0.	26-1	16.
26	32.	Wind Long	0.	26-1	32.
27	0.	Long	34.6699	27-1	0.
27	16.	Long	15.7957	27-1	16.
27	32.	Long	-3.0785	27-1	32.
27	0.	Wind Long	0.	27-1	0.
27	16.	Wind Long	0.	27-1	16.
27	32.	Wind Long	0.	27-1	32.
29	0.	Long	34.6699	29-1	0.
29	16.	Long	15.7957	29-1	16.
29	32.	Long	-3.0785	29-1	32.
29	0.	Wind Long	0.	29-1	0.
29	16.	Wind Long	0.	29-1	16.
29	32.	Wind Long	0.	29-1	32.
30	0.	Long	34.6052	30-1	0.
30	16.	Long	15.8131	30-1	16.
30	32.	Long	-2.979	30-1	32.
30	0.	Wind Long	0.	30-1	0.
30	16.	Wind Long	0.	30-1	16.
30	32.	Wind Long	0.	30-1	32.
31	0.	Long	29.7444	31-1	0.
31	16.	Long	18.4599	31-1	16.
31	32.	Long	7.1753	31-1	32.
31	0.	Wind Long	0.	31-1	0.
31	16.	Wind Long	0.	31-1	16.
31	32.	Wind Long	0.	31-1	32.
32	0.	Long	29.551	32-1	0.
32	16.	Long	18.5724	32-1	16.
32	32.	Long	7.5939	32-1	32.
32	0.	Wind Long	0.	32-1	0.
32	16.	Wind Long	0.	32-1	16.
32	32.	Wind Long	0.	32-1	32.
34	0.	Long	29.551	34-1	0.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
34	16.	Long	18.5724	34-1	16.
34	32.	Long	7.5939	34-1	32.
34	0.	Wind Long	0.	34-1	0.
34	16.	Wind Long	0.	34-1	16.
34	32.	Wind Long	0.	34-1	32.
35	0.	Long	29.7444	35-1	0.
35	16.	Long	18.4599	35-1	16.
35	32.	Long	7.1753	35-1	32.
35	0.	Wind Long	0.	35-1	0.
35	16.	Wind Long	0.	35-1	16.
35	32.	Wind Long	0.	35-1	32.
36	0.	Long	91.4945	36-1	0.
36	9.35	Long	40.6596	36-1	9.35
36	18.7	Long	-10.1753	36-1	18.7
36	0.	Wind Long	0.	36-1	0.
36	9.35	Wind Long	0.	36-1	9.35
36	18.7	Wind Long	0.	36-1	18.7
37	0.	Long	92.5235	37-1	0.
37	9.35	Long	40.3859	37-1	9.35
37	18.7	Long	-11.7518	37-1	18.7
37	0.	Wind Long	0.	37-1	0.
37	9.35	Wind Long	0.	37-1	9.35
37	18.7	Wind Long	0.	37-1	18.7
39	0.	Long	92.5235	39-1	0.
39	9.35	Long	40.3859	39-1	9.35
39	18.7	Long	-11.7518	39-1	18.7
39	0.	Wind Long	0.	39-1	0.
39	9.35	Wind Long	0.	39-1	9.35
39	18.7	Wind Long	0.	39-1	18.7
40	0.	Long	91.4945	40-1	0.
40	9.35	Long	40.6596	40-1	9.35
40	18.7	Long	-10.1753	40-1	18.7
40	0.	Wind Long	0.	40-1	0.
40	9.35	Wind Long	0.	40-1	9.35
40	18.7	Wind Long	0.	40-1	18.7
62	0.	Long	0.	62-1	0.
62	1.9072	Long	-1.375E-19	62-1	1.9072
62	3.8144	Long	-2.751E-19	62-1	3.8144
62	5.7217	Long	-4.126E-19	62-1	5.7217
62	7.6289	Long	-5.502E-19	62-1	7.6289
62	9.5361	Long	-6.877E-19	62-1	9.5361
62	11.4433	Long	-8.253E-19	62-1	11.4433
62	13.3506	Long	-9.628E-19	62-1	13.3506
62	15.2578	Long	-1.100E-18	62-1	15.2578
62	17.165	Long	-1.238E-18	62-1	17.165
62	19.0722	Long	-1.375E-18	62-1	19.0722
62	20.9794	Long	-1.513E-18	62-1	20.9794
62	22.8867	Long	-1.651E-18	62-1	22.8867
62	24.7939	Long	-1.788E-18	62-1	24.7939
62	26.7011	Long	-1.926E-18	62-1	26.7011
62	28.6083	Long	-2.063E-18	62-1	28.6083
62	30.5156	Long	-2.201E-18	62-1	30.5156
62	32.4228	Long	-2.338E-18	62-1	32.4228
62	34.33	Long	-2.476E-18	62-1	34.33

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
62	0.	Wind Long	0.	62-1	0.
62	1.9072	Wind Long	0.	62-1	1.9072
62	3.8144	Wind Long	0.	62-1	3.8144
62	5.7217	Wind Long	0.	62-1	5.7217
62	7.6289	Wind Long	0.	62-1	7.6289
62	9.5361	Wind Long	0.	62-1	9.5361
62	11.4433	Wind Long	0.	62-1	11.4433
62	13.3506	Wind Long	0.	62-1	13.3506
62	15.2578	Wind Long	0.	62-1	15.2578
62	17.165	Wind Long	0.	62-1	17.165
62	19.0722	Wind Long	0.	62-1	19.0722
62	20.9794	Wind Long	0.	62-1	20.9794
62	22.8867	Wind Long	0.	62-1	22.8867
62	24.7939	Wind Long	0.	62-1	24.7939
62	26.7011	Wind Long	0.	62-1	26.7011
62	28.6083	Wind Long	0.	62-1	28.6083
62	30.5156	Wind Long	0.	62-1	30.5156
62	32.4228	Wind Long	0.	62-1	32.4228
62	34.33	Wind Long	0.	62-1	34.33
63	0.	Long	0.	63-1	0.
63	2.	Long	6.144E-10	63-1	2.
63	4.	Long	1.229E-09	63-1	4.
63	6.	Long	1.843E-09	63-1	6.
63	8.	Long	2.458E-09	63-1	8.
63	10.	Long	3.072E-09	63-1	10.
63	12.	Long	3.686E-09	63-1	12.
63	14.	Long	4.301E-09	63-1	14.
63	16.	Long	4.915E-09	63-1	16.
63	18.	Long	5.529E-09	63-1	18.
63	20.	Long	6.144E-09	63-1	20.
63	22.	Long	6.758E-09	63-1	22.
63	24.	Long	7.373E-09	63-1	24.
63	26.	Long	7.987E-09	63-1	26.
63	28.	Long	8.601E-09	63-1	28.
63	30.	Long	9.216E-09	63-1	30.
63	32.	Long	9.830E-09	63-1	32.
63	34.	Long	1.044E-08	63-1	34.
63	36.	Long	1.106E-08	63-1	36.
63	38.	Long	1.167E-08	63-1	38.
63	40.	Long	1.229E-08	63-1	40.
63	42.	Long	1.290E-08	63-1	42.
63	44.	Long	1.352E-08	63-1	44.
63	46.	Long	1.413E-08	63-1	46.
63	48.	Long	1.475E-08	63-1	48.
63	0.	Wind Long	0.	63-1	0.
63	2.	Wind Long	0.	63-1	2.
63	4.	Wind Long	0.	63-1	4.
63	6.	Wind Long	0.	63-1	6.
63	8.	Wind Long	0.	63-1	8.
63	10.	Wind Long	0.	63-1	10.
63	12.	Wind Long	0.	63-1	12.
63	14.	Wind Long	0.	63-1	14.
63	16.	Wind Long	0.	63-1	16.
63	18.	Wind Long	0.	63-1	18.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
63	20.	Wind Long	0.	63-1	20.
63	22.	Wind Long	0.	63-1	22.
63	24.	Wind Long	0.	63-1	24.
63	26.	Wind Long	0.	63-1	26.
63	28.	Wind Long	0.	63-1	28.
63	30.	Wind Long	0.	63-1	30.
63	32.	Wind Long	0.	63-1	32.
63	34.	Wind Long	0.	63-1	34.
63	36.	Wind Long	0.	63-1	36.
63	38.	Wind Long	0.	63-1	38.
63	40.	Wind Long	0.	63-1	40.
63	42.	Wind Long	0.	63-1	42.
63	44.	Wind Long	0.	63-1	44.
63	46.	Wind Long	0.	63-1	46.
63	48.	Wind Long	0.	63-1	48.
64	0.	Long	0.	64-1	0.
64	1.9888	Long	8.161E-14	64-1	1.9888
64	3.9777	Long	1.632E-13	64-1	3.9777
64	5.9665	Long	2.448E-13	64-1	5.9665
64	7.9554	Long	3.264E-13	64-1	7.9554
64	9.9442	Long	4.081E-13	64-1	9.9442
64	11.9331	Long	4.897E-13	64-1	11.9331
64	13.9219	Long	5.713E-13	64-1	13.9219
64	15.9108	Long	6.529E-13	64-1	15.9108
64	17.8996	Long	7.345E-13	64-1	17.8996
64	19.8885	Long	8.161E-13	64-1	19.8885
64	21.8773	Long	8.977E-13	64-1	21.8773
64	23.8662	Long	9.793E-13	64-1	23.8662
64	25.855	Long	1.061E-12	64-1	25.855
64	27.8438	Long	1.143E-12	64-1	27.8438
64	29.8327	Long	1.224E-12	64-1	29.8327
64	31.8215	Long	1.306E-12	64-1	31.8215
64	33.8104	Long	1.387E-12	64-1	33.8104
64	35.7992	Long	1.469E-12	64-1	35.7992
64	37.7881	Long	1.551E-12	64-1	37.7881
64	39.7769	Long	1.632E-12	64-1	39.7769
64	41.7658	Long	1.714E-12	64-1	41.7658
64	43.7546	Long	1.795E-12	64-1	43.7546
64	45.7435	Long	1.877E-12	64-1	45.7435
64	47.7323	Long	1.959E-12	64-1	47.7323
64	49.7212	Long	2.040E-12	64-1	49.7212
64	51.71	Long	2.122E-12	64-1	51.71
64	53.6988	Long	2.204E-12	64-1	53.6988
64	55.6877	Long	2.285E-12	64-1	55.6877
64	57.6765	Long	2.367E-12	64-1	57.6765
64	59.6654	Long	2.448E-12	64-1	59.6654
64	61.6542	Long	2.530E-12	64-1	61.6542
64	63.6431	Long	2.612E-12	64-1	63.6431
64	65.6319	Long	2.693E-12	64-1	65.6319
64	67.6208	Long	2.775E-12	64-1	67.6208
64	69.6096	Long	2.856E-12	64-1	69.6096
64	71.5985	Long	2.938E-12	64-1	71.5985
64	73.5873	Long	3.020E-12	64-1	73.5873
64	75.5762	Long	3.101E-12	64-1	75.5762

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
64	77.565	Long	3.183E-12	64-1	77.565
64	79.5538	Long	3.264E-12	64-1	79.5538
64	81.5427	Long	3.346E-12	64-1	81.5427
64	83.5315	Long	3.428E-12	64-1	83.5315
64	85.5204	Long	3.509E-12	64-1	85.5204
64	87.5092	Long	3.591E-12	64-1	87.5092
64	89.4981	Long	3.673E-12	64-1	89.4981
64	91.4869	Long	3.754E-12	64-1	91.4869
64	93.4758	Long	3.836E-12	64-1	93.4758
64	95.4646	Long	3.917E-12	64-1	95.4646
64	97.4535	Long	3.999E-12	64-1	97.4535
64	99.4423	Long	4.081E-12	64-1	99.4423
64	101.4312	Long	4.162E-12	64-1	101.4312
64	103.42	Long	4.244E-12	64-1	103.42
64	0.	Wind Long	0.	64-1	0.
64	1.9888	Wind Long	0.	64-1	1.9888
64	3.9777	Wind Long	0.	64-1	3.9777
64	5.9665	Wind Long	0.	64-1	5.9665
64	7.9554	Wind Long	0.	64-1	7.9554
64	9.9442	Wind Long	0.	64-1	9.9442
64	11.9331	Wind Long	0.	64-1	11.9331
64	13.9219	Wind Long	0.	64-1	13.9219
64	15.9108	Wind Long	0.	64-1	15.9108
64	17.8996	Wind Long	0.	64-1	17.8996
64	19.8885	Wind Long	0.	64-1	19.8885
64	21.8773	Wind Long	0.	64-1	21.8773
64	23.8662	Wind Long	0.	64-1	23.8662
64	25.855	Wind Long	0.	64-1	25.855
64	27.8438	Wind Long	0.	64-1	27.8438
64	29.8327	Wind Long	0.	64-1	29.8327
64	31.8215	Wind Long	0.	64-1	31.8215
64	33.8104	Wind Long	0.	64-1	33.8104
64	35.7992	Wind Long	0.	64-1	35.7992
64	37.7881	Wind Long	0.	64-1	37.7881
64	39.7769	Wind Long	0.	64-1	39.7769
64	41.7658	Wind Long	0.	64-1	41.7658
64	43.7546	Wind Long	0.	64-1	43.7546
64	45.7435	Wind Long	0.	64-1	45.7435
64	47.7323	Wind Long	0.	64-1	47.7323
64	49.7212	Wind Long	0.	64-1	49.7212
64	51.71	Wind Long	0.	64-1	51.71
64	53.6988	Wind Long	0.	64-1	53.6988
64	55.6877	Wind Long	0.	64-1	55.6877
64	57.6765	Wind Long	0.	64-1	57.6765
64	59.6654	Wind Long	0.	64-1	59.6654
64	61.6542	Wind Long	0.	64-1	61.6542
64	63.6431	Wind Long	0.	64-1	63.6431
64	65.6319	Wind Long	0.	64-1	65.6319
64	67.6208	Wind Long	0.	64-1	67.6208
64	69.6096	Wind Long	0.	64-1	69.6096
64	71.5985	Wind Long	0.	64-1	71.5985
64	73.5873	Wind Long	0.	64-1	73.5873
64	75.5762	Wind Long	0.	64-1	75.5762
64	77.565	Wind Long	0.	64-1	77.565

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
64	79.5538	Wind Long	0.	64-1	79.5538
64	81.5427	Wind Long	0.	64-1	81.5427
64	83.5315	Wind Long	0.	64-1	83.5315
64	85.5204	Wind Long	0.	64-1	85.5204
64	87.5092	Wind Long	0.	64-1	87.5092
64	89.4981	Wind Long	0.	64-1	89.4981
64	91.4869	Wind Long	0.	64-1	91.4869
64	93.4758	Wind Long	0.	64-1	93.4758
64	95.4646	Wind Long	0.	64-1	95.4646
64	97.4535	Wind Long	0.	64-1	97.4535
64	99.4423	Wind Long	0.	64-1	99.4423
64	101.4312	Wind Long	0.	64-1	101.4312
64	103.42	Wind Long	0.	64-1	103.42
65	0.	Long	0.	65-1	0.
65	1.8908	Long	-8.632E-10	65-1	1.8908
65	3.7815	Long	-1.726E-09	65-1	3.7815
65	5.6723	Long	-2.590E-09	65-1	5.6723
65	7.5631	Long	-3.453E-09	65-1	7.5631
65	9.4538	Long	-4.316E-09	65-1	9.4538
65	11.3446	Long	-5.179E-09	65-1	11.3446
65	13.2354	Long	-6.043E-09	65-1	13.2354
65	15.1262	Long	-6.906E-09	65-1	15.1262
65	17.0169	Long	-7.769E-09	65-1	17.0169
65	18.9077	Long	-8.632E-09	65-1	18.9077
65	20.7985	Long	-9.496E-09	65-1	20.7985
65	22.6892	Long	-1.036E-08	65-1	22.6892
65	24.58	Long	-1.122E-08	65-1	24.58
65	0.	Wind Long	0.	65-1	0.
65	1.8908	Wind Long	0.	65-1	1.8908
65	3.7815	Wind Long	0.	65-1	3.7815
65	5.6723	Wind Long	0.	65-1	5.6723
65	7.5631	Wind Long	0.	65-1	7.5631
65	9.4538	Wind Long	0.	65-1	9.4538
65	11.3446	Wind Long	0.	65-1	11.3446
65	13.2354	Wind Long	0.	65-1	13.2354
65	15.1262	Wind Long	0.	65-1	15.1262
65	17.0169	Wind Long	0.	65-1	17.0169
65	18.9077	Wind Long	0.	65-1	18.9077
65	20.7985	Wind Long	0.	65-1	20.7985
65	22.6892	Wind Long	0.	65-1	22.6892
65	24.58	Wind Long	0.	65-1	24.58
68	0.	Long	0.	68-1	0.
68	2.	Long	0.	68-1	2.
68	4.	Long	0.	68-1	4.
68	6.	Long	0.	68-1	6.
68	8.	Long	0.	68-1	8.
68	10.	Long	0.	68-1	10.
68	12.	Long	0.	68-1	12.
68	14.	Long	0.	68-1	14.
68	16.	Long	0.	68-1	16.
68	18.	Long	0.	68-1	18.
68	20.	Long	0.	68-1	20.
68	22.	Long	0.	68-1	22.
68	24.	Long	0.	68-1	24.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
68	26.	Long	0.	68-1	26.
68	28.	Long	0.	68-1	28.
68	30.	Long	0.	68-1	30.
68	32.	Long	0.	68-1	32.
68	34.	Long	0.	68-1	34.
68	36.	Long	0.	68-1	36.
68	38.	Long	0.	68-1	38.
68	40.	Long	0.	68-1	40.
68	42.	Long	0.	68-1	42.
68	44.	Long	0.	68-1	44.
68	46.	Long	0.	68-1	46.
68	48.	Long	0.	68-1	48.
68	0.	Wind Long	0.	68-1	0.
68	2.	Wind Long	0.	68-1	2.
68	4.	Wind Long	0.	68-1	4.
68	6.	Wind Long	0.	68-1	6.
68	8.	Wind Long	0.	68-1	8.
68	10.	Wind Long	0.	68-1	10.
68	12.	Wind Long	0.	68-1	12.
68	14.	Wind Long	0.	68-1	14.
68	16.	Wind Long	0.	68-1	16.
68	18.	Wind Long	0.	68-1	18.
68	20.	Wind Long	0.	68-1	20.
68	22.	Wind Long	0.	68-1	22.
68	24.	Wind Long	0.	68-1	24.
68	26.	Wind Long	0.	68-1	26.
68	28.	Wind Long	0.	68-1	28.
68	30.	Wind Long	0.	68-1	30.
68	32.	Wind Long	0.	68-1	32.
68	34.	Wind Long	0.	68-1	34.
68	36.	Wind Long	0.	68-1	36.
68	38.	Wind Long	0.	68-1	38.
68	40.	Wind Long	0.	68-1	40.
68	42.	Wind Long	0.	68-1	42.
68	44.	Wind Long	0.	68-1	44.
68	46.	Wind Long	0.	68-1	46.
68	48.	Wind Long	0.	68-1	48.
86	0.	Long	0.944	86-1	0.
86	2.	Long	-48.6731	86-1	2.
86	4.	Long	-98.2903	86-1	4.
86	0.	Wind Long	0.	86-1	0.
86	2.	Wind Long	0.	86-1	2.
86	4.	Wind Long	0.	86-1	4.
87	0.	Long	-99.9816	87-1	0.
87	2.	Long	-189.5161	87-1	2.
87	0.	Wind Long	0.	87-1	0.
87	2.	Wind Long	0.	87-1	2.
88	0.	Long	189.5161	88-1	0.
88	2.	Long	99.9816	88-1	2.
88	0.	Wind Long	0.	88-1	0.
88	2.	Wind Long	0.	88-1	2.
89	0.	Long	98.2903	89-1	0.
89	2.	Long	48.6731	89-1	2.
89	4.	Long	-0.944	89-1	4.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
89	0.	Wind Long	0.	89-1	0.
89	2.	Wind Long	0.	89-1	2.
89	4.	Wind Long	0.	89-1	4.
90	0.	Long	-39.0852	90-1	0.
90	0.4005	Long	-26.7857	90-1	0.4005
90	0.4005	Long	-26.7857	90-2	0.
90	0.801	Long	-14.4863	90-2	0.4005
90	0.801	Long	-14.4863	90-3	0.
90	1.2015	Long	-2.1868	90-3	0.4005
90	1.2015	Long	-2.1868	90-4	0.
90	1.602	Long	10.1127	90-4	0.4005
90	1.602	Long	10.1127	90-5	0.
90	2.0026	Long	22.4122	90-5	0.4005
90	2.0026	Long	22.4122	90-6	0.
90	2.4031	Long	34.7116	90-6	0.4005
90	2.4031	Long	34.7116	90-7	0.
90	2.8036	Long	47.0111	90-7	0.4005
90	2.8036	Long	47.0111	90-8	0.
90	3.2041	Long	59.3106	90-8	0.4005
90	3.2041	Long	59.3106	90-9	0.
90	3.6046	Long	71.6101	90-9	0.4005
90	3.6046	Long	71.6101	90-10	0.
90	4.0051	Long	83.9095	90-10	0.4005
90	0.	Wind Long	0.	90-1	0.
90	0.4005	Wind Long	0.	90-1	0.4005
90	0.4005	Wind Long	0.	90-2	0.
90	0.801	Wind Long	0.	90-2	0.4005
90	0.801	Wind Long	0.	90-3	0.
90	1.2015	Wind Long	0.	90-3	0.4005
90	1.2015	Wind Long	0.	90-4	0.
90	1.602	Wind Long	0.	90-4	0.4005
90	1.602	Wind Long	0.	90-5	0.
90	2.0026	Wind Long	0.	90-5	0.4005
90	2.0026	Wind Long	0.	90-6	0.
90	2.4031	Wind Long	0.	90-6	0.4005
90	2.4031	Wind Long	0.	90-7	0.
90	2.8036	Wind Long	0.	90-7	0.4005
90	2.8036	Wind Long	0.	90-8	0.
90	3.2041	Wind Long	0.	90-8	0.4005
90	3.2041	Wind Long	0.	90-9	0.
90	3.6046	Wind Long	0.	90-9	0.4005
90	3.6046	Wind Long	0.	90-10	0.
90	4.0051	Wind Long	0.	90-10	0.4005
91	0.	Long	45.4074	91-1	0.
91	0.1998	Long	54.4033	91-1	0.1998
91	0.1998	Long	54.4033	91-2	0.
91	0.3996	Long	63.3992	91-2	0.1998
91	0.3996	Long	63.3992	91-3	0.
91	0.5995	Long	72.395	91-3	0.1998
91	0.5995	Long	72.395	91-4	0.
91	0.7993	Long	81.3909	91-4	0.1998
91	0.7993	Long	81.3909	91-5	0.
91	0.9991	Long	90.3868	91-5	0.1998
91	0.9991	Long	90.3868	91-6	0.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
91	1.1989	Long	99.3827	91-6	0.1998
91	1.1989	Long	99.3827	91-7	0.
91	1.3988	Long	108.3786	91-7	0.1998
91	1.3988	Long	108.3786	91-8	0.
91	1.5986	Long	117.3745	91-8	0.1998
91	1.5986	Long	117.3745	91-9	0.
91	1.7984	Long	126.3704	91-9	0.1998
91	1.7984	Long	126.3704	91-10	0.
91	1.9982	Long	135.3662	91-10	0.1998
91	0.	Wind Long	0.	91-1	0.
91	0.1998	Wind Long	0.	91-1	0.1998
91	0.1998	Wind Long	0.	91-2	0.
91	0.3996	Wind Long	0.	91-2	0.1998
91	0.3996	Wind Long	0.	91-3	0.
91	0.5995	Wind Long	0.	91-3	0.1998
91	0.5995	Wind Long	0.	91-4	0.
91	0.7993	Wind Long	0.	91-4	0.1998
91	0.7993	Wind Long	0.	91-5	0.
91	0.9991	Wind Long	0.	91-5	0.1998
91	0.9991	Wind Long	0.	91-6	0.
91	1.1989	Wind Long	0.	91-6	0.1998
91	1.1989	Wind Long	0.	91-7	0.
91	1.3988	Wind Long	0.	91-7	0.1998
91	1.3988	Wind Long	0.	91-8	0.
91	1.5986	Wind Long	0.	91-8	0.1998
91	1.5986	Wind Long	0.	91-9	0.
91	1.7984	Wind Long	0.	91-9	0.1998
91	1.7984	Wind Long	0.	91-10	0.
91	1.9982	Wind Long	0.	91-10	0.1998
92	0.	Long	-135.3662	92-1	0.
92	0.1998	Long	-126.3704	92-1	0.1998
92	0.1998	Long	-126.3704	92-2	0.
92	0.3996	Long	-117.3745	92-2	0.1998
92	0.3996	Long	-117.3745	92-3	0.
92	0.5995	Long	-108.3786	92-3	0.1998
92	0.5995	Long	-108.3786	92-4	0.
92	0.7993	Long	-99.3827	92-4	0.1998
92	0.7993	Long	-99.3827	92-5	0.
92	0.9991	Long	-90.3868	92-5	0.1998
92	0.9991	Long	-90.3868	92-6	0.
92	1.1989	Long	-81.3909	92-6	0.1998
92	1.1989	Long	-81.3909	92-7	0.
92	1.3988	Long	-72.395	92-7	0.1998
92	1.3988	Long	-72.395	92-8	0.
92	1.5986	Long	-63.3992	92-8	0.1998
92	1.5986	Long	-63.3992	92-9	0.
92	1.7984	Long	-54.4033	92-9	0.1998
92	1.7984	Long	-54.4033	92-10	0.
92	1.9982	Long	-45.4074	92-10	0.1998
92	0.	Wind Long	0.	92-1	0.
92	0.1998	Wind Long	0.	92-1	0.1998
92	0.1998	Wind Long	0.	92-2	0.
92	0.3996	Wind Long	0.	92-2	0.1998
92	0.3996	Wind Long	0.	92-3	0.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
92	0.5995	Wind Long	0.	92-3	0.1998
92	0.5995	Wind Long	0.	92-4	0.
92	0.7993	Wind Long	0.	92-4	0.1998
92	0.7993	Wind Long	0.	92-5	0.
92	0.9991	Wind Long	0.	92-5	0.1998
92	0.9991	Wind Long	0.	92-6	0.
92	1.1989	Wind Long	0.	92-6	0.1998
92	1.1989	Wind Long	0.	92-7	0.
92	1.3988	Wind Long	0.	92-7	0.1998
92	1.3988	Wind Long	0.	92-8	0.
92	1.5986	Wind Long	0.	92-8	0.1998
92	1.5986	Wind Long	0.	92-9	0.
92	1.7984	Wind Long	0.	92-9	0.1998
92	1.7984	Wind Long	0.	92-10	0.
92	1.9982	Wind Long	0.	92-10	0.1998
93	0.	Long	-83.9095	93-1	0.
93	0.4005	Long	-71.6101	93-1	0.4005
93	0.4005	Long	-71.6101	93-2	0.
93	0.801	Long	-59.3106	93-2	0.4005
93	0.801	Long	-59.3106	93-3	0.
93	1.2015	Long	-47.0111	93-3	0.4005
93	1.2015	Long	-47.0111	93-4	0.
93	1.602	Long	-34.7116	93-4	0.4005
93	1.602	Long	-34.7116	93-5	0.
93	2.0026	Long	-22.4122	93-5	0.4005
93	2.0026	Long	-22.4122	93-6	0.
93	2.4031	Long	-10.1127	93-6	0.4005
93	2.4031	Long	-10.1127	93-7	0.
93	2.8036	Long	2.1868	93-7	0.4005
93	2.8036	Long	2.1868	93-8	0.
93	3.2041	Long	14.4863	93-8	0.4005
93	3.2041	Long	14.4863	93-9	0.
93	3.6046	Long	26.7857	93-9	0.4005
93	3.6046	Long	26.7857	93-10	0.
93	4.0051	Long	39.0852	93-10	0.4005
93	0.	Wind Long	0.	93-1	0.
93	0.4005	Wind Long	0.	93-1	0.4005
93	0.4005	Wind Long	0.	93-2	0.
93	0.801	Wind Long	0.	93-2	0.4005
93	0.801	Wind Long	0.	93-3	0.
93	1.2015	Wind Long	0.	93-3	0.4005
93	1.2015	Wind Long	0.	93-4	0.
93	1.602	Wind Long	0.	93-4	0.4005
93	1.602	Wind Long	0.	93-5	0.
93	2.0026	Wind Long	0.	93-5	0.4005
93	2.0026	Wind Long	0.	93-6	0.
93	2.4031	Wind Long	0.	93-6	0.4005
93	2.4031	Wind Long	0.	93-7	0.
93	2.8036	Wind Long	0.	93-7	0.4005
93	2.8036	Wind Long	0.	93-8	0.
93	3.2041	Wind Long	0.	93-8	0.4005
93	3.2041	Wind Long	0.	93-9	0.
93	3.6046	Wind Long	0.	93-9	0.4005
93	3.6046	Wind Long	0.	93-10	0.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
93	4.0051	Wind Long	0.	93-10	0.4005
94	0.	Long	-3.001E-11	94-1	0.
94	0.3002	Long	-2.919E-11	94-1	0.3002
94	0.3002	Long	-5.912E-11	94-2	0.
94	0.6003	Long	-5.775E-11	94-2	0.3002
94	0.6003	Long	-1.082E-10	94-3	0.
94	0.9005	Long	-1.063E-10	94-3	0.3002
94	0.9005	Long	-9.823E-11	94-4	0.
94	1.2007	Long	-9.659E-11	94-4	0.3002
94	1.2007	Long	-5.912E-11	94-5	0.
94	1.5008	Long	-5.721E-11	94-5	0.3002
94	1.5008	Long	-9.823E-11	94-6	0.
94	1.801	Long	-9.659E-11	94-6	0.3002
94	1.801	Long	-5.912E-11	94-7	0.
94	2.1012	Long	-5.748E-11	94-7	0.3002
94	2.1012	Long	-8.822E-11	94-8	0.
94	2.4013	Long	-8.686E-11	94-8	0.3002
94	2.4013	Long	-7.731E-11	94-9	0.
94	2.7015	Long	-7.649E-11	94-9	0.3002
94	2.7015	Long	-1.273E-10	94-10	0.
94	3.0017	Long	-1.258E-10	94-10	0.3002
94	0.	Wind Long	0.	94-1	0.
94	0.3002	Wind Long	0.	94-1	0.3002
94	0.3002	Wind Long	0.	94-2	0.
94	0.6003	Wind Long	0.	94-2	0.3002
94	0.6003	Wind Long	0.	94-3	0.
94	0.9005	Wind Long	0.	94-3	0.3002
94	0.9005	Wind Long	0.	94-4	0.
94	1.2007	Wind Long	0.	94-4	0.3002
94	1.2007	Wind Long	0.	94-5	0.
94	1.5008	Wind Long	0.	94-5	0.3002
94	1.5008	Wind Long	0.	94-6	0.
94	1.801	Wind Long	0.	94-6	0.3002
94	1.801	Wind Long	0.	94-7	0.
94	2.1012	Wind Long	0.	94-7	0.3002
94	2.1012	Wind Long	0.	94-8	0.
94	2.4013	Wind Long	0.	94-8	0.3002
94	2.4013	Wind Long	0.	94-9	0.
94	2.7015	Wind Long	0.	94-9	0.3002
94	2.7015	Wind Long	0.	94-10	0.
94	3.0017	Wind Long	0.	94-10	0.3002
95	0.	Long	-244.8847	95-1	0.
95	0.5255	Long	-217.7307	95-1	0.5255
95	0.5255	Long	-217.7307	95-2	0.
95	1.0511	Long	-190.5767	95-2	0.5255
95	1.0511	Long	-190.5767	95-3	0.
95	1.5766	Long	-163.4227	95-3	0.5255
95	1.5766	Long	-163.4227	95-4	0.
95	2.1022	Long	-136.2687	95-4	0.5255
95	2.1022	Long	-136.2687	95-5	0.
95	2.6277	Long	-109.1147	95-5	0.5255
95	2.6277	Long	-109.1147	95-6	0.
95	3.1532	Long	-81.9607	95-6	0.5255
95	3.1532	Long	-81.9607	95-7	0.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
95	3.6788	Long	-54.8067	95-7	0.5255
95	3.6788	Long	-54.8067	95-8	0.
95	4.2043	Long	-27.6527	95-8	0.5255
95	4.2043	Long	-27.6527	95-9	0.
95	4.7299	Long	-0.4987	95-9	0.5255
95	4.7299	Long	-0.4987	95-10	0.
95	5.2554	Long	26.6553	95-10	0.5255
95	0.	Wind Long	0.	95-1	0.
95	0.5255	Wind Long	0.	95-1	0.5255
95	0.5255	Wind Long	0.	95-2	0.
95	1.0511	Wind Long	0.	95-2	0.5255
95	1.0511	Wind Long	0.	95-3	0.
95	1.5766	Wind Long	0.	95-3	0.5255
95	1.5766	Wind Long	0.	95-4	0.
95	2.1022	Wind Long	0.	95-4	0.5255
95	2.1022	Wind Long	0.	95-5	0.
95	2.6277	Wind Long	0.	95-5	0.5255
95	2.6277	Wind Long	0.	95-6	0.
95	3.1532	Wind Long	0.	95-6	0.5255
95	3.1532	Wind Long	0.	95-7	0.
95	3.6788	Wind Long	0.	95-7	0.5255
95	3.6788	Wind Long	0.	95-8	0.
95	4.2043	Wind Long	0.	95-8	0.5255
95	4.2043	Wind Long	0.	95-9	0.
95	4.7299	Wind Long	0.	95-9	0.5255
95	4.7299	Wind Long	0.	95-10	0.
95	5.2554	Wind Long	0.	95-10	0.5255
96	0.	Long	-26.4302	96-1	0.
96	0.525	Long	0.6979	96-1	0.525
96	0.525	Long	0.6979	96-2	0.
96	1.0501	Long	27.8261	96-2	0.525
96	1.0501	Long	27.8261	96-3	0.
96	1.5751	Long	54.9543	96-3	0.525
96	1.5751	Long	54.9543	96-4	0.
96	2.1002	Long	82.0824	96-4	0.525
96	2.1002	Long	82.0824	96-5	0.
96	2.6252	Long	109.2106	96-5	0.525
96	2.6252	Long	109.2106	96-6	0.
96	3.1503	Long	136.3388	96-6	0.525
96	3.1503	Long	136.3388	96-7	0.
96	3.6753	Long	163.467	96-7	0.525
96	3.6753	Long	163.467	96-8	0.
96	4.2003	Long	190.5951	96-8	0.525
96	4.2003	Long	190.5951	96-9	0.
96	4.7254	Long	217.7233	96-9	0.525
96	4.7254	Long	217.7233	96-10	0.
96	5.2504	Long	244.8515	96-10	0.525
96	0.	Wind Long	0.	96-1	0.
96	0.525	Wind Long	0.	96-1	0.525
96	0.525	Wind Long	0.	96-2	0.
96	1.0501	Wind Long	0.	96-2	0.525
96	1.0501	Wind Long	0.	96-3	0.
96	1.5751	Wind Long	0.	96-3	0.525
96	1.5751	Wind Long	0.	96-4	0.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
96	2.1002	Wind Long	0.	96-4	0.525
96	2.1002	Wind Long	0.	96-5	0.
96	2.6252	Wind Long	0.	96-5	0.525
96	2.6252	Wind Long	0.	96-6	0.
96	3.1503	Wind Long	0.	96-6	0.525
96	3.1503	Wind Long	0.	96-7	0.
96	3.6753	Wind Long	0.	96-7	0.525
96	3.6753	Wind Long	0.	96-8	0.
96	4.2003	Wind Long	0.	96-8	0.525
96	4.2003	Wind Long	0.	96-9	0.
96	4.7254	Wind Long	0.	96-9	0.525
96	4.7254	Wind Long	0.	96-10	0.
96	5.2504	Wind Long	0.	96-10	0.525
97	0.	Long	1.000E-11	97-1	0.
97	0.3002	Long	9.868E-12	97-1	0.3002
97	0.3002	Long	-2.910E-11	97-2	0.
97	0.6003	Long	-2.883E-11	97-2	0.3002
97	0.6003	Long	-3.820E-11	97-3	0.
97	0.9005	Long	-3.847E-11	97-3	0.3002
97	0.9005	Long	-7.731E-11	97-4	0.
97	1.2007	Long	-7.758E-11	97-4	0.3002
97	1.2007	Long	-7.822E-11	97-5	0.
97	1.5008	Long	-7.876E-11	97-5	0.3002
97	1.5008	Long	-2.819E-11	97-6	0.
97	1.801	Long	-2.874E-11	97-6	0.3002
97	1.801	Long	-2.910E-11	97-7	0.
97	2.1012	Long	-2.938E-11	97-7	0.3002
97	2.1012	Long	-3.820E-11	97-8	0.
97	2.4013	Long	-3.847E-11	97-8	0.3002
97	2.4013	Long	-1.000E-11	97-9	0.
97	2.7015	Long	-9.185E-12	97-9	0.3002
97	2.7015	Long	-2.910E-11	97-10	0.
97	3.0017	Long	-2.856E-11	97-10	0.3002
97	0.	Wind Long	0.	97-1	0.
97	0.3002	Wind Long	0.	97-1	0.3002
97	0.3002	Wind Long	0.	97-2	0.
97	0.6003	Wind Long	0.	97-2	0.3002
97	0.6003	Wind Long	0.	97-3	0.
97	0.9005	Wind Long	0.	97-3	0.3002
97	0.9005	Wind Long	0.	97-4	0.
97	1.2007	Wind Long	0.	97-4	0.3002
97	1.2007	Wind Long	0.	97-5	0.
97	1.5008	Wind Long	0.	97-5	0.3002
97	1.5008	Wind Long	0.	97-6	0.
97	1.801	Wind Long	0.	97-6	0.3002
97	1.801	Wind Long	0.	97-7	0.
97	2.1012	Wind Long	0.	97-7	0.3002
97	2.1012	Wind Long	0.	97-8	0.
97	2.4013	Wind Long	0.	97-8	0.3002
97	2.4013	Wind Long	0.	97-9	0.
97	2.7015	Wind Long	0.	97-9	0.3002
97	2.7015	Wind Long	0.	97-10	0.
97	3.0017	Wind Long	0.	97-10	0.3002
98	0.	Long	-2.046E-12	98-1	0.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
98	1.5008	Long	-1.961E-12	98-1	1.5008
98	3.0017	Long	-1.876E-12	98-1	3.0017
98	0.	Wind Long	0.	98-1	0.
98	1.5008	Wind Long	0.	98-1	1.5008
98	3.0017	Wind Long	0.	98-1	3.0017
99	0.	Long	-239.5215	99-1	0.
99	1.7518	Long	-161.3254	99-1	1.7518
99	3.5036	Long	-83.1293	99-1	3.5036
99	5.2554	Long	-4.9332	99-1	5.2554
99	0.	Wind Long	0.	99-1	0.
99	1.7518	Wind Long	0.	99-1	1.7518
99	3.5036	Wind Long	0.	99-1	3.5036
99	5.2554	Wind Long	0.	99-1	5.2554
100	0.	Long	5.1588	100-1	0.
100	1.7501	Long	83.2805	100-1	1.7501
100	3.5003	Long	161.4023	100-1	3.5003
100	5.2504	Long	239.524	100-1	5.2504
100	0.	Wind Long	0.	100-1	0.
100	1.7501	Wind Long	0.	100-1	1.7501
100	3.5003	Wind Long	0.	100-1	3.5003
100	5.2504	Wind Long	0.	100-1	5.2504
101	0.	Long	2.274E-13	101-1	0.
101	1.5008	Long	-2.856E-14	101-1	1.5008
101	3.0017	Long	-2.845E-13	101-1	3.0017
101	0.	Wind Long	0.	101-1	0.
101	1.5008	Wind Long	0.	101-1	1.5008
101	3.0017	Wind Long	0.	101-1	3.0017
102	0.	Long	-8.0463	102-1	0.
102	1.335	Long	-6.4262	102-1	1.335
102	2.6701	Long	-4.8061	102-1	2.6701
102	4.0051	Long	-3.186	102-1	4.0051
102	0.	Wind Long	0.	102-1	0.
102	1.335	Wind Long	0.	102-1	1.335
102	2.6701	Wind Long	0.	102-1	2.6701
102	4.0051	Wind Long	0.	102-1	4.0051
103	0.	Long	-11.3274	103-1	0.
103	1.9982	Long	-8.546	103-1	1.9982
103	0.	Wind Long	0.	103-1	0.
103	1.9982	Wind Long	0.	103-1	1.9982
104	0.	Long	8.546	104-1	0.
104	1.9982	Long	11.3274	104-1	1.9982
104	0.	Wind Long	0.	104-1	0.
104	1.9982	Wind Long	0.	104-1	1.9982
105	0.	Long	3.186	105-1	0.
105	1.335	Long	4.8061	105-1	1.335
105	2.6701	Long	6.4262	105-1	2.6701
105	4.0051	Long	8.0463	105-1	4.0051
105	0.	Wind Long	0.	105-1	0.
105	1.335	Wind Long	0.	105-1	1.335
105	2.6701	Wind Long	0.	105-1	2.6701
105	4.0051	Wind Long	0.	105-1	4.0051
106	0.	Long	-4.3644	106-1	0.
106	1.335	Long	-1.9848	106-1	1.335
106	2.6701	Long	0.3948	106-1	2.6701

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
106	4.0051	Long	2.7744	106-1	4.0051
106	0.	Wind Long	0.	106-1	0.
106	1.335	Wind Long	0.	106-1	1.335
106	2.6701	Wind Long	0.	106-1	2.6701
106	4.0051	Wind Long	0.	106-1	4.0051
107	0.	Long	-1.6381	107-1	0.
107	1.9982	Long	3.3427	107-1	1.9982
107	0.	Wind Long	0.	107-1	0.
107	1.9982	Wind Long	0.	107-1	1.9982
108	0.	Long	-3.3427	108-1	0.
108	1.9982	Long	1.6381	108-1	1.9982
108	0.	Wind Long	0.	108-1	0.
108	1.9982	Wind Long	0.	108-1	1.9982
109	0.	Long	-2.7744	109-1	0.
109	1.335	Long	-0.3948	109-1	1.335
109	2.6701	Long	1.9848	109-1	2.6701
109	4.0051	Long	4.3644	109-1	4.0051
109	0.	Wind Long	0.	109-1	0.
109	1.335	Wind Long	0.	109-1	1.335
109	2.6701	Wind Long	0.	109-1	2.6701
109	4.0051	Wind Long	0.	109-1	4.0051
110	0.	Long	-6.3579	110-1	0.
110	1.335	Long	-8.6735	110-1	1.335
110	2.6701	Long	-10.9891	110-1	2.6701
110	4.0051	Long	-13.3047	110-1	4.0051
110	0.	Wind Long	0.	110-1	0.
110	1.335	Wind Long	0.	110-1	1.335
110	2.6701	Wind Long	0.	110-1	2.6701
110	4.0051	Wind Long	0.	110-1	4.0051
111	0.	Long	-19.8213	111-1	0.
111	1.9982	Long	-25.5772	111-1	1.9982
111	0.	Wind Long	0.	111-1	0.
111	1.9982	Wind Long	0.	111-1	1.9982
112	0.	Long	25.5772	112-1	0.
112	1.9982	Long	19.8213	112-1	1.9982
112	0.	Wind Long	0.	112-1	0.
112	1.9982	Wind Long	0.	112-1	1.9982
113	0.	Long	13.3047	113-1	0.
113	1.335	Long	10.9891	113-1	1.335
113	2.6701	Long	8.6735	113-1	2.6701
113	4.0051	Long	6.3579	113-1	4.0051
113	0.	Wind Long	0.	113-1	0.
113	1.335	Wind Long	0.	113-1	1.335
113	2.6701	Wind Long	0.	113-1	2.6701
113	4.0051	Wind Long	0.	113-1	4.0051
114	0.	Long	-29.4123	114-1	0.
114	1.335	Long	-10.3468	114-1	1.335
114	2.6701	Long	8.7187	114-1	2.6701
114	4.0051	Long	27.7843	114-1	4.0051
114	0.	Wind Long	0.	114-1	0.
114	1.335	Wind Long	0.	114-1	1.335
114	2.6701	Wind Long	0.	114-1	2.6701
114	4.0051	Wind Long	0.	114-1	4.0051
115	0.	Long	-1.6843	115-1	0.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
115	1.9982	Long	38.0053	115-1	1.9982
115	0.	Wind Long	0.	115-1	0.
115	1.9982	Wind Long	0.	115-1	1.9982
116	0.	Long	-38.0053	116-1	0.
116	1.9982	Long	1.6843	116-1	1.9982
116	0.	Wind Long	0.	116-1	0.
116	1.9982	Wind Long	0.	116-1	1.9982
117	0.	Long	-27.7843	117-1	0.
117	1.335	Long	-8.7187	117-1	1.335
117	2.6701	Long	10.3468	117-1	2.6701
117	4.0051	Long	29.4123	117-1	4.0051
117	0.	Wind Long	0.	117-1	0.
117	1.335	Wind Long	0.	117-1	1.335
117	2.6701	Wind Long	0.	117-1	2.6701
117	4.0051	Wind Long	0.	117-1	4.0051

Table: Frame Section Assignments

Table: Frame Section Assignments

Frame	SectionType	AutoSelect	AnalSect	DesignSect	MatProp
1	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
2	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
3	Rectangular	N.A.	FSEC2	FSEC2	Default
4	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
5	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
6	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
7	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
8	Rectangular	N.A.	FSEC2	FSEC2	Default
9	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
10	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
12	Circle	N.A.	Shaft	Shaft	Default
14	Circle	N.A.	Shaft	Shaft	Default
17	Circle	N.A.	Shaft	Shaft	Default
19	Circle	N.A.	Shaft	Shaft	Default
21	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
22	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
24	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
25	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
26	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
27	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
29	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
30	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
31	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
32	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
34	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
35	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
36	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
37	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
39	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
40	I/Wide Flange	N.A.	HP14x117	HP14x117	Default
62	Rectangular	N.A.	FSEC2	FSEC2	Default
63	Rectangular	N.A.	FSEC2	FSEC2	Default

Table: Frame Section Assignments

Frame	SectionType	AutoSelect	AnalSect	DesignSect	MatProp
64	Rectangular	N.A.	FSEC2	FSEC2	Default
65	Rectangular	N.A.	FSEC2	FSEC2	Default
68	Rectangular	N.A.	FSEC2	FSEC2	Default
86	Rectangular	N.A.	Pile Cap	Pile Cap	Default
87	Rectangular	N.A.	Pile Cap	Pile Cap	Default
88	Rectangular	N.A.	Pile Cap	Pile Cap	Default
89	Rectangular	N.A.	Pile Cap	Pile Cap	Default
90	Rectangular	N.A.	Pile Cap	Pile Cap	Default
91	Rectangular	N.A.	Pile Cap	Pile Cap	Default
92	Rectangular	N.A.	Pile Cap	Pile Cap	Default
93	Rectangular	N.A.	Pile Cap	Pile Cap	Default
94	Rectangular	N.A.	Pier Cap	Pier Cap	Default
95	Rectangular	N.A.	Pier Cap	Pier Cap	Default
96	Rectangular	N.A.	Pier Cap	Pier Cap	Default
97	Rectangular	N.A.	Pier Cap	Pier Cap	Default
98	Rectangular	N.A.	Pier Cap	Pier Cap	Default
99	Rectangular	N.A.	Pier Cap	Pier Cap	Default
100	Rectangular	N.A.	Pier Cap	Pier Cap	Default
101	Rectangular	N.A.	Pier Cap	Pier Cap	Default
102	Rectangular	N.A.	Pile Cap	Pile Cap	Default
103	Rectangular	N.A.	Pile Cap	Pile Cap	Default
104	Rectangular	N.A.	Pile Cap	Pile Cap	Default
105	Rectangular	N.A.	Pile Cap	Pile Cap	Default
106	Rectangular	N.A.	Pile Cap	Pile Cap	Default
107	Rectangular	N.A.	Pile Cap	Pile Cap	Default
108	Rectangular	N.A.	Pile Cap	Pile Cap	Default
109	Rectangular	N.A.	Pile Cap	Pile Cap	Default
110	Rectangular	N.A.	Pile Cap	Pile Cap	Default
111	Rectangular	N.A.	Pile Cap	Pile Cap	Default
112	Rectangular	N.A.	Pile Cap	Pile Cap	Default
113	Rectangular	N.A.	Pile Cap	Pile Cap	Default
114	Rectangular	N.A.	Pile Cap	Pile Cap	Default
115	Rectangular	N.A.	Pile Cap	Pile Cap	Default
116	Rectangular	N.A.	Pile Cap	Pile Cap	Default
117	Rectangular	N.A.	Pile Cap	Pile Cap	Default

Table: Frame Section Properties 01 - General, Part 1 of 7

Table: Frame Section Properties 01 - General, Part 1 of 7

SectionName	Material	Shape	t3 ft	t2 ft	tf ft	tw ft
FSEC1	A709Gr50	I/Wide Flange	1.	0.41667	0.03167	0.02083
FSEC2	4000Psi	Rectangular	5.	5.		
HP14x117	A709Gr50	I/Wide Flange	1.18	1.24	0.067	0.067
Pier Cap	4000Psi	Rectangular	5.	5.		
Pile Cap	4000Psi	Rectangular	2.67	3.		
Shaft	4000Psi	Circle	4.			

Table: Frame Section Properties 01 - General, Part 2 of 7**Table: Frame Section Properties 01 - General, Part 2 of 7**

SectionName	t2b ft	tfb ft	FilletRadius ft	Area ft2	TorsConst ft4	I33 ft4	I22 ft4
FSEC1	0.41667	0.03167	0.	0.0459	0.000011	0.007615	0.000382
FSEC2				25.	88.020833	52.083333	52.083333
HP14x117	1.24	0.067	0.	0.2362	0.000341	0.05791	0.021317
Pier Cap				25.	88.020833	52.083333	52.083333
Pile Cap				8.01	8.919719	4.758541	6.0075
Shaft				12.5664	25.132741	12.566371	12.566371

Table: Frame Section Properties 01 - General, Part 3 of 7**Table: Frame Section Properties 01 - General, Part 3 of 7**

SectionName	I23 ft4	AS2 ft2	AS3 ft2	S33Top ft3	S33Bot ft3	S22Left ft3	S22Right ft3
FSEC1	0.	0.0208	0.022	0.01523	0.01523	0.001836	0.001836
FSEC2	0.	20.8333	20.8333	20.833333	20.833333	20.833333	20.833333
HP14x117	0.	0.0791	0.1385	0.098153	0.098153	0.034382	0.034382
Pier Cap	0.	20.8333	20.8333	20.833333	20.833333	20.833333	20.833333
Pile Cap	0.	6.675	6.675	3.56445	3.56445	4.005	4.005
Shaft	0.	11.3097	11.3097	6.283185	6.283185	6.283185	6.283185

Table: Frame Section Properties 01 - General, Part 4 of 7**Table: Frame Section Properties 01 - General, Part 4 of 7**

SectionName	Z33 ft3	Z22 ft3	R33 ft	R22 ft	CGOffset3 ft	CGOffset2 ft	EccV2 ft
FSEC1	0.017346	0.00285	0.4073	0.09128	0.	0.	0.
FSEC2	31.25	31.25	1.44338	1.44338	0.	0.	0.
HP14x117	0.110794	0.052683	0.49511	0.30039	0.	0.	0.
Pier Cap	31.25	31.25	1.44338	1.44338	0.	0.	0.
Pile Cap	5.346675	6.0075	0.77076	0.86603	0.	0.	0.
Shaft	10.666667	10.666667	1.	1.	0.	0.	0.

Table: Frame Section Properties 01 - General, Part 5 of 7**Table: Frame Section Properties 01 - General, Part 5 of 7**

SectionName	EccV3 ft	Cw ft6	ConcCol	ConcBeam	Color	TotalWt Kip	TotalMass Kip-s2/ft
FSEC1	0.	0.000089	No	No	Gray8Dark	0.	0.
FSEC2	0.	0.	Yes	No	Yellow	0.	41.3
HP14x117	0.	0.006594	No	No	Gray8Dark	66.538	2.07
Pier Cap	0.	0.	Yes	No	Yellow	123.819	3.85
Pile Cap	0.	0.	Yes	No	Red	86.548	2.69
Shaft	0.	0.	Yes	No	Green	248.814	7.73

Table: Frame Section Properties 01 - General, Part 6 of 7**Table: Frame Section Properties 01 - General, Part 6 of 7**

SectionName	FromFile	AMod	A2Mod	A3Mod	JMod	I2Mod	I3Mod
FSEC1	No	1.	1.	1.	1.	1.	1.

Table: Frame Section Properties 01 - General, Part 6 of 7

SectionName	FromFile	AMod	A2Mod	A3Mod	JMod	I2Mod	I3Mod
FSEC2	No	1000000000.	1.	1.	1.	1000000000.	1000000000.
HP14x117	No	1.	1.	1.	1.	1.	1.
Pier Cap	No	1.	1.	1.	1.	1.	1.
Pile Cap	No	1.	1.	1.	1.	1.	1.
Shaft	No	1.	1.	1.	1.	1.	1.

Table: Frame Section Properties 01 - General, Part 7 of 7

Table: Frame Section Properties 01 - General, Part 7 of 7

SectionName	MMod	WMod	GUID	Notes
FSEC1	1.	1.		Added 3/28/2025 9:46:21 AM
FSEC2	1.	0.		Added 3/31/2025 4:34:18 PM
HP14x117	1.	1.		Added 4/4/2025 8:56:48 AM
Pier Cap	1.	1.		Added 4/4/2025 1:24:57 PM
Pile Cap	1.	1.		Added 4/4/2025 1:16:51 PM
Shaft	1.	1.		Added 4/4/2025 10:03:15 AM

Table: Frame Section Properties 02 - Concrete Column, Part 1 of 2

Table: Frame Section Properties 02 - Concrete Column, Part 1 of 2

SectionName	RebarMatL	RebarMatC	ReinfConfig	LatReinf	Cover	NumBars3D ir	NumBars2D ir	NumBarsCir c
					ft			
FSEC2	A615Gr60	A615Gr60	Rectangular	Ties	0.125	3	3	
Pier Cap	A615Gr60	A615Gr60	Rectangular	Ties	0.125	3	3	
Pile Cap	A615Gr60	A615Gr60	Rectangular	Ties	0.125	3	3	
Shaft	A615Gr60	A615Gr60	Circular	Ties	0.125			8

Table: Frame Section Properties 02 - Concrete Column, Part 2 of 2

Table: Frame Section Properties 02 - Concrete Column, Part 2 of 2

SectionName	BarSizeL	BarSizeC	SpacingC	NumCBars2	NumCBars3	ReinfType
			ft			
FSEC2	#9	#4	0.5	3	3	Design
Pier Cap	#9	#4	0.5	3	3	Design
Pile Cap	#9	#4	0.5	3	3	Design
Shaft	#9	#4	0.5			Design

Table: Joint Coordinates, Part 1 of 2

Table: Joint Coordinates, Part 1 of 2

Joint	CoordSys	CoordType	XorR	Y	Z	SpecialJt	GlobalX
			ft	ft	ft		ft
1	GLOBAL	Cartesian	0.	-6.	9.7	No	0.
2	GLOBAL	Cartesian	0.	-6.	20.	No	0.
3	GLOBAL	Cartesian	0.	-2.	9.7	No	0.
4	GLOBAL	Cartesian	0.	-2.	20.	No	0.
6	GLOBAL	Cartesian	0.	0.	20.	No	0.
7	GLOBAL	Cartesian	0.	2.	9.7	No	0.

Table: Joint Coordinates, Part 1 of 2

Joint	CoordSys	CoordType	XorR ft	Y ft	Z ft	SpecialJt	GlobalX ft
8	GLOBAL	Cartesian	0.	2.	20.	No	0.
9	GLOBAL	Cartesian	0.	6.	9.7	No	0.
10	GLOBAL	Cartesian	0.	6.	20.	No	0.
11	GLOBAL	Cartesian	37.33	-5.2	1.3	No	37.33
12	GLOBAL	Cartesian	37.33	-5.2	20.	No	37.33
13	GLOBAL	Cartesian	35.33	-1.73	1.3	No	35.33
14	GLOBAL	Cartesian	35.33	-1.73	20.	No	35.33
16	GLOBAL	Cartesian	34.33	0.	20.	No	34.33
17	GLOBAL	Cartesian	33.33	1.73	1.3	No	33.33
18	GLOBAL	Cartesian	33.33	1.73	20.	No	33.33
19	GLOBAL	Cartesian	31.33	5.2	1.3	No	31.33
20	GLOBAL	Cartesian	31.33	5.2	20.	No	31.33
22	GLOBAL	Cartesian	86.46	-7.15	20.	No	86.46
23	GLOBAL	Cartesian	84.96	-4.55	-13.	No	84.96
24	GLOBAL	Cartesian	84.96	-4.55	20.	No	84.96
26	GLOBAL	Cartesian	82.33	0.	20.	No	82.33
27	GLOBAL	Cartesian	79.71	4.55	-13.	No	79.71
28	GLOBAL	Cartesian	79.71	4.55	20.	No	79.71
30	GLOBAL	Cartesian	78.21	7.15	20.	No	78.21
32	GLOBAL	Cartesian	189.88	-7.15	20.	No	189.88
33	GLOBAL	Cartesian	188.38	-4.55	-13.	No	188.38
34	GLOBAL	Cartesian	188.38	-4.55	20.	No	188.38
36	GLOBAL	Cartesian	185.75	0.	20.	No	185.75
37	GLOBAL	Cartesian	183.13	4.55	-13.	No	183.13
38	GLOBAL	Cartesian	183.13	4.55	20.	No	183.13
40	GLOBAL	Cartesian	181.63	7.15	20.	No	181.63
41	GLOBAL	Cartesian	213.33	-5.2	-12.	No	213.33
42	GLOBAL	Cartesian	213.33	-5.2	20.	No	213.33
43	GLOBAL	Cartesian	211.33	-1.73	-12.	No	211.33
44	GLOBAL	Cartesian	211.33	-1.73	20.	No	211.33
46	GLOBAL	Cartesian	210.33	0.	20.	No	210.33
47	GLOBAL	Cartesian	209.33	1.73	-12.	No	209.33
48	GLOBAL	Cartesian	209.33	1.73	20.	No	209.33
49	GLOBAL	Cartesian	207.33	5.2	-12.	No	207.33
50	GLOBAL	Cartesian	207.33	5.2	20.	No	207.33
51	GLOBAL	Cartesian	261.33	-5.2	-12.	No	261.33
52	GLOBAL	Cartesian	261.33	-5.2	20.	No	261.33
53	GLOBAL	Cartesian	259.33	-1.73	-12.	No	259.33
54	GLOBAL	Cartesian	259.33	-1.73	20.	No	259.33
56	GLOBAL	Cartesian	258.33	0.	20.	No	258.33
57	GLOBAL	Cartesian	257.33	1.73	-12.	No	257.33
58	GLOBAL	Cartesian	257.33	1.73	20.	No	257.33
59	GLOBAL	Cartesian	255.33	5.2	-12.	No	255.33
60	GLOBAL	Cartesian	255.33	5.2	20.	No	255.33
61	GLOBAL	Cartesian	309.33	-5.2	-12.	No	309.33
62	GLOBAL	Cartesian	309.33	-5.2	20.	No	309.33
63	GLOBAL	Cartesian	307.33	-1.73	-12.	No	307.33
64	GLOBAL	Cartesian	307.33	-1.73	20.	No	307.33
66	GLOBAL	Cartesian	306.33	0.	20.	No	306.33
67	GLOBAL	Cartesian	305.33	1.73	-12.	No	305.33
68	GLOBAL	Cartesian	305.33	1.73	20.	No	305.33
69	GLOBAL	Cartesian	303.33	5.2	-12.	No	303.33
70	GLOBAL	Cartesian	303.33	5.2	20.	No	303.33
71	GLOBAL	Cartesian	357.33	-5.2	1.3	No	357.33

Table: Joint Coordinates, Part 1 of 2

Joint	CoordSys	CoordType	XorR ft	Y ft	Z ft	SpecialJt	GlobalX ft
72	GLOBAL	Cartesian	357.33	-5.2	20.	No	357.33
73	GLOBAL	Cartesian	355.33	-1.73	1.3	No	355.33
74	GLOBAL	Cartesian	355.33	-1.73	20.	No	355.33
76	GLOBAL	Cartesian	354.33	0.	20.	No	354.33
77	GLOBAL	Cartesian	353.33	1.73	1.3	No	353.33
78	GLOBAL	Cartesian	353.33	1.73	20.	No	353.33
79	GLOBAL	Cartesian	351.33	5.2	1.3	No	351.33
80	GLOBAL	Cartesian	351.33	5.2	20.	No	351.33

Table: Joint Coordinates, Part 2 of 2

Table: Joint Coordinates, Part 2 of 2

Joint	GlobalY ft	GlobalZ ft	GUID
1	-6.	9.7	0809ed7f-7d71-4217-aca f-53d3217d1551
2	-6.	20.	a02b7334-f49f-42aa-8efd -9d59e828bc21
3	-2.	9.7	e5537b39-0b0d-42ed-80 a9-d4be40c567ef
4	-2.	20.	c38524e6-e08f-4b3c-bcf 6-b53875cad8f
6	0.	20.	ba6ef406-2d66-4555-a35 1-f82288be0310
7	2.	9.7	7699e8b3-fa5d-4156-86f 0-647bbfdc81b2
8	2.	20.	24cd1603-6d8a-4be2-94f f-171510b38ba8
9	6.	9.7	10c4e439-b5a8-40ee-b9 e4-08a8b1131fe8
10	6.	20.	e3fe68c5-100e-4be0-b78 7-29197dd17ade
11	-5.2	1.3	a17c80fa-1b61-4219-92ff -99aec6abdedb
12	-5.2	20.	235acdba-f4a5-422e-b19 3-514197c1d76a
13	-1.73	1.3	7c7b07bc-caec-4b5b-bcb b-d166a75001a5
14	-1.73	20.	93a2a17b-ddcd-4584-87 10-e3f1363ad486
16	0.	20.	d2097db2-8ef0-4b00-8bb c-b823f0aca17b
17	1.73	1.3	751bb442-22ec-4787-bfb 1-8152659551e6
18	1.73	20.	dd0cdb2b-63dc-4986-94 ec-2f872267a9e1
19	5.2	1.3	48c9a610-ab26-43b7-8c 44-812dd5ee289e
20	5.2	20.	7e18f028-f56b-46c0-af80 -18fc2c81e0be
22	-7.15	20.	cd356439-7f66-417e-859 7-3206236645f4
23	-4.55	-13.	c0def2c4-9a74-43cf-8e0 6-6d6bf1e26c67
24	-4.55	20.	29aac39a-89b1-412f-ade e-9899353e7b76

Table: Joint Coordinates, Part 2 of 2

Joint	GlobalY ft	GlobalZ ft	GUID
26	0.	20.	c92583c7-1804-41dd-a7b5-14bd2cb20403
27	4.55	-13.	92d08974-ced0-4426-9dab-c67abca75a16
28	4.55	20.	1988b294-11d5-4a96-8122-3a671d42ad7e
30	7.15	20.	709c8b38-aea3-456c-8bd3-ed673c58469f
32	-7.15	20.	879bff8e-0d64-4a32-8ca7-0692b6da1791
33	-4.55	-13.	e84da8f1-a526-494c-9ce6-75d3b6fd49a5
34	-4.55	20.	34c0868d-3ade-4428-8ef5-753b4a6b0b9a
36	0.	20.	4b8c48b6-dd33-41e8-a3f9-3e8b88909d81
37	4.55	-13.	2cf089a3-4f19-4d7d-89cf-8c48f7906f86
38	4.55	20.	83b0c174-56ec-46f7-b133-0b06ff15b8ea
40	7.15	20.	d3af0cc5-4c17-4242-b10d-6c703fc53c6f
41	-5.2	-12.	0da0bba7-b979-4b0b-b030-7c1bf8ca5948
42	-5.2	20.	b3560c0f-a993-4830-a6db-55fda9983df3
43	-1.73	-12.	31a99feb-2d42-4f12-b6f5-111df4a7dff6
44	-1.73	20.	141acb1a-7a1a-4f3a-ba21-af2652c91434
46	0.	20.	38a3e8f4-61e0-4f68-8d52-eb2edfad7f7d
47	1.73	-12.	ad09351c-5d92-4457-b468-edda2fd2194d
48	1.73	20.	4aad1712-bcd8-4a63-86a7-3c83dc0e96a1
49	5.2	-12.	c8e3cd4f-d013-454f-bec6-239a53db7469
50	5.2	20.	b13d8751-132a-4a8f-9a42-be61e869fdd3
51	-5.2	-12.	8187925f-e8c5-47c9-97a0-c5758e11b09f
52	-5.2	20.	f99e60ab-3378-4bd9-9168-0f5f55474c5b
53	-1.73	-12.	a83c100c-ba9c-42e2-9831-55debd10ca4f
54	-1.73	20.	f64f85b9-819e-4513-9ac2-3faf366051cf
56	0.	20.	e286f292-03a8-49cd-8ee9-3374b61e87bb
57	1.73	-12.	55162f5a-90b8-4362-89f7-c3730327f7a5
58	1.73	20.	9e9f46e7-d34c-40dd-b5a1-0e50743141e8
59	5.2	-12.	746e5d8f-6077-4a89-a5c2-43c9b568f41e
60	5.2	20.	7b2610a3-1b30-4284-8e68-148794ab67ed
61	-5.2	-12.	774ffaed-9a7d-43d5-b8bc-a0f13d64d954

Table: Joint Coordinates, Part 2 of 2

Joint	GlobalY ft	GlobalZ ft	GUID
62	-5.2	20.	83dd4f74-1491-491d-be51-a050470540df
63	-1.73	-12.	0af98571-9df5-4b97-b430-7ab2df6da282
64	-1.73	20.	20ab6946-adf8-473c-90a7-f639be4b5da6
66	0.	20.	ffc1b0c7-b051-4a86-a0d8-031b798cb2d1
67	1.73	-12.	376a2359-b7a1-4778-a3f7-778cb243b65f
68	1.73	20.	aa52f7d3-c50d-4cbe-940d-8a8831287260
69	5.2	-12.	196d777b-f0b0-4629-adc3-2a2c30f6eb73
70	5.2	20.	b1c631d1-eacd-496a-97eb-9f936eb86770
71	-5.2	1.3	64ad7ad9-d5cd-45c9-9b32-84cda3c2b807
72	-5.2	20.	f0d582d9-ab4b-4671-b069-fdd8b6d38d2b
73	-1.73	1.3	4e2e27d9-cda0-4593-b30f-a0596c20d9a9
74	-1.73	20.	290efc69-7431-4451-8db2-4b41aa7512bb
76	0.	20.	22660b81-7e0f-412d-a8a4-663b08bb55cb
77	1.73	1.3	da54e72f-06f8-43bb-989a-a7494dc375cf
78	1.73	20.	2757dc39-7f73-4bd3-92d9-adf2a7de02e7
79	5.2	1.3	314e91ed-01a2-453d-a0bb-d76dfef519ed
80	5.2	20.	84e284a7-c95a-4b6d-ab35-2ba2ed2bcf53

Table: Joint Displacements

Table: Joint Displacements

Joint	OutputCase	CaseType	U1 ft	U2 ft	U3 ft	R1 Radians	R2 Radians	R3 Radians
1	Long	LinStatic	0.	0.	0.	0.	0.	0.
1	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
2	Long	LinStatic	0.046143	0.000223	0.000259	-3.825E-06	0.006422	-0.000184
2	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
3	Long	LinStatic	0.	0.	0.	0.	0.	0.
3	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
4	Long	LinStatic	0.046861	0.000223	0.000208	-0.000083	0.00643	-0.000111
4	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
6	Long	LinStatic	0.047066	0.000223	-6.773E-20	-0.0002	0.00643	-1.193E-16
6	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
7	Long	LinStatic	0.	0.	0.	0.	0.	0.
7	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
8	Long	LinStatic	0.046861	0.000223	-0.000208	-0.000083	0.00643	0.000111
8	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
9	Long	LinStatic	0.	0.	0.	0.	0.	0.
9	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.

Table: Joint Displacements

Joint	OutputCase	CaseType	U1 ft	U2 ft	U3 ft	R1 Radians	R2 Radians	R3 Radians
10	Long	LinStatic	0.046143	0.000223	-0.000259	-3.825E-06	0.006422	0.000184
10	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
11	Long	LinStatic	0.	0.	0.	0.	0.	0.
11	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
12	Long	LinStatic	0.046863	-0.004349	-0.000582	-0.001057	0.002029	-0.000046
12	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
13	Long	LinStatic	0.	0.	0.	0.	0.	0.
13	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
14	Long	LinStatic	0.04702	-0.004263	-0.000271	-0.000987	0.00198	-0.000028
14	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
16	Long	LinStatic	0.047066	-0.004241	-2.676E-15	-0.000883	0.001947	-2.789E-14
16	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
17	Long	LinStatic	0.	0.	0.	0.	0.	0.
17	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
18	Long	LinStatic	0.04702	-0.004263	0.000271	-0.000987	0.00198	0.000028
18	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
19	Long	LinStatic	0.	0.	0.	0.	0.	0.
19	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
20	Long	LinStatic	0.046863	-0.004349	0.000582	-0.001057	0.002029	0.000046
20	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
22	Long	LinStatic	0.046958	0.017045	-0.00049	-0.001034	0.001945	-0.000014
22	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
23	Long	LinStatic	0.	0.	0.	0.	0.	0.
23	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
24	Long	LinStatic	0.046993	0.017065	-0.000261	-0.001034	0.001945	-0.000014
24	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
26	Long	LinStatic	0.047066	0.017099	9.622E-06	-0.001051	0.001931	-1.851E-08
26	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
27	Long	LinStatic	0.	0.	0.	0.	0.	0.
27	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
28	Long	LinStatic	0.046994	0.017065	0.000261	-0.001034	0.001945	0.000013
28	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
30	Long	LinStatic	0.046959	0.017045	0.00049	-0.001034	0.001945	0.000013
30	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
32	Long	LinStatic	0.046961	0.017419	-0.000432	-0.001057	0.001969	-0.000013
32	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
33	Long	LinStatic	0.	0.	0.	0.	0.	0.
33	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
34	Long	LinStatic	0.046995	0.017439	-0.000226	-0.001057	0.001969	-0.000013
34	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
36	Long	LinStatic	0.047066	0.017472	9.767E-06	-0.001078	0.001958	-1.804E-08
36	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
37	Long	LinStatic	0.	0.	0.	0.	0.	0.
37	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
38	Long	LinStatic	0.046996	0.017439	0.000226	-0.001057	0.001969	0.000013
38	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
40	Long	LinStatic	0.046961	0.017419	0.000432	-0.001057	0.001969	0.000013
40	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
41	Long	LinStatic	0.	0.	0.	0.	0.	0.
41	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
42	Long	LinStatic	0.047041	0.008871	-0.000039	-0.00108	0.001902	-5.661E-06
42	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
43	Long	LinStatic	0.	0.	0.	0.	0.	0.
43	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.

Table: Joint Displacements

Joint	OutputCase	CaseType	U1 ft	U2 ft	U3 ft	R1 Radians	R2 Radians	R3 Radians
44	Long	LinStatic	0.04706	0.008881	-5.786E-06	-0.00109	0.001902	-3.391E-06
44	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
46	Long	LinStatic	0.047066	0.008884	-5.757E-15	-0.001099	0.001902	-7.620E-16
46	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
47	Long	LinStatic	0.	0.	0.	0.	0.	0.
47	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
48	Long	LinStatic	0.04706	0.008881	5.786E-06	-0.00109	0.001902	3.391E-06
48	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
49	Long	LinStatic	0.	0.	0.	0.	0.	0.
49	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
50	Long	LinStatic	0.047041	0.008871	0.000039	-0.00108	0.001902	5.661E-06
50	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
51	Long	LinStatic	0.	0.	0.	0.	0.	0.
51	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
52	Long	LinStatic	0.047037	0.019078	-0.000058	-0.001193	0.002092	-6.533E-06
52	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
53	Long	LinStatic	0.	0.	0.	0.	0.	0.
53	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
54	Long	LinStatic	0.047059	0.019091	-0.000023	-0.001193	0.00209	-3.916E-06
54	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
56	Long	LinStatic	0.047066	0.019094	-3.699E-17	-0.001191	0.002089	-6.358E-15
56	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
57	Long	LinStatic	0.	0.	0.	0.	0.	0.
57	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
58	Long	LinStatic	0.047059	0.019091	0.000023	-0.001193	0.00209	3.916E-06
58	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
59	Long	LinStatic	0.	0.	0.	0.	0.	0.
59	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
60	Long	LinStatic	0.047037	0.019078	0.000058	-0.001193	0.002092	6.533E-06
60	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
61	Long	LinStatic	0.	0.	0.	0.	0.	0.
61	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
62	Long	LinStatic	0.047046	0.012962	0.000056	-0.001219	0.002117	-4.516E-06
62	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
63	Long	LinStatic	0.	0.	0.	0.	0.	0.
63	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
64	Long	LinStatic	0.047061	0.012971	0.000037	-0.00124	0.002122	-2.701E-06
64	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
66	Long	LinStatic	0.047066	0.012973	-9.822E-19	-0.001264	0.002126	-5.525E-15
66	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
67	Long	LinStatic	0.	0.	0.	0.	0.	0.
67	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
68	Long	LinStatic	0.047061	0.012971	-0.000037	-0.00124	0.002122	2.701E-06
68	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
69	Long	LinStatic	0.	0.	0.	0.	0.	0.
69	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
70	Long	LinStatic	0.047046	0.012962	-0.000056	-0.001219	0.002117	4.516E-06
70	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
71	Long	LinStatic	0.	0.	0.	0.	0.	0.
71	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
72	Long	LinStatic	0.046911	0.003645	-0.000271	-0.001519	0.002754	-0.000035
72	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
73	Long	LinStatic	0.	0.	0.	0.	0.	0.
73	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.

Table: Joint Displacements

Joint	OutputCase	CaseType	U1 ft	U2 ft	U3 ft	R1 Radians	R2 Radians	R3 Radians
74	Long	LinStatic	0.047031	0.003711	-0.000106	-0.001509	0.002735	-0.000021
74	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
76	Long	LinStatic	0.047066	0.003727	-2.234E-18	-0.001485	0.002722	-9.131E-16
76	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
77	Long	LinStatic	0.	0.	0.	0.	0.	0.
77	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
78	Long	LinStatic	0.047031	0.003711	0.000106	-0.001509	0.002735	0.000021
78	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
79	Long	LinStatic	0.	0.	0.	0.	0.	0.
79	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
80	Long	LinStatic	0.046911	0.003645	0.000271	-0.001519	0.002754	0.000035
80	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~1	Long	LinStatic	0.04688	-0.004339	-0.000553	-0.001058	0.002019	-0.000046
~1	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~2	Long	LinStatic	0.046898	-0.004329	-0.000525	-0.001057	0.002011	-0.000045
~2	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~3	Long	LinStatic	0.046915	-0.00432	-0.000499	-0.001054	0.002004	-0.000044
~3	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~4	Long	LinStatic	0.046933	-0.00431	-0.000472	-0.00105	0.001997	-0.000043
~4	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~5	Long	LinStatic	0.046949	-0.004301	-0.000445	-0.001044	0.001992	-0.000041
~5	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~6	Long	LinStatic	0.046965	-0.004293	-0.000416	-0.001036	0.001988	-0.000039
~6	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~7	Long	LinStatic	0.04698	-0.004285	-0.000385	-0.001026	0.001984	-0.000037
~7	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~8	Long	LinStatic	0.046994	-0.004277	-0.000351	-0.001015	0.001982	-0.000034
~8	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~9	Long	LinStatic	0.047008	-0.00427	-0.000314	-0.001002	0.001981	-0.000031
~9	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~10	Long	LinStatic	0.047026	-0.00426	-0.00025	-0.00098	0.001975	-0.000026
~10	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~11	Long	LinStatic	0.047032	-0.004257	-0.000228	-0.000971	0.001971	-0.000024
~11	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~12	Long	LinStatic	0.047038	-0.004254	-0.000204	-0.000963	0.001966	-0.000021
~12	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~13	Long	LinStatic	0.047044	-0.004251	-0.00018	-0.000953	0.001963	-0.000019
~13	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~14	Long	LinStatic	0.047049	-0.004249	-0.000154	-0.000943	0.001959	-0.000016
~14	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~15	Long	LinStatic	0.047053	-0.004247	-0.000127	-0.000932	0.001956	-0.000013
~15	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~16	Long	LinStatic	0.047057	-0.004245	-0.000098	-0.000921	0.001953	-0.00001
~16	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~17	Long	LinStatic	0.04706	-0.004243	-0.000067	-0.000909	0.001951	-7.003E-06
~17	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~18	Long	LinStatic	0.047063	-0.004242	-0.000035	-0.000897	0.001949	-3.595E-06
~18	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~19	Long	LinStatic	0.047063	-0.004242	0.000035	-0.000897	0.001949	3.595E-06
~19	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~20	Long	LinStatic	0.04706	-0.004243	0.000067	-0.000909	0.001951	7.003E-06
~20	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~21	Long	LinStatic	0.047057	-0.004245	0.000098	-0.000921	0.001953	0.00001
~21	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.

Table: Joint Displacements

Joint	OutputCase	CaseType	U1 ft	U2 ft	U3 ft	R1 Radians	R2 Radians	R3 Radians
~22	Long	LinStatic	0.047053	-0.004247	0.000127	-0.000932	0.001956	0.000013
~22	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~23	Long	LinStatic	0.047049	-0.004249	0.000154	-0.000943	0.001959	0.000016
~23	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~24	Long	LinStatic	0.047044	-0.004251	0.00018	-0.000953	0.001963	0.000019
~24	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~25	Long	LinStatic	0.047038	-0.004254	0.000204	-0.000963	0.001966	0.000021
~25	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~26	Long	LinStatic	0.047032	-0.004257	0.000228	-0.000971	0.001971	0.000024
~26	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~27	Long	LinStatic	0.047026	-0.00426	0.00025	-0.00098	0.001975	0.000026
~27	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~28	Long	LinStatic	0.047008	-0.00427	0.000314	-0.001002	0.001981	0.000031
~28	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~29	Long	LinStatic	0.046994	-0.004277	0.000351	-0.001015	0.001982	0.000034
~29	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~30	Long	LinStatic	0.04698	-0.004285	0.000385	-0.001026	0.001984	0.000037
~30	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~31	Long	LinStatic	0.046965	-0.004293	0.000416	-0.001036	0.001988	0.000039
~31	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~32	Long	LinStatic	0.046949	-0.004301	0.000445	-0.001044	0.001992	0.000041
~32	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~33	Long	LinStatic	0.046933	-0.00431	0.000472	-0.00105	0.001997	0.000043
~33	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~34	Long	LinStatic	0.046915	-0.00432	0.000499	-0.001054	0.002004	0.000044
~34	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~35	Long	LinStatic	0.046898	-0.004329	0.000525	-0.001057	0.002011	0.000045
~35	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~36	Long	LinStatic	0.04688	-0.004339	0.000553	-0.001058	0.002019	0.000046
~36	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~37	Long	LinStatic	0.046962	0.017047	-0.000467	-0.001034	0.001945	-0.000014
~37	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~38	Long	LinStatic	0.046965	0.017049	-0.000444	-0.001034	0.001945	-0.000014
~38	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~39	Long	LinStatic	0.046969	0.017051	-0.000422	-0.001034	0.001945	-0.000014
~39	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~40	Long	LinStatic	0.046972	0.017053	-0.000399	-0.001034	0.001945	-0.000014
~40	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~41	Long	LinStatic	0.046976	0.017055	-0.000376	-0.001034	0.001945	-0.000014
~41	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~42	Long	LinStatic	0.046979	0.017057	-0.000353	-0.001034	0.001945	-0.000014
~42	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~43	Long	LinStatic	0.046983	0.017059	-0.00033	-0.001034	0.001945	-0.000014
~43	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~44	Long	LinStatic	0.046986	0.017061	-0.000307	-0.001034	0.001945	-0.000014
~44	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~45	Long	LinStatic	0.04699	0.017063	-0.000284	-0.001034	0.001945	-0.000014
~45	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~46	Long	LinStatic	0.047003	0.017069	-0.000228	-0.001038	0.001943	-0.000013
~46	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~47	Long	LinStatic	0.047012	0.017074	-0.000196	-0.001041	0.00194	-0.000013
~47	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~48	Long	LinStatic	0.047021	0.017078	-0.000166	-0.001044	0.001938	-0.000012
~48	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.

Table: Joint Displacements

Joint	OutputCase	CaseType	U1 ft	U2 ft	U3 ft	R1 Radians	R2 Radians	R3 Radians
~49	Long	LinStatic	0.047029	0.017083	-0.000138	-0.001046	0.001936	-0.000011
~49	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~50	Long	LinStatic	0.047037	0.017086	-0.000112	-0.001048	0.001935	-0.000001
~50	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~51	Long	LinStatic	0.047045	0.01709	-0.000087	-0.001049	0.001933	-8.767E-06
~51	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~52	Long	LinStatic	0.047051	0.017093	-0.000062	-0.00105	0.001932	-6.998E-06
~52	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~53	Long	LinStatic	0.047057	0.017096	-0.000038	-0.001051	0.001932	-4.951E-06
~53	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~54	Long	LinStatic	0.047062	0.017098	-0.000014	-0.001051	0.001931	-2.624E-06
~54	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~55	Long	LinStatic	0.047062	0.017098	0.000031	-0.001051	0.001931	2.584E-06
~55	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~56	Long	LinStatic	0.047057	0.017096	0.000053	-0.001051	0.001932	4.909E-06
~56	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~57	Long	LinStatic	0.047051	0.017093	0.000075	-0.00105	0.001932	6.955E-06
~57	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~58	Long	LinStatic	0.047045	0.01709	0.000098	-0.001049	0.001934	8.722E-06
~58	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~59	Long	LinStatic	0.047037	0.017087	0.000122	-0.001048	0.001935	0.000001
~59	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~60	Long	LinStatic	0.047029	0.017083	0.000146	-0.001046	0.001936	0.000011
~60	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~61	Long	LinStatic	0.047021	0.017079	0.000172	-0.001044	0.001938	0.000012
~61	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~62	Long	LinStatic	0.047012	0.017074	0.0002	-0.001041	0.00194	0.000013
~62	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~63	Long	LinStatic	0.047003	0.01707	0.00023	-0.001038	0.001943	0.000013
~63	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~64	Long	LinStatic	0.04699	0.017063	0.000284	-0.001034	0.001945	0.000013
~64	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~65	Long	LinStatic	0.046987	0.017061	0.000307	-0.001034	0.001945	0.000013
~65	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~66	Long	LinStatic	0.046983	0.017059	0.00033	-0.001034	0.001945	0.000013
~66	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~67	Long	LinStatic	0.04698	0.017057	0.000353	-0.001034	0.001945	0.000013
~67	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~68	Long	LinStatic	0.046976	0.017055	0.000376	-0.001034	0.001945	0.000013
~68	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~69	Long	LinStatic	0.046973	0.017053	0.000399	-0.001034	0.001945	0.000013
~69	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~70	Long	LinStatic	0.046969	0.017051	0.000422	-0.001034	0.001945	0.000013
~70	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~71	Long	LinStatic	0.046966	0.017049	0.000444	-0.001034	0.001945	0.000013
~71	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
~72	Long	LinStatic	0.046962	0.017047	0.000467	-0.001034	0.001945	0.000013
~72	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.

Table: Joint Loads - Force, Part 1 of 2**Table: Joint Loads - Force, Part 1 of 2**

Joint	LoadPat	CoordSys	F1 Kip	F2 Kip	F3 Kip	M1 Kip-ft	M2 Kip-ft
6	Wind Long	GLOBAL	30.	0.	0.	0.	0.
6	Long	GLOBAL	312.7	0.	0.	0.	0.

Table: Joint Loads - Force, Part 2 of 2**Table: Joint Loads - Force, Part 2 of 2**

Joint	LoadPat	M3 Kip-ft	GUID
6	Wind Long	0.	5c00d057-a738-4434-9be1-0c44a4a2cdc4
6	Long	0.	8a5f5c7d-12b2-4ac4-ba0b-5c8c6f9d2e13

Table: Joint Reactions**Table: Joint Reactions**

Joint	OutputCase	CaseType	F1 Kip	F2 Kip	F3 Kip	M1 Kip-ft	M2 Kip-ft	M3 Kip-ft
1	Long	LinStatic	-28.556	-0.19	-24.809	1.0101	-297.8519	0.0098
1	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
3	Long	LinStatic	-30.037	0.19	-19.959	-0.2628	-305.6622	0.0059
3	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
7	Long	LinStatic	-30.037	0.19	19.959	-0.2628	-305.6622	-0.0059
7	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
9	Long	LinStatic	-28.556	-0.19	24.809	1.0101	-297.8519	-0.0098
9	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
11	Long	LinStatic	-8.265	0.117	30.709	13.2785	-103.1091	0.0013
11	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
13	Long	LinStatic	-8.561	-0.117	14.31	14.8131	-105.1029	8.065E-04
13	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
17	Long	LinStatic	-8.561	-0.117	-14.31	14.8131	-105.1029	-8.065E-04
17	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
19	Long	LinStatic	-8.265	0.117	-30.709	13.2785	-103.1091	-0.0013
19	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
23	Long	LinStatic	-31.526	-2.051E-04	51.669	204.4498	-904.6979	2.2282
23	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
27	Long	LinStatic	-31.524	2.044E-04	-51.669	204.4482	-904.6836	-2.2201
27	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
33	Long	LinStatic	-30.694	-3.064E-04	44.637	208.9279	-895.7045	2.1694
33	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
37	Long	LinStatic	-30.692	3.060E-04	-44.637	208.9241	-895.6919	-2.1616
37	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
41	Long	LinStatic	-1.017	-3.306E-03	1.214	8.2775	-30.6046	9.684E-05
41	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
43	Long	LinStatic	-1.015	3.307E-03	0.178	8.2125	-30.5931	5.801E-05
43	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
47	Long	LinStatic	-1.015	3.307E-03	-0.178	8.2125	-30.5931	-5.801E-05
47	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
49	Long	LinStatic	-1.017	-3.306E-03	-1.214	8.2775	-30.6046	-9.684E-05
49	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
51	Long	LinStatic	-1.175	1.569E-04	1.782	3.3154	-34.6052	1.117E-04

Table: Joint Reactions

Joint	OutputCase	CaseType	F1 Kip	F2 Kip	F3 Kip	M1 Kip-ft	M2 Kip-ft	M3 Kip-ft
51	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
53	Long	LinStatic	-1.18	-1.572E-04	0.71	3.3209	-34.6699	6.698E-05
53	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
57	Long	LinStatic	-1.18	-1.572E-04	-0.71	3.3209	-34.6699	-6.698E-05
57	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
59	Long	LinStatic	-1.175	1.569E-04	-1.782	3.3154	-34.6052	-1.117E-04
59	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
61	Long	LinStatic	-0.81	-8.367E-03	-1.735	9.3569	-28.9436	7.724E-05
61	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
63	Long	LinStatic	-0.797	8.367E-03	-1.146	9.1838	-28.8203	4.620E-05
63	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
67	Long	LinStatic	-0.797	8.367E-03	1.146	9.1838	-28.8203	-4.620E-05
67	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
69	Long	LinStatic	-0.81	-8.367E-03	1.735	9.3569	-28.9436	-7.724E-05
69	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
71	Long	LinStatic	-6.297	0.034	14.281	19.7597	-94.2405	0.001
71	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
73	Long	LinStatic	-6.419	-0.034	5.581	20.2593	-95.1403	6.149E-04
73	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
77	Long	LinStatic	-6.419	-0.034	-5.581	20.2593	-95.1403	-6.149E-04
77	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.
79	Long	LinStatic	-6.297	0.034	-14.281	19.7597	-94.2405	-0.001
79	Wind Long	LinStatic	0.	0.	0.	0.	0.	0.

Table: Joint Restraint Assignments

Table: Joint Restraint Assignments

Joint	U1	U2	U3	R1	R2	R3
1	Yes	Yes	Yes	Yes	Yes	Yes
3	Yes	Yes	Yes	Yes	Yes	Yes
7	Yes	Yes	Yes	Yes	Yes	Yes
9	Yes	Yes	Yes	Yes	Yes	Yes
11	Yes	Yes	Yes	Yes	Yes	Yes
13	Yes	Yes	Yes	Yes	Yes	Yes
17	Yes	Yes	Yes	Yes	Yes	Yes
19	Yes	Yes	Yes	Yes	Yes	Yes
23	Yes	Yes	Yes	Yes	Yes	Yes
27	Yes	Yes	Yes	Yes	Yes	Yes
33	Yes	Yes	Yes	Yes	Yes	Yes
37	Yes	Yes	Yes	Yes	Yes	Yes
41	Yes	Yes	Yes	Yes	Yes	Yes
43	Yes	Yes	Yes	Yes	Yes	Yes
47	Yes	Yes	Yes	Yes	Yes	Yes
49	Yes	Yes	Yes	Yes	Yes	Yes
51	Yes	Yes	Yes	Yes	Yes	Yes
53	Yes	Yes	Yes	Yes	Yes	Yes
57	Yes	Yes	Yes	Yes	Yes	Yes
59	Yes	Yes	Yes	Yes	Yes	Yes
61	Yes	Yes	Yes	Yes	Yes	Yes
63	Yes	Yes	Yes	Yes	Yes	Yes
67	Yes	Yes	Yes	Yes	Yes	Yes
69	Yes	Yes	Yes	Yes	Yes	Yes

Table: Joint Restraint Assignments

Joint	U1	U2	U3	R1	R2	R3
71	Yes	Yes	Yes	Yes	Yes	Yes
73	Yes	Yes	Yes	Yes	Yes	Yes
77	Yes	Yes	Yes	Yes	Yes	Yes
79	Yes	Yes	Yes	Yes	Yes	Yes

Table: Load Case Definitions, Part 1 of 3

Table: Load Case Definitions, Part 1 of 3

Case	Type	InitialCond	ModalCase	BaseCase	MassSource	DesTypeOpt	DesignType
Long	LinStatic	Zero				Prog Det	Dead
Wind Long	LinStatic	Zero				Prog Det	Other

Table: Load Case Definitions, Part 2 of 3

Table: Load Case Definitions, Part 2 of 3

Case	DesActOpt	DesignAct	AutoType	RunCase	CaseStatus	GUID
Long	Prog Det	Non-Composite	None	Yes	Finished	8595711f-bf6a-4dbc-8f87-9b8ca17ff1b1
Wind Long	Prog Det	Other	None	Yes	Finished	c6c92cf7-bd8d-45ab-9aa5-7bd97a790d31

Table: Load Case Definitions, Part 3 of 3

Table: Load Case Definitions, Part 3 of 3

Case	Notes
Long	
Wind Long	

Table: Load Pattern Definitions

Table: Load Pattern Definitions

LoadPat	DesignType	SelfWtMult	AutoLoad	GUID	Notes
Long	Dead	0.		31946b4a-8427-4b19-9141-dbc8ec4bdceb	Added 4/4/2025 1:31:26 PM
Wind Long	Wind	0.	None	1bc38465-12e9-4eb4-9e72-ef913ffec89	Added 4/22/2025 2:18:15 PM

Table: Material Properties 01 - General, Part 1 of 2

Table: Material Properties 01 - General, Part 1 of 2

Material	Type	Grade	SymType	TempDepend	Color	GUID
4000Psi	Concrete	f'c 4000 psi	Isotropic	No	Yellow	07796f6a-7db1-431e-897c-4a42ae1ca049
A416Gr270	Tendon	Grade 270	Uniaxial	No	Green	4807776f-43f5-42a7-a03c-4cc0dbc30e9b

Table: Material Properties 01 - General, Part 1 of 2

Material	Type	Grade	SymType	TempDepen d	Color	GUID
A615Gr60	Rebar	Grade 60	Uniaxial	No	White	4aa2e513-e9ee-4022-9924-30bfab2ea13a
A709Gr50	Steel	Grade 50	Isotropic	No	Magenta	

Table: Material Properties 01 - General, Part 2 of 2**Table: Material Properties 01 - General, Part 2 of 2**

Material	Notes
4000Psi	Customary f'c 4000 psi 3/28/2025 9:45:21 AM
A416Gr270	ASTM A416 Grade 270 3/28/2025 9:48:11 AM
A615Gr60	ASTM A615 Grade 60 3/31/2025 4:34:24 PM
A709Gr50	ASTM A709 Grade 50 3/28/2025 9:45:21 AM

Table: Material Properties 03a - Steel Data, Part 1 of 2**Table: Material Properties 03a - Steel Data, Part 1 of 2**

Material	Fy Kip/ft2	Fu Kip/ft2	EffFy Kip/ft2	EffFu Kip/ft2	SSCurveOpt	SSHysType	SHard	SMax
A709Gr50	7200.	9360.	7920.	10296.	Simple	Kinematic	0.015	0.11

Table: Material Properties 03a - Steel Data, Part 2 of 2**Table: Material Properties 03a - Steel Data, Part 2 of 2**

Material	SRup	FinalSlope	CoupModType
A709Gr50	0.17	-0.1	Von Mises

Table: Material Properties 03b - Concrete Data, Part 1 of 2**Table: Material Properties 03b - Concrete Data, Part 1 of 2**

Material	Fc Kip/ft2	eFc Kip/ft2	LtWtConc	SSCurveOpt	SSHysType	SFc	SCap	FinalSlope
4000Psi	576.	576.	No	Mander	Takeda	0.002219	0.005	-0.1

Table: Material Properties 03b - Concrete Data, Part 2 of 2**Table: Material Properties 03b - Concrete Data, Part 2 of 2**

Material	FAngle Degrees	DAngle Degrees	CoupModType
4000Psi	0.	0.	Modified Darwin-Pecknold

Table: Objects And Elements - Frames

Table: Objects And Elements - Frames			
FrameElem	FrameObject	ElemJtl	ElemJtJ
1-1	1	1	2
2-1	2	3	4
4-1	4	7	8
5-1	5	9	10
6-1	6	11	12
7-1	7	13	14
9-1	9	17	18
10-1	10	19	20
12-1	12	23	24
14-1	14	27	28
17-1	17	33	34
19-1	19	37	38
21-1	21	41	42
22-1	22	43	44
24-1	24	47	48
25-1	25	49	50
26-1	26	51	52
27-1	27	53	54
29-1	29	57	58
30-1	30	59	60
31-1	31	61	62
32-1	32	63	64
34-1	34	67	68
35-1	35	69	70
36-1	36	71	72
37-1	37	73	74
39-1	39	77	78
40-1	40	79	80
62-1	62	6	16
63-1	63	16	26
64-1	64	26	36
65-1	65	36	46
68-1	68	66	76
86-1	86	2	4
87-1	87	4	6
88-1	88	6	8
89-1	89	8	10
90-1	90	12	~1
90-2	90	~1	~2
90-3	90	~2	~3
90-4	90	~3	~4
90-5	90	~4	~5
90-6	90	~5	~6
90-7	90	~6	~7
90-8	90	~7	~8
90-9	90	~8	~9
90-10	90	~9	14
91-1	91	14	~10
91-2	91	~10	~11
91-3	91	~11	~12

Table: Objects And Elements - Frames

FrameElem	FrameObject	ElemJtl	ElemJtJ
91-4	91	~12	~13
91-5	91	~13	~14
91-6	91	~14	~15
91-7	91	~15	~16
91-8	91	~16	~17
91-9	91	~17	~18
91-10	91	~18	16
92-1	92	16	~19
92-2	92	~19	~20
92-3	92	~20	~21
92-4	92	~21	~22
92-5	92	~22	~23
92-6	92	~23	~24
92-7	92	~24	~25
92-8	92	~25	~26
92-9	92	~26	~27
92-10	92	~27	18
93-1	93	18	~28
93-2	93	~28	~29
93-3	93	~29	~30
93-4	93	~30	~31
93-5	93	~31	~32
93-6	93	~32	~33
93-7	93	~33	~34
93-8	93	~34	~35
93-9	93	~35	~36
93-10	93	~36	20
94-1	94	22	~37
94-2	94	~37	~38
94-3	94	~38	~39
94-4	94	~39	~40
94-5	94	~40	~41
94-6	94	~41	~42
94-7	94	~42	~43
94-8	94	~43	~44
94-9	94	~44	~45
94-10	94	~45	24
95-1	95	24	~46
95-2	95	~46	~47
95-3	95	~47	~48
95-4	95	~48	~49
95-5	95	~49	~50
95-6	95	~50	~51
95-7	95	~51	~52
95-8	95	~52	~53
95-9	95	~53	~54
95-10	95	~54	26
96-1	96	26	~55
96-2	96	~55	~56
96-3	96	~56	~57
96-4	96	~57	~58
96-5	96	~58	~59
96-6	96	~59	~60

Table: Objects And Elements - Frames

FrameElem	FrameObject	ElemJtl	ElemJtJ
96-7	96	~60	~61
96-8	96	~61	~62
96-9	96	~62	~63
96-10	96	~63	28
97-1	97	28	~64
97-2	97	~64	~65
97-3	97	~65	~66
97-4	97	~66	~67
97-5	97	~67	~68
97-6	97	~68	~69
97-7	97	~69	~70
97-8	97	~70	~71
97-9	97	~71	~72
97-10	97	~72	30
98-1	98	32	34
99-1	99	34	36
100-1	100	36	38
101-1	101	38	40
102-1	102	42	44
103-1	103	44	46
104-1	104	46	48
105-1	105	48	50
106-1	106	52	54
107-1	107	54	56
108-1	108	56	58
109-1	109	58	60
110-1	110	62	64
111-1	111	64	66
112-1	112	66	68
113-1	113	68	70
114-1	114	72	74
115-1	115	74	76
116-1	116	76	78
117-1	117	78	80
3-1	3	46	56
8-1	8	56	66

Table: Objects And Elements - Joints**Table: Objects And Elements - Joints**

JointElem	JointObject	GlobalX ft	GlobalY ft	GlobalZ ft
1	1	0.	-6.	9.7
2	2	0.	-6.	20.
3	3	0.	-2.	9.7
4	4	0.	-2.	20.
6	6	0.	0.	20.
7	7	0.	2.	9.7
8	8	0.	2.	20.
9	9	0.	6.	9.7
10	10	0.	6.	20.
11	11	37.33	-5.2	1.3
12	12	37.33	-5.2	20.

Table: Objects And Elements - Joints

JointElem	JointObject	GlobalX ft	GlobalY ft	GlobalZ ft
13	13	35.33	-1.73	1.3
14	14	35.33	-1.73	20.
16	16	34.33	0.	20.
17	17	33.33	1.73	1.3
18	18	33.33	1.73	20.
19	19	31.33	5.2	1.3
20	20	31.33	5.2	20.
22	22	86.46	-7.15	20.
23	23	84.96	-4.55	-13.
24	24	84.96	-4.55	20.
26	26	82.33	0.	20.
27	27	79.71	4.55	-13.
28	28	79.71	4.55	20.
30	30	78.21	7.15	20.
32	32	189.88	-7.15	20.
33	33	188.38	-4.55	-13.
34	34	188.38	-4.55	20.
36	36	185.75	0.	20.
37	37	183.13	4.55	-13.
38	38	183.13	4.55	20.
40	40	181.63	7.15	20.
41	41	213.33	-5.2	-12.
42	42	213.33	-5.2	20.
43	43	211.33	-1.73	-12.
44	44	211.33	-1.73	20.
46	46	210.33	0.	20.
47	47	209.33	1.73	-12.
48	48	209.33	1.73	20.
49	49	207.33	5.2	-12.
50	50	207.33	5.2	20.
51	51	261.33	-5.2	-12.
52	52	261.33	-5.2	20.
53	53	259.33	-1.73	-12.
54	54	259.33	-1.73	20.
56	56	258.33	0.	20.
57	57	257.33	1.73	-12.
58	58	257.33	1.73	20.
59	59	255.33	5.2	-12.
60	60	255.33	5.2	20.
61	61	309.33	-5.2	-12.
62	62	309.33	-5.2	20.
63	63	307.33	-1.73	-12.
64	64	307.33	-1.73	20.
66	66	306.33	0.	20.
67	67	305.33	1.73	-12.
68	68	305.33	1.73	20.
69	69	303.33	5.2	-12.
70	70	303.33	5.2	20.
71	71	357.33	-5.2	1.3
72	72	357.33	-5.2	20.
73	73	355.33	-1.73	1.3
74	74	355.33	-1.73	20.
76	76	354.33	0.	20.
77	77	353.33	1.73	1.3

Table: Objects And Elements - Joints

JointElem	JointObject	GlobalX ft	GlobalY ft	GlobalZ ft
78	78	353.33	1.73	20.
79	79	351.33	5.2	1.3
80	80	351.33	5.2	20.
~1		37.13	-4.853	20.
~2		36.93	-4.506	20.
~3		36.73	-4.159	20.
~4		36.53	-3.812	20.
~5		36.33	-3.465	20.
~6		36.13	-3.118	20.
~7		35.93	-2.771	20.
~8		35.73	-2.424	20.
~9		35.53	-2.077	20.
~10		35.23	-1.557	20.
~11		35.13	-1.384	20.
~12		35.03	-1.211	20.
~13		34.93	-1.038	20.
~14		34.83	-0.865	20.
~15		34.73	-0.692	20.
~16		34.63	-0.519	20.
~17		34.53	-0.346	20.
~18		34.43	-0.173	20.
~19		34.23	0.173	20.
~20		34.13	0.346	20.
~21		34.03	0.519	20.
~22		33.93	0.692	20.
~23		33.83	0.865	20.
~24		33.73	1.038	20.
~25		33.63	1.211	20.
~26		33.53	1.384	20.
~27		33.43	1.557	20.
~28		33.13	2.077	20.
~29		32.93	2.424	20.
~30		32.73	2.771	20.
~31		32.53	3.118	20.
~32		32.33	3.465	20.
~33		32.13	3.812	20.
~34		31.93	4.159	20.
~35		31.73	4.506	20.
~36		31.53	4.853	20.
~37		86.31	-6.89	20.
~38		86.16	-6.63	20.
~39		86.01	-6.37	20.
~40		85.86	-6.11	20.
~41		85.71	-5.85	20.
~42		85.56	-5.59	20.
~43		85.41	-5.33	20.
~44		85.26	-5.07	20.
~45		85.11	-4.81	20.
~46		84.697	-4.095	20.
~47		84.434	-3.64	20.
~48		84.171	-3.185	20.
~49		83.908	-2.73	20.
~50		83.645	-2.275	20.
~51		83.382	-1.82	20.

Table: Objects And Elements - Joints

JointElem	JointObject	GlobalX ft	GlobalY ft	GlobalZ ft
~52		83.119	-1.365	20.
~53		82.856	-0.91	20.
~54		82.593	-0.455	20.
~55		82.068	0.455	20.
~56		81.806	0.91	20.
~57		81.544	1.365	20.
~58		81.282	1.82	20.
~59		81.02	2.275	20.
~60		80.758	2.73	20.
~61		80.496	3.185	20.
~62		80.234	3.64	20.
~63		79.972	4.095	20.
~64		79.56	4.81	20.
~65		79.41	5.07	20.
~66		79.26	5.33	20.
~67		79.11	5.59	20.
~68		78.96	5.85	20.
~69		78.81	6.11	20.
~70		78.66	6.37	20.
~71		78.51	6.63	20.
~72		78.36	6.89	20.

Table: Solid Property Definitions, Part 1 of 2

Table: Solid Property Definitions, Part 1 of 2

SolidProp	Material	MatAngleA Degrees	MatAngleB Degrees	MatAngleC Degrees	InComp	Color
Solid1	4000Psi	0.	0.	0.	Yes	Blue

Table: Solid Property Definitions, Part 2 of 2

Table: Solid Property Definitions, Part 2 of 2

SolidProp	GUID	Notes	TotalWt Kip	TotalMass Kip-s2/ft
Solid1			0.	0.

ABUTMENT DESIGN

HNTB	Document number: QF 06
Calculation Cover Sheet	Page 1 of __

Project: NSRR Shoofly over I-70	Job No: 71886	Design Criteria Document: Below
Client: NSRR/ MODOT	Discipline: Bridge	Calculation No:

Name or Description of Calculation: Abutment design
--

Note: Unique QF 06 to be created for each revision of a calculation.

Calc. Rev. No.	Description of Change (i.e., Original Issue or description of changes since last revision)	Confirmation required with other deliverables (Y/N)	List Deliverables for which confirmation is required (NA if none) Add additional rows as necessary	Confirmation Verified by Originator of Calc for each deliverable listed (Y/N)

Calculation Objective: Cap, backwall, wingwall, and pile design at the abutments
--

Calculation Methodology/List of Assumptions: AREMA 2024 chapter 15 with some detail items from BNSF standards

References/Inputs: AREMA 2024, BNSF Standard Drawings 2024
--

Attachments: (List each attachment following the subject calculation)
--

Conclusions: Standard style caps 3'x2' with 10" backwall and bolted on winwalls. Supported by HP14x117 piles that are driven to seat on bedrock.
--

Document Check:	Name:	Initials:	Date:
Originator:	Todd Kelley	TSK	7/14/2025
Checker:	Jansen Bundridge	JKB	7/18/2025
Backchecker:	Todd Kelley	TSK	7/31/2025
Updater:	Todd Kelley	TSK	7/31/2025
Verifier:			

PILE ABUTMENT HAND CALCULATIONS

NS - Shoofly Pile abutment

- Abutment cap is designed as a continuous beam. Assume that dead load and live load from beam reactions is distributed evenly across the pile cap under the beams. Controlling spans are 34.33'. All loads are extracted from CSI model.

References:

AREMA Manual for Railway Engineering, 2024

ACI Building Code Requirements for Structural Concrete 318-14

AISC Steel Construction Manual, 14th Edition

Material Properties

Reinforcing Yield Strength	$f_y := 60 \text{ ksi}$	
Reinf. Steel Modulus of Elasticity	$E_s := 29000 \text{ ksi}$	
Concrete Strength	$f'_c := 4.5 \text{ ksi}$	
Weight of Concrete (For Properties)	$w_c := 145 \text{ pcf}$	(Unreinforced, AREMA 8-2-38)
Concrete Modulus of Elasticity	$E_c := 33 \cdot \left(\frac{w_c}{\text{pcf}} \right)^{1.5} \cdot \sqrt{\frac{f'_c}{\text{psi}}} \cdot \text{psi} = 3865.2 \text{ ksi}$	(AREMA 8-2.23.4)
Modulus of Rupture (Tensile Strength)	$f_r := 7.5 \cdot \sqrt{f'_c \cdot \text{psi}} = 0.503 \text{ ksi}$	(AREMA 8-2.26.1)
Modular Ratio	$n := \text{round} \left(\frac{E_s}{E_c} \right) = 8$	
Weight of Concrete	$\gamma_{conc} := 150 \text{ pcf}$	

Geometry

Steel Girder - W44x230	$Flange_{width} := 15.8 \text{ in}$	
Average Bearing Width	$w_{brg} := 10 \text{ ft}$	out to out of girder flanges measured from DGN
Height of Cap	$h_{cap} := 2 \text{ ft}$	
Length of Cap	$L_{cap} := 16.75 \text{ ft}$	
Cap Width	$w_{cap} := 3 \text{ ft}$	
Span 1 Length - steel	$L_{span1} := 34.33 \text{ ft}$	
Concrete Cover	$cover := 2 \text{ in}$	
Section Moment of Inertia	$I_x := \frac{w_{cap} \cdot h_{cap}^3}{12} = 41472 \text{ in}^4$	

Loads

Distributed Dead Load for Span 1

$$w_{DL_span1} := 2 \text{ klf}$$

(Entire Superstructure, from Load Calcs)

Span 1 Dead Load Reaction

$$R_{DL_span1} := w_{DL_span1} \cdot \frac{L_{span1}}{2} = 34.33 \text{ kip}$$

Impact Load (*maximum*)

$$IM := \left\| \begin{array}{l} \text{if } L_{span1} \leq 14 \cdot ft \\ \left\| \begin{array}{l} 0.6 \\ \text{else} \\ \frac{225}{\sqrt{\frac{L_{span1}}{ft}}} \cdot 0.01 \end{array} \right\| \end{array} \right\| = 0.384$$

(AREMA 8-2-13)

Live Load Reaction from Span 1 =
max shear

$$R_{LL_span} := 2 \cdot 156 \text{ kip} \cdot (1 + IM) = 431.812 \text{ kip}$$

(Used 50' conservatively)

Distributed Loads

Distributed Girder DL Reaction

For Span 1

$$w_{DLI} := \frac{R_{DL_span1}}{w_{brg}} = 3.433 \text{ klf}$$

Backwall Dead load

$$BW_{DL} := 10 \text{ in} \cdot 4.75 \text{ ft} \cdot 150 \cdot \frac{lb}{ft^3} = 593.75 \frac{lb}{ft}$$

Wingwall Dead load - applied as
point load

$$WW_{DL} := ((5.83 \text{ ft} + 3.67 \text{ ft}) \cdot 6.75 \text{ ft} - (3.67 \text{ ft} \cdot 1.42 \text{ ft} + 0.5 \cdot 3.33 \text{ ft} \cdot 3.67 \text{ ft})) \cdot 0.83 \text{ ft} \cdot 150 \cdot \frac{lb}{ft^3} = 6.574 \text{ kip}$$

Distributed Girder LL Reaction

For Span 1

$$w_{LLI} := \frac{R_{LL_span}}{w_{brg}} = 43.181 \text{ klf}$$

Wind Loads

Loads from the superstructure calculations

Wind Load on Live load applied
at 8 ft above rail

$$WL := 0.3 \frac{kip}{ft}$$

$$R_{WL} := WL \cdot \frac{(L_{span1})}{2} = 5.15 \text{ kip}$$

$$Arm_{WL} := 8 \text{ ft} + 8 \text{ in} + 10 \text{ in} + 44 \text{ in} + 4 \text{ in} = 13.5 \text{ ft}$$

$$M_{WL} := R_{WL} \cdot Arm_{WL} = 69.518 \text{ kip} \cdot ft$$

Wind Load on loaded bridge
applied at superstructure center

$$WS := 0.2 \frac{kip}{ft} \quad \text{minimum controls}$$

$$R_{WS} := WS \cdot \left(\frac{L_{span1}}{2} \right) = 3.433 \text{ kip}$$

$$Arm_{WS} := \frac{44 \text{ in} + 4 \text{ in}}{2} = 2 \text{ ft}$$

$$M_{WS} := R_{WS} \cdot Arm_{WS} = 6.866 \text{ kip} \cdot ft$$

Wind on live load controls

Compare with AREMA 15.1.3.7b wind on loaded structure:
(0.03ksf * 43" girder height * 1.5 = 0.16 klf)

Cap Analysis Results

See CSI output - loads applied CL to
CL of outside piles conservatively

	<u>Dead SW</u> <u>(Includes BW</u> <u>and WW wt</u>	<u>Dead Super</u>	<u>Live + Impact</u>
Positive Moment	$M_{dead.pos.sw} := 3 \text{ kip} \cdot \text{ft}$	$M_{dead.pos.sup} := 5.3 \text{ kip} \cdot \text{ft}$	$M_{live.pos} := 57.1 \text{ kip} \cdot \text{ft}$
Negative Moment	$M_{dead.neg.sw} := 29.5 \text{ kip} \cdot \text{ft}$	$M_{dead.neg.sup} := 6.5 \text{ kip} \cdot \text{ft}$	$M_{live.neg} := 64.5 \text{ kip} \cdot \text{ft}$
Shear	$V_{dead.sw} := 11.5 \text{ kip}$	$V_{dead.sup} := 10.2 \text{ kip}$	$V_{live} := 102.6 \text{ kip}$
	<u>Wind - Struct</u>	<u>Wind - Live</u>	
Positive Moment	$M_{WS.pos} := 3.5 \text{ kip} \cdot \text{ft}$	$M_{WL.pos} := 34.8 \text{ kip} \cdot \text{ft}$	
Negative Moment	$M_{WS.neg} := 3.5 \text{ kip} \cdot \text{ft}$	$M_{WL.neg} := 34.8 \text{ kip} \cdot \text{ft}$	
Shear	$V_{WS} := 1.7 \text{ kip}$	$V_{WL} := 16.5 \text{ kip}$	

Factored loads (Group I)

$$M_{strI.pos} := 1.4 \cdot \left(M_{dead.pos.sw} + M_{dead.pos.sup} + \frac{5}{3} \cdot \langle M_{live.pos} \rangle \right) = 144.853 \text{ kip} \cdot \text{ft}$$

$$M_{strI.neg} := 1.4 \cdot \left(M_{dead.neg.sw} + M_{dead.neg.sup} + \frac{5}{3} \cdot \langle M_{live.neg} \rangle \right) = 200.9 \text{ kip} \cdot \text{ft}$$

$$V_{strI} := 1.4 \cdot \left(V_{dead.sw} + V_{dead.sup} + \frac{5}{3} \cdot \langle V_{live} \rangle \right) = 269.78 \text{ kip}$$

Factored loads (Group III)

$$M_{strIII.pos} := 1.4 \cdot \left(M_{dead.pos.sw} + M_{dead.pos.sup} + M_{live.pos} + 0.5 \cdot M_{WS.pos} + M_{WL.pos} \right) = 142.73 \text{ kip} \cdot \text{ft}$$

$$M_{strIII.neg} := 1.4 \cdot \left(M_{dead.neg.sw} + M_{dead.neg.sup} + M_{live.neg} + 0.5 \cdot M_{WS.neg} + M_{WL.neg} \right) = 191.87 \text{ kip} \cdot \text{ft}$$

$$V_{strIII} := 1.4 \cdot \left(V_{dead.sw} + V_{dead.sup} + V_{live} + 0.5 \cdot V_{WS} + V_{WL} \right) = 198.31 \text{ kip}$$

Service loads (Group I)

$$M_{svceI.pos} := M_{dead.pos.sw} + M_{dead.pos.sup} + M_{live.pos} = 65.4 \text{ kip} \cdot \text{ft}$$

$$M_{svceI.neg} := M_{dead.neg.sw} + M_{dead.neg.sup} + M_{live.neg} = 100.5 \text{ kip} \cdot \text{ft}$$

$$V_{svceI} := V_{dead.sw} + V_{dead.sup} + V_{live} = 124.3 \text{ kip}$$

Flexure (Negative Moment)

(AREMA 8-2.32)

Longitudinal Reinforcing

$$bar_{size.neg} := 7$$

Number of Bars in cross-section

$$n_{bars} := 6$$

Stirrup Reinforcing

$$bar_{size.v} \equiv 6$$

Width of Design Section

$$b := w_{cap} = 3 \text{ ft}$$

Effective Depth

$$d := h_{cap} - cover - \frac{D_b (bar_{size.neg})}{2} - D_b (bar_{size.v}) = 20.813 \text{ in}$$

Area of Flexural Reinforcing

$$A_s := n_{bars} \cdot A_b (bar_{size.neg}) = 3.6 \text{ in}^2$$

Concrete Strength Factor

$$\beta_1 := \max \left(0.65, \min \left(0.85, 0.85 - 0.05 \cdot \frac{f'_c - 4 \text{ ksi}}{\text{ksi}} \right) \right) = 0.825 \quad (\text{AREMA 8-2.31.1(f)})$$

Balanced Reinforcing Ratio

$$\rho_b := \frac{0.85 \cdot \beta_1 \cdot f'_c}{f_y} \cdot \left(\frac{87 \cdot \text{ksi}}{87 \cdot \text{ksi} + f_y} \right) = 0.031 \quad (\text{AREMA 8-2.32.2(b)})$$

Depth of Compression Block

$$a := \frac{A_s \cdot f_y}{0.85 \cdot f'_c \cdot b} = 1.569 \text{ in} \quad (\text{AREMA 8-2.32.2})$$

Verify Tension controlled

$$c := \frac{a}{0.85} = 1.845 \text{ in} \quad (\text{AREMA 8-2.32.2})$$

$$e_{cl} := \text{if} \left(\frac{f_y}{E_s} < 0.002, \frac{f_y}{E_s}, 0.002 \right) = 0.002$$

$$ratio_{ten} := \frac{0.003}{0.003 + e_{cl}}$$

$$tension.check := \text{if} \left(\frac{c}{d} < ratio_{ten}, \text{"OK"}, \text{"NG"} \right) = \text{"OK"}$$

Strength Reduction Factor

$$\phi := 0.9 \quad (\text{AREMA 8-2.30.2(b)})$$

Design Moment Strength

$$\phi M_n := \phi \cdot A_s \cdot f_y \cdot \left(d - \frac{a}{2} \right) = 324.46 \text{ kip} \cdot \text{ft} \quad (\text{AREMA Eq. 8-2-29})$$

Cracking Moment

$$M_{cr} := \frac{f_r \cdot I_x}{\left(\frac{h_{cap}}{2} \right)} = 144.897 \text{ kip} \cdot \text{ft} \quad (\text{AREMA Eq. 8-2-13})$$

Factored Design Moment - 25% is allowed for this combo, but not required in this case.

$$M_u := \left\| \begin{array}{l} \text{if } M_{str1.neg} > 1.2 \cdot M_{cr} \\ \quad \left\| M_{str1.neg} \right. \\ \text{else if } 1.2 \cdot M_{cr} > 1.33 \cdot M_{str1.neg} \\ \quad \left\| 1.33 \cdot M_{str1.neg} \right. \\ \text{else} \\ \quad \left\| 1.2 \cdot M_{cr} \right. \end{array} \right\| = 200.9 \text{ kip} \cdot \text{ft}$$

Capacity over Demand Ratio

$$\frac{\phi M_n}{M_u} = 1.615$$

$$\text{if} (\phi M_n \geq M_u, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Fatigue Negative Moment

(AREMA 8-2.38)

Dead Load Service Moment

$$M_{dead.neg.sw} + M_{dead.neg.sup} = 36 \text{ kip} \cdot \text{ft}$$

Reinforcing Ratio

$$\rho := \frac{A_s}{b \cdot d} = 0.005$$

Find Neutral Axis

$$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n = 0.241$$

Lever Arm Ratio

$$j := 1 - \frac{k}{3} = 0.92$$

Dead Load Stress in Steel

$$f_{s,DL} := \frac{M_{dead.neg.sw} + M_{dead.neg.sup}}{A_s \cdot j \cdot d} = 6.27 \text{ ksi}$$

Total Service Load Stress

$$f_{s,svr} := \frac{M_{svcl.neg}}{A_s \cdot j \cdot d} = 17.505 \text{ ksi}$$

Minimum Stress

$$f_{min} := f_{s,DL} = 6.27 \text{ ksi}$$

Allowable Stress Range

$$f_f := 21 \cdot \text{ksi} - 0.33 \cdot f_{min} + 8 \cdot 0.3 \cdot \text{ksi} = 21.331 \text{ ksi}$$

In-Service Stress Range

$$f_{s.range} := f_{s,svr} - f_{s,DL} = 11.235 \text{ ksi}$$

$$\text{if } (f_{s.range} \leq f_f, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Distribution of Reinforcing - Negative Moment

(AREMA 8-2.39)

Exposure Condition Stress

$$Z := 170 \frac{\text{kip}}{\text{in}}$$

Area of concrete surrounding main tension rebar with same centroid

$$A := \frac{b \cdot \left(\text{cover} + \frac{D_b (\text{bar}_{size.neg})}{2} \right) \cdot 2}{n_{bars}} = 29.25 \text{ in}^2$$

Distance to tension rebar from extreme tension fiber

$$d_c := \min(\text{cover}, 2 \cdot \text{in}) + \frac{D_b (\text{bar}_{size.neg})}{2} = 2.438 \text{ in}$$

Service Stress in Rebar

$$f_s := f_{s,svr} = 17.505 \text{ ksi}$$

$$\text{if } \left(f_s \leq \min \left(\frac{Z}{\sqrt[3]{d_c \cdot A}}, 0.5 f_y \right), \text{"okay"}, \text{"not okay"} \right) = \text{"okay"}$$

Flexure (Positive Moment)

(AREMA 8-2.32.2)

Longitudinal Reinforcing

$$bar_{size,pos} := 7$$

Number of Bars in cross-section

$$n_{bars} := 4$$

Area of Flexural Reinforcing

$$A_s := n_{bars} \cdot A_b (bar_{size,pos}) = 2.4 \text{ in}^2$$

Depth of Compression Block

$$a := \frac{A_s \cdot f_y}{0.85 \cdot f'_c \cdot b} = 1.046 \text{ in}$$

(AREMA 8-2.32.2)

Verify Tension controlled

$$c := \frac{a}{0.85} = 1.23 \text{ in}$$

(AREMA 8-2.32.2)

$$e_c := \text{if} \left(\frac{f_y}{E_s} < 0.002, \frac{f_y}{E_s}, 0.002 \right) = 0.002$$

$$ratio_{ten2} := \frac{0.003}{0.003 + e_c}$$

$$tension.check2 := \text{if} \left(\frac{c}{d} < ratio_{ten}, \text{"OK"}, \text{"NG"} \right) = \text{"OK"}$$

Design Moment Strength

$$\phi M_n := \phi \cdot A_s \cdot f_y \cdot \left(d - \frac{a}{2} \right) = 219.13 \text{ kip} \cdot \text{ft}$$

(AREMA Eq. 8-2-29)

Cracking Moment

$$M_{cr} := \frac{f_r \cdot I_x}{\left(\frac{h_{cap}}{2} \right)} = 144.897 \text{ kip} \cdot \text{ft}$$

(AREMA Eq. 8-2-13)

Factored Design Moment

$$M_u := \left\| \begin{array}{l} \text{if } M_{str1,pos} > 1.2 \cdot M_{cr} \\ \quad \left\| M_{str1,pos} \right. \\ \text{else if } 1.2 \cdot M_{cr} > 1.33 \cdot M_{str1,pos} \\ \quad \left\| 1.33 \cdot M_{str1,pos} \right. \\ \text{else} \\ \quad \left\| 1.2 \cdot M_{cr} \right. \end{array} \right\| = 173.877 \text{ kip} \cdot \text{ft}$$

Capacity over Demand Ratio

$$\frac{\phi M_n}{M_u} = 1.26$$

$$\text{if} (\phi M_n \geq M_u, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Fatigue Positive Moment

(AREMA 8-2.38)

Dead Load Service Moment

$$M_{dead.pos.sw} + M_{dead.pos.sup} = 8.3 \text{ kip} \cdot \text{ft}$$

Reinforcing Ratio

$$\rho := \frac{A_s}{b \cdot d} = 0.003$$

Find Neutral Axis

$$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n = 0.202$$

Lever Arm Ratio

$$j := 1 - \frac{k}{3} = 0.933$$

Dead Load Stress in Steel

$$f_{s,DL} := \frac{M_{dead.pos.sw} + M_{dead.pos.sup}}{A_s \cdot j \cdot d} = 2.138 \text{ ksi}$$

Total Service Load Stress

$$f_{s,svl} := \frac{M_{svcl.pos}}{A_s \cdot j \cdot d} = 16.847 \text{ ksi}$$

Minimum Stress

$$f_{min} := f_{s,DL} = 2.138 \text{ ksi}$$

Allowable Stress Range

$$f_f := 21 \cdot \text{ksi} - 0.33 \cdot f_{min} + 8 \cdot 0.3 \cdot \text{ksi} = 22.694 \text{ ksi}$$

In-Service Stress Range

$$f_{s,range} := f_{s,svl} - f_{s,DL} = 14.709 \text{ ksi}$$

$$\text{if } (f_{s,range} \leq f_f, \text{“okay”}, \text{“not okay”}) = \text{“okay”}$$

Distribution of Reinforcing - Positive Moment

(AREMA 8-2.39)

Exposure Condition Stress

$$Z := 170 \frac{\text{kip}}{\text{in}}$$

Area of concrete surrounding main tension rebar with same centroid

$$A := \frac{b \cdot \left(\text{cover} + \frac{D_b (\text{bar}_{size.pos})}{2} \right) \cdot 2}{n_{bars}} = 43.875 \text{ in}^2$$

Distance to tension rebar from extreme tension fiber

$$d_s := \min(\text{cover}, 2 \cdot \text{in}) + \frac{D_b (\text{bar}_{size.pos})}{2} = 2.438 \text{ in}$$

Service Stress in Rebar

$$f_s := f_{s,svl} = 16.847 \text{ ksi}$$

$$\text{if } \left(f_s \leq \min \left(\frac{Z}{\sqrt[3]{d_c \cdot A}}, 0.5 f_y \right), \text{“okay”}, \text{“not okay”} \right) = \text{“okay”}$$

Shear

(AREMA 8-2.35)

Stirrup Spacing

$$s := 6 \text{ in}$$

Section Width

$$b_w := w_{cap} = 3 \text{ ft}$$

Resistance Factor

$$\phi_v := 0.85$$

(AREMA 8-2.30.2(b))

Effective Depth

$$d := h_{cap} - cover - 0.5 \cdot D_b \langle bar_{size.v} \rangle - D_b \langle bar_{size.pos} \rangle = 20.75 \text{ in}$$

Shear Stress Demand

$$v_u := \frac{V_{strl}}{\phi_v \cdot b_w \cdot d} = 0.425 \text{ ksi}$$

(AREMA Eq. 8-2-45)

Shear Stress carried by concrete

$$v_c := 2 \cdot \sqrt{\frac{f'_c}{psi}} \text{ psi} = 0.134 \text{ ksi}$$

(AREMA 8-2.35.2)

Steel Reinforcement

$$A_v := 4 \cdot A_b \langle bar_{size.v} \rangle = 1.76 \text{ in}^2$$

Required Steel Reinforcement

$$A_{v.req} := \frac{(v_u - v_c) \cdot w_{cap} \cdot s}{f_y} = 1.047 \text{ in}^2$$

Stirrup Reinforcement Check

$$\text{if } (A_v > A_{v.req}, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Stirrup Spacing Check

$$\text{if } (s < \min(0.5 \cdot d, 24 \text{ in}), \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

(AREMA 8-2.10.3)

Pile Foundations

Number of piles

$$n_{piles} := 4$$

Axial Loads**Dead Load**

Cap (2ftx3ftx16.75ft)

$$Cap_{DL} := 2 \text{ ft} \cdot 3 \text{ ft} \cdot 16.75 \text{ ft} \cdot \gamma_{conc} \cdot \frac{1}{n_{piles}} = 3.8 \text{ kip}$$

Backwall (10"x4.75ftx16.75ft)

$$BW_{DL.pile} := 10 \text{ in} \cdot 4.75 \text{ ft} \cdot 16.75 \text{ ft} \cdot \gamma_{conc} \cdot \frac{1}{n_{piles}} = 2.486 \text{ kip}$$

Wingwall

$$WW_{DL.pile} := WW_{DL} \cdot \frac{1}{n_{piles}} = 1.643 \text{ kip}$$

Piles - HP14x117 - assume 25' Length

$$Piles_{DL} := 117 \left(\frac{\text{lbft}}{\text{ft}} \right) \cdot 25 \text{ ft} = 2.9 \text{ kip}$$

Super Dead Load

$$P_{DL.sup} := R_{DL.span1} \cdot \frac{1}{n_{piles}} = 8.583 \text{ kip}$$

Live Load

Axial Live load excluding impact

$$P_{LL} := 2 \cdot 156 \text{ kip} \cdot \frac{1}{n_{piles}} = 78 \text{ kip}$$

Wind Load - CSI

Axial Wind on Live load

$$P_{WL} := 16 \text{ kip}$$

Axial Wind on Structure

$$P_{WS} := 1.6 \text{ kip}$$

Load Combinations

Group I axial loads

$$P_I := P_{DL.sup} + Cap_{DL} + Piles_{DL} + P_{LL} = 93.276 \text{ kip}$$

Group II axial loads (125% allow)

$$P_{II} := P_{DL.sup} + Cap_{DL} + Piles_{DL} + P_{LL} + P_{WL} + P_{WS} = 110.876 \text{ kip}$$

Moment Loads

X-X

Longitudinal Load - CSI

Moment

$$M_{LF.pile.x} := 300 \text{ kip} \cdot \text{ft}$$

Moment due to soil behind BW - active coeff = 0.36

$$M_{soil} := \frac{1}{n_{piles}} \cdot \left(\frac{1}{2} \cdot (6.75 \text{ ft})^2 \cdot 16.75 \text{ ft} \cdot 125 \cdot \frac{\text{lbft}}{\text{ft}^3} \cdot 0.36 \right) \cdot (0.33 \cdot 6.75 \text{ ft} + 10.3 \text{ ft}) = 53.779 \text{ kip} \cdot \text{ft}$$

Y-Y

Wind Load - CSI

Moment Wind on Live load

$$M_{WL.pile.y} := \frac{R_{WL}}{n_{piles}} \cdot 10.3 \text{ ft} = 13.3 \text{ kip} \cdot \text{ft}$$

Abutment depth to fixity = 10.3'

Moment Wind on Structure

$$M_{WS.pile.y} := \frac{R_{WS}}{n_{piles}} \cdot 10.3 \text{ ft} = 8.8 \text{ kip} \cdot \text{ft}$$

Load Combinations X-X

Group I loads - will not control

Group II loads (125% allow)

$$M_{II.x} := M_{LF.pile.x} + M_{soil} = 353.779 \text{ ft} \cdot \text{kip}$$

Load Combinations Y-Y

Group I loads - will not control

Group II loads (125% allow)

$$M_{II.y} := M_{WL.pile.y} + M_{WS.pile.y} = 22.1 \text{ ft} \cdot \text{kip}$$

Pile Capacity - Geotechnical

Bearing capacity - from
Geotechnology report
Pile Size

$$q_{all,pile} := 16 \text{ ksi}$$

$$SIZE := \text{"HP14X117"}$$

Pile Area

$$A := 34.4 \text{ in}^2$$

Pile capacity (FS of 2.5)

$$Q_{pile} := \frac{q_{all,pile} \cdot A}{2.5} = 220.2 \text{ kip}$$

4 Pile capacity

$$Q_{pile,4} := Q_{pile} \cdot 4 = 880.6 \text{ kip}$$

Capacity Check

$$Pile_{check} := \text{if}(Q_{pile,4} > P_I, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

Pile Capacity - Structural - 15-1-11

Axial capacity check

$$k_{pile} := 1.2 \quad AISC$$

Assume unbraced L=10 ft

$$r_y := 3.59 \text{ in} \quad r_x := 5.96 \text{ in} \quad L_{pile} := 10 \text{ ft} \quad K_{pile,x} := \frac{k_{pile} \cdot L_{pile}}{r_x} = 24.161$$

$$K_{pile} := \frac{k_{pile} \cdot L_{pile}}{r_y} = 40.111$$

KL/r limit 1

$$K_1 := \frac{0.629}{\sqrt{\frac{f_y}{E_s}}} = 13.828$$

KL/r limit 2

$$K_2 := \frac{5.034}{\sqrt{\frac{f_y}{E_s}}} = 110.672$$

Stress Limit 1

$$F_{a1} := 0.55 \cdot f_y = 33 \text{ ksi}$$

Stress Limit 2

$$F_{a2} := 0.6 \cdot f_y - \left(17500 \cdot \frac{f_y}{E_s} \right)^{\frac{3}{2}} \cdot (\text{psi}) \cdot K_{pile} = 27.261 \text{ ksi}$$

Stress Limit 3

$$F_{a3} := \frac{0.514 \cdot \pi^2 \cdot E_s}{K_{pile}^2} = 91.438 \text{ ksi}$$

$$F_a := \text{if}(K_{pile} \leq K_1, F_{a1}, \text{if}(K_{pile} < K_2, F_{a2}, F_{a3})) = 27.261 \text{ ksi}$$

$$f_a := \frac{P_I}{A} = 2.712 \text{ ksi}$$

$$Pile_{check_{axialI}} := \text{if}(F_a > f_a, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

$$f_{all} := \frac{P_{II}}{A} = 3.223 \text{ ksi}$$

$$Pile_{check_{axialII}} := \text{if}(F_a \cdot 1.25 > f_{all}, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

$$CD_I := \frac{f_a}{F_a} = 0.099 \quad CD_{II} := \frac{f_{all}}{F_a} = 0.118$$

Bending Stress - LC II - 125% allowable

HP14x117

$$S_x := 172 \text{ in}^3 \quad S_y := 59.5 \text{ in}^3$$

Tension Check - Bottom Flange X-X

Allowable Tensile Stress

$$f_{all.b.x} := 0.55 \cdot f_y \cdot 1.25 = 41.3 \text{ ksi}$$

(AREMA Table 15-1-12)

Tensile Flange Stress
due to Bending

$$f_{b.x} := \frac{M_{II.x}}{S_x} = 24.7 \text{ ksi}$$

Capacity over Demand Ratio

$$C.D := \frac{f_{all.b.x}}{f_{b.x}} = 1.67$$

$$\text{if } (f_{b.x} \leq f_{all.b.x}, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Tension Check - Bottom Flange Y-Y

Allowable Tensile Stress

$$f_{all.b.y} := 0.55 \cdot f_y \cdot 1.25 = 41.3 \text{ ksi}$$

Tensile Flange Stress
due to Bending

$$f_{b.y} := \frac{M_{II.y}}{S_y} = 4.5 \text{ ksi}$$

Capacity over Demand Ratio

$$C.D := \frac{f_{all.b.y}}{f_{b.y}} = 9.25$$

$$\text{if } (f_{b.y} \leq f_{all.b.y}, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Compression Check - Top Flange X-X

$$A_{tf} := 14.9 \text{ in} \cdot 0.805 \text{ in} = 11.995 \text{ in}^2$$

$$f_{all.1} := 0.55 \cdot f_y - \left(\frac{0.55 \cdot f_y^2}{6.3 \cdot \pi^2 \cdot E_s} \right) \cdot \left(\frac{L_{pile}}{r_y} \right)^2 = 31.773 \text{ ksi}$$

$$f_{all.2} := \frac{0.131 \cdot \pi \cdot E_s}{\left(L_{pile} \cdot d \cdot \sqrt{1 + 0.3} \right)} = 50.423 \text{ ksi} \quad f_{all.3} := 0.55 \cdot f_y = 33 \text{ ksi}$$

Allowable Compressive Stress

$$f_{c.all} := \text{if } (f_{all.1} < f_{all.2}, \text{if } (f_{all.2} > f_{all.3}, f_{all.3}, f_{all.2}), f_{all.1}) \cdot 1.25 = 41.25 \text{ ksi}$$

Compressive Flange Stress
due to Bending

$$f_c := \frac{M_{II.x}}{S_x} = 24.7 \text{ ksi}$$

(AREMA Table 15-1-12)

Capacity over Demand Ratio

$$C.D := \frac{f_{c.all}}{f_c} = 1.67$$

$$\text{if } (f_c \leq f_{c.all}, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Compression Check - Top Flange Y-Y

Allowable Compressive Stress

$$f_{all.y} := 0.55 \cdot f_y \cdot 1.25 = 41.25 \text{ ksi}$$

Compressive Flange Stress
due to Bending

$$f_{cy} := \frac{M_{II.y}}{S_y} = 4.5 \text{ ksi}$$

(AREMA Table 15-1-12)

Capacity over Demand Ratio

$$C.D := \frac{f_{all.y}}{f_{cy}} = 9.25$$

$$\text{if } (f_{cy} \leq f_{all.y}, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

BACKWALL & WINGWALL HAND CALCULATIONS

Backwall/Wingwall Design

NS shoofly

References:

AREMA Manual for Railway Engineering, 2024

Material Properties

Reinforcing Yield Strength	$f_y := 60 \text{ ksi}$
Reinf. Steel Modulus of Elasticity	$E_s := 29000 \text{ ksi}$
Concrete Strength	$f'_c := 4.5 \text{ ksi}$ (AREMA 8-2.31.1f)
Concrete Strength Factor	$\beta_1 := \max \left(0.65, \min \left(0.85, 0.85 - 0.05 \cdot \frac{f'_c - 4 \text{ ksi}}{1 \text{ ksi}} \right) \right) = 0.825$
Soil Unit Weight	$\gamma_{soil} := 125 \text{ pcf}$
Soil Active Coefficient	$k_a := 0.36$
Soil Passive Coefficient	$k_p := 2.77$
Weight of Concrete	$w_c := 150 \text{ pcf}$
Concrete Modulus of Elasticity	$E_c := 33 \cdot \left(\frac{w_c}{\text{pcf}} \right)^{1.5} \cdot \sqrt{\frac{f'_c}{\text{psi}}} \text{ psi} = 4066.84 \text{ ksi}$
Modulus of Rupture (Tensile Strength)	$f_r := 7.5 \cdot \sqrt{\frac{f'_c}{\text{psi}}} \text{ psi} = 0.503 \text{ ksi}$

Geometry

Beam Depth W44x230	$beam_d := 43 \text{ in}$
Bearing Depth	$bearing_d := 4 \text{ in}$
Tie Depth	$Tie_d := 10 \text{ in}$
Tie Length	$Tie_L := 10 \text{ ft}$
Backwall Height	$h_{bw} := bearing_d + beam_d + Tie_d = 4.75 \text{ ft}$
Backwall Thickness	$t_{bw} := 10 \text{ in}$
Design Width	$b := 1 \text{ ft}$

Loads

Earth Pressure & Live Load Surcharge

Soil Depth	$d_{soil} := h_{bw} = 4.75 \text{ ft}$
Moment on Backwall from Soil	$M_{soil_bw} := \frac{k_p \cdot \gamma_{soil} \cdot b \cdot d_{soil}^2}{2} \cdot \frac{d_{soil}}{3} = 6.185 \text{ kip} \cdot \text{ft}$
Assume 80 kip Axles	$P_{axle} := 80 \text{ kip}$
Spaced at 5' directly behind abutment	$spa_{axle} := 5 \text{ ft}$
Distributed Live load	$w_{axle} := \frac{P_{axle}}{spa_{axle}} = 16 \text{ klf}$

Loads (Continued)

Earth Pressure & Live Load Surcharge (Continued)

Live load surcharge distribution width	$W_{ab} := Tie_L + \left(\frac{d_{soil}}{2} - Tie_d \right) = 11.542 \text{ ft}$ distributed from edge of tie (2V:1H)
Surcharge Pressure on Backwall	$p_{surch} := 2 \cdot \left(\frac{k_a \cdot w_{axle}}{W_{ab}} \right) = 0.998 \text{ ksf}$ (80k axle distributed over tie width plus depth to mid-height of backwall) x2 (AREMA 8-5.3.1.c)
Live Load Surcharge Moment	$M_{surch} := p_{surch} \cdot b \cdot 0.5 h_{bw}^2 = 11.26 \text{ kip} \cdot \text{ft}$
Service Moment on Backwall	$M_{srv_bw} := M_{soil_bw} + M_{surch} = 17.445 \text{ kip} \cdot \text{ft}$
Group I - Strength Moment (controls by inspection)	$M_{strI_bw} := 1.4 \left(M_{soil_bw} + \frac{5}{3} M_{surch} \right) = 34.932 \text{ kip} \cdot \text{ft}$
Controlling Strength Moment	$M_{str_bw} := M_{strI_bw} = 34.932 \text{ kip} \cdot \text{ft}$

Flexure Design

(AREMA 8-2.32)

Section Height

$$h := t_{bw} = 0.833 \text{ ft}$$

Moment of Inertia

$$I_x := \frac{b \cdot h^3}{12} = (1 \cdot 10^3) \text{ in}^4$$

Vertical Reinforcing

$$bar_{dia} := .875 \text{ in}$$

$$bar_{area} := 0.6 \text{ in}^2$$

#7 @ 6"

Vertical Reinforcing Spacing

$$bar_{spa} := 6 \text{ in}$$

Concrete Cover

$$cover := 2 \text{ in}$$

Effective Depth of Section

$$d := h - cover - \frac{bar_{dia}}{2} = 7.563 \text{ in}$$

Number of Bars in Cross-Section

$$n_{bars} := \frac{b}{bar_{spa}} = 2$$

Area of Flexural Reinforcing

$$A_s := n_{bars} \cdot bar_{area} = 1.2 \text{ in}^2$$

Balanced Reinforcing Ratio

$$\rho_b := \frac{0.85 \beta_1 \cdot f'_c}{f_y} \cdot \left(\frac{87 \text{ ksi}}{87 \text{ ksi} + f_y} \right) = 0.031 \quad (\text{AREMA 8-2.32.2b})$$

Reinforcing Ratio

$$\rho := \frac{A_s}{b \cdot d} = 0.013$$

$$\text{if} \left(\frac{\rho}{\rho_b} \leq 0.75, \text{"ok"}, \text{"not ok"} \right) = \text{"ok"} \quad (\text{AREMA 8-2.32.1a})$$

Depth of Compression Block

$$a := \frac{A_s \cdot f_y}{0.85 \cdot f'_c \cdot b} = 1.569 \text{ in} \quad (\text{AREMA 8-2.32.2})$$

Verify Tension controlled

$$c := \frac{a}{\beta_1} = 1.901 \text{ in} \quad (\text{AREMA 8-2.32.2})$$

$$e_{c1} := \text{if} \left(\frac{f_y}{E_s} < 0.002, \frac{f_y}{E_s}, 0.002 \right) = 0.002 \quad ratio_{ten} := \frac{0.003}{0.003 + e_{c1}}$$

$$tension.check := \text{if} \left(\frac{c}{d} < ratio_{ten}, \text{"OK"}, \text{"NG"} \right) = \text{"OK"}$$

Strength Reduction Factor

$$\phi := 0.9 \quad (\text{AREMA 8-2.30.2b})$$

Design Moment Strength

$$\phi M_n := \phi \cdot A_s \cdot f_y \cdot \left(d - \frac{a}{2} \right) = 36.602 \text{ kip} \cdot \text{ft} \quad (\text{AREMA Eq. 8-2.29})$$

Cracking Moment

$$M_{cr} := \frac{f_r \cdot I_x}{0.5 \cdot b} = 6.988 \text{ kip} \cdot \text{ft} \quad (\text{AREMA Eq. 8-2.13})$$

Factored Design Moment

$$M_u := \left\| \begin{array}{l} \text{if } M_{str_bw} > 1.2 \cdot M_{cr} \\ \quad \left\| M_{str_bw} \right. \\ \text{else if } 1.2 \cdot M_{cr} > 1.33 \cdot M_{str_bw} \\ \quad \left\| 1.33 \cdot M_{str_bw} \right. \\ \text{else} \\ \quad \left\| 1.2 \cdot M_{cr} \right. \end{array} \right\| = 34.932 \text{ kip} \cdot \text{ft}$$

$$\text{D/C Ratio} \quad \frac{M_u}{\phi M_n} = 0.954$$

$$\text{if} (\phi M_n \geq M_u, \text{"ok"}, \text{"not ok"}) = \text{"ok"}$$

Distribution of Reinforcing

Modular Ratio	$n := \text{round} \left(\frac{E_s}{E_c} \right) = 7$
Find Neutral Axis	$k := \sqrt{(\rho \cdot n)^2 + 2 \rho \cdot n} - \rho \cdot n = 0.348$
Lever Arm Ratio	$j := 1 - \frac{k}{3} = 0.884$
Total Service Load Stress	$f_{s,sv} := \frac{M_{sv, bw}}{A_s \cdot j \cdot d} = (2.609 \cdot 10^4) \text{ psi}$
Exposure Condition Stress	$Z := 170 \frac{\text{kip}}{\text{in}}$
Area of Concrete Surrounding Main Tension Rebar <i>with same centroid over number of bars</i>	$A := \frac{b \cdot (\text{cover} + 0.5 \text{ bar}_{dia}) \cdot 2}{n_{bars}} = 29.25 \text{ in}^2$
Distance to Tension Rebar from Extreme Tension Fiber	$d_c := \min(\text{cover}, 2 \text{ in}) + 0.5 \text{ bar}_{dia} = 2.438 \text{ in}$
Service Stress in Rebar	$f_s := f_{s,sv} = 26.09 \text{ ksi}$
	$\text{if} \left(f_s \leq \min \left(\frac{Z}{\sqrt[3]{d_c \cdot A}}, 0.5 f_y \right), \text{"ok"}, \text{"not ok"} \right) = \text{"ok"}$

Wingwall Design

Wingwall simplified into a cantilever beam.

Geometry

Height of Wingwall	$h_{ww} := 6.75 \text{ ft}$
Length of Wingwall - beyond backwall	$l_{ww} := 5.5 \text{ ft} - 10 \text{ in}$
Thickness of Wingwall	$t_{ww} := 9 \text{ in}$

Earth Pressure

Active Earth Pressure at Bottom of Wall	$P_{a,earth,max} := k_a \cdot \gamma_{soil} \cdot h_{ww} = 303.75 \text{ psf}$
Active Earth Pressure at 1/2 of Wall	$P_{a,earth,min} := k_a \cdot \gamma_{soil} \cdot \frac{h_{ww}}{2} = 151.875 \text{ psf}$
Average Earth Pressure	$P_{earth,avg} := \frac{P_{a,earth,max} + P_{a,earth,min}}{2} = 227.813 \text{ psf}$
Earth Force on Wingwall <i>(Evaluating a 1-ft horizontal strip at the bottom of the wall)</i>	$P_{total,ww} := (P_{earth,avg}) \cdot 1 \text{ ft} = 0.228 \text{ klf}$
Moment on Wingwall	$M_{ww} := \frac{1.8 P_{total,ww} \cdot l_{ww}^2}{2} = 4.465 \text{ ft} \cdot \text{kip}$

Flexure at Wingwall

(AREMA 8-2.32)

Vertical Reinforcing

$$\bar{bar}_{dia} := .5 \text{ in}$$

$$\bar{bar}_{area} := 0.2 \text{ in}^2$$

#4 @ 9"

Vertical Reinforcing Spacing

$$\bar{bar}_{spa} := 9 \text{ in}$$

Concrete Cover

$$\bar{cover} := 2 \text{ in}$$

Effective Depth of Section

$$d_{ef,ww} := t_{ww} - \bar{cover} - 0.5 \text{ in} - \frac{\bar{bar}_{dia}}{2} = 6.25 \text{ in}$$

Number of Bars in Cross-Section - per foot

$$\bar{n}_{bars} := \frac{b}{\bar{bar}_{spa}} = 1.333$$

Area of Flexural Reinforcing

$$A_{s,ww} := \bar{n}_{bars} \cdot \bar{bar}_{area} = 0.267 \text{ in}^2$$

Moment of Inertia - Retaining Wall

$$I_{wwx} := \frac{b \cdot t_{ww}^3}{12} = 729 \text{ in}^4$$

Balanced Reinforcing Ratio

$$\bar{\rho}_b := \frac{0.85 \beta_1 \cdot f'_c}{f_y} \cdot \left(\frac{87 \text{ ksi}}{87 \text{ ksi} + f_y} \right) = 0.031 \quad (\text{AREMA 8-2.32.2b})$$

Reinforcing Ratio

$$\bar{\rho} := \frac{A_s}{t_{ww} \cdot d} = 0.018$$

$$\text{if} \left(\frac{\bar{\rho}}{\bar{\rho}_b} \leq 0.75, \text{"ok"}, \text{"not ok"} \right) = \text{"ok"} \quad (\text{AREMA 8-2.32.1a})$$

Depth of Compression Block

$$\bar{a} := \frac{A_{s,ww} \cdot f_y}{0.85 \cdot f'_c \cdot b} = 0.349 \text{ in} \quad (\text{AREMA 8-2.32.2a})$$

Verify Tension controlled

$$\bar{c} := \frac{a}{\beta_1} = 0.423 \text{ in}$$

$$\bar{e}_{c1} := \text{if} \left(\frac{f_y}{E_s} < 0.002, \frac{f_y}{E_s}, 0.002 \right) = 0.002 \quad \bar{ratio}_{ten} := \frac{0.003}{0.003 + \bar{e}_{c1}}$$

$$\bar{tension.check} := \text{if} \left(\frac{c}{d} < \bar{ratio}_{ten}, \text{"OK"}, \text{"NG"} \right) = \text{"OK"}$$

Design Moment Strength

$$\phi M_{n,ww} := \phi \cdot A_{s,ww} \cdot f_y \cdot (d_{ef,ww} - 0.5 a) = 7.291 \text{ ft} \cdot \text{kip} \quad (\text{AREMA EQ. 8-2-29})$$

Cracking Moment

$$M_{cr,ww} := \frac{f_r \cdot I_{wwx}}{(0.5 t_{ww})} = 6.792 \text{ ft} \cdot \text{kip} \quad (\text{AREMA EQ. 8-2-13})$$

(AREMA Section 2.7a)

Factored Design Moment

$$M_{u,ww} := \left\| \begin{array}{l} \text{if } M_{ww} > 1.2 \cdot M_{cr,ww} \\ \left\| M_{ww} \right. \\ \text{else if } 1.2 \cdot M_{cr,ww} > 1.33 \cdot M_{ww} \\ \left\| 1.33 \cdot M_{ww} \right. \\ \text{else} \\ \left\| 1.2 \cdot M_{cr,ww} \right. \end{array} \right\| = 5.939 \text{ kip} \cdot \text{ft}$$

D/C Ratio

$$\frac{\phi M_{n,ww}}{M_{u,ww}} = 1.228$$

if $(\phi M_{n,ww} \geq M_{u,ww}, \text{"ok"}, \text{"not ok"}) = \text{"ok"}$

Shear at Wingwall

Factored Shear Force due to Soil
per foot

$$V_{soil_ww} := 1.8 \cdot P_{total_ww} \cdot l_{ww} = 1.914 \text{ kip}$$

Shear Stress

$$v := \frac{V_{soil_ww}}{t_{ww} \cdot b} = 0.018 \text{ ksi}$$

Shear Stress carried by concrete

$$v_c := 2 \cdot \sqrt{\frac{f'_c}{psi}} \text{ psi} = 0.134 \text{ ksi}$$

Shear check OK

Check anchorage for Wingwall to abutment

Factored Shear Force due to Soil
- per foot load x wing height

$$V_{soil_ww.anchor} := \frac{V_{soil_ww}}{ft} \cdot h_{ww} = 12.917 \text{ kip}$$

B17 DOUBLE FLARED COIL
LOOP INSERT Capacity
(tension) - 1.25 x12" see below

$$T_{allow} := 9 \text{ kip}$$

Number of Anchors Required

$$Anchors := \frac{V_{soil_ww.anchor}}{T_{allow}} = 1.435$$

4 anchors are provided - OK

CSI MODEL OUTPUT

Table: Case - Static 1 - Load Assignments**Table: Case - Static 1 - Load Assignments**

Case	LoadType	LoadName	LoadSF
DEAD	Load pattern	DEAD	1.
E80 Reaction	Load pattern	E80 Reaction	1.
weight	Load pattern	weight	1.
weight	Load pattern	BW Dead	1.
Wind Live	Load pattern	Wind Live	1.
Wind Struct	Load pattern	Wind Struct	1.

Table: Element Forces - Frames, Part 1 of 2**Table: Element Forces - Frames, Part 1 of 2**

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
1	0.	DEAD	LinStatic	0.	-1.35	0.	0.	0.
1	1.5	DEAD	LinStatic	0.	9.437E-16	0.	0.	0.
1	0.	Wind Struct	LinStatic	0.	1.388E-17	0.	0.	0.
1	1.5	Wind Struct	LinStatic	0.	1.388E-17	0.	0.	0.
2	0.	DEAD	LinStatic	0.	-7.424	0.	0.	0.
2	0.4	DEAD	LinStatic	0.	-5.664	0.	0.	0.
2	0.4	DEAD	LinStatic	0.	-5.664	0.	0.	0.
2	0.8	DEAD	LinStatic	0.	-3.904	0.	0.	0.
2	0.8	DEAD	LinStatic	0.	-3.904	0.	0.	0.
2	1.2	DEAD	LinStatic	0.	-2.144	0.	0.	0.
2	1.2	DEAD	LinStatic	0.	-2.144	0.	0.	0.
2	1.6	DEAD	LinStatic	0.	-0.384	0.	0.	0.
2	1.6	DEAD	LinStatic	0.	-0.384	0.	0.	0.
2	2.	DEAD	LinStatic	0.	1.376	0.	0.	0.
2	2.	DEAD	LinStatic	0.	1.376	0.	0.	0.
2	2.4	DEAD	LinStatic	0.	3.136	0.	0.	0.
2	2.4	DEAD	LinStatic	0.	3.136	0.	0.	0.
2	2.8	DEAD	LinStatic	0.	4.896	0.	0.	0.
2	2.8	DEAD	LinStatic	0.	4.896	0.	0.	0.
2	3.2	DEAD	LinStatic	0.	6.656	0.	0.	0.
2	3.2	DEAD	LinStatic	0.	6.656	0.	0.	0.
2	3.6	DEAD	LinStatic	0.	8.416	0.	0.	0.
2	3.6	DEAD	LinStatic	0.	8.416	0.	0.	0.
2	4.	DEAD	LinStatic	0.	10.176	0.	0.	0.
2	0.	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	0.4	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	0.4	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	0.8	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	0.8	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	1.2	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	1.2	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	1.6	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	1.6	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	2.	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	2.	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	2.4	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	2.4	Wind Struct	LinStatic	0.	0.047	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
2	2.8	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	2.8	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	3.2	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	3.2	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	3.6	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	3.6	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
2	4.	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
3	0.	DEAD	LinStatic	0.	-8.947	0.	0.	0.
3	0.4	DEAD	LinStatic	0.	-7.187	0.	0.	0.
3	0.4	DEAD	LinStatic	0.	-7.187	0.	0.	0.
3	0.8	DEAD	LinStatic	0.	-5.427	0.	0.	0.
3	0.8	DEAD	LinStatic	0.	-5.427	0.	0.	0.
3	1.2	DEAD	LinStatic	0.	-3.667	0.	0.	0.
3	1.2	DEAD	LinStatic	0.	-3.667	0.	0.	0.
3	1.6	DEAD	LinStatic	0.	-1.907	0.	0.	0.
3	1.6	DEAD	LinStatic	0.	-1.907	0.	0.	0.
3	2.	DEAD	LinStatic	0.	-0.147	0.	0.	0.
3	2.	DEAD	LinStatic	0.	-0.147	0.	0.	0.
3	2.4	DEAD	LinStatic	0.	1.613	0.	0.	0.
3	2.4	DEAD	LinStatic	0.	1.613	0.	0.	0.
3	2.8	DEAD	LinStatic	0.	3.373	0.	0.	0.
3	2.8	DEAD	LinStatic	0.	3.373	0.	0.	0.
3	3.2	DEAD	LinStatic	0.	5.133	0.	0.	0.
3	3.2	DEAD	LinStatic	0.	5.133	0.	0.	0.
3	3.6	DEAD	LinStatic	0.	6.893	0.	0.	0.
3	3.6	DEAD	LinStatic	0.	6.893	0.	0.	0.
3	4.	DEAD	LinStatic	0.	8.653	0.	0.	0.
3	0.	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	0.4	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	0.4	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	0.8	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	0.8	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	1.2	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	1.2	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	1.6	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	1.6	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	2.	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	2.	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	2.4	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	2.4	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	2.8	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	2.8	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	3.2	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	3.2	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	3.6	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	3.6	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
3	4.	Wind Struct	LinStatic	0.	1.632	0.	0.	0.
4	0.	DEAD	LinStatic	0.	-9.094	0.	0.	0.
4	0.4	DEAD	LinStatic	0.	-7.334	0.	0.	0.
4	0.4	DEAD	LinStatic	0.	-7.334	0.	0.	0.
4	0.8	DEAD	LinStatic	0.	-5.574	0.	0.	0.
4	0.8	DEAD	LinStatic	0.	-5.574	0.	0.	0.
4	1.2	DEAD	LinStatic	0.	-3.814	0.	0.	0.
4	1.2	DEAD	LinStatic	0.	-3.814	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
4	1.6	DEAD	LinStatic	0.	-2.054	0.	0.	0.
4	1.6	DEAD	LinStatic	0.	-2.054	0.	0.	0.
4	2.	DEAD	LinStatic	0.	-0.294	0.	0.	0.
4	2.	DEAD	LinStatic	0.	-0.294	0.	0.	0.
4	2.4	DEAD	LinStatic	0.	1.466	0.	0.	0.
4	2.4	DEAD	LinStatic	0.	1.466	0.	0.	0.
4	2.8	DEAD	LinStatic	0.	3.226	0.	0.	0.
4	2.8	DEAD	LinStatic	0.	3.226	0.	0.	0.
4	3.2	DEAD	LinStatic	0.	4.986	0.	0.	0.
4	3.2	DEAD	LinStatic	0.	4.986	0.	0.	0.
4	3.6	DEAD	LinStatic	0.	6.746	0.	0.	0.
4	3.6	DEAD	LinStatic	0.	6.746	0.	0.	0.
4	4.	DEAD	LinStatic	0.	8.506	0.	0.	0.
4	0.	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	0.4	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	0.4	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	0.8	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	0.8	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	1.2	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	1.2	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	1.6	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	1.6	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	2.	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	2.	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	2.4	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	2.4	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	2.8	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	2.8	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	3.2	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	3.2	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	3.6	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	3.6	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
4	4.	Wind Struct	LinStatic	0.	0.047	0.	0.	0.
5	0.	DEAD	LinStatic	0.	-2.925	0.	0.	0.
5	1.625	DEAD	LinStatic	0.	-1.463	0.	0.	0.
5	3.25	DEAD	LinStatic	0.	-4.580E-16	0.	0.	0.
5	0.	Wind Struct	LinStatic	0.	6.939E-18	0.	0.	0.
5	1.625	Wind Struct	LinStatic	0.	6.939E-18	0.	0.	0.
5	3.25	Wind Struct	LinStatic	0.	6.939E-18	0.	0.	0.

Table: Element Forces - Frames, Part 2 of 2

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
1	0.	DEAD	-1.0125	1-1	0.
1	1.5	DEAD	-1.554E-15	1-1	1.5
1	0.	Wind Struct	1.388E-17	1-1	0.
1	1.5	Wind Struct	-6.939E-18	1-1	1.5
2	0.	DEAD	-1.0125	2-1	0.
2	0.4	DEAD	1.6051	2-1	0.4
2	0.4	DEAD	1.6051	2-2	0.
2	0.8	DEAD	3.5187	2-2	0.4

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
2	0.8	DEAD	3.5187	2-3	0.
2	1.2	DEAD	4.7284	2-3	0.4
2	1.2	DEAD	4.7284	2-4	0.
2	1.6	DEAD	5.234	2-4	0.4
2	1.6	DEAD	5.234	2-5	0.
2	2.	DEAD	5.0356	2-5	0.4
2	2.	DEAD	5.0356	2-6	0.
2	2.4	DEAD	4.1332	2-6	0.4
2	2.4	DEAD	4.1332	2-7	0.
2	2.8	DEAD	2.5268	2-7	0.4
2	2.8	DEAD	2.5268	2-8	0.
2	3.2	DEAD	0.2164	2-8	0.4
2	3.2	DEAD	0.2164	2-9	0.
2	3.6	DEAD	-2.7979	2-9	0.4
2	3.6	DEAD	-2.7979	2-10	0.
2	4.	DEAD	-6.5163	2-10	0.4
2	0.	Wind Struct	0.	2-1	0.
2	0.4	Wind Struct	-0.0186	2-1	0.4
2	0.4	Wind Struct	-0.0186	2-2	0.
2	0.8	Wind Struct	-0.0372	2-2	0.4
2	0.8	Wind Struct	-0.0372	2-3	0.
2	1.2	Wind Struct	-0.0558	2-3	0.4
2	1.2	Wind Struct	-0.0558	2-4	0.
2	1.6	Wind Struct	-0.0744	2-4	0.4
2	1.6	Wind Struct	-0.0744	2-5	0.
2	2.	Wind Struct	-0.093	2-5	0.4
2	2.	Wind Struct	-0.093	2-6	0.
2	2.4	Wind Struct	-0.1116	2-6	0.4
2	2.4	Wind Struct	-0.1116	2-7	0.
2	2.8	Wind Struct	-0.1302	2-7	0.4
2	2.8	Wind Struct	-0.1302	2-8	0.
2	3.2	Wind Struct	-0.1488	2-8	0.4
2	3.2	Wind Struct	-0.1488	2-9	0.
2	3.6	Wind Struct	-0.1674	2-9	0.4
2	3.6	Wind Struct	-0.1674	2-10	0.
2	4.	Wind Struct	-0.186	2-10	0.4
3	0.	DEAD	-6.5163	3-1	0.
3	0.4	DEAD	-3.2897	3-1	0.4
3	0.4	DEAD	-3.2897	3-2	0.
3	0.8	DEAD	-0.767	3-2	0.4
3	0.8	DEAD	-0.767	3-3	0.
3	1.2	DEAD	1.0517	3-3	0.4
3	1.2	DEAD	1.0517	3-4	0.
3	1.6	DEAD	2.1664	3-4	0.4
3	1.6	DEAD	2.1664	3-5	0.
3	2.	DEAD	2.5771	3-5	0.4
3	2.	DEAD	2.5771	3-6	0.
3	2.4	DEAD	2.2837	3-6	0.4
3	2.4	DEAD	2.2837	3-7	0.
3	2.8	DEAD	1.2864	3-7	0.4
3	2.8	DEAD	1.2864	3-8	0.
3	3.2	DEAD	-0.4149	3-8	0.4
3	3.2	DEAD	-0.4149	3-9	0.
3	3.6	DEAD	-2.8202	3-9	0.4

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
3	3.6	DEAD	-2.8202	3-10	0.
3	4.	DEAD	-5.9296	3-10	0.4
3	0.	Wind Struct	-0.186	3-1	0.
3	0.4	Wind Struct	-0.8388	3-1	0.4
3	0.4	Wind Struct	-0.8388	3-2	0.
3	0.8	Wind Struct	-1.4916	3-2	0.4
3	0.8	Wind Struct	-1.4916	3-3	0.
3	1.2	Wind Struct	-2.1444	3-3	0.4
3	1.2	Wind Struct	-2.1444	3-4	0.
3	1.6	Wind Struct	-2.7972	3-4	0.4
3	1.6	Wind Struct	-2.7972	3-5	0.
3	2.	Wind Struct	-3.45	3-5	0.4
3	2.	Wind Struct	3.45	3-6	0.
3	2.4	Wind Struct	2.7972	3-6	0.4
3	2.4	Wind Struct	2.7972	3-7	0.
3	2.8	Wind Struct	2.1444	3-7	0.4
3	2.8	Wind Struct	2.1444	3-8	0.
3	3.2	Wind Struct	1.4916	3-8	0.4
3	3.2	Wind Struct	1.4916	3-9	0.
3	3.6	Wind Struct	0.8388	3-9	0.4
3	3.6	Wind Struct	0.8388	3-10	0.
3	4.	Wind Struct	0.186	3-10	0.4
4	0.	DEAD	-5.9296	4-1	0.
4	0.4	DEAD	-2.6439	4-1	0.4
4	0.4	DEAD	-2.6439	4-2	0.
4	0.8	DEAD	-0.0623	4-2	0.4
4	0.8	DEAD	-0.0623	4-3	0.
4	1.2	DEAD	1.8154	4-3	0.4
4	1.2	DEAD	1.8154	4-4	0.
4	1.6	DEAD	2.989	4-4	0.4
4	1.6	DEAD	2.989	4-5	0.
4	2.	DEAD	3.4587	4-5	0.4
4	2.	DEAD	3.4587	4-6	0.
4	2.4	DEAD	3.2243	4-6	0.4
4	2.4	DEAD	3.2243	4-7	0.
4	2.8	DEAD	2.2859	4-7	0.4
4	2.8	DEAD	2.2859	4-8	0.
4	3.2	DEAD	0.6436	4-8	0.4
4	3.2	DEAD	0.6436	4-9	0.
4	3.6	DEAD	-1.7028	4-9	0.4
4	3.6	DEAD	-1.7028	4-10	0.
4	4.	DEAD	-4.7531	4-10	0.4
4	0.	Wind Struct	0.186	4-1	0.
4	0.4	Wind Struct	0.1674	4-1	0.4
4	0.4	Wind Struct	0.1674	4-2	0.
4	0.8	Wind Struct	0.1488	4-2	0.4
4	0.8	Wind Struct	0.1488	4-3	0.
4	1.2	Wind Struct	0.1302	4-3	0.4
4	1.2	Wind Struct	0.1302	4-4	0.
4	1.6	Wind Struct	0.1116	4-4	0.4
4	1.6	Wind Struct	0.1116	4-5	0.
4	2.	Wind Struct	0.093	4-5	0.4
4	2.	Wind Struct	0.093	4-6	0.
4	2.4	Wind Struct	0.0744	4-6	0.4

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
4	2.4	Wind Struct	0.0744	4-7	0.
4	2.8	Wind Struct	0.0558	4-7	0.4
4	2.8	Wind Struct	0.0558	4-8	0.
4	3.2	Wind Struct	0.0372	4-8	0.4
4	3.2	Wind Struct	0.0372	4-9	0.
4	3.6	Wind Struct	0.0186	4-9	0.4
4	3.6	Wind Struct	0.0186	4-10	0.
4	4.	Wind Struct	1.678E-17	4-10	0.4
5	0.	DEAD	-4.7531	5-1	0.
5	1.625	DEAD	-1.1883	5-1	1.625
5	3.25	DEAD	1.360E-15	5-1	3.25
5	0.	Wind Struct	0.	5-1	0.
5	1.625	Wind Struct	-1.128E-17	5-1	1.625
5	3.25	Wind Struct	-2.255E-17	5-1	3.25

Table: Frame Loads - Distributed, Part 1 of 3

Table: Frame Loads - Distributed, Part 1 of 3

Frame	LoadPat	CoordSys	Type	Dir	DistType	RelDistA
2	DEAD	GLOBAL	Force	Gravity	RelDist	0.
2	E80 Reaction	GLOBAL	Force	Gravity	RelDist	0.
2	BW Dead	GLOBAL	Force	Gravity	RelDist	0.
3	DEAD	GLOBAL	Force	Gravity	RelDist	0.
3	E80 Reaction	GLOBAL	Force	Gravity	RelDist	0.
3	BW Dead	GLOBAL	Force	Gravity	RelDist	0.
4	DEAD	GLOBAL	Force	Gravity	RelDist	0.
4	E80 Reaction	GLOBAL	Force	Gravity	RelDist	0.
4	BW Dead	GLOBAL	Force	Gravity	RelDist	0.
1	BW Dead	GLOBAL	Force	Gravity	RelDist	0.
5	BW Dead	GLOBAL	Force	Gravity	RelDist	0.

Table: Frame Loads - Distributed, Part 2 of 3

Table: Frame Loads - Distributed, Part 2 of 3

Frame	LoadPat	RelDistB	AbsDistA ft	AbsDistB ft	FOverLA Kip/ft	FOverLB Kip/ft
2	DEAD	1.	0.	4.	3.5	3.5
2	E80 Reaction	1.	0.	4.	43.2	43.2
2	BW Dead	1.	0.	4.	0.6	0.6
3	DEAD	1.	0.	4.	3.5	3.5
3	E80 Reaction	1.	0.	4.	43.2	43.2
3	BW Dead	1.	0.	4.	0.6	0.6
4	DEAD	1.	0.	4.	3.5	3.5
4	E80 Reaction	1.	0.	4.	43.2	43.2
4	BW Dead	1.	0.	4.	0.6	0.6
1	BW Dead	1.	0.	1.5	0.6	0.6
5	BW Dead	1.	0.	3.25	0.6	0.6

Table: Frame Loads - Distributed, Part 3 of 3**Table: Frame Loads - Distributed, Part 3 of 3**

Frame	LoadPat	GUID
2	DEAD	3e5cb784-e8f7-4884-8d48-ec0e59e91f4c
2	E80 Reaction	e21a449e-e7e7-4c2f-ad7c-152cec32cc53
2	BW Dead	eebbef2f-e9ab-47d0-a771-752b6f5ff6c6
3	DEAD	0b63b72f-f93c-444c-8311-a1472570572a
3	E80 Reaction	b6476b6a-562c-48d2-b351-e0f865756dde
3	BW Dead	1d25343c-1e44-47fe-86fe-ac77262045ca
4	DEAD	4c799904-f122-4d06-b37a-17f9a8e1083b
4	E80 Reaction	7ce8fe1f-4367-4a80-96b7-e43decde9fb8
4	BW Dead	efc0d9a2-a07d-44c1-b02b-ab3fd3896057
1	BW Dead	289a7be2-7b87-49dc-8f8d-b23d1d8c7ac1
5	BW Dead	c2981ae5-3ac3-4e79-aaec-e0a2fc6bdeb1

Table: Frame Loads - Point, Part 1 of 2**Table: Frame Loads - Point, Part 1 of 2**

Frame	LoadPat	CoordSys	Type	Dir	DistType	RelDist
3	Wind Live	GLOBAL	Moment	Y	RelDist	0.5
3	Wind Struct	GLOBAL	Moment	Y	RelDist	0.5

Table: Frame Loads - Point, Part 2 of 2**Table: Frame Loads - Point, Part 2 of 2**

Frame	LoadPat	AbsDist ft	Moment Kip-ft	GUID
3	Wind Live	2.	69.52	7f7ac74d-b5ed-441a-a211-6f6e815e800c
3	Wind Struct	2.	6.9	cdff8611-c5f6-4a2c-9c07-190ff89d3bde

Table: Frame Section Assignments**Table: Frame Section Assignments**

Frame	SectionType	AutoSelect	AnalSect	DesignSect	MatProp
1	Rectangular	N.A.	CAP	CAP	Default
2	Rectangular	N.A.	CAP	CAP	Default
3	Rectangular	N.A.	CAP	CAP	Default
4	Rectangular	N.A.	CAP	CAP	Default
5	Rectangular	N.A.	CAP	CAP	Default

Table: Frame Section Properties 01 - General, Part 1 of 7

Table: Frame Section Properties 01 - General, Part 1 of 7

SectionName	Material	Shape	t3 ft	t2 ft	tf ft	tw ft
CAP	4000Psi	Rectangular	2.	3.		
HP14x117	A709Gr50	I/Wide Flange	1.18	1.24	0.067	0.067

Table: Frame Section Properties 01 - General, Part 2 of 7

Table: Frame Section Properties 01 - General, Part 2 of 7

SectionName	t2b ft	tfb ft	FilletRadius ft	Area ft2	TorsConst ft4	I33 ft4	I22 ft4
CAP				6.	4.695309	2.	4.5
HP14x117	1.24	0.067	0.	0.2362	0.000341	0.05791	0.021317

Table: Frame Section Properties 01 - General, Part 3 of 7

Table: Frame Section Properties 01 - General, Part 3 of 7

SectionName	I23 ft4	AS2 ft2	AS3 ft2	S33Top ft3	S33Bot ft3	S22Left ft3	S22Right ft3
CAP	0.	5.	5.	2.	2.	3.	3.
HP14x117	0.	0.0791	0.1385	0.098153	0.098153	0.034382	0.034382

Table: Frame Section Properties 01 - General, Part 4 of 7

Table: Frame Section Properties 01 - General, Part 4 of 7

SectionName	Z33 ft3	Z22 ft3	R33 ft	R22 ft	CGOffset3 ft	CGOffset2 ft	EccV2 ft
CAP	3.	4.5	0.57735	0.86603	0.	0.	0.
HP14x117	0.110794	0.052683	0.49511	0.30039	0.	0.	0.

Table: Frame Section Properties 01 - General, Part 5 of 7

Table: Frame Section Properties 01 - General, Part 5 of 7

SectionName	EccV3 ft	Cw ft6	ConcCol	ConcBeam	Color	TotalWt Kip	TotalMass Kip-s2/ft
CAP	0.	0.	Yes	No	Magenta	15.075	0.47
HP14x117	0.	0.006594	No	No	Green	0.	0.

Table: Frame Section Properties 01 - General, Part 6 of 7

Table: Frame Section Properties 01 - General, Part 6 of 7

SectionName	FromFile	AMod	A2Mod	A3Mod	JMod	I2Mod	I3Mod
CAP	No	1.	1.	1.	1.	1.	1.
HP14x117	No	1.	1.	1.	1.	1.	1.

Table: Frame Section Properties 01 - General, Part 7 of 7

Table: Frame Section Properties 01 - General, Part 7 of 7

SectionName	MMod	WMod	GUID	Notes
CAP	1.	1.		Added 4/7/2025 11:21:17 AM
HP14x117	1.	1.		Added 7/6/2025 2:05:51 PM

Table: Joint Coordinates, Part 1 of 2

Table: Joint Coordinates, Part 1 of 2

Joint	CoordSys	CoordType	XorR ft	Y ft	Z ft	SpecialJt	GlobalX ft
1	GLOBAL	Cartesian	-7.5	0.	0.	No	-7.5
2	GLOBAL	Cartesian	-6.	0.	0.	No	-6.
3	GLOBAL	Cartesian	-2.	0.	0.	No	-2.
4	GLOBAL	Cartesian	2.	0.	0.	No	2.
5	GLOBAL	Cartesian	6.	0.	0.	No	6.
6	GLOBAL	Cartesian	9.25	0.	0.	No	9.25

Table: Joint Coordinates, Part 2 of 2

Table: Joint Coordinates, Part 2 of 2

Joint	GlobalY ft	GlobalZ ft	GUID
1	0.	0.	7f72fa35-af06-4277-be19-d6a3a1934a82
2	0.	0.	0c7acf2e-2701-4baf-bf5e-a1c7a86c47fb
3	0.	0.	75a9c4c4-a892-4123-b180-4c13c75f760c
4	0.	0.	bb38e22b-fe21-453a-bea1-8ac063932f0c
5	0.	0.	809a0159-1084-471a-ae2d-6131f207d755
6	0.	0.	bda850a7-fea9-4700-ba63-91b2e670c7f9

Table: Joint Displacements

Table: Joint Displacements

Joint	OutputCase	CaseType	U1 ft	U2 ft	U3 ft	R1 Radians	R2 Radians	R3 Radians
1	DEAD	LinStatic	0.	0.	9.149E-06	0.	6.601E-06	0.
1	Wind Struct	LinStatic	0.	0.	-1.147E-07	0.	-7.645E-08	0.
2	DEAD	LinStatic	0.	0.	0.	0.	7.089E-06	0.
2	Wind Struct	LinStatic	0.	0.	0.	0.	-7.645E-08	0.
3	DEAD	LinStatic	0.	0.	0.	0.	-1.010E-06	0.
3	Wind Struct	LinStatic	0.	0.	0.	0.	2.819E-07	0.
4	DEAD	LinStatic	0.	0.	0.	0.	3.623E-07	0.
4	Wind Struct	LinStatic	0.	0.	0.	0.	2.819E-07	0.
5	DEAD	LinStatic	0.	0.	0.	0.	-1.662E-06	0.
5	Wind Struct	LinStatic	0.	0.	0.	0.	-7.645E-08	0.
6	DEAD	LinStatic	0.	0.	-0.000011	0.	3.298E-06	0.
6	Wind Struct	LinStatic	0.	0.	2.485E-07	0.	-7.645E-08	0.
~1	DEAD	LinStatic	0.	0.	-5.262E-06	0.	6.952E-06	0.

Table: Joint Displacements

Joint	OutputCase	CaseType	U1 ft	U2 ft	U3 ft	R1 Radians	R2 Radians	R3 Radians
~1	Wind Struct	LinStatic	0.	0.	4.730E-08	0.	-7.287E-08	0.
~2	DEAD	LinStatic	0.	0.	-9.635E-06	0.	5.943E-06	0.
~2	Wind Struct	LinStatic	0.	0.	9.174E-08	0.	-6.211E-08	0.
~3	DEAD	LinStatic	0.	0.	-0.000013	0.	4.331E-06	0.
~3	Wind Struct	LinStatic	0.	0.	1.304E-07	0.	-4.420E-08	0.
~4	DEAD	LinStatic	0.	0.	-0.000015	0.	2.390E-06	0.
~4	Wind Struct	LinStatic	0.	0.	1.605E-07	0.	-1.911E-08	0.
~5	DEAD	LinStatic	0.	0.	-0.000015	0.	3.887E-07	0.
~5	Wind Struct	LinStatic	0.	0.	1.792E-07	0.	1.314E-08	0.
~6	DEAD	LinStatic	0.	0.	-0.000014	0.	-1.400E-06	0.
~6	Wind Struct	LinStatic	0.	0.	1.835E-07	0.	5.256E-08	0.
~7	DEAD	LinStatic	0.	0.	-0.000012	0.	-2.706E-06	0.
~7	Wind Struct	LinStatic	0.	0.	1.706E-07	0.	9.915E-08	0.
~8	DEAD	LinStatic	0.	0.	-8.278E-06	0.	-3.257E-06	0.
~8	Wind Struct	LinStatic	0.	0.	1.376E-07	0.	1.529E-07	0.
~9	DEAD	LinStatic	0.	0.	-4.244E-06	0.	-2.782E-06	0.
~9	Wind Struct	LinStatic	0.	0.	8.171E-08	0.	2.138E-07	0.
~10	DEAD	LinStatic	0.	0.	-2.994E-06	0.	8.560E-07	0.
~10	Wind Struct	LinStatic	0.	0.	4.597E-07	0.	4.793E-07	0.
~11	DEAD	LinStatic	0.	0.	-5.853E-06	0.	1.615E-06	0.
~11	Wind Struct	LinStatic	0.	0.	7.902E-07	0.	9.282E-07	0.
~12	DEAD	LinStatic	0.	0.	-8.189E-06	0.	1.537E-06	0.
~12	Wind Struct	LinStatic	0.	0.	8.908E-07	0.	1.629E-06	0.
~13	DEAD	LinStatic	0.	0.	-9.720E-06	0.	8.949E-07	0.
~13	Wind Struct	LinStatic	0.	0.	6.609E-07	0.	2.581E-06	0.
~14	DEAD	LinStatic	0.	0.	-0.00001	0.	-4.144E-08	0.
~14	Wind Struct	LinStatic	0.	0.	0.	0.	3.784E-06	0.
~15	DEAD	LinStatic	0.	0.	-9.792E-06	0.	-1.000E-06	0.
~15	Wind Struct	LinStatic	0.	0.	-6.609E-07	0.	2.581E-06	0.
~16	DEAD	LinStatic	0.	0.	-8.315E-06	0.	-1.711E-06	0.
~16	Wind Struct	LinStatic	0.	0.	-8.908E-07	0.	1.629E-06	0.
~17	DEAD	LinStatic	0.	0.	-5.998E-06	0.	-1.901E-06	0.
~17	Wind Struct	LinStatic	0.	0.	-7.902E-07	0.	9.282E-07	0.
~18	DEAD	LinStatic	0.	0.	-3.103E-06	0.	-1.301E-06	0.
~18	Wind Struct	LinStatic	0.	0.	-4.597E-07	0.	4.793E-07	0.
~19	DEAD	LinStatic	0.	0.	-3.551E-06	0.	1.991E-06	0.
~19	Wind Struct	LinStatic	0.	0.	-8.171E-08	0.	2.138E-07	0.
~20	DEAD	LinStatic	0.	0.	-6.867E-06	0.	2.490E-06	0.
~20	Wind Struct	LinStatic	0.	0.	-1.376E-07	0.	1.529E-07	0.
~21	DEAD	LinStatic	0.	0.	-9.552E-06	0.	2.130E-06	0.
~21	Wind Struct	LinStatic	0.	0.	-1.706E-07	0.	9.915E-08	0.
~22	DEAD	LinStatic	0.	0.	-0.000011	0.	1.182E-06	0.
~22	Wind Struct	LinStatic	0.	0.	-1.835E-07	0.	5.256E-08	0.
~23	DEAD	LinStatic	0.	0.	-0.000012	0.	-8.309E-08	0.
~23	Wind Struct	LinStatic	0.	0.	-1.792E-07	0.	1.314E-08	0.
~24	DEAD	LinStatic	0.	0.	-0.000011	0.	-1.393E-06	0.
~24	Wind Struct	LinStatic	0.	0.	-1.605E-07	0.	-1.911E-08	0.
~25	DEAD	LinStatic	0.	0.	-9.805E-06	0.	-2.477E-06	0.
~25	Wind Struct	LinStatic	0.	0.	-1.304E-07	0.	-4.420E-08	0.
~26	DEAD	LinStatic	0.	0.	-7.158E-06	0.	-3.064E-06	0.
~26	Wind Struct	LinStatic	0.	0.	-9.174E-08	0.	-6.211E-08	0.
~27	DEAD	LinStatic	0.	0.	-3.769E-06	0.	-2.883E-06	0.
~27	Wind Struct	LinStatic	0.	0.	-4.730E-08	0.	-7.287E-08	0.

Table: Joint Reactions

Table: Joint Reactions								
Joint	OutputCase	CaseType	F1 Kip	F2 Kip	F3 Kip	M1 Kip-ft	M2 Kip-ft	M3 Kip-ft
2	DEAD	LinStatic	0.	0.	8.774	0.	0.	0.
2	Wind Struct	LinStatic	0.	0.	-0.047	0.	0.	0.
3	DEAD	LinStatic	0.	0.	19.123	0.	0.	0.
3	Wind Struct	LinStatic	0.	0.	-1.585	0.	0.	0.
4	DEAD	LinStatic	0.	0.	17.747	0.	0.	0.
4	Wind Struct	LinStatic	0.	0.	1.585	0.	0.	0.
5	DEAD	LinStatic	0.	0.	11.431	0.	0.	0.
5	Wind Struct	LinStatic	0.	0.	0.047	0.	0.	0.

Table: Load Case Definitions, Part 1 of 3

Table: Load Case Definitions, Part 1 of 3							
Case	Type	InitialCond	ModalCase	BaseCase	MassSource	DesTypeOpt	DesignType
DEAD	LinStatic	Zero				Prog Det	Dead
E80	LinStatic	Zero				Prog Det	Dead
Reaction							
weight	LinStatic	Zero				Prog Det	Dead
Wind Live	LinStatic	Zero				Prog Det	Wind
Wind Struct	LinStatic	Zero				Prog Det	Wind

Table: Load Case Definitions, Part 2 of 3

Table: Load Case Definitions, Part 2 of 3						
Case	DesActOpt	DesignAct	AutoType	RunCase	CaseStatus	GUID
DEAD	Prog Det	Non-Composite	None	Yes	Finished	588952f8-6a22-42cc-8d61-64e17181b34a
E80	Prog Det	Non-Composite	None	Yes	Finished	05630d75-0474-4e4c-b6e0-6d2c101e373a
Reaction						
weight	Prog Det	Non-Composite	None	Yes	Finished	fea48c94-933e-408a-8b6b-af9587381fdf
Wind Live	Prog Det	Short-Term Composite	None	Yes	Finished	834625ab-08b5-45d9-b8bd-f824f287ec88
Wind Struct	Prog Det	Short-Term Composite	None	Yes	Finished	40aa1ce4-9a78-45d1-be3f-cc3817fdb0d6

Table: Load Case Definitions, Part 3 of 3

Table: Load Case Definitions, Part 3 of 3	
Case	Notes
DEAD	
E80	
Reaction	
weight	
Wind Live	
Wind Struct	

Table: Load Pattern Definitions

Table: Load Pattern Definitions					
LoadPat	DesignType	SelfWtMult	AutoLoad	GUID	Notes
DEAD	Dead	1.		7a9d4d55-8722-4ebb-a863-67cb64165a97	
E80 Reaction	Dead	0.		d922e619-c010-4f85-9492-ffb228a92ab0	Added 4/7/2025 11:31:38 AM
weight	Dead	1.		edf6ae72-a2b0-402a-ae55-73cbcecd06f2	Added 7/6/2025 2:17:07 PM
Wind Live	Wind	0.	None	ccb6f0a9-b5d3-4214-8faa-e21a68a048a4	Added 7/7/2025 11:10:30 AM
Wind Struct	Wind	0.	None	4d95b835-c263-4b2a-8152-d28376431cce	Added 7/7/2025 11:17:59 AM
BW Dead	Dead	0.		964597d3-64ea-4129-9e38-2e2de64ac53e	Added 7/15/2025 10:43:11 AM

Table: Material Properties 03b - Concrete Data, Part 1 of 2

Table: Material Properties 03b - Concrete Data, Part 1 of 2								
Material	Fc Kip/ft2	eFc Kip/ft2	LtWtConc	SSCurveOpt	SSHysType	SFc	SCap	FinalSlope
4000Psi	576.	576.	No	Mander	Takeda	0.002219	0.005	-0.1

Table: Material Properties 03b - Concrete Data, Part 2 of 2

Table: Material Properties 03b - Concrete Data, Part 2 of 2

Material	FAngle Degrees	DAngle Degrees	CoupModType
4000Psi	0.	0.	Modified Darwin-Peck nold

**MAIN PIER
DESIGN
(PIER 6 & 7)**

HNTB	Document number: QF 06
Calculation Cover Sheet	Page 1 of __

Project: NSRR Shoofly over I-70	Job No: 71886	Design Criteria Document: Below
Client: NSRR / MODOT	Discipline: Bridge	Calculation No:

Name or Description of Calculation: Main Pier design – piers 6&7

Note: Unique QF 06 to be created for each revision of a calculation.

Calc. Rev. No.	Description of Change (i.e., Original Issue or description of changes since last revision)	Confirmation required with other deliverables (Y/N)	List Deliverables for which confirmation is required (NA if none) Add additional rows as necessary	Confirmation Verified by Originator of Calc for each deliverable listed (Y/N)

Calculation Objective: Cap, column, and shaft design
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Calculation Methodology/List of Assumptions: AREMA 2024 chapter 8

References/Inputs: AREMA 2024,
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Attachments: (List each attachment following the subject calculation)
--

Conclusions: 5'x5' caps supported on 48" columns. Supported by 42" drilled shafts socketed in rock.

Document Check:	Name:	Initials:	Date:
Originator:	Todd Kelley	TSK	7/16/2025
Checker:	Sean Cooney	STC	7/17/2025
Backchecker:	Todd Kelley	TSK	7/18/2025
Updater:	Todd Kelley	TSK	7/18/2025
Verifier:	-	-	-

PIER DESIGN HAND CALCULATIONS

NS - Shoofly Main span Bent - Drilled Shaft Supported

- Pier cap is designed as a continuous beam. Column/ Drilled shafts are 4' diameter. All loads are extracted from CSI.

References:

AREMA Manual for Railway Engineering, 2024

ACI Building Code Requirements for Structural Concrete 318-14

AISC Steel Construction Manual, 14th Edition

Material Properties

Reinforcing Yield Strength	$f_y := 60 \text{ ksi}$	
Reinf. Steel Modulus of Elasticity	$E_s := 29000 \text{ ksi}$	
Concrete Strength	$f'_c := 4.5 \text{ ksi}$	
Weight of Concrete (For Properties)	$w_c := 145 \text{ pcf}$	(Unreinforced, AREMA 8-2-38)
Concrete Modulus of Elasticity	$E_c := 33 \cdot \left(\frac{w_c}{\text{pcf}}\right)^{1.5} \cdot \sqrt{\frac{f'_c}{\text{psi}}} \cdot \text{psi} = 3865.2 \text{ ksi}$	(AREMA 8-2.23.4)
Modulus of Rupture (Tensile Strength)	$f_r := 7.5 \cdot \sqrt{f'_c \cdot \text{psi}} = 0.503 \text{ ksi}$	(AREMA 8-2.26.1)
Modular Ratio	$n := \text{round}\left(\frac{E_s}{E_c}\right) = 8$	
Weight of Concrete	$\gamma_{conc} := 150 \text{ pcf}$	

Geometry

CL to CL space from column/shaft increased to 5.25' (4.5ft in 30% plans), Shaft spacing is 2.85D

Average Bearing Width	$w_{brg} := 11.33 \text{ ft}$	out to out of girder flanges - measured from DGN
Height of Cap	$h_{cap} := 5 \text{ ft}$	
Length of Cap	$L_{cap} := 16.5 \text{ ft}$	
Cap Width	$w_{cap} := 5 \text{ ft}$	
Span 6 Length - DPG	$L_{span6} := 103 \text{ ft} + 1 \text{ in}$	
Span 7 Length - Steel beam	$L_{span7} := 48 \text{ ft}$	
Concrete Cover	$cover := 2 \text{ in}$	
Section Moment of Inertia	$I_x := \frac{w_{cap} \cdot h_{cap}^3}{12} = (1.1 \cdot 10^6) \text{ in}^4$	

Loads

Distributed Dead Load for Span 6

$$w_{DL_span6} := 2.8 \text{ klf}$$

(Entire Superstructure, from Load Calcs)

Distributed Dead Load for Span 7

$$w_{DL_span7} := 2 \text{ klf}$$

(Entire Superstructure, from Load Calcs)

Span 6 Dead Load Reaction

$$R_{DL_span6} := w_{DL_span6} \cdot \frac{L_{span6}}{2} = 144.317 \text{ kip}$$

Span 7 Dead Load Reaction

$$R_{DL_span7} := w_{DL_span7} \cdot \frac{L_{span7}}{2} = 48 \text{ kip}$$

Cap step dead load

$$Capstep_{DL} := 2.5 \text{ ft} \cdot 3.33 \text{ ft} \cdot \gamma_{conc} = 1.249 \frac{\text{kip}}{\text{ft}}$$

Impact Load (*maximum*)

$$IM := \left\| \begin{array}{l} \text{if } L_{span7} \leq 14 \cdot \text{ft} \\ \quad \left\| \begin{array}{l} 0.6 \\ \text{else} \\ \frac{225}{\sqrt{\frac{L_{span7}}{\text{ft}}}} \cdot 0.01 \end{array} \right\| \end{array} \right\| = 0.325$$

(AREMA 8-2-15)

Live Load Reaction from Span 6 & 7

$$R_{LL_span} := 377 \text{ kip} \cdot 2 \cdot (1 + IM) = 998.869 \text{ kip}$$

(Cooper Program)

Wind Loads

Loads from the superstructure calculations

Wind Load on Live load applied
at 8 ft above rail

$$WL := 0.3 \frac{\text{kip}}{\text{ft}}$$

$$R_{WL} := WL \cdot \left(\frac{L_{span6}}{2} + \frac{L_{span7}}{2} \right) = 22.663 \text{ kip}$$

$$Arm_{WL} := 8 \text{ ft} + 8 \text{ in} + 10 \text{ in} + 83 \text{ in} + 4 \text{ in} = 16.75 \text{ ft}$$

$$M_{WL} := R_{WL} \cdot Arm_{WL} = 379.597 \text{ kip} \cdot \text{ft}$$

Wind Load on loaded bridge
applied at superstructure center

$$WS_6 := 0.31 \frac{\text{kip}}{\text{ft}} \quad WS_7 := 0.2 \frac{\text{kip}}{\text{ft}}$$

$$R_{WS} := WS_6 \cdot \left(\frac{L_{span6}}{2} \right) + WS_7 \cdot \left(\frac{L_{span7}}{2} \right) = 20.778 \text{ kip}$$

$$Arm_{WS} := \frac{83 \text{ in} + 4 \text{ in}}{2} = 3.625 \text{ ft}$$

$$M_{WS} := R_{WS} \cdot Arm_{WS} = 75.32 \text{ kip} \cdot \text{ft}$$

Wind on live load controls

Longitudinal Force

LF force per concrete column/shaft as determined from CSI Bridge model $LF := 31.5 \text{ kip}$

Distributed Loads**Distributed Girder DL Reaction**

$$\text{For Span 6} \quad w_{DL6} := \frac{R_{DL_span6}}{w_{brg}} = 12.738 \text{ klf}$$

$$\text{For Span 7} \quad w_{DL7} := \frac{R_{DL_span7}}{w_{brg}} = 4.237 \text{ klf}$$

$$\text{Total:} \quad w_{DL_tot} := w_{DL6} + w_{DL7} = 17 \text{ klf}$$

Distributed Girder LL Reaction

$$\text{For Span 6\&7} \quad w_{LLI} := \frac{R_{LL_span}}{w_{brg}} = 88.161 \text{ klf}$$

CAP Analysis Results (shears taken at d away from the CL of column)

<i>See CSI output</i>	<u>Dead SW</u>	<u>Dead Super</u>	<u>Live + Impact</u>	<u>LF</u>
Positive Moment	$M_{dead,pos,sw} := 43.2 \text{ kip} \cdot \text{ft}$	$M_{dead,pos,sup} := 211.8 \text{ kip} \cdot \text{ft}$	$M_{live,pos} := 1109 \text{ kip} \cdot \text{ft}$	$M_{LF,pos} := 212 \text{ kip} \cdot \text{ft}$
Negative Moment	$M_{dead,neg,sw} := 25.7 \text{ kip} \cdot \text{ft}$	$M_{dead,neg,sup} := 22.5 \text{ kip} \cdot \text{ft}$	$M_{live,neg} := 117.8 \text{ kip} \cdot \text{ft}$	$M_{LF,neg} := 212 \text{ kip} \cdot \text{ft}$
Shear	$V_{dead,sw} := 6 \text{ kip}$	$V_{dead,sup} := 27 \text{ kip}$	$V_{live} := 120 \text{ kip}$	$V_{LF} := 43 \text{ kip}$
	<u>Wind - struct</u>	<u>Wind - Live</u>		
Positive Moment	$M_{WS,pos} := 155 \text{ kip} \cdot \text{ft}$	$M_{WL,pos} := 190 \text{ kip} \cdot \text{ft}$		
Negative Moment	$M_{WS,neg} := 155 \text{ kip} \cdot \text{ft}$	$M_{WL,neg} := 190 \text{ kip} \cdot \text{ft}$		
Shear	$V_{WS} := 37 \text{ kip}$	$V_{WL} := 68 \text{ kip}$		

$$\text{Factored loads (Group I)} \quad M_{strI,pos} := 1.4 \cdot \left(\langle M_{dead,pos,sw} + M_{dead,pos,sup} \rangle + \frac{5}{3} \cdot \langle M_{live,pos} \rangle \right) = 2944.667 \text{ kip} \cdot \text{ft}$$

$$M_{strI,neg} := 1.4 \cdot \left(\langle M_{dead,neg,sw} + M_{dead,neg,sup} \rangle + \frac{5}{3} \cdot \langle M_{live,neg} \rangle \right) = 342.347 \text{ kip} \cdot \text{ft}$$

$$V_{strI} := 1.4 \cdot \left(\langle V_{dead,sw} + V_{dead,sup} \rangle + \frac{5}{3} \cdot \langle V_{live} \rangle \right) = 326.2 \text{ kip}$$

$$\text{Factored loads (Group III)} \quad M_{strIII,pos} := 1.4 \cdot \langle M_{dead,pos,sw} + M_{dead,pos,sup} + M_{live,pos} + 0.5 \cdot M_{WS,pos} + M_{WL,pos} + M_{LF,pos} \rangle = 2580.9 \text{ kip} \cdot \text{ft}$$

$$M_{strIII,neg} := 1.4 \cdot \langle M_{dead,neg,sw} + M_{dead,neg,sup} + M_{live,neg} + 0.5 \cdot M_{WS,neg} + M_{WL,neg} + M_{LF,neg} \rangle = 903.7 \text{ kip} \cdot \text{ft}$$

$$V_{strIII} := 1.4 \cdot \langle V_{dead,sw} + V_{dead,sup} + V_{live} + V_{LF} + 0.5 \cdot V_{WS} + V_{WL} \rangle = 395.5 \text{ kip}$$

$$\text{Service loads (Group I)} \quad M_{svceI,pos} := M_{dead,pos,sw} + M_{dead,pos,sup} + M_{live,pos} = 1364 \text{ kip} \cdot \text{ft}$$

$$M_{svceI,neg} := M_{dead,neg,sw} + M_{dead,neg,sup} + M_{live,neg} = 166 \text{ kip} \cdot \text{ft}$$

$$V_{svceI} := V_{dead,sw} + V_{dead,sup} + V_{live} = 153 \text{ kip}$$

Column Analysis Results

<i>See CSI output</i>	<u>Dead SW</u>	<u>Dead Super</u>	<u>Live + Impact</u>	<u>LF</u>
X-X Moment	$M_{dead.x.sw} := 3.2 \text{ kip} \cdot ft$	$M_{dead.x.sup} := 21 \text{ kip} \cdot ft$	$M_{live.x} := 109.9 \text{ kip} \cdot ft$	$M_{LF.x} := 0 \text{ kip} \cdot ft$
Y-Y Moment	$M_{dead.y.sw} := 0 \text{ kip} \cdot ft$	$M_{dead.y.sup} := 0 \text{ kip} \cdot ft$	$M_{live.y} := 0 \text{ kip} \cdot ft$	$M_{LF.y} := 992.3 \text{ kip} \cdot ft$
Shear	$V_{dead.sw.col} := 0.15 \text{ kip}$	$V_{dead.sup.col} := 1 \text{ kip}$	$V_{live.col} := 5.2 \text{ kip}$	$V_{LF.col} := 31.5 \text{ kip}$
Axial	$P_{dead.sw} := 100.6 \text{ kip}$	$P_{dead.sup} := 96.4 \text{ kip}$	$P_{live} := 504.7 \text{ kip}$	$P_{LF} := 0 \text{ kip}$

	<u>Wind - struct</u>	<u>Wind - Live</u>
X-X Moment	$M_{WS.x} := 175.9 \text{ kip} \cdot ft$	$M_{WL.x} := 198 \text{ kip} \cdot ft$
Y-Y Moment	$M_{WS.y} := 0 \text{ kip} \cdot ft$	$M_{WL.y} := 0 \text{ kip} \cdot ft$
Shear	$V_{WS.col} := 10.5 \text{ kip}$	$V_{WL.col} := 11.5 \text{ kip}$
	$P_{WS} := 36.8 \text{ kip}$	$P_{WL} := 67.5 \text{ kip}$

Factored loads (Group I) $M_{strI.x} := 1.4 \cdot \left(\langle M_{dead.x.sw} + M_{dead.x.sup} \rangle + \frac{5}{3} \cdot \langle M_{live.x} \rangle \right) = 290.313 \text{ kip} \cdot ft$

$$M_{strI.y} := 1.4 \cdot \left(\langle M_{dead.y.sw} + M_{dead.y.sup} \rangle + \frac{5}{3} \cdot \langle M_{live.y} \rangle \right) = 0 \text{ kip} \cdot ft$$

$$V_{strI.col} := 1.4 \cdot \left(\langle V_{dead.sw.col} + V_{dead.sup.col} \rangle + \frac{5}{3} \cdot \langle V_{live.col} \rangle \right) = 13.743 \text{ kip}$$

Factored loads (Group III) $M_{strIII.x} := 1.4 \cdot \langle M_{dead.x.sw} + M_{dead.x.sup} + M_{live.x} + 0.5 \cdot M_{WS.x} + M_{WL.x} + M_{LF.x} \rangle = 588.07 \text{ kip} \cdot ft$

$$M_{strIII.y} := 1.4 \cdot \langle M_{dead.y.sw} + M_{dead.y.sup} + M_{live.y} + 0.5 \cdot M_{WS.y} + M_{WL.y} + M_{LF.y} \rangle = 1389.22 \text{ kip} \cdot ft$$

$$V_{strIII.col} := 1.4 \cdot \langle V_{dead.sw.col} + V_{dead.sup.col} + V_{live.col} + V_{LF.col} + 0.5 \cdot V_{WS.col} + V_{WL.col} \rangle = 76.44 \text{ kip}$$

Factored loads (Group III) Vertical $P_{strIII} := 1.4 \cdot \langle P_{dead.sw} + P_{dead.sup} + P_{live} + 0.5 \cdot P_{WS} + P_{WL} + P_{LF} \rangle = 1102.64 \text{ kip}$

Cap Flexure (Negative Moment)

(AREMA 8-2.32)

Longitudinal Reinforcing

$$bar_{size.neg} := 8$$

Number of Bars in cross-section

$$n_{bars} := 8$$

Stirrup Reinforcing

$$bar_{size.v} := 5$$

Width of Design Section

$$b := w_{cap} = 5 \text{ ft}$$

Effective Depth

$$d := h_{cap} - cover - \frac{D_b (bar_{size.neg})}{2} - D_b (bar_{size.v}) = 56.875 \text{ in}$$

Area of Flexural Reinforcing

$$A_s := n_{bars} \cdot A_b (bar_{size.neg}) = 6.32 \text{ in}^2$$

Concrete Strength Factor

$$\beta_1 := \max \left(0.65, \min \left(0.85, 0.85 - 0.05 \cdot \frac{f'_c - 4 \text{ ksi}}{\text{ksi}} \right) \right) = 0.825 \quad (\text{AREMA 8-2.31.1(d)})$$

Depth of Compression Block

$$a := \frac{A_s \cdot f_y}{0.85 \cdot f'_c \cdot b} = 1.652 \text{ in} \quad (\text{AREMA 8-2.32.3})$$

Verify Tension controlled

$$c := \frac{a}{0.85} = 1.944 \text{ in} \quad (\text{AREMA 8-2.32.2})$$

$$e_{cl} := \text{if} \left(\frac{f_y}{E_s} < 0.002, \frac{f_y}{E_s}, 0.002 \right) = 0.002$$

$$ratio_{ten} := \frac{0.003}{0.003 + e_{cl}}$$

$$tension.check := \text{if} \left(\frac{c}{d} < ratio_{ten}, \text{"OK"}, \text{"NG"} \right) = \text{"OK"}$$

Strength Reduction Factor

$$\phi := 0.9 \quad (\text{AREMA 8-2.30.2(b)})$$

Design Moment Strength

$$\phi M_n := \phi \cdot A_s \cdot f_y \cdot \left(d - \frac{a}{2} \right) = 1594.03 \text{ kip} \cdot \text{ft} \quad (\text{AREMA Eq. 8-2-28})$$

Minimum Reinforcement Check - 8.2.7

Cracking Moment

$$M_{cr} := \frac{f_r \cdot I_x}{\left(\frac{h_{cap}}{2} \right)} = (1.509 \cdot 10^3) \text{ kip} \cdot \text{ft} \quad (\text{AREMA Eq. 8-2-13})$$

Factored Design Moment

$$M_u := \left\| \begin{array}{l} \text{if } M_{strIII.neg} > 1.2 \cdot M_{cr} \\ \quad \left\| M_{strIII.neg} \right. \\ \text{else if } 1.2 \cdot M_{cr} > 1.33 \cdot M_{strIII.neg} \\ \quad \left\| 1.33 \cdot M_{strIII.neg} \right. \\ \text{else} \\ \quad \left\| 1.2 \cdot M_{cr} \right. \end{array} \right\| = (1.202 \cdot 10^3) \text{ kip} \cdot \text{ft}$$

Capacity over Demand Ratio

$$\frac{\phi M_n}{M_u} = 1.326$$

$$\text{if} (\phi M_n \geq M_u, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Cap Negative Fatigue

(AREMA 8-2.38)

Dead Load Service Moment

$$M_{dead.neg.sw} + M_{dead.neg.sup} = 48.2 \text{ kip} \cdot \text{ft}$$

Reinforcing Ratio

$$\rho := \frac{A_s}{b \cdot d} = 0.002$$

Find Neutral Axis

$$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n = 0.158$$

Lever Arm Ratio

$$j := 1 - \frac{k}{3} = 0.947$$

Dead Load Stress in Steel

$$f_{s.DL} := \frac{M_{dead.neg.sw} + M_{dead.neg.sup}}{A_s \cdot j \cdot d} = 1.699 \text{ ksi}$$

Total Service Load Stress

$$f_{s.srv} := \frac{M_{svcl.neg}}{A_s \cdot j \cdot d} = 5.85 \text{ ksi}$$

Minimum Stress

$$f_{min} := f_{s.DL} = 1.699 \text{ ksi}$$

Allowable Stress Range

$$f_f := 21 \cdot \text{ksi} - 0.33 \cdot f_{min} + 8 \cdot 0.3 \cdot \text{ksi} = 22.839 \text{ ksi}$$

In-Service Stress Range

$$f_{s.range} := f_{s.srv} - f_{s.DL} = 4.151 \text{ ksi}$$

$$\text{if } (f_{s.range} \leq f_f, \text{“okay”}, \text{“not okay”}) = \text{“okay”}$$

Cap Neg Distribution of Reinforcing

(AREMA 8-2.39)

Exposure Condition Stress

$$Z := 170 \frac{\text{kip}}{\text{in}}$$

Area of concrete surrounding main tension rebar with same centroid

$$A := \frac{b \cdot \left(\text{cover} + \frac{D_b (\text{bar}_{size.neg})}{2} \right) \cdot 2}{n_{bars}} = 37.5 \text{ in}^2$$

Distance to tension rebar from extreme tension fiber

$$d_c := \min(\text{cover}, 2 \cdot \text{in}) + \frac{D_b (\text{bar}_{size.neg})}{2} = 2.5 \text{ in}$$

Service Stress in Rebar

$$f_s := f_{s.srv} = 5.85 \text{ ksi}$$

$$\text{if } \left(f_s \leq \min \left(\frac{Z}{\sqrt[3]{d_c \cdot A}}, 0.5 f_y \right), \text{“okay”}, \text{“not okay”} \right) = \text{“okay”}$$

Cap Flexure (Positive Moment)

(AREMA 8-2.32.2)

Longitudinal Reinforcing

$$bar_{size,pos} := 11$$

Number of Bars in cross-section

$$n_{bars} := 10$$

Effective Depth

$$d := h_{cap} - cover - \frac{D_b (bar_{size,pos})}{2} - D_b (bar_{size,v}) - 2 \text{ in} = 54.67 \text{ in}$$

Area of Flexural Reinforcing

$$A_s := n_{bars} \cdot A_b (bar_{size,pos}) = 15.6 \text{ in}^2$$

Concrete Strength Factor

$$\beta_1 := \max \left(0.65, \min \left(0.85, 0.85 - 0.05 \cdot \frac{f'_c - 4 \cdot ksi}{ksi} \right) \right) = 0.825 \text{ (AREMA 8-2.31.1(d))}$$

Depth of Compression Block

$$a := \frac{A_s \cdot f_y}{0.85 \cdot f'_c \cdot b} = 4.078 \text{ in} \quad \text{(AREMA 8-2.32.3)}$$

Verify Tension controlled

$$c := \frac{a}{0.85} = 4.798 \text{ in} \quad \text{(AREMA 8-2.32.2)}$$

$$e_{cl} := \text{if} \left(\frac{f_y}{E_s} < 0.002, \frac{f_y}{E_s}, 0.002 \right) = 0.002$$

$$ratio_{ten} := \frac{0.003}{0.003 + e_{cl}} = 0.6$$

$$tension.check := \text{if} \left(\frac{c}{d} < ratio_{ten}, \text{"OK"}, \text{"NG"} \right) = \text{"OK"}$$

Strength Reduction Factor

$$\phi := 0.9 \quad \text{(AREMA 8-2.30.2(b))}$$

Design Moment Strength

$$\phi M_n := \phi \cdot A_s \cdot f_y \cdot \left(d - \frac{a}{2} \right) = 3694.68 \text{ kip} \cdot \text{ft} \quad \text{(AREMA Eq. 8-2-29)}$$

Cracking Moment

$$M_{cr} := \frac{f_r \cdot I_x}{\left(\frac{h_{cap}}{2} \right)} = 1509.346 \text{ kip} \cdot \text{ft} \quad \text{(AREMA Eq. 8-2-13)}$$

Factored Design Moment

$$M_u := \left\| \begin{array}{l} \text{if } M_{strI,pos} > 1.2 \cdot M_{cr} \\ \quad \left\| M_{strI,pos} \right. \\ \text{else if } 1.2 \cdot M_{cr} > 1.33 \cdot M_{strI,pos} \\ \quad \left\| 1.33 \cdot M_{strI,pos} \right. \\ \text{else} \\ \quad \left\| 1.2 \cdot M_{cr} \right. \end{array} \right\| = 2944.667 \text{ kip} \cdot \text{ft}$$

Capacity over Demand Ratio

$$\frac{\phi M_n}{M_u} = 1.255$$

$$\text{if} (\phi M_n \geq M_u, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Cap Pos Fatigue

(AREMA 8-2.38)

Dead Load Service Moment

$$M_{dead.pos.sw} + M_{dead.pos.sup} = 255 \text{ kip} \cdot \text{ft}$$

Reinforcing Ratio

$$\rho := \frac{A_s}{b \cdot d} = 0.005$$

Find Neutral Axis

$$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n = 0.24$$

Lever Arm Ratio

$$j := 1 - \frac{k}{3} = 0.92$$

Dead Load Stress in Steel

$$f_{s,DL} := \frac{M_{dead.pos.sw} + M_{dead.pos.sup}}{A_s \cdot j \cdot d} = 3.901 \text{ ksi}$$

Total Service Load Stress

$$f_{s,svl} := \frac{M_{svcl.pos}}{A_s \cdot j \cdot d} = 20.864 \text{ ksi}$$

Minimum Stress

$$f_{min} := f_{s,DL} = 3.901 \text{ ksi}$$

Allowable Stress Range

$$f_f := 21 \cdot \text{ksi} - 0.33 \cdot f_{min} + 8 \cdot 0.3 \cdot \text{ksi} = 22.113 \text{ ksi}$$

In-Service Stress Range

$$f_{s,range} := f_{s,svl} - f_{s,DL} = 16.964 \text{ ksi}$$

$$\text{if } (f_{s,range} \leq f_f, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Cap Pos Distribution of Reinforcing

(AREMA 8-2.39)

Exposure Condition Stress

$$Z := 170 \frac{\text{kip}}{\text{in}}$$

Area of concrete surrounding main tension rebar with same centroid

$$A := \frac{b \cdot \left(\text{cover} + \frac{D_b (bar_{size.pos})}{2} \right) \cdot 2}{n_{bars}} = 32.46 \text{ in}^2$$

Distance to tension rebar from extreme tension fiber

$$d_c := \min(\text{cover}, 2 \cdot \text{in}) + \frac{D_b (bar_{size.pos})}{2} = 2.705 \text{ in}$$

Service Stress in Rebar

$$f_s := f_{s,svl} = 20.864 \text{ ksi}$$

$$\text{if } \left(f_s \leq \min \left(\frac{Z}{\sqrt[3]{d_c \cdot A}}, 0.5 f_y \right), \text{"okay"}, \text{"not okay"} \right) = \text{"okay"}$$

Cap Shear

(AREMA 8-2.35)

Stirrup Spacing

$$s := 12 \text{ in}$$

Section Width

$$b_w := w_{cap} = 5 \text{ ft}$$

Resistance Factor

$$\phi_v := 0.85$$

(AREMA 8-2.30.2(b))

Effective Depth

$$d := h_{cap} - \text{cover} - D_b \langle bar_{size,v} \rangle - \frac{D_b \langle bar_{size,pos} \rangle}{2} = 56.67 \text{ in}$$

Shear Stress Demand

$$v_u := \frac{V_{strIII}}{\phi_v \cdot b_w \cdot d} = 0.137 \text{ ksi}$$

(AREMA Eq. 8-2-45)

Shear Stress carried by concrete

$$v_c := 2 \cdot \sqrt{\frac{f'_c}{psi}} \text{ psi} = 0.134 \text{ ksi}$$

(AREMA 8-2.35.2)

Steel Reinforcement

$$A_v := 4 \cdot A_b \langle bar_{size,v} \rangle = 1.24 \text{ in}^2$$

Required Steel Reinforcement

$$A_{v,req} := \frac{(v_u - v_c) \cdot w_{cap} \cdot s}{f_y} = 0.032 \text{ in}^2$$

Stirrup Reinforcement Check

$$\text{if } (A_v > A_{v,req}, \text{ "okay", "not okay"}) = \text{ "okay"}$$

Stirrup Spacing Check

$$\text{if } (s < \min(0.5 \cdot d, 24 \text{ in}), \text{ "okay", "not okay"}) = \text{ "okay"}$$

(AREMA 8-2.10.3)

Double column/drilled shaft CIP conc**Pier Dead Load**

Cap (Assume 5x5x16.5)

$$Cap_{DL} := 5 \text{ ft} \cdot 5 \text{ ft} \cdot 16.5 \text{ ft} \cdot \gamma_{conc} = 61.9 \text{ kip}$$

Columns/shafts (assume 48" DIA)
45' assumed length

$$Columns_{DL} := 2 \cdot \pi \cdot (2 \text{ ft})^2 \cdot 45 \text{ ft} \cdot \gamma_{conc} = 169.6 \text{ kip}$$

Pier Live Load

Reaction

$$R_{LL} := 377 \text{ kip} \cdot 2 = 754 \text{ kip}$$

Total Pier Load

Total

$$R_{Total} := R_{DL_span6} + R_{DL_span7} + Cap_{DL} + Columns_{DL} + R_{LL} = 1177.8 \text{ kip}$$

Shaft CapacityBearing capacity - From
Geotechnology report

$$q_{all.bear} := 80 \text{ ksf}$$

Skin friction capacity (assume
poorer rock) - From
Geotechnology Report

$$q_{all.skin} := 6 \text{ ksf}$$

Shaft Area - 42 in Diameter

$$A_{shaft} := \pi \cdot (21 \text{ in})^2 = 9.6 \text{ ft}^2$$

Shaft Embedment (assume 20')

$$A_{embed} := \pi \cdot 42 \text{ in} \cdot 20 \text{ ft} = 219.9 \text{ ft}^2$$

2 Shaft capacity (FS of 2.5)

$$Q_{Shaft.2} := \left(\frac{q_{all.bear} \cdot A_{shaft} + q_{all.skin} \cdot A_{embed}}{2.5} \right) \cdot 2 = 1671.3 \text{ kip}$$

Shaft Check

$$Shaft_{check} := \text{if}(Q_{Shaft.2} > R_{Total}, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

See SP column output for bending
check

Column/Shaft Shear - using shaft dimensions

(AREMA 8-2.35)

Stirrup Reinforcing

$$\bar{bar}_{size.v} := 5$$

Stirrup Spacing

$$\bar{s} := 12 \text{ in}$$

Section Width

$$\bar{b}_w := 42 \text{ in}$$

Resistance Factor

$$\bar{\phi}_v := 0.85$$

(AREMA 8-2.30.2(b))

Effective Depth

$$\bar{d} := b_w - 3 \text{ in} - D_b (\bar{bar}_{size.v}) - \frac{\left(\frac{11 \text{ in}}{8} \right)}{2} = 37.688 \text{ in}$$

Shear Stress Demand

$$\bar{v}_u := \frac{V_{strll.col}}{\bar{\phi}_v \cdot \bar{b}_w \cdot \bar{d}} = 0.057 \text{ ksi}$$

(AREMA Eq. 8-2-45)

Shear Stress carried by concrete

$$\bar{v}_c := 2 \cdot \sqrt{\frac{f'_c}{\text{psi}}} \text{ psi} = 0.134 \text{ ksi}$$

(AREMA 8-2.35.2)

Steel Reinforcement

$$\bar{A}_v := 2 \cdot A_b (\bar{bar}_{size.v}) = 0.62 \text{ in}^2$$

Required Steel Reinforcement

$$\bar{A}_{v.req} := \frac{(\bar{v}_u - \bar{v}_c) \cdot w_{cap} \cdot s}{f_y} = -0.928 \text{ in}^2$$

Stirrup Reinforcement Check

$$\text{if} (\bar{A}_v > \bar{A}_{v.req}, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Stirrup Spacing Check

$$\text{if} (s < \min(0.5 \cdot \bar{d}, 24 \text{ in}), \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

(AREMA 8-2.10.3)

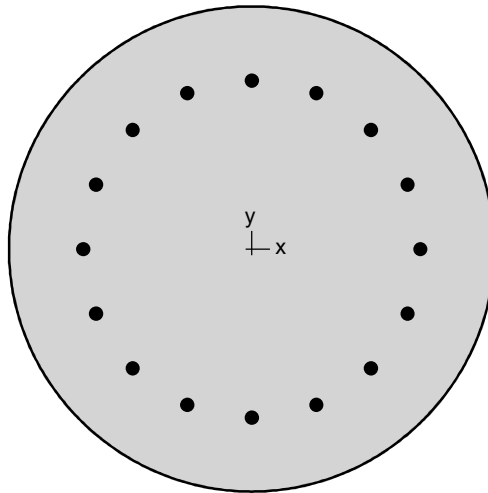
Column Summary - vertical bars -
16-#11 bars, ties - #12 @ 12"

SP COLUMN DESIGN CALCULATIONS

Column Check



spColumn v10.10 (TM)
Computer program for the Strength Design of Reinforced Concrete Sections
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1. General Information

File Name	C:\Users\tkelley\OneDrive - HNTB...\NSRR Col.colx
Project	NSRR Shoofly
Column	Main Pier Column
Engineer	TSK
Code	ACI 318-19
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	Biaxial
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Critical capacity

2. Material Properties

2.1. Concrete

Type	Standard
f'_c	4.5 ksi
E_c	3823.68 ksi
f_c	3.825 ksi
ϵ_u	0.003 in/in
β_1	0.825

2.2. Steel

Type	Standard
f_y	60 ksi
E_s	29000 ksi
ϵ_{ty}	0.00206897 in/in

3. Section

3.1. Shape and Properties

Type	Circular
Diameter	48 in
A_g	1809.56 in ²
I_x	260576 in ⁴
I_y	260576 in ⁴
r_x	12 in
r_y	12 in
X_o	0 in
Y_o	0 in

3.2. Section Figure

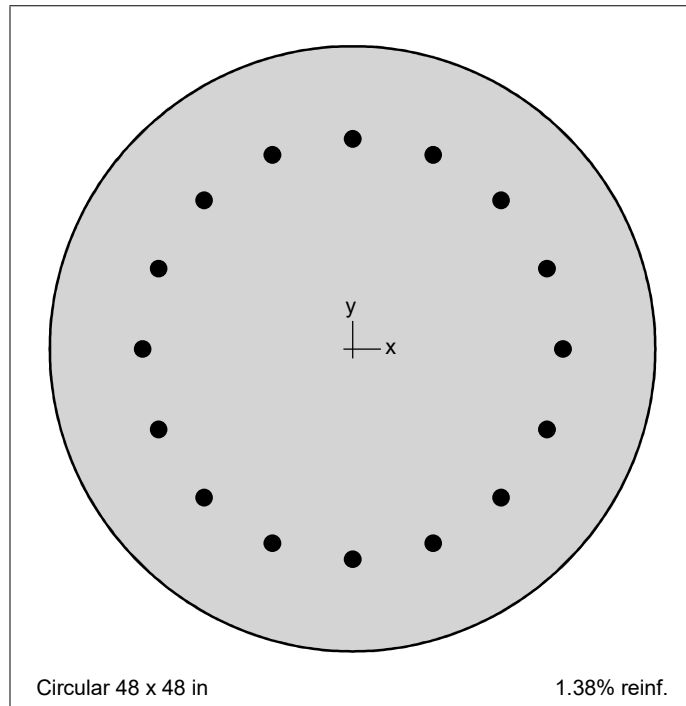


Figure 1: Column section

4. Reinforcement

4.1. Bar Set: ASTM A615

Bar	Diameter in	Area in ²	Bar	Diameter in	Area in ²	Bar	Diameter in	Area in ²
#3	0.38	0.11	#4	0.50	0.20	#5	0.63	0.31
#6	0.75	0.44	#7	0.88	0.60	#8	1.00	0.79
#9	1.13	1.00	#10	1.27	1.27	#11	1.41	1.56
#14	1.69	2.25	#18	2.26	4.00			

4.2. Confinement and Factors

Confinement type	Tied
For #10 bars or less	#3 ties
For larger bars	#5 ties
Capacity Reduction Factors	
Axial compression, (a)	0.8
Tension controlled ϕ , (b)	0.9
Compression controlled ϕ , (c)	0.65

4.3. Arrangement

Pattern	All sides equal
Bar layout	Circular
Cover to	Transverse bars
Clear cover	6 in
Bars	16 #11

Total steel area, A_s	24.96 in ²
Rho	1.38 %
Minimum clear spacing	5.09 in

5. Control Points

About Point	P kip	X-Moment k-ft	Y-Moment k-ft	NA Depth in	d_t Depth in	ϵ_t	ϕ
X @ Max compression	5410.4	0.00	0.00	131.05	40.67	-0.00207	0.65000
X @ Allowable comp.	4328.3	1388.13	0.00	45.28	40.67	-0.00031	0.65000
X @ $f_s = 0.0$	3863.8	1812.95	0.00	40.67	40.67	0.00000	0.65000
X @ $f_s = 0.5 f_y$	2608.6	2404.07	0.00	30.24	40.67	0.00103	0.65000
X @ Balanced point	1734.1	2475.95	0.00	24.07	40.67	0.00207	0.65000
X @ Tension control	701.2	2588.11	0.00	15.12	40.67	0.00507	0.90000
X @ Pure bending	0.0	1896.21	0.00	11.19	40.67	0.00791	0.90000
X @ Max tension	-1347.8	0.00	0.00	0.00	40.67	9.99999	0.90000
Y @ Max compression	5410.4	0.00	0.00	131.05	40.67	-0.00207	0.65000
Y @ Allowable comp.	4328.3	0.00	1388.13	45.28	40.67	-0.00031	0.65000
Y @ $f_s = 0.0$	3863.8	0.00	1812.95	40.67	40.67	0.00000	0.65000
Y @ $f_s = 0.5 f_y$	2608.6	0.00	2404.07	30.24	40.67	0.00103	0.65000
Y @ Balanced point	1734.1	0.00	2475.95	24.07	40.67	0.00207	0.65000
Y @ Tension control	701.2	0.00	2588.11	15.12	40.67	0.00507	0.90000
Y @ Pure bending	0.0	0.00	1896.21	11.19	40.67	0.00791	0.90000
Y @ Max tension	-1347.8	0.00	0.00	0.00	40.67	9.99999	0.90000
-X @ Max compression	5410.4	0.00	0.00	131.05	40.67	-0.00207	0.65000
-X @ Allowable comp.	4328.3	-1388.13	0.00	45.28	40.67	-0.00031	0.65000
-X @ $f_s = 0.0$	3863.8	-1812.95	0.00	40.67	40.67	0.00000	0.65000
-X @ $f_s = 0.5 f_y$	2608.6	-2404.07	0.00	30.24	40.67	0.00103	0.65000
-X @ Balanced point	1734.1	-2475.95	0.00	24.07	40.67	0.00207	0.65000
-X @ Tension control	701.2	-2588.11	0.00	15.12	40.67	0.00507	0.90000
-X @ Pure bending	0.0	-1896.21	0.00	11.19	40.67	0.00791	0.90000
-X @ Max tension	-1347.8	0.00	0.00	0.00	40.67	9.99999	0.90000
-Y @ Max compression	5410.4	0.00	0.00	131.05	40.67	-0.00207	0.65000
-Y @ Allowable comp.	4328.3	0.00	-1388.13	45.28	40.67	-0.00031	0.65000
-Y @ $f_s = 0.0$	3863.8	0.00	-1812.95	40.67	40.67	0.00000	0.65000
-Y @ $f_s = 0.5 f_y$	2608.6	0.00	-2404.07	30.24	40.67	0.00103	0.65000
-Y @ Balanced point	1734.1	0.00	-2475.95	24.07	40.67	0.00207	0.65000
-Y @ Tension control	701.2	0.00	-2588.11	15.12	40.67	0.00507	0.90000
-Y @ Pure bending	0.0	0.00	-1896.21	11.19	40.67	0.00791	0.90000
-Y @ Max tension	-1347.8	0.00	0.00	0.00	40.67	9.99999	0.90000

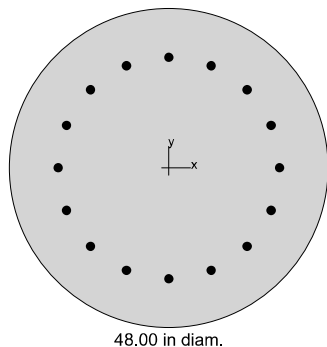
6. Factored Loads and Moments with Corresponding Capacity Ratios

NOTE: Calculations are based on "Critical Capacity" Method.

No.	Demand			Capacity			Parameters at Capacity			Capacity Ratio
	P_u kip	M_{ux} k-ft	M_{uy} k-ft	ϕP_n kip	ϕM_{nx} k-ft	ϕM_{ny} k-ft	NA Depth in	ϵ_t	ϕ	
1	1103.00	588.00	1389.20	0.00	737.00	1741.22	11.18	0.00790	0.900	0.71

7. Diagrams

7.1. PM at $\theta=0$ [deg]



General Information

Project	NSRR Shoo-fly
Column	Main Pier Column
Engineer	TSK
Code	ACI 318-19
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	Biaxial
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Critical capacity

Materials

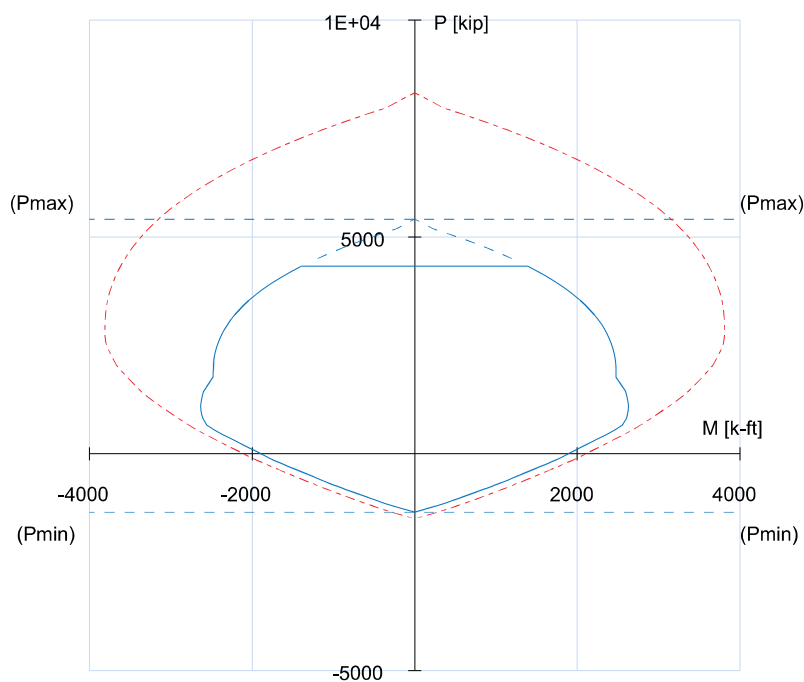
f'_c	4.5 ksi
E_c	3823.68 ksi
f_y	60 ksi
E_s	29000 ksi

Section

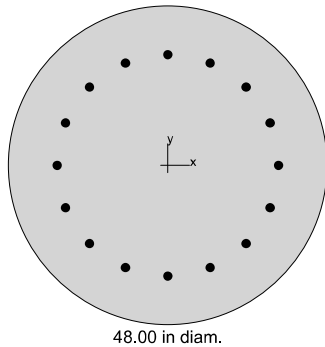
Type	Circular
Diameter	48 in
A_g	1809.56 in ²
I_x	260576 in ⁴
I_y	260576 in ⁴

Reinforcement

Pattern	All sides equal
Bar layout	Circular
Cover to	Transverse bars
Clear cover	6 in
Bars	16 #11
Confinement type	Tied
Total steel area, A_s	24.96 in ²
Rho	1.38 %
Min. clear spacing	5.09 in



7.2. PM at $\theta=67$ [deg]



General Information

Project	NSRR Shoo-fly
Column	Main Pier Column
Engineer	TSK
Code	ACI 318-19
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	Biaxial
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Critical capacity

Materials

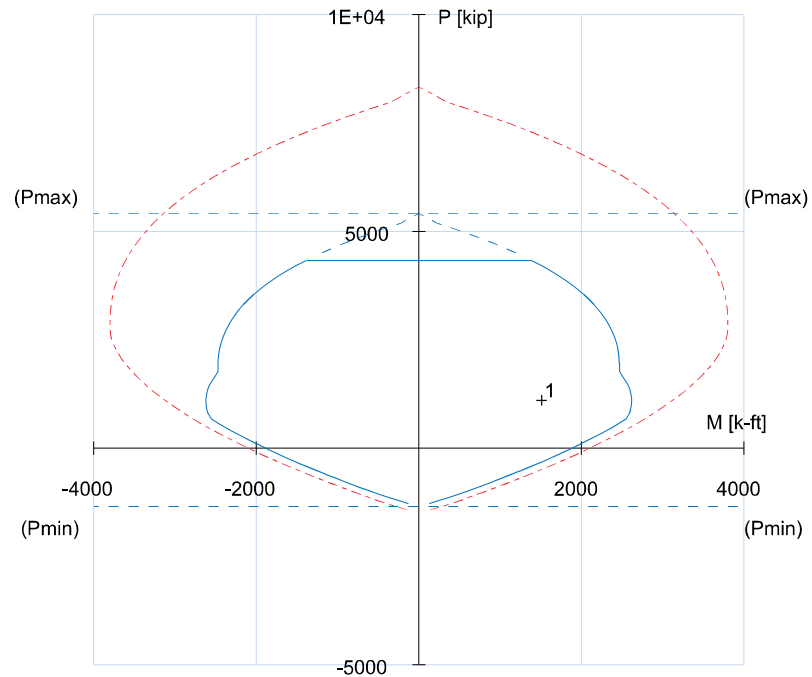
f'_c	4.5 ksi
E_c	3823.68 ksi
f_y	60 ksi
E_s	29000 ksi

Section

Type	Circular
Diameter	48 in
A_g	1809.56 in ²
I_x	260576 in ⁴
I_y	260576 in ⁴

Reinforcement

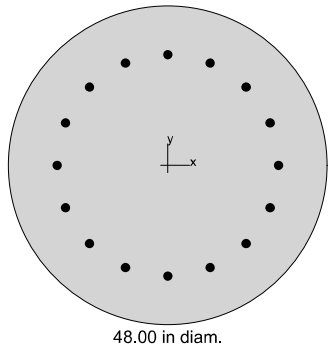
Pattern	All sides equal
Bar layout	Circular
Cover to	Transverse bars
Clear cover	6 in
Bars	16 #11
Confinement type	Tied
Total steel area, A_s	24.96 in ²
Rho	1.38 %
Min. clear spacing	5.09 in



No.	P_u kip	M_{ux} k-ft	M_{uy} k-ft	ϕP_n kip	ϕM_{nx} k-ft	ϕM_{ny} k-ft	Capacity Ratio
1	1103.0	588.0	1389.2	0.00	737.00	1741.22	0.71

Max. Capacity Ratio: 0.71

7.3. PM at $\theta=90$ [deg]



General Information

Project	NSRR Shoofly
Column	Main Pier Column
Engineer	TSK
Code	ACI 318-19
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	Biaxial
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Critical capacity

Materials

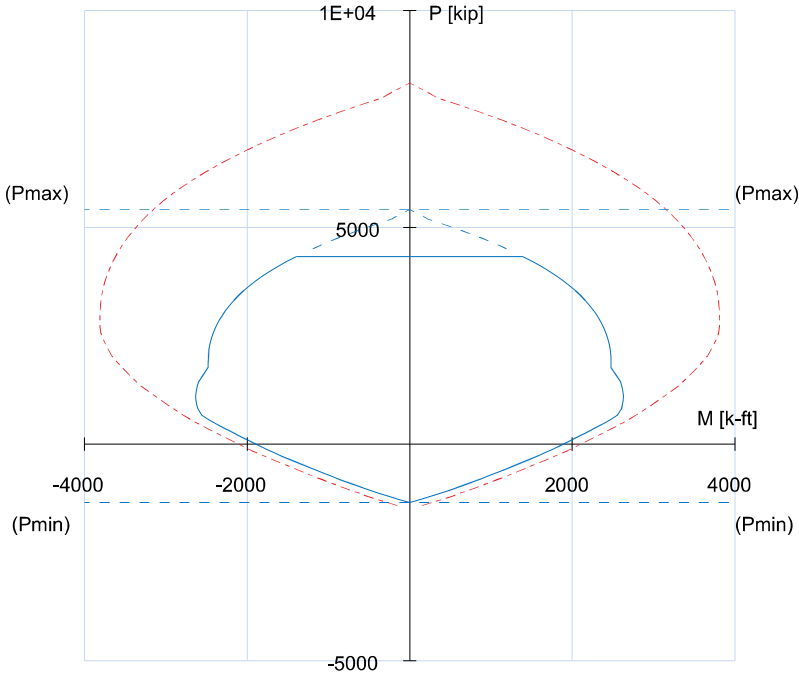
f'_c	4.5 ksi
E_c	3823.68 ksi
f_y	60 ksi
E_s	29000 ksi

Section

Type	Circular
Diameter	48 in
A_g	1809.56 in ²
I_x	260576 in ⁴
I_y	260576 in ⁴

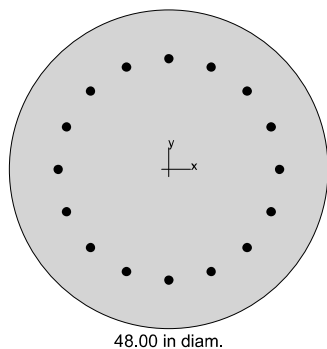
Reinforcement

Pattern	All sides equal
Bar layout	Circular
Cover to	Transverse bars
Clear cover	6 in
Bars	16 #11
Confinement type	Tied
Total steel area, A_s	24.96 in ²
Rho	1.38 %
Min. clear spacing	5.09 in



PM at 90.0 [deg]

7.4. MM at P=0 [kip]



General Information

Project	NSRR Shoo-fly
Column	Main Pier Column
Engineer	TSK
Code	ACI 318-19
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	Biaxial
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Critical capacity

Materials

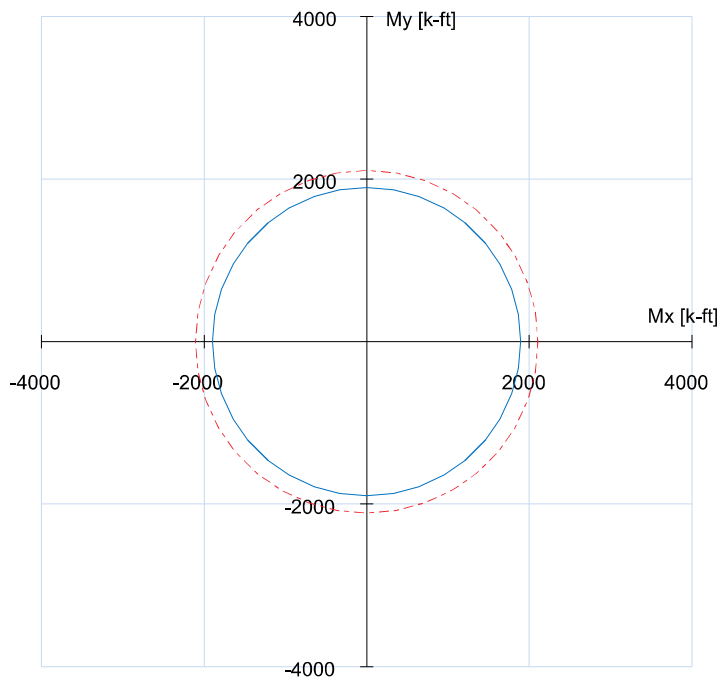
f'_c	4.5 ksi
E_c	3823.68 ksi
f_y	60 ksi
E_s	29000 ksi

Section

Type	Circular
Diameter	48 in
A_g	1809.56 in ²
I_x	260576 in ⁴
I_y	260576 in ⁴

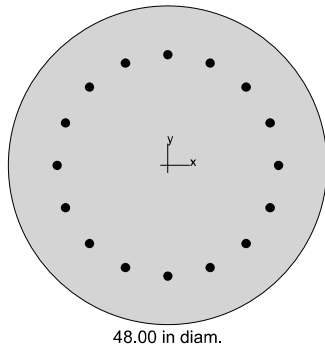
Reinforcement

Pattern	All sides equal
Bar layout	Circular
Cover to	Transverse bars
Clear cover	6 in
Bars	16 #11
Confinement type	Tied
Total steel area, A_s	24.96 in ²
Rho	1.38 %
Min. clear spacing	5.09 in



MM at P=0.0 [kip]

7.5. MM at P=1103 [kip]



General Information

Project	NSRR Shoofly
Column	Main Pier Column
Engineer	TSK
Code	ACI 318-19
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	Biaxial
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Critical capacity

Materials

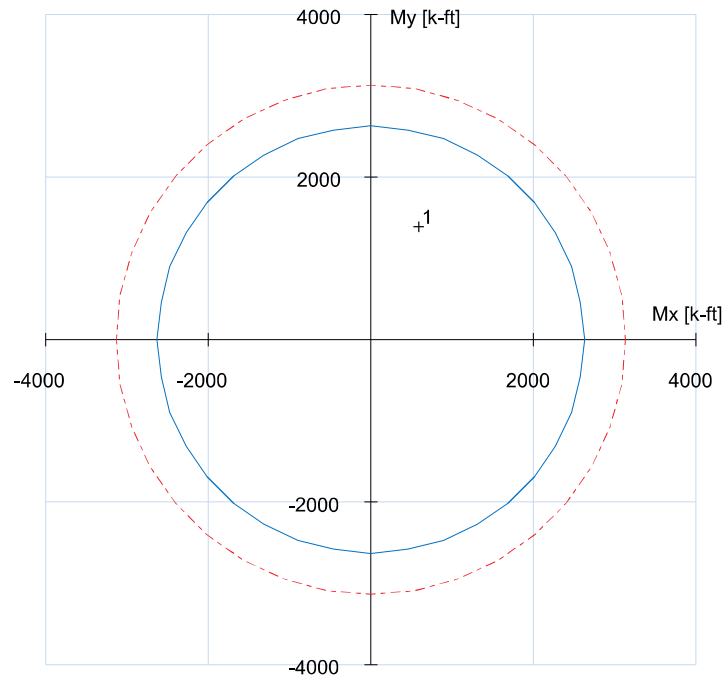
f'_c	4.5 ksi
E_c	3823.68 ksi
f_y	60 ksi
E_s	29000 ksi

Section

Type	Circular
Diameter	48 in
A_g	1809.56 in ²
I_x	260576 in ⁴
I_y	260576 in ⁴

Reinforcement

Pattern	All sides equal
Bar layout	Circular
Cover to	Transverse bars
Clear cover	6 in
Bars	16 #11
Confinement type	Tied
Total steel area, A_s	24.96 in ²
Rho	1.38 %
Min. clear spacing	5.09 in



MM at P=1103.0 [kip]

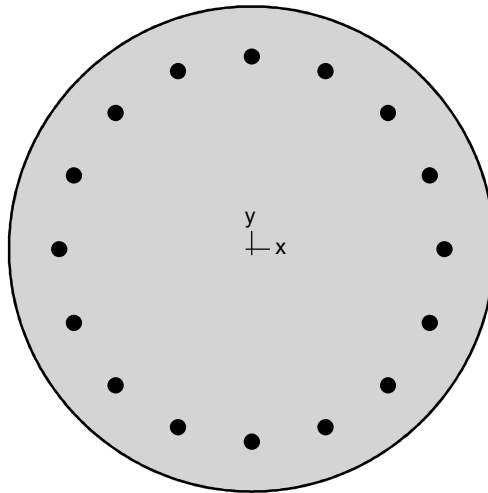
No.	P_u kip	M_{ux} k-ft	M_{uy} k-ft	ϕP_n kip	ϕM_{nx} k-ft	ϕM_{ny} k-ft	Capacity Ratio
1	1103.0	588.0	1389.2	0.00	737.00	1741.22	0.71

Max. Capacity Ratio: 0.71

Drilled shaft check



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Computer program for the Strength Design of Reinforced Concrete Sections
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1. General Information

File Name	C:\Users\tkelley\OneDrive - HN...\NSRR Shaft.colx
Project	NSRR Shoofly
Column	Main Pier Column
Engineer	TSK
Code	ACI 318-19
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	Biaxial
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Critical capacity

2. Material Properties

2.1. Concrete

Type	Standard
f'_c	4.5 ksi
E_c	3823.68 ksi
f_c	3.825 ksi
ϵ_u	0.003 in/in
β_1	0.825

2.2. Steel

Type	Standard
f_y	60 ksi
E_s	29000 ksi
ϵ_{ty}	0.00206897 in/in

3. Section

3.1. Shape and Properties

Type	Circular
Diameter	42 in
A_g	1385.44 in ²
I_x	152745 in ⁴
I_y	152745 in ⁴
r_x	10.5 in
r_y	10.5 in
X_o	0 in
Y_o	0 in

3.2. Section Figure

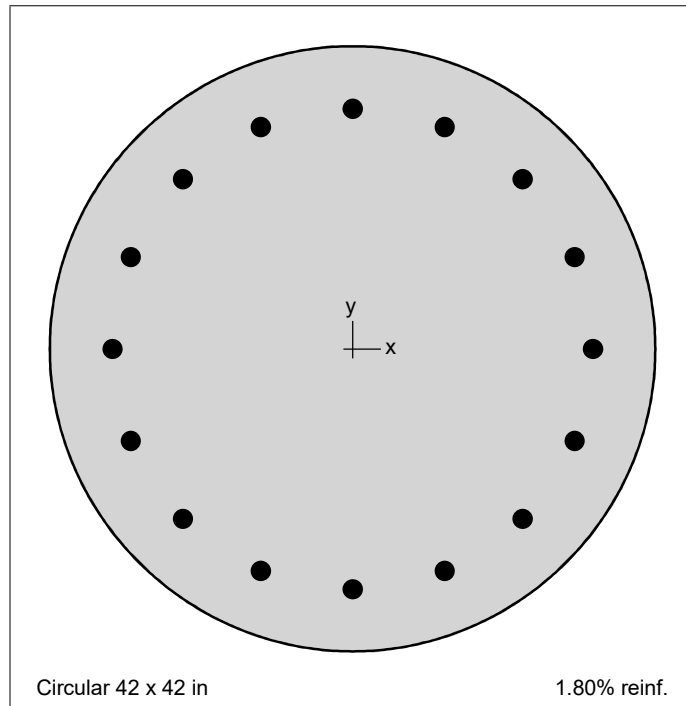


Figure 1: Column section

4. Reinforcement

4.1. Bar Set: ASTM A615

Bar	Diameter in	Area in ²	Bar	Diameter in	Area in ²	Bar	Diameter in	Area in ²
#3	0.38	0.11	#4	0.50	0.20	#5	0.63	0.31
#6	0.75	0.44	#7	0.88	0.60	#8	1.00	0.79
#9	1.13	1.00	#10	1.27	1.27	#11	1.41	1.56
#14	1.69	2.25	#18	2.26	4.00			

4.2. Confinement and Factors

Confinement type	Tied
For #10 bars or less	#3 ties
For larger bars	#5 ties
Capacity Reduction Factors	
Axial compression, (a)	0.8
Tension controlled ϕ , (b)	0.9
Compression controlled ϕ , (c)	0.65

4.3. Arrangement

Pattern	All sides equal
Bar layout	Circular
Cover to	Transverse bars
Clear cover	3 in
Bars	16 #11

Total steel area, A_s	24.96 in ²
Rho	1.80 %
Minimum clear spacing	5.09 in

5. Control Points

About Point	P kip	X-Moment k-ft	Y-Moment k-ft	NA Depth in	d_t Depth in	ϵ_t	ϕ
X @ Max compression	4355.9	0.00	0.00	121.38	37.67	-0.00207	0.65000
X @ Allowable comp.	3484.8	1000.60	0.00	40.27	37.67	-0.00019	0.65000
X @ $f_s = 0.0$	3257.3	1202.73	0.00	37.67	37.67	0.00000	0.65000
X @ $f_s = 0.5 f_y$	2227.3	1772.14	0.00	28.01	37.67	0.00103	0.65000
X @ Balanced point	1484.9	1928.05	0.00	22.29	37.67	0.00207	0.65000
X @ Tension control	631.8	2200.03	0.00	14.01	37.67	0.00507	0.90000
X @ Pure bending	0.0	1677.14	0.00	10.17	37.67	0.00811	0.90000
X @ Max tension	-1347.8	0.00	0.00	0.00	37.67	9.99999	0.90000
Y @ Max compression	4355.9	0.00	0.00	121.38	37.67	-0.00207	0.65000
Y @ Allowable comp.	3484.8	0.00	1000.60	40.27	37.67	-0.00019	0.65000
Y @ $f_s = 0.0$	3257.3	0.00	1202.73	37.67	37.67	0.00000	0.65000
Y @ $f_s = 0.5 f_y$	2227.3	0.00	1772.14	28.01	37.67	0.00103	0.65000
Y @ Balanced point	1484.9	0.00	1928.05	22.29	37.67	0.00207	0.65000
Y @ Tension control	631.8	0.00	2200.03	14.01	37.67	0.00507	0.90000
Y @ Pure bending	0.0	0.00	1677.14	10.17	37.67	0.00811	0.90000
Y @ Max tension	-1347.8	0.00	0.00	0.00	37.67	9.99999	0.90000
-X @ Max compression	4355.9	0.00	0.00	121.38	37.67	-0.00207	0.65000
-X @ Allowable comp.	3484.8	-1000.60	0.00	40.27	37.67	-0.00019	0.65000
-X @ $f_s = 0.0$	3257.3	-1202.73	0.00	37.67	37.67	0.00000	0.65000
-X @ $f_s = 0.5 f_y$	2227.3	-1772.14	0.00	28.01	37.67	0.00103	0.65000
-X @ Balanced point	1484.9	-1928.05	0.00	22.29	37.67	0.00207	0.65000
-X @ Tension control	631.8	-2200.03	0.00	14.01	37.67	0.00507	0.90000
-X @ Pure bending	0.0	-1677.14	0.00	10.17	37.67	0.00811	0.90000
-X @ Max tension	-1347.8	0.00	0.00	0.00	37.67	9.99999	0.90000
-Y @ Max compression	4355.9	0.00	0.00	121.38	37.67	-0.00207	0.65000
-Y @ Allowable comp.	3484.8	0.00	-1000.60	40.27	37.67	-0.00019	0.65000
-Y @ $f_s = 0.0$	3257.3	0.00	-1202.73	37.67	37.67	0.00000	0.65000
-Y @ $f_s = 0.5 f_y$	2227.3	0.00	-1772.14	28.01	37.67	0.00103	0.65000
-Y @ Balanced point	1484.9	0.00	-1928.05	22.29	37.67	0.00207	0.65000
-Y @ Tension control	631.8	0.00	-2200.03	14.01	37.67	0.00507	0.90000
-Y @ Pure bending	0.0	0.00	-1677.14	10.17	37.67	0.00811	0.90000
-Y @ Max tension	-1347.8	0.00	0.00	0.00	37.67	9.99999	0.90000

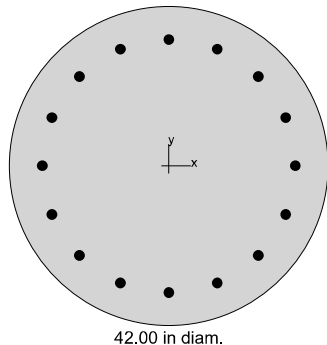
6. Factored Loads and Moments with Corresponding Capacity Ratios

NOTE: Calculations are based on "Critical Capacity" Method.

No.	Demand			Capacity			Parameters at Capacity			Capacity Ratio
	P_u kip	M_{ux} k-ft	M_{uy} k-ft	ϕP_n kip	ϕM_{nx} k-ft	ϕM_{ny} k-ft	NA Depth in	ϵ_t	ϕ	
1	1103.00	588.00	1389.20	1511.24	748.11	1767.48	22.48	0.00202	0.650	0.78

7. Diagrams

7.1. PM at $\theta=0$ [deg]



General Information

Project	NSRR Shoofly
Column	Main Pier Column
Engineer	TSK
Code	ACI 318-19
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	Biaxial
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Critical capacity

Materials

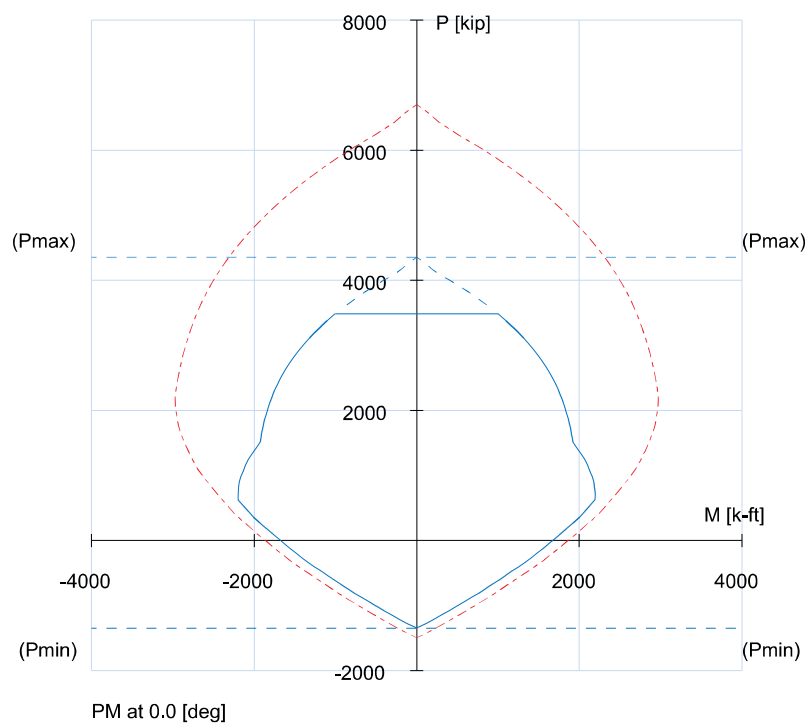
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E_c	3823.68 ksi
f_y	60 ksi
E_s	29000 ksi

Section

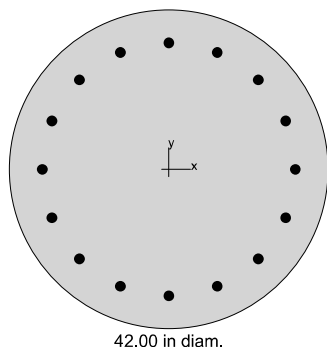
Type	Circular
Diameter	42 in
A_g	1385.44 in ²
I_x	152745 in ⁴
I_y	152745 in ⁴

Reinforcement

Pattern	All sides equal
Bar layout	Circular
Cover to	Transverse bars
Clear cover	3 in
Bars	16 #11
Confinement type	Tied
Total steel area, A_s	24.96 in ²
Rho	1.80 %
Min. clear spacing	5.09 in



7.2. PM at $\theta=67$ [deg]



General Information

Project	NSRR Shoo-fly
Column	Main Pier Column
Engineer	TSK
Code	ACI 318-19
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	Biaxial
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Critical capacity

Materials

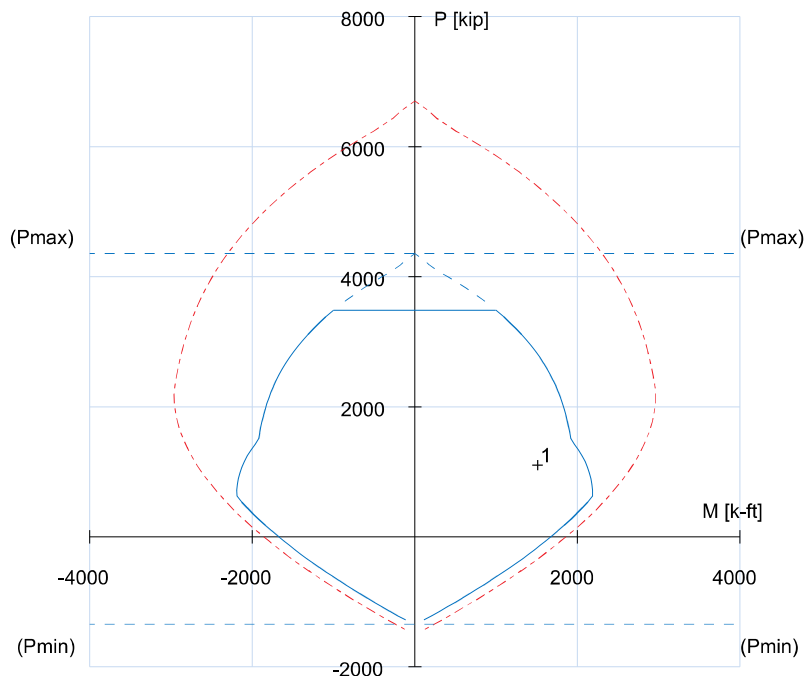
f'_c	4.5 ksi
E_c	3823.68 ksi
f_y	60 ksi
E_s	29000 ksi

Section

Type	Circular
Diameter	42 in
A_g	1385.44 in ²
I_x	152745 in ⁴
I_y	152745 in ⁴

Reinforcement

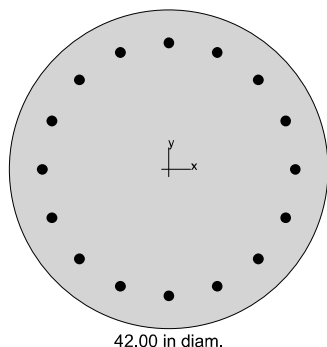
Pattern	All sides equal
Bar layout	Circular
Cover to	Transverse bars
Clear cover	3 in
Bars	16 #11
Confinement type	Tied
Total steel area, A_s	24.96 in ²
Rho	1.80 %
Min. clear spacing	5.09 in



No.	P_u kip	M_{ux} k-ft	M_{uy} k-ft	ϕP_n kip	ϕM_{nx} k-ft	ϕM_{ny} k-ft	Capacity Ratio
1	1103.0	588.0	1389.2	1511.24	748.11	1767.48	0.78

Max. Capacity Ratio: 0.78

7.3. PM at $\theta=90$ [deg]



General Information

Project	NSRR Shoo-fly
Column	Main Pier Column
Engineer	TSK
Code	ACI 318-19
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	Biaxial
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Critical capacity

Materials

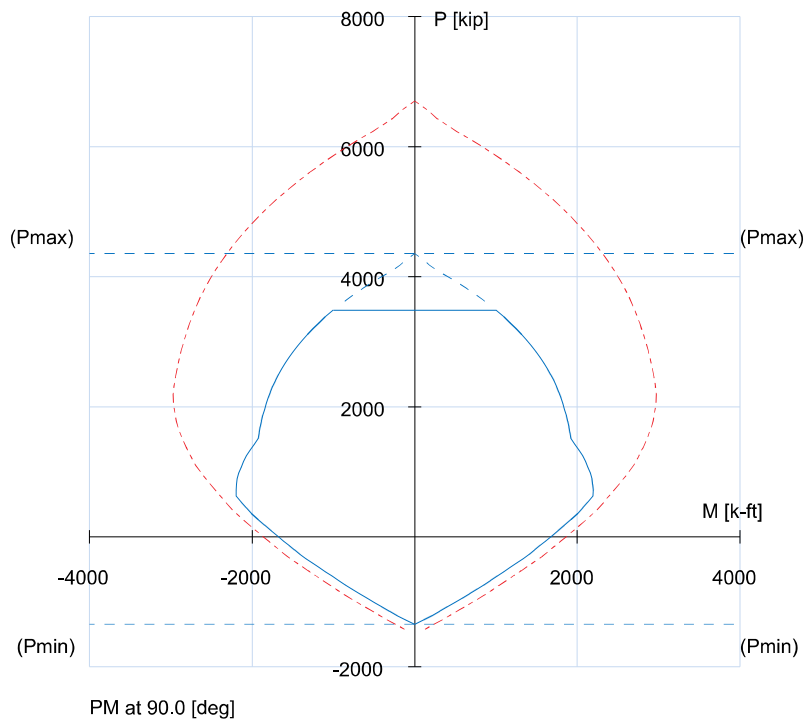
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E_c	3823.68 ksi
f_y	60 ksi
E_s	29000 ksi

Section

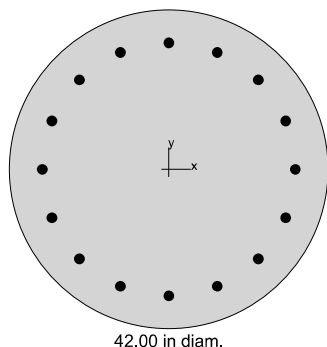
Type	Circular
Diameter	42 in
A_g	1385.44 in ²
I_x	152745 in ⁴
I_y	152745 in ⁴

Reinforcement

Pattern	All sides equal
Bar layout	Circular
Cover to	Transverse bars
Clear cover	3 in
Bars	16 #11
Confinement type	Tied
Total steel area, A_s	24.96 in ²
Rho	1.80 %
Min. clear spacing	5.09 in



7.4. MM at P=0 [kip]



General Information

Project	NSRR Shoo-fly
Column	Main Pier Column
Engineer	TSK
Code	ACI 318-19
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	Biaxial
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Critical capacity

Materials

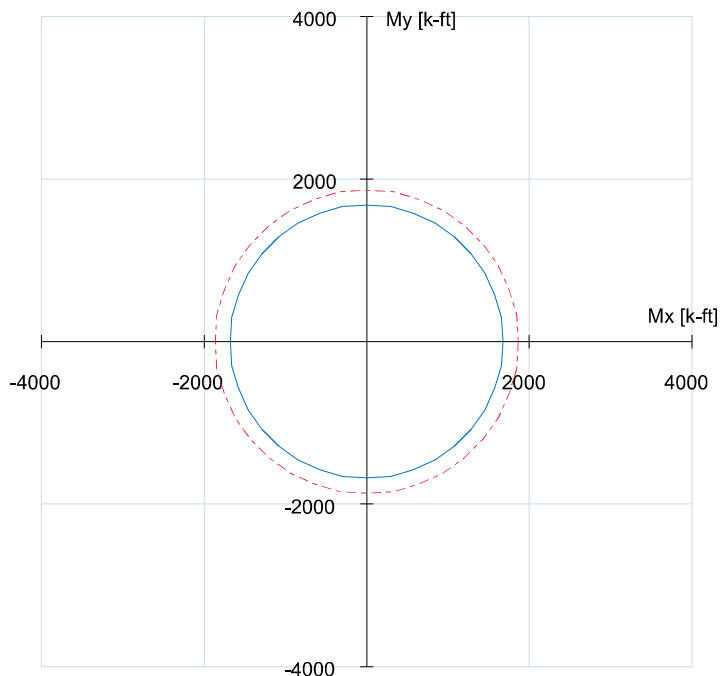
f'_c	4.5 ksi
E_c	3823.68 ksi
f_y	60 ksi
E_s	29000 ksi

Section

Type	Circular
Diameter	42 in
A_g	1385.44 in ²
I_x	152745 in ⁴
I_y	152745 in ⁴

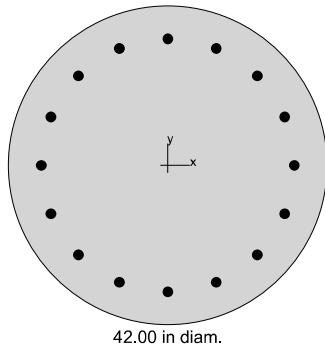
Reinforcement

Pattern	All sides equal
Bar layout	Circular
Cover to	Transverse bars
Clear cover	3 in
Bars	16 #11
Confinement type	Tied
Total steel area, A_s	24.96 in ²
Rho	1.80 %
Min. clear spacing	5.09 in



MM at P=0.0 [kip]

7.5. MM at P=1103 [kip]



General Information

Project	NSRR Shoo-fly
Column	Main Pier Column
Engineer	TSK
Code	ACI 318-19
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	Biaxial
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Critical capacity

Materials

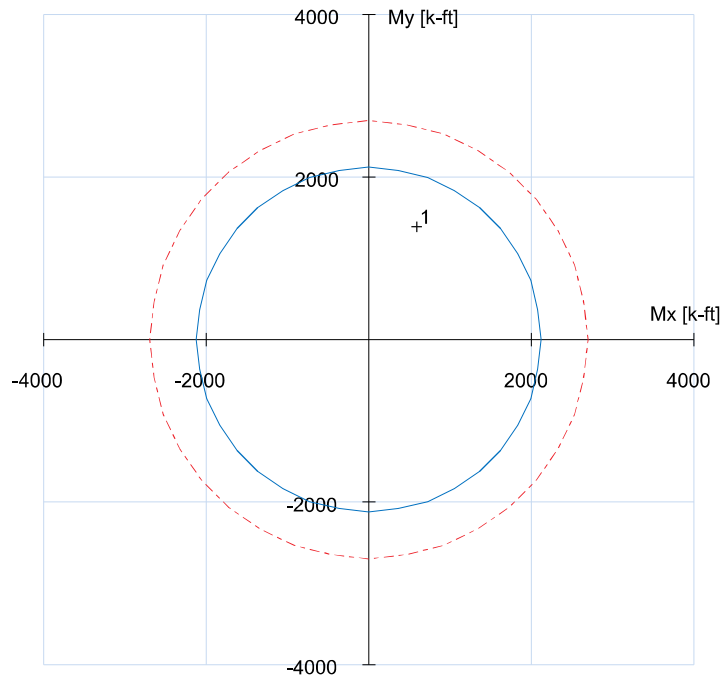
f'_c	4.5 ksi
E_c	3823.68 ksi
f_y	60 ksi
E_s	29000 ksi

Section

Type	Circular
Diameter	42 in
A_g	1385.44 in ²
I_x	152745 in ⁴
I_y	152745 in ⁴

Reinforcement

Pattern	All sides equal
Bar layout	Circular
Cover to	Transverse bars
Clear cover	3 in
Bars	16 #11
Confinement type	Tied
Total steel area, A_s	24.96 in ²
Rho	1.80 %
Min. clear spacing	5.09 in



MM at P=1103.0 [kip]

No.	P_u kip	M_{ux} k-ft	M_{uy} k-ft	ϕP_n kip	ϕM_{nx} k-ft	ϕM_{ny} k-ft	Capacity Ratio
1	1103.0	588.0	1389.2	1511.24	748.11	1767.48	0.78

Max. Capacity Ratio: 0.78

CSI MODEL OUTPUT

Table: Case - Static 1 - Load Assignments**Table: Case - Static 1 - Load Assignments**

Case	LoadType	LoadName	LoadSF
DEAD	Load pattern	DEAD	1.
Super DL	Load pattern	Super DL	1.
Live plus Impact	Load pattern	Live plus Impact	1.
Wind on Live	Load pattern	Wind on Live	1.
Wind on Struct	Load pattern	Wind on Struct	1.
LF	Load pattern	LF	1.

Table: Connectivity - Frame, Part 1 of 2**Table: Connectivity - Frame, Part 1 of 2**

Frame	JointI	JointJ	IsCurved	Length ft	CentroidX ft	CentroidY ft	CentroidZ ft
1	8	1	No	3.	6.75	0.	31.5
2	6	2	No	3.	-6.75	0.	31.5
3	5	6	No	31.5	-5.25	0.	15.75
4	7	8	No	31.5	5.25	0.	15.75
9	6	8	No	10.5	0.	0.	31.5

Table: Connectivity - Frame, Part 2 of 2**Table: Connectivity - Frame, Part 2 of 2**

Frame	GUID
1	cec10785-e59c-45e2-a125-bee96044b4ed
2	bd52ec97-a5f0-4a5f-a5f2-0a78c0512472
3	c94f05d8-aa9e-48f0-b97d-eb4c66b07845
4	23b53c5b-f576-407f-ab7e-170611c2c8f5
9	c20e9540-a795-464f-89e-e-74b74da2cbd3

Table: Element Forces - Frames, Part 1 of 2**Table: Element Forces - Frames, Part 1 of 2**

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
1	0.	DEAD	LinStatic	0.	-15.	0.	0.	0.
1	1.5	DEAD	LinStatic	0.	-7.5	0.	0.	0.
1	3.	DEAD	LinStatic	0.	-4.885E-14	0.	0.	0.
1	0.	Super DL	LinStatic	0.	-7.14	0.	0.	0.
1	1.5	Super DL	LinStatic	0.	1.243E-14	0.	0.	0.
1	3.	Super DL	LinStatic	0.	1.243E-14	0.	0.	0.
1	0.	Live plus Impact	LinStatic	0.	-37.38	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
1	1.5	Live plus Impact	LinStatic	0.	3.393E-13	0.	0.	0.
1	3.	Live plus Impact	LinStatic	0.	3.393E-13	0.	0.	0.
2	0.	DEAD	LinStatic	0.	-15.	0.	0.	0.
2	1.5	DEAD	LinStatic	0.	-7.5	0.	0.	0.
2	3.	DEAD	LinStatic	0.	-4.885E-14	0.	0.	0.
2	0.	Super DL	LinStatic	0.	-7.14	0.	0.	0.
2	1.5	Super DL	LinStatic	0.	1.243E-14	0.	0.	0.
2	3.	Super DL	LinStatic	0.	1.243E-14	0.	0.	0.
2	0.	Live plus Impact	LinStatic	0.	-37.38	0.	0.	0.
2	1.5	Live plus Impact	LinStatic	0.	-1.155E-13	0.	0.	0.
2	3.	Live plus Impact	LinStatic	0.	-1.155E-13	0.	0.	0.
3	0.	DEAD	LinStatic	-100.626	-0.15	0.	0.	0.
3	15.75	DEAD	LinStatic	-70.938	-0.15	0.	0.	0.
3	31.5	DEAD	LinStatic	-41.25	-0.15	0.	0.	0.
3	0.	Super DL	LinStatic	-96.39	-0.991	0.	0.	0.
3	15.75	Super DL	LinStatic	-96.39	-0.991	0.	0.	0.
3	31.5	Super DL	LinStatic	-96.39	-0.991	0.	0.	0.
3	0.	Live plus Impact	LinStatic	-504.63	-5.189	0.	0.	0.
3	15.75	Live plus Impact	LinStatic	-504.63	-5.189	0.	0.	0.
3	31.5	Live plus Impact	LinStatic	-504.63	-5.189	0.	0.	0.
4	0.	DEAD	LinStatic	-100.626	0.15	0.	0.	0.
4	15.75	DEAD	LinStatic	-70.938	0.15	0.	0.	0.
4	31.5	DEAD	LinStatic	-41.25	0.15	0.	0.	0.
4	0.	Super DL	LinStatic	-96.39	0.991	0.	0.	0.
4	15.75	Super DL	LinStatic	-96.39	0.991	0.	0.	0.
4	31.5	Super DL	LinStatic	-96.39	0.991	0.	0.	0.
4	0.	Live plus Impact	LinStatic	-504.63	5.189	0.	0.	0.
4	15.75	Live plus Impact	LinStatic	-504.63	5.189	0.	0.	0.
4	31.5	Live plus Impact	LinStatic	-504.63	5.189	0.	0.	0.
9	0.	DEAD	LinStatic	-0.15	-26.25	0.	0.	0.
9	1.05	DEAD	LinStatic	-0.15	-21.	0.	0.	0.
9	1.05	DEAD	LinStatic	-0.15	-21.	0.	0.	0.
9	2.1	DEAD	LinStatic	-0.15	-15.75	0.	0.	0.
9	2.1	DEAD	LinStatic	-0.15	-15.75	0.	0.	0.
9	3.15	DEAD	LinStatic	-0.15	-10.5	0.	0.	0.
9	3.15	DEAD	LinStatic	-0.15	-10.5	0.	0.	0.
9	4.2	DEAD	LinStatic	-0.15	-5.25	0.	0.	0.
9	4.2	DEAD	LinStatic	-0.15	-5.25	0.	0.	0.
9	5.25	DEAD	LinStatic	-0.15	-9.897E-13	0.	0.	0.
9	5.25	DEAD	LinStatic	-0.15	-6.821E-13	0.	0.	0.
9	6.3	DEAD	LinStatic	-0.15	5.25	0.	0.	0.
9	6.3	DEAD	LinStatic	-0.15	5.25	0.	0.	0.
9	7.35	DEAD	LinStatic	-0.15	10.5	0.	0.	0.
9	7.35	DEAD	LinStatic	-0.15	10.5	0.	0.	0.
9	8.4	DEAD	LinStatic	-0.15	15.75	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
9	8.4	DEAD	LinStatic	-0.15	15.75	0.	0.	0.
9	9.45	DEAD	LinStatic	-0.15	21.	0.	0.	0.
9	9.45	DEAD	LinStatic	-0.15	21.	0.	0.	0.
9	10.5	DEAD	LinStatic	-0.15	26.25	0.	0.	0.
9	0.	Super DL	LinStatic	-0.991	-89.25	0.	0.	0.
9	1.05	Super DL	LinStatic	-0.991	-71.4	0.	0.	0.
9	1.05	Super DL	LinStatic	-0.991	-71.4	0.	0.	0.
9	2.1	Super DL	LinStatic	-0.991	-53.55	0.	0.	0.
9	2.1	Super DL	LinStatic	-0.991	-53.55	0.	0.	0.
9	3.15	Super DL	LinStatic	-0.991	-35.7	0.	0.	0.
9	3.15	Super DL	LinStatic	-0.991	-35.7	0.	0.	0.
9	4.2	Super DL	LinStatic	-0.991	-17.85	0.	0.	0.
9	4.2	Super DL	LinStatic	-0.991	-17.85	0.	0.	0.
9	5.25	Super DL	LinStatic	-0.991	-1.276E-12	0.	0.	0.
9	5.25	Super DL	LinStatic	-0.991	-1.364E-12	0.	0.	0.
9	6.3	Super DL	LinStatic	-0.991	17.85	0.	0.	0.
9	6.3	Super DL	LinStatic	-0.991	17.85	0.	0.	0.
9	7.35	Super DL	LinStatic	-0.991	35.7	0.	0.	0.
9	7.35	Super DL	LinStatic	-0.991	35.7	0.	0.	0.
9	8.4	Super DL	LinStatic	-0.991	53.55	0.	0.	0.
9	8.4	Super DL	LinStatic	-0.991	53.55	0.	0.	0.
9	9.45	Super DL	LinStatic	-0.991	71.4	0.	0.	0.
9	9.45	Super DL	LinStatic	-0.991	71.4	0.	0.	0.
9	10.5	Super DL	LinStatic	-0.991	89.25	0.	0.	0.
9	0.	Live plus Impact	LinStatic	-5.189	-467.25	0.	0.	0.
9	1.05	Live plus Impact	LinStatic	-5.189	-373.8	0.	0.	0.
9	1.05	Live plus Impact	LinStatic	-5.189	-373.8	0.	0.	0.
9	2.1	Live plus Impact	LinStatic	-5.189	-280.35	0.	0.	0.
9	2.1	Live plus Impact	LinStatic	-5.189	-280.35	0.	0.	0.
9	3.15	Live plus Impact	LinStatic	-5.189	-186.9	0.	0.	0.
9	3.15	Live plus Impact	LinStatic	-5.189	-186.9	0.	0.	0.
9	4.2	Live plus Impact	LinStatic	-5.189	-93.45	0.	0.	0.
9	4.2	Live plus Impact	LinStatic	-5.189	-93.45	0.	0.	0.
9	5.25	Live plus Impact	LinStatic	-5.189	-8.019E-12	0.	0.	0.
9	5.25	Live plus Impact	LinStatic	-5.189	-5.457E-12	0.	0.	0.
9	6.3	Live plus Impact	LinStatic	-5.189	93.45	0.	0.	0.
9	6.3	Live plus Impact	LinStatic	-5.189	93.45	0.	0.	0.
9	7.35	Live plus Impact	LinStatic	-5.189	186.9	0.	0.	0.
9	7.35	Live plus Impact	LinStatic	-5.189	186.9	0.	0.	0.
9	8.4	Live plus Impact	LinStatic	-5.189	280.35	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
9	8.4	Live plus Impact	LinStatic	-5.189	280.35	0.	0.	0.
9	9.45	Live plus Impact	LinStatic	-5.189	373.8	0.	0.	0.
9	9.45	Live plus Impact	LinStatic	-5.189	373.8	0.	0.	0.
9	10.5	Live plus Impact	LinStatic	-5.189	467.25	0.	0.	0.

Table: Element Forces - Frames, Part 2 of 2

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
1	0.	DEAD	-22.5	1-1	0.
1	1.5	DEAD	-5.625	1-1	1.5
1	3.	DEAD	1.621E-14	1-1	3.
1	0.	Super DL	-1.4994	1-1	0.
1	1.5	Super DL	-5.571E-14	1-1	1.5
1	3.	Super DL	-7.436E-14	1-1	3.
1	0.	Live plus Impact	-7.8498	1-1	0.
1	1.5	Live plus Impact	-1.572E-14	1-1	1.5
1	3.	Live plus Impact	-5.246E-13	1-1	3.
2	0.	DEAD	-22.5	2-1	0.
2	1.5	DEAD	-5.625	2-1	1.5
2	3.	DEAD	1.621E-14	2-1	3.
2	0.	Super DL	-1.4994	2-1	0.
2	1.5	Super DL	5.798E-14	2-1	1.5
2	3.	Super DL	3.932E-14	2-1	3.
2	0.	Live plus Impact	-7.8498	2-1	0.
2	1.5	Live plus Impact	-2.431E-13	2-1	1.5
2	3.	Live plus Impact	-6.990E-14	2-1	3.
3	0.	DEAD	-1.5506	3-1	0.
3	15.75	DEAD	0.8146	3-1	15.75
3	31.5	DEAD	3.1798	3-1	31.5
3	0.	Super DL	-10.2337	3-1	0.
3	15.75	Super DL	5.3765	3-1	15.75
3	31.5	Super DL	20.9866	3-1	31.5
3	0.	Live plus Impact	-53.5763	3-1	0.
3	15.75	Live plus Impact	28.1473	3-1	15.75
3	31.5	Live plus Impact	109.871	3-1	31.5
4	0.	DEAD	1.5506	4-1	0.
4	15.75	DEAD	-0.8146	4-1	15.75
4	31.5	DEAD	-3.1798	4-1	31.5
4	0.	Super DL	10.2337	4-1	0.
4	15.75	Super DL	-5.3765	4-1	15.75
4	31.5	Super DL	-20.9866	4-1	31.5

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
4	0.	Live plus Impact	53.5763	4-1	0.
4	15.75	Live plus Impact	-28.1473	4-1	15.75
4	31.5	Live plus Impact	-109.871	4-1	31.5
9	0.	DEAD	-25.6798	9-1	0.
9	1.05	DEAD	-0.8735	9-1	1.05
9	1.05	DEAD	-0.8735	9-2	0.
9	2.1	DEAD	18.4202	9-2	1.05
9	2.1	DEAD	18.4202	9-3	0.
9	3.15	DEAD	32.2015	9-3	1.05
9	3.15	DEAD	32.2015	9-4	0.
9	4.2	DEAD	40.4702	9-4	1.05
9	4.2	DEAD	40.4702	9-5	0.
9	5.25	DEAD	43.2265	9-5	1.05
9	5.25	DEAD	43.2265	9-6	0.
9	6.3	DEAD	40.4702	9-6	1.05
9	6.3	DEAD	40.4702	9-7	0.
9	7.35	DEAD	32.2015	9-7	1.05
9	7.35	DEAD	32.2015	9-8	0.
9	8.4	DEAD	18.4202	9-8	1.05
9	8.4	DEAD	18.4202	9-9	0.
9	9.45	DEAD	-0.8735	9-9	1.05
9	9.45	DEAD	-0.8735	9-10	0.
9	10.5	DEAD	-25.6798	9-10	1.05
9	0.	Super DL	-22.486	9-1	0.
9	1.05	Super DL	61.8553	9-1	1.05
9	1.05	Super DL	61.8553	9-2	0.
9	2.1	Super DL	127.454	9-2	1.05
9	2.1	Super DL	127.454	9-3	0.
9	3.15	Super DL	174.3103	9-3	1.05
9	3.15	Super DL	174.3103	9-4	0.
9	4.2	Super DL	202.424	9-4	1.05
9	4.2	Super DL	202.424	9-5	0.
9	5.25	Super DL	211.7953	9-5	1.05
9	5.25	Super DL	211.7953	9-6	0.
9	6.3	Super DL	202.424	9-6	1.05
9	6.3	Super DL	202.424	9-7	0.
9	7.35	Super DL	174.3103	9-7	1.05
9	7.35	Super DL	174.3103	9-8	0.
9	8.4	Super DL	127.454	9-8	1.05
9	8.4	Super DL	127.454	9-9	0.
9	9.45	Super DL	61.8553	9-9	1.05
9	9.45	Super DL	61.8553	9-10	0.
9	10.5	Super DL	-22.486	9-10	1.05
9	0.	Live plus Impact	-117.7208	9-1	0.
9	1.05	Live plus Impact	323.8305	9-1	1.05
9	1.05	Live plus Impact	323.8305	9-2	0.
9	2.1	Live plus Impact	667.2592	9-2	1.05
9	2.1	Live plus Impact	667.2592	9-3	0.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
9	3.15	Live plus Impact	912.5655	9-3	1.05
9	3.15	Live plus Impact	912.5655	9-4	0.
9	4.2	Live plus Impact	1059.7492	9-4	1.05
9	4.2	Live plus Impact	1059.7492	9-5	0.
9	5.25	Live plus Impact	1108.8105	9-5	1.05
9	5.25	Live plus Impact	1108.8105	9-6	0.
9	6.3	Live plus Impact	1059.7492	9-6	1.05
9	6.3	Live plus Impact	1059.7492	9-7	0.
9	7.35	Live plus Impact	912.5655	9-7	1.05
9	7.35	Live plus Impact	912.5655	9-8	0.
9	8.4	Live plus Impact	667.2592	9-8	1.05
9	8.4	Live plus Impact	667.2592	9-9	0.
9	9.45	Live plus Impact	323.8305	9-9	1.05
9	9.45	Live plus Impact	323.8305	9-10	0.
9	10.5	Live plus Impact	-117.7208	9-10	1.05

Table: Frame Loads - Distributed, Part 1 of 3

Table: Frame Loads - Distributed, Part 1 of 3

Frame	LoadPat	CoordSys	Type	Dir	DistType	RelDistA
9	Live plus Impact	GLOBAL	Force	Gravity	RelDist	0.
9	Super DL	GLOBAL	Force	Gravity	RelDist	0.
9	DEAD	GLOBAL	Force	Gravity	RelDist	0.
1	Super DL	GLOBAL	Force	Gravity	RelDist	0.
1	Live plus Impact	GLOBAL	Force	Gravity	RelDist	0.
1	DEAD	GLOBAL	Force	Gravity	RelDist	0.
2	Super DL	GLOBAL	Force	Gravity	RelDist	0.
2	Live plus Impact	GLOBAL	Force	Gravity	RelDist	0.
2	DEAD	GLOBAL	Force	Gravity	RelDist	0.

Table: Frame Loads - Distributed, Part 2 of 3

Table: Frame Loads - Distributed, Part 2 of 3

Frame	LoadPat	RelDistB	AbsDistA ft	AbsDistB ft	FOverLA Kip/ft	FOverLB Kip/ft
9	Live plus Impact	1.	0.	10.5	89.	89.
9	Super DL	1.	0.	10.5	17.	17.
9	DEAD	1.	0.	10.5	1.25	1.25
1	Super DL	0.14	0.	0.42	17.	17.

Table: Frame Loads - Distributed, Part 2 of 3

Frame	LoadPat	RelDistB	AbsDistA ft	AbsDistB ft	FOverLA Kip/ft	FOverLB Kip/ft
1	Live plus Impact	0.14	0.	0.42	89.	89.
1	DEAD	1.	0.	3.	1.25	1.25
2	Super DL	0.14	0.	0.42	17.	17.
2	Live plus Impact	0.14	0.	0.42	89.	89.
2	DEAD	1.	0.	3.	1.25	1.25

Table: Frame Loads - Distributed, Part 3 of 3

Table: Frame Loads - Distributed, Part 3 of 3

Frame	LoadPat	GUID
9	Live plus Impact	e86c19be-6e02-4302-be5d-704ed348fe0b
9	Super DL	c3b5e1fd-7ea8-4a5d-9520-6c9a76e9d324
9	DEAD	c05af52b-db5b-4250-9a4d-96576c431266
1	Super DL	1620e6ab-272f-45a5-a387-281e965e2b17
1	Live plus Impact	7a071b48-0afe-443b-9cf6-be044831a7b9
1	DEAD	33ac1898-e8dd-487e-b4a8-04cee4bac089
2	Super DL	526aabe0-a831-40f1-864f-88d2e33af02b
2	Live plus Impact	7b988bb7-c950-46df-95e6-0475181d8fc8
2	DEAD	eed4fe72-c475-4961-ac9c-d4ed461af34b

Table: Frame Loads - Point, Part 1 of 2

Table: Frame Loads - Point, Part 1 of 2

Frame	LoadPat	CoordSys	Type	Dir	DistType	RelDist
9	Wind on Live	GLOBAL	Moment	Y	RelDist	0.5
9	Wind on Struct	GLOBAL	Moment	Y	RelDist	0.5

Table: Frame Loads - Point, Part 2 of 2

Table: Frame Loads - Point, Part 2 of 2

Frame	LoadPat	AbsDist ft	Moment Kip-ft	GUID
9	Wind on Live	5.25	380.	cc507092-d86c-45f5-b10c-8774260acd26
9	Wind on Struct	5.25	76.	4364d9f3-8adf-4bbd-91f8-b37e3e73be90

Table: Frame Section Assignments**Table: Frame Section Assignments**

Frame	SectionType	AutoSelect	AnalSect	DesignSect	MatProp
1	Rectangular	N.A.	CAP	CAP	Default
2	Rectangular	N.A.	CAP	CAP	Default
3	Circle	N.A.	Column	Column	Default
4	Circle	N.A.	Column	Column	Default
9	Rectangular	N.A.	CAP	CAP	Default

Table: Frame Section Properties 01 - General, Part 1 of 7**Table: Frame Section Properties 01 - General, Part 1 of 7**

SectionName	Material	Shape	t3 ft	t2 ft	tf ft	tw ft
CAP	4000Psi	Rectangular	5.	5.		
Column	4000Psi	Circle	4.			
FSEC1	A709Gr50	I/Wide Flange	1.	0.41667	0.03167	0.02083

Table: Frame Section Properties 01 - General, Part 2 of 7**Table: Frame Section Properties 01 - General, Part 2 of 7**

SectionName	t2b ft	tfb ft	FilletRadius ft	Area ft2	TorsConst ft4	I33 ft4	I22 ft4
CAP				25.	88.020833	52.083333	52.083333
Column				12.5664	25.132741	12.566371	12.566371
FSEC1	0.41667	0.03167	0.	0.0459	0.000011	0.007615	0.000382

Table: Frame Section Properties 01 - General, Part 3 of 7**Table: Frame Section Properties 01 - General, Part 3 of 7**

SectionName	I23 ft4	AS2 ft2	AS3 ft2	S33Top ft3	S33Bot ft3	S22Left ft3	S22Right ft3
CAP	0.	20.8333	20.8333	20.833333	20.833333	20.833333	20.833333
Column	0.	11.3097	11.3097	6.283185	6.283185	6.283185	6.283185
FSEC1	0.	0.0208	0.022	0.01523	0.01523	0.001836	0.001836

Table: Frame Section Properties 01 - General, Part 4 of 7**Table: Frame Section Properties 01 - General, Part 4 of 7**

SectionName	Z33 ft3	Z22 ft3	R33 ft	R22 ft	CGOffset3 ft	CGOffset2 ft	EccV2 ft
CAP	31.25	31.25	1.44338	1.44338	0.	0.	0.
Column	10.666667	10.666667	1.	1.	0.	0.	0.
FSEC1	0.017346	0.00285	0.4073	0.09128	0.	0.	0.

Table: Frame Section Properties 01 - General, Part 5 of 7**Table: Frame Section Properties 01 - General, Part 5 of 7**

SectionName	EccV3 ft	Cw ft6	ConcCol	ConcBeam	Color	TotalWt Kip	TotalMass Kip-s2/ft
CAP	0.	0.	Yes	No	Cyan	61.875	1.92

Table: Frame Section Properties 01 - General, Part 5 of 7

SectionName	EccV3 ft	Cw ft6	ConcCol	ConcBeam	Color	TotalWt Kip	TotalMass Kip-s2/ft
Column	0.	0.	Yes	No	Yellow	118.752	3.69
FSEC1	0.	0.000089	No	No	White	0.	0.

Table: Frame Section Properties 01 - General, Part 6 of 7

Table: Frame Section Properties 01 - General, Part 6 of 7

SectionName	FromFile	AMod	A2Mod	A3Mod	JMod	I2Mod	I3Mod
CAP	No	1.	1.	1.	1.	1.	1.
Column	No	1.	1.	1.	1.	1.	1.
FSEC1	No	1.	1.	1.	1.	1.	1.

Table: Frame Section Properties 01 - General, Part 7 of 7

Table: Frame Section Properties 01 - General, Part 7 of 7

SectionName	MMod	WMod	GUID	Notes
CAP	1.	1.		Added 3/31/2025 1:27:20 PM
Column	1.	1.		Added 3/31/2025 1:31:11 PM
FSEC1	1.	1.		Added 3/31/2025 1:19:27 PM

Table: Frame Section Properties 02 - Concrete Column, Part 1 of 2

Table: Frame Section Properties 02 - Concrete Column, Part 1 of 2

SectionName	RebarMatL	RebarMatC	ReinfConfig	LatReinf	Cover ft	NumBars3D ir	NumBars2D ir	NumBarsCir c
CAP	A615Gr60	A615Gr60	Rectangular	Ties	0.125	3	3	
Column	A615Gr60	A615Gr60	Circular	Ties	0.125			8

Table: Frame Section Properties 02 - Concrete Column, Part 2 of 2

Table: Frame Section Properties 02 - Concrete Column, Part 2 of 2

SectionName	BarSizeL	BarSizeC	SpacingC ft	NumCBars2	NumCBars3	ReinfType
CAP	#9	#4	0.5	3	3	Design
Column	#9	#4	0.5			Design

Table: Joint Coordinates, Part 1 of 2

Table: Joint Coordinates, Part 1 of 2

Joint	CoordSys	CoordType	XorR ft	Y ft	Z ft	SpecialJt	GlobalX ft
1	GLOBAL	Cartesian	8.25	0.	31.5	No	8.25
2	GLOBAL	Cartesian	-8.25	0.	31.5	No	-8.25
5	GLOBAL	Cartesian	-5.25	0.	0.	No	-5.25
6	GLOBAL	Cartesian	-5.25	0.	31.5	No	-5.25
7	GLOBAL	Cartesian	5.25	0.	0.	No	5.25
8	GLOBAL	Cartesian	5.25	0.	31.5	No	5.25

Table: Joint Coordinates, Part 2 of 2

Table: Joint Coordinates, Part 2 of 2			
Joint	GlobalY ft	GlobalZ ft	GUID
1	0.	31.5	8534217d-d166-49b5-a0e2-d22f0d1805aa
2	0.	31.5	ed8f92bc-c1d1-4204-a211-b527713096ba
5	0.	0.	08e35e46-6761-4146-bf1e-2d06654da472
6	0.	31.5	38726b1b-8e67-4a48-8d88-02004a20bd40
7	0.	0.	88d1f436-66ff-4896-93e6-f6d8b7835c83
8	0.	31.5	5f4c22be-35d1-40f1-a093-e163432f5ebf

Table: Joint Displacements

Table: Joint Displacements								
Joint	OutputCase	CaseType	U1 ft	U2 ft	U3 ft	R1 Radians	R2 Radians	R3 Radians
1	DEAD	LinStatic	-6.075E-08	0.	-0.000338	0.	-3.101E-06	0.
1	Super DL	LinStatic	-4.009E-07	0.	-0.000388	0.	-0.000026	0.
1	Live plus Impact	LinStatic	-2.099E-06	0.	-0.002031	0.	-0.000136	0.
2	DEAD	LinStatic	6.075E-08	0.	-0.000338	0.	3.101E-06	0.
2	Super DL	LinStatic	4.009E-07	0.	-0.000388	0.	0.000026	0.
2	Live plus Impact	LinStatic	2.099E-06	0.	-0.002031	0.	0.000136	0.
5	DEAD	LinStatic	0.	0.	0.	0.	0.	0.
5	Super DL	LinStatic	0.	0.	0.	0.	0.	0.
5	Live plus Impact	LinStatic	0.	0.	0.	0.	0.	0.
6	DEAD	LinStatic	6.075E-08	0.	-0.000343	0.	3.934E-06	0.
6	Super DL	LinStatic	4.009E-07	0.	-0.000465	0.	0.000026	0.
6	Live plus Impact	LinStatic	2.099E-06	0.	-0.002437	0.	0.000136	0.
7	DEAD	LinStatic	0.	0.	0.	0.	0.	0.
7	Super DL	LinStatic	0.	0.	0.	0.	0.	0.
7	Live plus Impact	LinStatic	0.	0.	0.	0.	0.	0.
8	DEAD	LinStatic	-6.075E-08	0.	-0.000343	0.	-3.934E-06	0.
8	Super DL	LinStatic	-4.009E-07	0.	-0.000465	0.	-0.000026	0.
8	Live plus Impact	LinStatic	-2.099E-06	0.	-0.002437	0.	-0.000136	0.
~1	DEAD	LinStatic	4.860E-08	0.	-0.000353	0.	4.431E-06	0.
~1	Super DL	LinStatic	3.208E-07	0.	-0.000511	0.	0.000025	0.
~1	Live plus Impact	LinStatic	1.679E-06	0.	-0.002677	0.	0.000132	0.
~2	DEAD	LinStatic	3.645E-08	0.	-0.000361	0.	4.073E-06	0.
~2	Super DL	LinStatic	2.406E-07	0.	-0.00055	0.	0.000021	0.
~2	Live plus Impact	LinStatic	1.259E-06	0.	-0.002882	0.	0.000112	0.
~3	DEAD	LinStatic	2.430E-08	0.	-0.000368	0.	3.072E-06	0.
~3	Super DL	LinStatic	1.604E-07	0.	-0.00058	0.	0.000015	0.

Table: Joint Displacements

Joint	OutputCase	CaseType	U1 ft	U2 ft	U3 ft	R1 Radians	R2 Radians	R3 Radians
~3	Live plus Impact	LinStatic	8.396E-07	0.	-0.003039	0.	0.000081	0.
~4	DEAD	LinStatic	1.215E-08	0.	-0.000373	0.	1.643E-06	0.
~4	Super DL	LinStatic	8.019E-08	0.	-0.000599	0.	8.104E-06	0.
~4	Live plus Impact	LinStatic	4.198E-07	0.	-0.003137	0.	0.000042	0.
~5	DEAD	LinStatic	7.594E-18	0.	-0.000374	0.	6.584E-19	0.
~5	Super DL	LinStatic	1.123E-17	0.	-0.000605	0.	1.015E-18	0.
~5	Live plus Impact	LinStatic	5.884E-17	0.	-0.00317	0.	5.325E-18	0.
~6	DEAD	LinStatic	-1.215E-08	0.	-0.000373	0.	-1.643E-06	0.
~6	Super DL	LinStatic	-8.019E-08	0.	-0.000599	0.	-8.104E-06	0.
~6	Live plus Impact	LinStatic	-4.198E-07	0.	-0.003137	0.	-0.000042	0.
~7	DEAD	LinStatic	-2.430E-08	0.	-0.000368	0.	-3.072E-06	0.
~7	Super DL	LinStatic	-1.604E-07	0.	-0.00058	0.	-0.000015	0.
~7	Live plus Impact	LinStatic	-8.396E-07	0.	-0.003039	0.	-0.000081	0.
~8	DEAD	LinStatic	-3.645E-08	0.	-0.000361	0.	-4.073E-06	0.
~8	Super DL	LinStatic	-2.406E-07	0.	-0.00055	0.	-0.000021	0.
~8	Live plus Impact	LinStatic	-1.259E-06	0.	-0.002882	0.	-0.000112	0.
~9	DEAD	LinStatic	-4.860E-08	0.	-0.000353	0.	-4.431E-06	0.
~9	Super DL	LinStatic	-3.208E-07	0.	-0.000511	0.	-0.000025	0.
~9	Live plus Impact	LinStatic	-1.679E-06	0.	-0.002677	0.	-0.000132	0.

Table: Joint Loads - Force, Part 1 of 2

Table: Joint Loads - Force, Part 1 of 2

Joint	LoadPat	CoordSys	F1 Kip	F2 Kip	F3 Kip	M1 Kip-ft	M2 Kip-ft
6	Wind on Live	GLOBAL	11.5	0.	0.	0.	0.
6	Wind on Struct	GLOBAL	10.5	0.	0.	0.	0.
6	LF	GLOBAL	0.	31.5	0.	0.	0.
8	Wind on Live	GLOBAL	11.5	0.	0.	0.	0.
8	Wind on Struct	GLOBAL	10.5	0.	0.	0.	0.
8	LF	GLOBAL	0.	31.5	0.	0.	0.

Table: Joint Loads - Force, Part 2 of 2

Table: Joint Loads - Force, Part 2 of 2

Joint	LoadPat	M3 Kip-ft	GUID
6	Wind on Live	0.	ff981045-0348-4fba-82d5-06f510aaac3
6	Wind on Struct	0.	e3dda49c-38c5-4cff-a343-6c41a7e001a3
6	LF	0.	81ded307-6441-4970-b9a4-bf86fced20b7
8	Wind on Live	0.	0b893381-46a8-4ba4-ad3f-b611886e7dc9
8	Wind on Struct	0.	1a653aa9-2d62-44cc-baef-0b25a86693e1

Table: Joint Loads - Force, Part 2 of 2

Joint	LoadPat	M3 Kip-ft	GUID
8	LF	0.	974392c7-ca9d-4bf8-b9c5-0d74eede2e58

Table: Joint Reactions

Table: Joint Reactions

Joint	OutputCase	CaseType	F1 Kip	F2 Kip	F3 Kip	M1 Kip-ft	M2 Kip-ft	M3 Kip-ft
5	DEAD	LinStatic	0.15	0.	100.626	0.	1.5506	0.
5	Super DL	LinStatic	0.991	0.	96.39	0.	10.2337	0.
5	Live plus Impact	LinStatic	5.189	0.	504.63	0.	53.5763	0.
7	DEAD	LinStatic	-0.15	0.	100.626	0.	-1.5506	0.
7	Super DL	LinStatic	-0.991	0.	96.39	0.	-10.2337	0.
7	Live plus Impact	LinStatic	-5.189	0.	504.63	0.	-53.5763	0.

Table: Joint Restraint Assignments

Table: Joint Restraint Assignments

Joint	U1	U2	U3	R1	R2	R3
5	Yes	Yes	Yes	Yes	Yes	Yes
7	Yes	Yes	Yes	Yes	Yes	Yes

Table: Load Case Definitions, Part 1 of 3

Table: Load Case Definitions, Part 1 of 3

Case	Type	InitialCond	ModalCase	BaseCase	MassSource	DesTypeOpt	DesignType
DEAD	LinStatic	Zero				Prog Det	Dead
Super DL	LinStatic	Zero				Prog Det	Dead
Live plus Impact	LinStatic	Zero				Prog Det	Dead
Wind on Live	LinStatic	Zero				Prog Det	Wind
Wind on Struct	LinStatic	Zero				Prog Det	Wind
LF	LinStatic	Zero				Prog Det	Dead

Table: Load Case Definitions, Part 2 of 3

Table: Load Case Definitions, Part 2 of 3

Case	DesActOpt	DesignAct	AutoType	RunCase	CaseStatus	GUID
DEAD	Prog Det	Non-Composite	None	Yes	Finished	a0a58365-e89d-46e8-8a43-8dc35bc15120
Super DL	Prog Det	Non-Composite	None	Yes	Finished	886100ba-75c1-453a-986f-0b2b35498685
Live plus Impact	Prog Det	Non-Composite	None	Yes	Finished	331550e6-c710-4328-a091-5f89111b16f3
Wind on Live	Prog Det	Short-Term Composite	None	Yes	Finished	c66f85e7-e13f-4a05-be8d-9dc7886a1f3c

Table: Load Case Definitions, Part 2 of 3

Case	DesActOpt	DesignAct	AutoType	RunCase	CaseStatus	GUID
Wind on Struct	Prog Det	Short-Term Composite	None	Yes	Finished	7ac30c09-1c6b-44db-a7c-e-fb4759aec35b
LF	Prog Det	Non-Composite	None	Yes	Finished	4057b5e5-62f6-4c1e-bb2-5-6b0af5cefc49

Table: Load Case Definitions, Part 3 of 3

Table: Load Case Definitions, Part 3 of 3

Case	Notes
DEAD	
Super DL	
Live plus Impact	
Wind on Live	
Wind on Struct	
LF	

Table: Load Pattern Definitions

Table: Load Pattern Definitions

LoadPat	DesignType	SelfWtMult	AutoLoad	GUID	Notes
DEAD	Dead	1.		6cbe70a4-e4fc-4da6-937-7-88be7f82fca7	
Super DL	Dead	0.		5d0e0955-c21d-44e3-88b8-c62b83e2e125	Added 3/31/2025 1:38:39 PM
Live plus Impact	Dead	0.		22d2bbe7-3fdd-47be-896-5-e25678aa959c	Added 3/31/2025 2:14:10 PM
Wind on Live	Wind	0.	None	3afc705f-71d4-43f4-9ff7-45965f5ddb50	Added 7/10/2025 4:09:50 PM
Wind on Struct	Wind	0.	None	79db1c3a-4e79-4eea-b227-f4251171c8fd	Added 7/10/2025 4:10:00 PM
LF	Dead	0.		2cc1eab2-cf69-4a54-a764-a2467b637ffc	Added 7/10/2025 4:10:18 PM

Table: Material Properties 01 - General, Part 1 of 2

Table: Material Properties 01 - General, Part 1 of 2

Material	Type	Grade	SymType	TempDepend	Color	GUID
4000Psi	Concrete	f'c 4000 psi	Isotropic	No	Magenta	d27976e1-0a97-4e10-b1aa-6d59daa0f389
A416Gr270	Tendon	Grade 270	Uniaxial	No	Blue	9d9dec5e-5edd-4e94-978c-fa83502c5c31
A615Gr60	Rebar	Grade 60	Uniaxial	No	Red	5d662574-4e5e-4b57-b81b-1239732ac2fe
A709Gr50	Steel	Grade 50	Isotropic	No	Red	

Table: Material Properties 01 - General, Part 2 of 2**Table: Material Properties 01 - General, Part 2 of 2**

Material	Notes
4000Psi	Customary f _c 4000 psi 3/31/2025 1:18:45 PM
A416Gr270	ASTM A416 Grade 270 3/31/2025 1:20:54 PM
A615Gr60	ASTM A615 Grade 60 3/31/2025 1:27:37 PM
A709Gr50	ASTM A709 Grade 50 3/31/2025 1:18:45 PM

Table: Material Properties 03a - Steel Data, Part 1 of 2**Table: Material Properties 03a - Steel Data, Part 1 of 2**

Material	F _y Kip/ft ²	F _u Kip/ft ²	EffF _y Kip/ft ²	EffF _u Kip/ft ²	SSCurveOpt	SSHysType	S _{Hard}	S _{Max}
A709Gr50	7200.	9360.	7920.	10296.	Simple	Kinematic	0.015	0.11

Table: Material Properties 03a - Steel Data, Part 2 of 2**Table: Material Properties 03a - Steel Data, Part 2 of 2**

Material	S _{Rup}	FinalSlope	CoupModType
A709Gr50	0.17	-0.1	Von Mises

Table: Material Properties 03b - Concrete Data, Part 1 of 2**Table: Material Properties 03b - Concrete Data, Part 1 of 2**

Material	F _c Kip/ft ²	eF _c Kip/ft ²	LtWtConc	SSCurveOpt	SSHysType	S _{Fc}	S _{Cap}	FinalSlope
4000Psi	576.	576.	No	Mander	Takeda	0.002219	0.005	-0.1

Table: Material Properties 03b - Concrete Data, Part 2 of 2**Table: Material Properties 03b - Concrete Data, Part 2 of 2**

Material	F _{Angle} Degrees	D _{Angle} Degrees	CoupModType
4000Psi	0.	0.	Modified Darwin-Peck nold

Table: Solid Property Definitions, Part 1 of 2**Table: Solid Property Definitions, Part 1 of 2**

SolidProp	Material	MatAngleA Degrees	MatAngleB Degrees	MatAngleC Degrees	InComp	Color
Solid1	4000Psi	0.	0.	0.	Yes	Gray8Dark

Table: Solid Property Definitions, Part 2 of 2

Table: Solid Property Definitions, Part 2 of 2				
SolidProp	GUID	Notes	TotalWt Kip	TotalMass Kip-s2/ft
Solid1			0.	0.

INTERMEDIATE PILE BENT DESIGN

HNTB	Document number: QF 06
Calculation Cover Sheet	Page 1 of __

Project: NSRR Shoofly over I-70	Job No: 71886	Design Criteria Document: Below
Client: MODOT	Discipline: Bridge	Calculation No:

Name or Description of Calculation: Intermediate pile bent design
--

Note: Unique QF 06 to be created for each revision of a calculation.

Calc. Rev. No.	Description of Change (i.e., Original Issue or description of changes since last revision)	Confirmation required with other deliverables (Y/N)	List Deliverables for which confirmation is required (NA if none) Add additional rows as necessary	Confirmation Verified by Originator of Calc for each deliverable listed (Y/N)

Calculation Objective: Cap and pile design for all intermediate bents except 6 & 7
--

Calculation Methodology/List of Assumptions: AREMA 2024 chapter 15 with some detail items from BNSF standards

References/Inputs: AREMA 2024, BNSF Standard Drawings 2024
--

Attachments: (List each attachment following the subject calculation)
--

Conclusions: Standard style caps 3'x2.67' supported by HP14x117 piles that are socketed into bedrock
--

Document Check:	Name:	Initials:	Date:
Originator:	Todd Kelley	TSK	7/14/2025
Checker:	Jansen Bundridge	JKB	7/17/2025
Backchecker:	Todd Kelley	TSK	7/17/2025
Updater:	Todd Kelley	TSK	7/17/2025
Verifier:	-	-	-

PILE BENT DESIGN HAND CALCULATIONS

NS - Shoofly Pile Bent

- Pier cap is designed as a continuous beam. Assume that dead load and live load from box beam reactions is distributed evenly across the pile cap under the beams. Controlling spans are 48' and 48'. All loads are extracted from CSI model.

References:

AREMA Manual for Railway Engineering, 2024

ACI Building Code Requirements for Structural Concrete 318-14

AISC Steel Construction Manual, 14th Edition

Material Properties

Reinforcing Yield Strength	$f_y := 60 \text{ ksi}$	
Reinf. Steel Modulus of Elasticity	$E_s := 29000 \text{ ksi}$	
Concrete Strength	$f'_c := 4.5 \text{ ksi}$	
Weight of Concrete (For Properties)	$w_c := 145 \text{ pcf}$	(Unreinforced, AREMA 8-2-38)
Concrete Modulus of Elasticity	$E_c := 33 \cdot \left(\frac{w_c}{\text{pcf}}\right)^{1.5} \cdot \sqrt{\frac{f'_c}{\text{psi}}} \cdot \text{psi} = 3865.2 \text{ ksi}$	(AREMA 8-2.23.4)
Modulus of Rupture (Tensile Strength)	$f_r := 7.5 \cdot \sqrt{f'_c \cdot \text{psi}} = 0.503 \text{ ksi}$	(AREMA 8-2.26.1)
Modular Ratio	$n := \text{round}\left(\frac{E_s}{E_c}\right) = 8$	
Weight of Concrete	$\gamma_{conc} := 150 \text{ pcf}$	

Geometry

Steel Girder - W44x230	$Flange_{width} := 15.8 \text{ in}$	
Average Bearing Width	$w_{brg} := 11.33 \text{ ft}$	out to out of girder flanges measured from DGN
Height of Cap	$h_{cap} := 3 \text{ ft}$	
Length of Cap	$L_{cap} := 15 \text{ ft}$	
Cap Width	$w_{cap} := 3 \text{ ft}$	
Span 3 Length - Steel	$L_{span3} := 48 \text{ ft}$	
Span 4 Length - Steel	$L_{span4} := 48 \text{ ft}$	
Concrete Cover	$cover := 2 \text{ in}$	
Section Moment of Inertia	$I_x := \frac{w_{cap} \cdot h_{cap}^3}{12} = 139968 \text{ in}^4$	

Loads

Distributed Dead Load for Span 3

$$w_{DL_span3} := 2.2 \text{ klf} \quad (\text{Entire Superstructure, from Load Calcs})$$

Distributed Dead Load for Span 4

$$w_{DL_span4} := 2.2 \text{ klf} \quad (\text{Entire Superstructure, from Load Calcs})$$

Span 3 Dead Load Reaction

$$R_{DL_span3} := w_{DL_span3} \cdot \frac{L_{span3}}{2} = 52.8 \text{ kip}$$

Span 4 Dead Load Reaction

$$R_{DL_span4} := w_{DL_span4} \cdot \frac{L_{span4}}{2} = 52.8 \text{ kip}$$

Impact Load (*maximum*)

$$IM := \left\| \begin{array}{l} \text{if } L_{span3} < 80 \cdot ft \\ \left\| \left(40 - \frac{3 L_{span3}^2}{1600 \text{ ft}^2} \right) \cdot 0.01 \right\| \\ \text{else} \\ \left\| \left(16 + \frac{600 \text{ ft}}{L_{span3} - 30 \text{ ft}} \right) \cdot 0.01 \right\| \end{array} \right\| = 0.357 \quad (\text{AREMA 8-2-13})$$

Live Load Reaction from Span 1 & 2

$$R_{LL_span} := 2 \cdot 250 \text{ kip} \cdot (1 + IM) = 678.4 \text{ kip} \quad (\text{Used 50' conservatively})$$

Distributed Loads

Distributed Girder DL Reaction

For Span 3

$$w_{DL3} := \frac{R_{DL_span3}}{w_{brg}} = 4.66 \text{ klf}$$

For Span 4

$$w_{DL4} := \frac{R_{DL_span4}}{w_{brg}} = 4.66 \text{ klf}$$

Total:

$$w_{DL_tot} := w_{DL3} + w_{DL4} = 9.3 \text{ klf}$$

Distributed Girder LL Reaction

For Span 3+4

$$w_{LLI} := \frac{R_{LL_span}}{w_{brg}} = 59.876 \text{ klf}$$

Wind Loads

Loads from the superstructure calculations

Wind Load on Live load applied
at 8 ft above rail

$$WL := 0.3 \frac{\text{kip}}{\text{ft}}$$

$$R_{WL} := WL \cdot \frac{(L_{span3} + L_{span4})}{2} = 14.4 \text{ kip}$$

$$Arm_{WL} := 8 \text{ ft} + 8 \text{ in} + 10 \text{ in} + 43 \text{ in} + 4 \text{ in} = 13.417 \text{ ft}$$

$$M_{WL} := R_{WL} \cdot Arm_{WL} = 193.2 \text{ kip} \cdot \text{ft}$$

Wind Load on loaded bridge
applied at superstructure center

$$WS := 0.2 \frac{\text{kip}}{\text{ft}} \quad \text{minimum controls}$$

$$R_{WS} := WS \cdot \left(\frac{L_{span3}}{2} + \frac{L_{span4}}{2} \right) = 9.6 \text{ kip}$$

$$Arm_{WS} := \frac{44 \text{ in} + 4 \text{ in}}{2} = 2 \text{ ft}$$

$$M_{WS} := R_{WS} \cdot Arm_{WS} = 19.2 \text{ kip} \cdot \text{ft}$$

Wind on live load controls

Compare with AREMA 15.1.3.7b wind on loaded structure:
(0.03ksf * 43" girder height * 1.5 = 0.16 klf)

Cap Analysis Results

See CSI output - loads applied CL to
CL of outside piles conservatively

	<u>Dead SW</u>	<u>Dead Super</u>	<u>Live + Impact</u>
Positive Moment	$M_{dead,pos.sw} := 1 \text{ kip} \cdot ft$	$M_{dead,pos.sup} := 13.5 \text{ kip} \cdot ft$	$M_{live,pos} := 81 \text{ kip} \cdot ft$
Negative Moment	$M_{dead,neg.sw} := 1.7 \text{ kip} \cdot ft$	$M_{dead,neg.sup} := 14.77 \text{ kip} \cdot ft$	$M_{live,neg} := 85 \text{ kip} \cdot ft$
Shear	$V_{dead.sw} := 2.5 \text{ kip}$	$V_{dead.sup} := 24.4 \text{ kip}$	$V_{live} := 141 \text{ kip}$
	<u>Wind - Struct</u>	<u>Wind - Live</u>	
Positive Moment	$M_{WS,pos} := 9.6 \text{ kip} \cdot ft$	$M_{WL,pos} := 97 \text{ kip} \cdot ft$	
Negative Moment	$M_{WS,neg} := 9.6 \text{ kip} \cdot ft$	$M_{WL,neg} := 97 \text{ kip} \cdot ft$	
Shear	$V_{WS} := 4.1 \text{ kip}$	$V_{WL} := 41 \text{ kip}$	

Factored loads (Group I)

$$M_{strI,pos} := 1.4 \cdot \left(M_{dead,pos.sw} + M_{dead,pos.sup} + \frac{5}{3} \cdot \langle M_{live,pos} \rangle \right) = 209.3 \text{ kip} \cdot ft$$

$$M_{strI,neg} := 1.4 \cdot \left(M_{dead,neg.sw} + M_{dead,neg.sup} + \frac{5}{3} \cdot \langle M_{live,neg} \rangle \right) = 221.391 \text{ kip} \cdot ft$$

$$V_{strI} := 1.4 \cdot \left(V_{dead.sw} + V_{dead.sup} + \frac{5}{3} \cdot \langle V_{live} \rangle \right) = 366.66 \text{ kip}$$

Factored loads (Group III)

$$M_{strIII,pos} := 1.4 \cdot \left(M_{dead,pos.sw} + M_{dead,pos.sup} + M_{live,pos} + 0.5 \cdot M_{WS,pos} + M_{WL,pos} \right) = 276.22 \text{ kip} \cdot ft$$

$$M_{strIII,neg} := 1.4 \cdot \left(M_{dead,neg.sw} + M_{dead,neg.sup} + M_{live,neg} + 0.5 \cdot M_{WS,neg} + M_{WL,neg} \right) = 284.578 \text{ kip} \cdot ft$$

$$V_{strIII} := 1.4 \cdot \left(V_{dead.sw} + V_{dead.sup} + V_{live} + 0.5 \cdot V_{WS} + V_{WL} \right) = 295.33 \text{ kip}$$

Service loads (Group I)

$$M_{svcel,pos} := M_{dead,pos.sw} + M_{dead,pos.sup} + M_{live,pos} = 95.5 \text{ kip} \cdot ft$$

$$M_{svcel,neg} := M_{dead,neg.sw} + M_{dead,neg.sup} + M_{live,neg} = 101.47 \text{ kip} \cdot ft$$

$$V_{svcel} := V_{dead.sw} + V_{dead.sup} + V_{live} = 167.9 \text{ kip}$$

Flexure (Negative Moment)

(AREMA 8-2.32)

Longitudinal Reinforcing

$$bar_{size.neg} := 8$$

Number of Bars in cross-section

$$n_{bars} := 6$$

Stirrup Reinforcing

$$bar_{size.v} := 5$$

Width of Design Section

$$b := w_{cap} = 3 \text{ ft}$$

Effective Depth

$$d := h_{cap} - cover - \frac{D_b (bar_{size.neg})}{2} - D_b (bar_{size.v}) = 32.875 \text{ in}$$

Area of Flexural Reinforcing

$$A_s := n_{bars} \cdot A_b (bar_{size.neg}) = 4.74 \text{ in}^2$$

Concrete Strength Factor

$$\beta_1 := \max \left(0.65, \min \left(0.85, 0.85 - 0.05 \cdot \frac{f'_c - 4 \text{ ksi}}{\text{ksi}} \right) \right) = 0.825 \quad (\text{AREMA 8-2.31.1(f)})$$

Balanced Reinforcing Ratio

$$\rho_b := \frac{0.85 \cdot \beta_1 \cdot f'_c}{f_y} \cdot \left(\frac{87 \cdot \text{ksi}}{87 \cdot \text{ksi} + f_y} \right) = 0.031 \quad (\text{AREMA 8-2.32.2(b)})$$

Depth of Compression Block

$$a := \frac{A_s \cdot f_y}{0.85 \cdot f'_c \cdot b} = 2.065 \text{ in} \quad (\text{AREMA 8-2.32.2})$$

Verify Tension controlled

$$c := \frac{a}{0.85} = 2.43 \text{ in} \quad (\text{AREMA 8-2.32.2})$$

$$e_{cl} := \text{if} \left(\frac{f_y}{E_s} < 0.002, \frac{f_y}{E_s}, 0.002 \right) = 0.002$$

$$ratio_{ten} := \frac{0.003}{0.003 + e_{cl}}$$

$$tension.check := \text{if} \left(\frac{c}{d} < ratio_{ten}, \text{"OK"}, \text{"NG"} \right) = \text{"OK"}$$

Strength Reduction Factor

$$\phi := 0.9 \quad (\text{AREMA 8-2.30.2(b)})$$

Design Moment Strength

$$\phi M_n := \phi \cdot A_s \cdot f_y \cdot \left(d - \frac{a}{2} \right) = 679.2 \text{ kip} \cdot \text{ft} \quad (\text{AREMA Eq. 8-2-29})$$

Cracking Moment

$$M_{cr} := \frac{f_r \cdot I_x}{\left(\frac{h_{cap}}{2} \right)} = 326.019 \text{ kip} \cdot \text{ft} \quad (\text{AREMA Eq. 8-2-13})$$

Factored Design Moment - 25% is allowed for this combo, but not required in this case.

$$M_u := \left\| \begin{array}{l} \text{if } M_{strIII.neg} > 1.2 \cdot M_{cr} \\ \quad \left\| M_{strIII.neg} \right. \\ \text{else if } 1.2 \cdot M_{cr} > 1.33 \cdot M_{strIII.neg} \\ \quad \left\| 1.33 \cdot M_{strIII.neg} \right. \\ \text{else} \\ \quad \left\| 1.2 \cdot M_{cr} \right. \end{array} \right\| = 378.489 \text{ kip} \cdot \text{ft}$$

Capacity over Demand Ratio

$$\frac{\phi M_n}{M_u} = 1.794$$

$$\text{if} (\phi M_n \geq M_u, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Fatigue Negative Moment

(AREMA 8-2.38)

Dead Load Service Moment

$$M_{dead.neg.sw} + M_{dead.neg.sup} = 16.47 \text{ kip} \cdot \text{ft}$$

Reinforcing Ratio

$$\rho := \frac{A_s}{b \cdot d} = 0.004$$

Find Neutral Axis

$$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n = 0.223$$

Lever Arm Ratio

$$j := 1 - \frac{k}{3} = 0.926$$

Dead Load Stress in Steel

$$f_{s,DL} := \frac{M_{dead.neg.sw} + M_{dead.neg.sup}}{A_s \cdot j \cdot d} = 1.37 \text{ ksi}$$

Total Service Load Stress

$$f_{s,sv} := \frac{M_{svcl.neg}}{A_s \cdot j \cdot d} = 8.442 \text{ ksi}$$

Minimum Stress

$$f_{min} := f_{s,DL} = 1.37 \text{ ksi}$$

Allowable Stress Range

$$f_f := 21 \cdot \text{ksi} - 0.33 \cdot f_{min} + 8 \cdot 0.3 \cdot \text{ksi} = 22.948 \text{ ksi}$$

In-Service Stress Range

$$f_{s.range} := f_{s,sv} - f_{s,DL} = 7.072 \text{ ksi}$$

$$\text{if } (f_{s.range} \leq f_f, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Distribution of Reinforcing - Negative Moment

(AREMA 8-2.39)

Exposure Condition Stress

$$Z := 170 \frac{\text{kip}}{\text{in}}$$

Area of concrete surrounding main tension rebar with same centroid

$$A := \frac{b \cdot \left(\text{cover} + \frac{D_b (\text{bar}_{size.neg})}{2} \right) \cdot 2}{n_{bars}} = 30 \text{ in}^2$$

Distance to tension rebar from extreme tension fiber

$$d_c := \min(\text{cover}, 2 \cdot \text{in}) + \frac{D_b (\text{bar}_{size.neg})}{2} = 2.5 \text{ in}$$

Service Stress in Rebar

$$f_s := f_{s,sv} = 8.442 \text{ ksi}$$

$$\text{if } \left(f_s \leq \min \left(\frac{Z}{\sqrt[3]{d_c \cdot A}}, 0.5 f_y \right), \text{"okay"}, \text{"not okay"} \right) = \text{"okay"}$$

Flexure (Positive Moment)

(AREMA 8-2.32.2)

Longitudinal Reinforcing

$$bar_{size,pos} := 10$$

Number of Bars in cross-section

$$n_{bars} := 6$$

Area of Flexural Reinforcing

$$A_s := n_{bars} \cdot A_b (bar_{size,pos}) = 7.62 \text{ in}^2$$

Depth of Compression Block

$$a := \frac{A_s \cdot f_y}{0.85 \cdot f'_c \cdot b} = 3.32 \text{ in} \quad (\text{AREMA 8-2.32.2})$$

Verify Tension controlled

$$c := \frac{a}{0.85} = 3.906 \text{ in} \quad (\text{AREMA 8-2.32.2})$$

$$e_c := \text{if} \left(\frac{f_y}{E_s} < 0.002, \frac{f_y}{E_s}, 0.002 \right) = 0.002$$

$$ratio_{ten2} := \frac{0.003}{0.003 + e_c}$$

$$tension.check2 := \text{if} \left(\frac{c}{d} < ratio_{ten}, \text{"OK"}, \text{"NG"} \right) = \text{"OK"}$$

Design Moment Strength

$$\phi M_n := \phi \cdot A_s \cdot f_y \cdot \left(d - \frac{a}{2} \right) = 1070.36 \text{ kip} \cdot \text{ft} \quad (\text{AREMA Eq. 8-2-29})$$

Cracking Moment

$$M_{cr} := \frac{f_r \cdot I_x}{\left(\frac{h_{cap}}{2} \right)} = 326.019 \text{ kip} \cdot \text{ft} \quad (\text{AREMA Eq. 8-2-13})$$

Factored Design Moment

$$M_u := \left\| \begin{array}{l} \text{if } M_{strIII,pos} > 1.2 \cdot M_{cr} \\ \quad \left\| M_{strIII,pos} \right\| \\ \text{else if } 1.2 \cdot M_{cr} > 1.33 \cdot M_{strIII,pos} \\ \quad \left\| 1.33 \cdot M_{strIII,pos} \right\| \\ \text{else} \\ \quad \left\| 1.2 \cdot M_{cr} \right\| \end{array} \right\| = 367.373 \text{ kip} \cdot \text{ft}$$

Capacity over Demand Ratio

$$\frac{\phi M_n}{M_u} = 2.914$$

$$\text{if} (\phi M_n \geq M_u, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Fatigue Positive Moment

(AREMA 8-2.38)

Dead Load Service Moment

$$M_{dead.pos.sw} + M_{dead.pos.sup} = 14.5 \text{ kip} \cdot \text{ft}$$

Reinforcing Ratio

$$\rho := \frac{A_s}{b \cdot d} = 0.006$$

Find Neutral Axis

$$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n = 0.274$$

Lever Arm Ratio

$$j := 1 - \frac{k}{3} = 0.909$$

Dead Load Stress in Steel

$$f_{s,DL} := \frac{M_{dead.pos.sw} + M_{dead.pos.sup}}{A_s \cdot j \cdot d} = 0.764 \text{ ksi}$$

Total Service Load Stress

$$f_{s,svl} := \frac{M_{svcl.pos}}{A_s \cdot j \cdot d} = 5.034 \text{ ksi}$$

Minimum Stress

$$f_{min} := f_{s,DL} = 0.764 \text{ ksi}$$

Allowable Stress Range

$$f_f := 21 \cdot \text{ksi} - 0.33 \cdot f_{min} + 8 \cdot 0.3 \cdot \text{ksi} = 23.148 \text{ ksi}$$

In-Service Stress Range

$$f_{s,range} := f_{s,svl} - f_{s,DL} = 4.269 \text{ ksi}$$

$$\text{if } (f_{s,range} \leq f_f, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Distribution of Reinforcing - Positive Moment

(AREMA 8-2.39)

Exposure Condition Stress

$$Z := 170 \frac{\text{kip}}{\text{in}}$$

Area of concrete surrounding main tension rebar with same centroid

$$A := \frac{b \cdot \left(\text{cover} + \frac{D_b (\text{bar}_{size.pos})}{2} \right) \cdot 2}{n_{bars}} = 31.62 \text{ in}^2$$

Distance to tension rebar from extreme tension fiber

$$d_g := \min(\text{cover}, 2 \cdot \text{in}) + \frac{D_b (\text{bar}_{size.pos})}{2} = 2.635 \text{ in}$$

Service Stress in Rebar

$$f_s := f_{s,svl} = 5.034 \text{ ksi}$$

$$\text{if } \left(f_s \leq \min \left(\frac{Z}{\sqrt[3]{d_c \cdot A}}, 0.5 f_y \right), \text{"okay"}, \text{"not okay"} \right) = \text{"okay"}$$

Shear

(AREMA 8-2.35)

Stirrup Spacing

$$s := 9 \text{ in}$$

Section Width

$$b_w := w_{cap} = 3 \text{ ft}$$

Resistance Factor

$$\phi_v := 0.9$$

(AREMA 8-2.30.2(b))

Effective Depth

$$d := h_{cap} - cover - 0.5 \cdot D_b \langle bar_{size.v} \rangle - D_b \langle bar_{size.pos} \rangle = 32.418 \text{ in}$$

Shear Stress Demand

$$v_u := \frac{V_{strl}}{\phi_v \cdot b_w \cdot d} = 0.349 \text{ ksi}$$

(AREMA Eq. 8-2-45)

Shear Stress carried by concrete

$$v_c := 2 \cdot \sqrt{\frac{f'_c}{psi}} \text{ psi} = 0.134 \text{ ksi}$$

(AREMA 8-2.35.2)

Steel Reinforcement

$$A_v := 4 \cdot A_b \langle bar_{size.v} \rangle = 1.24 \text{ in}^2$$

Required Steel Reinforcement

$$A_{v,req} := \frac{\langle v_u - v_c \rangle \cdot w_{cap} \cdot s}{f_y} = 1.161 \text{ in}^2$$

Stirrup Reinforcement Check

$$\text{if} \langle A_v > A_{v,req}, \text{"okay"}, \text{"not okay"} \rangle = \text{"okay"}$$

Stirrup Spacing Check

$$\text{if} \langle s < \min(0.5 \cdot d, 24 \text{ in}), \text{"okay"}, \text{"not okay"} \rangle = \text{"okay"}$$

(AREMA 8-2.10.3)

Socketed Pile Foundations

Number of piles

$$n_{piles} := 4$$

Axial Loads**Dead Load**

Cap (3x3x15)

$$Cap_{DL} := 3 \text{ ft} \cdot 3 \text{ ft} \cdot 15 \text{ ft} \cdot \gamma_{conc} \cdot \frac{1}{n_{piles}} = 5.1 \text{ kip}$$

Piles - HP14x117 - assume 80'
Length - 10' socket into rock
assumed conservatively
Super Dead Load

$$Piles_{DL} := 117 \left(\frac{lb}{ft} \right) \cdot 80 \text{ ft} = 9.4 \text{ kip}$$

$$P_{DL, sup} := (R_{DL, span3} + R_{DL, span4}) \cdot \frac{1}{n_{piles}} = 26.4 \text{ kip}$$

Live Load

Axial Live load excluding impact

$$P_{LL} := 2 \cdot 258 \text{ kip} \cdot \frac{1}{n_{piles}} = 129 \text{ kip}$$

Wind Load - CSI

Axial Wind on Live load

$$P_{WL} := 37 \text{ kip}$$

Axial Wind on Structure

$$P_{WS} := 3.7 \text{ kip}$$

Load Combinations

Group I axial loads

$$P_I := P_{DL, sup} + Cap_{DL} + Piles_{DL} + P_{LL} \cdot (1 + IM) = 215.85 \text{ kip}$$

Group II axial loads (125% allow)

$$P_{II} := P_{DL, sup} + Cap_{DL} + Piles_{DL} + P_{LL} \cdot (1 + IM) + P_{WL} + P_{WS} = 256.55 \text{ kip}$$

Moment Loads on a Single pile

X-X

Wind Load - CSI

Moment Wind on Live load

$$M_{WL, pile, x} := 38 \text{ kip} \cdot \text{ft}$$

Moment Wind on Structure

$$M_{WS, pile, x} := 25 \text{ kip} \cdot \text{ft}$$

Longitudinal Load - CSI

Moment

$$M_{LF, pile, x} := 103 \text{ kip} \cdot \text{ft}$$

Y-Y

Wind Load - CSI

Moment Wind on Live load

$$M_{WL, pile, y} := 117 \cdot \text{kip} \cdot \text{ft}$$

Moment Wind on Structure

$$M_{WS, pile, y} := 42 \text{ kip} \cdot \text{ft}$$

Longitudinal Load - CSI

Moment

$$M_{LF, pile, y} := 15 \text{ kip} \cdot \text{ft}$$

Load Combinations X-X

Group I loads - will not control

Group II loads (125% allow)

$$M_{II, x} := M_{WL, pile, x} + M_{WS, pile, x} + M_{LF, pile, x} = 166 \text{ ft} \cdot \text{kip}$$

Load Combinations Y-Y

Group I loads - will not control

Group II loads (125% allow)

$$M_{II, y} := M_{WL, pile, y} + M_{WS, pile, y} + M_{LF, pile, y} = 174 \text{ ft} \cdot \text{kip}$$

Pile Capacity - Geotechnical

Bearing capacity - from
Geotechnology report - section 7.1

$$q_{all,pile} := 16 \text{ ksi}$$

Pile Size

$$SIZE := \text{"HP14X117"}$$

Pile Area

$$A := 34.4 \text{ in}^2$$

Pile capacity (FS of 2.5)

$$Q_{pile} := \frac{q_{all,pile} \cdot A}{2.5} = 220.2 \text{ kip}$$

4 Pile capacity

$$Q_{pile,4} := Q_{pile} \cdot 4 = 880.6 \text{ kip}$$

Capacity Check

$$Pile_{check} := \text{if}(Q_{pile,4} > P_I, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

Pile Capacity - Structural - 15-1-11

Axial capacity check

$$k_{pile} := 1.2 \quad AISC$$

Assume unbraced L=10 ft

$$r_y := 3.59 \text{ in}$$

$$r_x := 5.96 \text{ in}$$

$$L_{pile} := 10 \text{ ft}$$

$$K_{pile,x} := \frac{k_{pile} \cdot L_{pile}}{r_x} = 24.161$$

$$K_{pile} := \frac{k_{pile} \cdot L_{pile}}{r_y} = 40.111$$

KL/r limit 1

$$K_1 := \frac{0.629}{\sqrt{\frac{f_y}{E_s}}} = 13.828 \quad \text{KL/r limit 2}$$

$$K_2 := \frac{5.034}{\sqrt{\frac{f_y}{E_s}}} = 110.672$$

Stress Limit 1

$$F_{a1} := 0.55 \cdot f_y = 33 \text{ ksi}$$

Stress Limit 2

$$F_{a2} := 0.6 \cdot f_y - \left(17500 \cdot \frac{f_y}{E_s} \right)^{\frac{3}{2}} \cdot (\text{psi}) \cdot K_{pile} = 27.261 \text{ ksi}$$

Stress Limit 3

$$F_{a3} := \frac{0.514 \cdot \pi^2 \cdot E_s}{K_{pile}^2} = 91.438 \text{ ksi}$$

$$F_a := \text{if}(K_{pile} \leq K_1, F_{a1}, \text{if}(K_{pile} < K_2, F_{a2}, F_{a3})) = 27.261 \text{ ksi}$$

$$f_a := \frac{P_I}{A} = 6.275 \text{ ksi}$$

$$Pile_{check}_{axialI} := \text{if}(F_a > f_a, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

$$f_{aII} := \frac{P_{II}}{A} = 7.458 \text{ ksi}$$

$$Pile_{check}_{axialII} := \text{if}(F_a \cdot 1.25 > f_{aII}, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

$$CD_I := \frac{f_a}{F_a} = 0.23$$

$$CD_{II} := \frac{f_{aII}}{F_a} = 0.274$$

Bending Stress - LC II - 125% allowable

HP14x117

$$S_x := 172 \text{ in}^3 \quad S_y := 59.5 \text{ in}^3$$

Tension Check - Bottom Flange X-X

Allowable Tensile Stress

$$f_{all.b.x} := 0.55 \cdot f_y \cdot 1.25 = 41.3 \text{ ksi}$$

(AREMA Table 15-1-12)

Tensile Flange Stress
due to Bending

$$f_{b.x} := \frac{M_{II.x}}{S_x} = 11.6 \text{ ksi}$$

Capacity over Demand Ratio

$$C.D := \frac{f_{all.b.x}}{f_{b.x}} = 3.56$$

$$\text{if } (f_{b.x} \leq f_{all.b.x}, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Tension Check - Bottom Flange Y-Y

Allowable Tensile Stress

$$f_{all.b.y} := 0.55 \cdot f_y \cdot 1.25 = 41.3 \text{ ksi}$$

Tensile Flange Stress
due to Bending

$$f_{b.y} := \frac{M_{II.y}}{S_y} = 35.1 \text{ ksi}$$

Capacity over Demand Ratio

$$C.D := \frac{f_{all.b.y}}{f_{b.y}} = 1.18$$

$$\text{if } (f_{b.y} \leq f_{all.b.y}, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Compression Check - Top Flange X-X

$$A_{tf} := 14.9 \text{ in} \cdot 0.805 \text{ in} = 11.995 \text{ in}^2$$

$$f_{all.1} := 0.55 \cdot f_y - \left(\frac{0.55 \cdot f_y^2}{6.3 \cdot \pi^2 \cdot E_s} \right) \cdot \left(\frac{L_{pile}}{r_y} \right)^2 = 31.773 \text{ ksi}$$

$$f_{all.2} := \frac{0.131 \cdot \pi \cdot E_s}{(L_{pile} \cdot d \cdot \sqrt{1 + 0.3})} = 32.275 \text{ ksi} \quad f_{all.3} := 0.55 \cdot f_y = 33 \text{ ksi}$$

Allowable Compressive Stress

$$f_{c.all} := \text{if } (f_{all.1} < f_{all.2}, \text{if } (f_{all.2} > f_{all.3}, f_{all.3}, f_{all.2}), f_{all.1}) \cdot 1.25 = 40.344 \text{ ksi}$$

Compressive Flange Stress
due to Bending

$$f_c := \frac{M_{II.x}}{S_x} = 11.6 \text{ ksi}$$

(AREMA Table 15-1-12)

Capacity over Demand Ratio

$$C.D := \frac{f_{c.all}}{f_c} = 3.48$$

$$\text{if } (f_c \leq f_{c.all}, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

Compression Check - Top Flange Y-Y

Allowable Compressive Stress

$$f_{all.y} := 0.55 \cdot f_y \cdot 1.25 = 41.25 \text{ ksi}$$

Compressive Flange Stress
due to Bending

$$f_{cy} := \frac{M_{II.y}}{S_y} = 35.1 \text{ ksi}$$

(AREMA Table 15-1-12)

Capacity over Demand Ratio

$$C.D := \frac{f_{all.y}}{f_{cy}} = 1.18$$

$$\text{if } (f_{cy} \leq f_{all.y}, \text{"okay"}, \text{"not okay"}) = \text{"okay"}$$

CSI MODEL OUTPUT

Table: Element Forces - Frames, Part 1 of 2**Table: Element Forces - Frames, Part 1 of 2**

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
1	0.	DEAD	LinStatic	0.	-1.802	0.	0.	0.
1	1.5	DEAD	LinStatic	0.	1.110E-16	0.	0.	0.
2	0.	DEAD	LinStatic	0.	-17.64	0.	0.	0.
2	0.4	DEAD	LinStatic	0.	-13.439	0.	0.	0.
2	0.4	DEAD	LinStatic	0.	-13.439	0.	0.	0.
2	0.8	DEAD	LinStatic	0.	-9.238	0.	0.	0.
2	0.8	DEAD	LinStatic	0.	-9.238	0.	0.	0.
2	1.2	DEAD	LinStatic	0.	-5.038	0.	0.	0.
2	1.2	DEAD	LinStatic	0.	-5.038	0.	0.	0.
2	1.6	DEAD	LinStatic	0.	-0.837	0.	0.	0.
2	1.6	DEAD	LinStatic	0.	-0.837	0.	0.	0.
2	2.	DEAD	LinStatic	0.	3.363	0.	0.	0.
2	2.	DEAD	LinStatic	0.	3.363	0.	0.	0.
2	2.4	DEAD	LinStatic	0.	7.564	0.	0.	0.
2	2.4	DEAD	LinStatic	0.	7.564	0.	0.	0.
2	2.8	DEAD	LinStatic	0.	11.765	0.	0.	0.
2	2.8	DEAD	LinStatic	0.	11.765	0.	0.	0.
2	3.2	DEAD	LinStatic	0.	15.965	0.	0.	0.
2	3.2	DEAD	LinStatic	0.	15.965	0.	0.	0.
2	3.6	DEAD	LinStatic	0.	20.166	0.	0.	0.
2	3.6	DEAD	LinStatic	0.	20.166	0.	0.	0.
2	4.	DEAD	LinStatic	0.	24.366	0.	0.	0.
3	0.	DEAD	LinStatic	0.	-21.003	0.	0.	0.
3	0.4	DEAD	LinStatic	0.	-16.802	0.	0.	0.
3	0.4	DEAD	LinStatic	0.	-16.802	0.	0.	0.
3	0.8	DEAD	LinStatic	0.	-12.602	0.	0.	0.
3	0.8	DEAD	LinStatic	0.	-12.602	0.	0.	0.
3	1.2	DEAD	LinStatic	0.	-8.401	0.	0.	0.
3	1.2	DEAD	LinStatic	0.	-8.401	0.	0.	0.
3	1.6	DEAD	LinStatic	0.	-4.201	0.	0.	0.
3	1.6	DEAD	LinStatic	0.	-4.201	0.	0.	0.
3	2.	DEAD	LinStatic	0.	-1.181E-15	0.	0.	0.
3	2.	DEAD	LinStatic	0.	-1.421E-14	0.	0.	0.
3	2.4	DEAD	LinStatic	0.	4.201	0.	0.	0.
3	2.4	DEAD	LinStatic	0.	4.201	0.	0.	0.
3	2.8	DEAD	LinStatic	0.	8.401	0.	0.	0.
3	2.8	DEAD	LinStatic	0.	8.401	0.	0.	0.
3	3.2	DEAD	LinStatic	0.	12.602	0.	0.	0.
3	3.2	DEAD	LinStatic	0.	12.602	0.	0.	0.
3	3.6	DEAD	LinStatic	0.	16.802	0.	0.	0.
3	3.6	DEAD	LinStatic	0.	16.802	0.	0.	0.
3	4.	DEAD	LinStatic	0.	21.003	0.	0.	0.
4	0.	DEAD	LinStatic	0.	-24.366	0.	0.	0.
4	0.4	DEAD	LinStatic	0.	-20.166	0.	0.	0.
4	0.4	DEAD	LinStatic	0.	-20.166	0.	0.	0.
4	0.8	DEAD	LinStatic	0.	-15.965	0.	0.	0.
4	0.8	DEAD	LinStatic	0.	-15.965	0.	0.	0.
4	1.2	DEAD	LinStatic	0.	-11.765	0.	0.	0.
4	1.2	DEAD	LinStatic	0.	-11.765	0.	0.	0.
4	1.6	DEAD	LinStatic	0.	-7.564	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
4	1.6	DEAD	LinStatic	0.	-7.564	0.	0.	0.
4	2.	DEAD	LinStatic	0.	-3.363	0.	0.	0.
4	2.	DEAD	LinStatic	0.	-3.363	0.	0.	0.
4	2.4	DEAD	LinStatic	0.	0.837	0.	0.	0.
4	2.4	DEAD	LinStatic	0.	0.837	0.	0.	0.
4	2.8	DEAD	LinStatic	0.	5.038	0.	0.	0.
4	2.8	DEAD	LinStatic	0.	5.038	0.	0.	0.
4	3.2	DEAD	LinStatic	0.	9.238	0.	0.	0.
4	3.2	DEAD	LinStatic	0.	9.238	0.	0.	0.
4	3.6	DEAD	LinStatic	0.	13.439	0.	0.	0.
4	3.6	DEAD	LinStatic	0.	13.439	0.	0.	0.
4	4.	DEAD	LinStatic	0.	17.64	0.	0.	0.
5	0.	DEAD	LinStatic	0.	-1.802	0.	0.	0.
5	1.5	DEAD	LinStatic	0.	2.776E-15	0.	0.	0.

Table: Element Forces - Frames, Part 2 of 2

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
1	0.	DEAD	-1.3517	1-1	0.
1	1.5	DEAD	2.665E-15	1-1	1.5
2	0.	DEAD	-1.3517	2-1	0.
2	0.4	DEAD	4.864	2-1	0.4
2	0.4	DEAD	4.864	2-2	0.
2	0.8	DEAD	9.3994	2-2	0.4
2	0.8	DEAD	9.3994	2-3	0.
2	1.2	DEAD	12.2546	2-3	0.4
2	1.2	DEAD	12.2546	2-4	0.
2	1.6	DEAD	13.4296	2-4	0.4
2	1.6	DEAD	13.4296	2-5	0.
2	2.	DEAD	12.9243	2-5	0.4
2	2.	DEAD	12.9243	2-6	0.
2	2.4	DEAD	10.7388	2-6	0.4
2	2.4	DEAD	10.7388	2-7	0.
2	2.8	DEAD	6.8731	2-7	0.4
2	2.8	DEAD	6.8731	2-8	0.
2	3.2	DEAD	1.3271	2-8	0.4
2	3.2	DEAD	1.3271	2-9	0.
2	3.6	DEAD	-5.8992	2-9	0.4
2	3.6	DEAD	-5.8992	2-10	0.
2	4.	DEAD	-14.8056	2-10	0.4
3	0.	DEAD	-14.8056	3-1	0.
3	0.4	DEAD	-7.2446	3-1	0.4
3	0.4	DEAD	-7.2446	3-2	0.
3	0.8	DEAD	-1.3637	3-2	0.4
3	0.8	DEAD	-1.3637	3-3	0.
3	1.2	DEAD	2.8369	3-3	0.4
3	1.2	DEAD	2.8369	3-4	0.
3	1.6	DEAD	5.3572	3-4	0.4
3	1.6	DEAD	5.3572	3-5	0.
3	2.	DEAD	6.1974	3-5	0.4
3	2.	DEAD	6.1974	3-6	0.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
3	2.4	DEAD	5.3572	3-6	0.4
3	2.4	DEAD	5.3572	3-7	0.
3	2.8	DEAD	2.8369	3-7	0.4
3	2.8	DEAD	2.8369	3-8	0.
3	3.2	DEAD	-1.3637	3-8	0.4
3	3.2	DEAD	-1.3637	3-9	0.
3	3.6	DEAD	-7.2446	3-9	0.4
3	3.6	DEAD	-7.2446	3-10	0.
3	4.	DEAD	-14.8056	3-10	0.4
4	0.	DEAD	-14.8056	4-1	0.
4	0.4	DEAD	-5.8992	4-1	0.4
4	0.4	DEAD	-5.8992	4-2	0.
4	0.8	DEAD	1.3271	4-2	0.4
4	0.8	DEAD	1.3271	4-3	0.
4	1.2	DEAD	6.8731	4-3	0.4
4	1.2	DEAD	6.8731	4-4	0.
4	1.6	DEAD	10.7388	4-4	0.4
4	1.6	DEAD	10.7388	4-5	0.
4	2.	DEAD	12.9243	4-5	0.4
4	2.	DEAD	12.9243	4-6	0.
4	2.4	DEAD	13.4296	4-6	0.4
4	2.4	DEAD	13.4296	4-7	0.
4	2.8	DEAD	12.2546	4-7	0.4
4	2.8	DEAD	12.2546	4-8	0.
4	3.2	DEAD	9.3994	4-8	0.4
4	3.2	DEAD	9.3994	4-9	0.
4	3.6	DEAD	4.864	4-9	0.4
4	3.6	DEAD	4.864	4-10	0.
4	4.	DEAD	-1.3517	4-10	0.4
5	0.	DEAD	-1.3517	5-1	0.
5	1.5	DEAD	-1.332E-15	5-1	1.5

Table: Frame Loads - Distributed, Part 1 of 3

Table: Frame Loads - Distributed, Part 1 of 3

Frame	LoadPat	CoordSys	Type	Dir	DistType	RelDistA
2	DEAD	GLOBAL	Force	Gravity	RelDist	0.
2	E80 Reaction	GLOBAL	Force	Gravity	RelDist	0.
3	DEAD	GLOBAL	Force	Gravity	RelDist	0.
3	E80 Reaction	GLOBAL	Force	Gravity	RelDist	0.
4	DEAD	GLOBAL	Force	Gravity	RelDist	0.
4	E80 Reaction	GLOBAL	Force	Gravity	RelDist	0.

Table: Frame Loads - Distributed, Part 2 of 3

Table: Frame Loads - Distributed, Part 2 of 3

Frame	LoadPat	RelDistB	AbsDistA ft	AbsDistB ft	FOverLA Kip/ft	FOverLB Kip/ft
2	DEAD	1.	0.	4.	9.3	9.3
2	E80 Reaction	1.	0.	4.	59.88	59.88
3	DEAD	1.	0.	4.	9.3	9.3
3	E80 Reaction	1.	0.	4.	59.88	59.88

Table: Frame Loads - Distributed, Part 2 of 3

Frame	LoadPat	RelDistB	AbsDistA ft	AbsDistB ft	FOverLA Kip/ft	FOverLB Kip/ft
4	DEAD	1.	0.	4.	9.3	9.3
4	E80 Reaction	1.	0.	4.	59.88	59.88

Table: Frame Loads - Distributed, Part 3 of 3

Table: Frame Loads - Distributed, Part 3 of 3

Frame	LoadPat	GUID
2	DEAD	637ee67f-34af-467c-831e-af90fba459f0
2	E80 Reaction	ba5eabad-8ff2-4d35-8f7c-b5e6aada42dd
3	DEAD	4953a584-c896-4e7a-b449-4f731b90aecd
3	E80 Reaction	78ad6970-159b-4d2a-ad60-ddcba0ae9e5e
4	DEAD	4c00942b-35ee-4dd8-9026-a5cf544e0a52
4	E80 Reaction	6b66a324-26fc-44b4-9828-245d51dc729d

Table: Frame Section Assignments

Table: Frame Section Assignments

Frame	SectionType	AutoSelect	AnalSect	DesignSect	MatProp
1	Rectangular	N.A.	CAP	CAP	Default
2	Rectangular	N.A.	CAP	CAP	Default
3	Rectangular	N.A.	CAP	CAP	Default
4	Rectangular	N.A.	CAP	CAP	Default
5	Rectangular	N.A.	CAP	CAP	Default

Table: Frame Section Properties 01 - General, Part 1 of 7

Table: Frame Section Properties 01 - General, Part 1 of 7

SectionName	Material	Shape	t3 ft	t2 ft	tf ft	tw ft
CAP	4000Psi	Rectangular	2.67	3.		
HP14x117	A709Gr50	I/Wide Flange	1.18	1.24	0.067	0.067

Table: Frame Section Properties 01 - General, Part 2 of 7

Table: Frame Section Properties 01 - General, Part 2 of 7

SectionName	t2b ft	tfb ft	FilletRadius ft	Area ft2	TorsConst ft4	I33 ft4	I22 ft4
CAP				8.01	8.919719	4.758541	6.0075
HP14x117	1.24	0.067	0.	0.2362	0.000341	0.05791	0.021317

Table: Frame Section Properties 01 - General, Part 3 of 7

Table: Frame Section Properties 01 - General, Part 3 of 7							
SectionName	I23 ft4	AS2 ft2	AS3 ft2	S33Top ft3	S33Bot ft3	S22Left ft3	S22Right ft3
CAP	0.	6.675	6.675	3.56445	3.56445	4.005	4.005
HP14x117	0.	0.0791	0.1385	0.098153	0.098153	0.034382	0.034382

Table: Frame Section Properties 01 - General, Part 4 of 7

Table: Frame Section Properties 01 - General, Part 4 of 7							
SectionName	Z33 ft3	Z22 ft3	R33 ft	R22 ft	CGOffset3 ft	CGOffset2 ft	EccV2 ft
CAP	5.346675	6.0075	0.77076	0.86603	0.	0.	0.
HP14x117	0.110794	0.052683	0.49511	0.30039	0.	0.	0.

Table: Frame Section Properties 01 - General, Part 5 of 7

Table: Frame Section Properties 01 - General, Part 5 of 7							
SectionName	EccV3 ft	Cw ft6	ConcCol	ConcBeam	Color	TotalWt Kip	TotalMass Kip-s2/ft
CAP	0.	0.	Yes	No	Magenta	18.023	0.56
HP14x117	0.	0.006594	No	No	Green	0.	0.

Table: Frame Section Properties 01 - General, Part 6 of 7

Table: Frame Section Properties 01 - General, Part 6 of 7							
SectionName	FromFile	AMod	A2Mod	A3Mod	JMod	I2Mod	I3Mod
CAP	No	1.	1.	1.	1.	1.	1.
HP14x117	No	1.	1.	1.	1.	1.	1.

Table: Frame Section Properties 01 - General, Part 7 of 7

Table: Frame Section Properties 01 - General, Part 7 of 7				
SectionName	MMod	WMod	GUID	Notes
CAP	1.	1.		Added 4/7/2025 11:21:17 AM
HP14x117	1.	1.		Added 7/6/2025 2:05:51 PM

Table: Joint Coordinates, Part 1 of 2

Table: Joint Coordinates, Part 1 of 2							
Joint	CoordSys	CoordType	XorR ft	Y ft	Z ft	SpecialJt	GlobalX ft
1	GLOBAL	Cartesian	-7.5	0.	0.	No	-7.5
2	GLOBAL	Cartesian	-6.	0.	0.	No	-6.
3	GLOBAL	Cartesian	-2.	0.	0.	No	-2.
4	GLOBAL	Cartesian	2.	0.	0.	No	2.
5	GLOBAL	Cartesian	6.	0.	0.	No	6.
6	GLOBAL	Cartesian	7.5	0.	0.	No	7.5

Table: Joint Coordinates, Part 2 of 2

Table: Joint Coordinates, Part 2 of 2			
Joint	GlobalY ft	GlobalZ ft	GUID
1	0.	0.	7f72fa35-af06-4277-be19 -d6a3a1934a82
2	0.	0.	0c7acf2e-2701-4baf-bf5e -a1c7a86c47fb
3	0.	0.	75a9c4c4-a892-4123-b1 80-4c13c75f760c
4	0.	0.	bb38e22b-fe21-453a-bea 1-8ac063932f0c
5	0.	0.	809a0159-1084-471a-ae 2d-6131f207d755
6	0.	0.	bda850a7-fea9-4700-ba6 3-91b2e670c7f9

Table: Joint Displacements

Table: Joint Displacements								
Joint	OutputCase	CaseType	U1 ft	U2 ft	U3 ft	R1 Radians	R2 Radians	R3 Radians
1	DEAD	LinStatic	0.	0.	0.000012	0.	8.667E-06	0.
2	DEAD	LinStatic	0.	0.	0.	0.	8.941E-06	0.
3	DEAD	LinStatic	0.	0.	0.	0.	-6.507E-07	0.
4	DEAD	LinStatic	0.	0.	0.	0.	6.507E-07	0.
5	DEAD	LinStatic	0.	0.	0.	0.	-8.941E-06	0.
6	DEAD	LinStatic	0.	0.	0.000012	0.	-8.667E-06	0.
~1	DEAD	LinStatic	0.	0.	-7.854E-06	0.	8.634E-06	0.
~2	DEAD	LinStatic	0.	0.	-0.000014	0.	7.456E-06	0.
~3	DEAD	LinStatic	0.	0.	-0.000019	0.	5.680E-06	0.
~4	DEAD	LinStatic	0.	0.	-0.000022	0.	3.578E-06	0.
~5	DEAD	LinStatic	0.	0.	-0.000022	0.	1.422E-06	0.
~6	DEAD	LinStatic	0.	0.	-0.000021	0.	-5.166E-07	0.
~7	DEAD	LinStatic	0.	0.	-0.000018	0.	-1.965E-06	0.
~8	DEAD	LinStatic	0.	0.	-0.000013	0.	-2.652E-06	0.
~9	DEAD	LinStatic	0.	0.	-6.808E-06	0.	-2.304E-06	0.
~10	DEAD	LinStatic	0.	0.	-5.370E-06	0.	1.112E-06	0.
~11	DEAD	LinStatic	0.	0.	-0.00001	0.	1.786E-06	0.
~12	DEAD	LinStatic	0.	0.	-0.000014	0.	1.644E-06	0.
~13	DEAD	LinStatic	0.	0.	-0.000016	0.	9.582E-07	0.
~14	DEAD	LinStatic	0.	0.	-0.000017	0.	0.	0.
~15	DEAD	LinStatic	0.	0.	-0.000016	0.	-9.582E-07	0.
~16	DEAD	LinStatic	0.	0.	-0.000014	0.	-1.644E-06	0.
~17	DEAD	LinStatic	0.	0.	-0.00001	0.	-1.786E-06	0.
~18	DEAD	LinStatic	0.	0.	-5.370E-06	0.	-1.112E-06	0.
~19	DEAD	LinStatic	0.	0.	-6.808E-06	0.	2.304E-06	0.
~20	DEAD	LinStatic	0.	0.	-0.000013	0.	2.652E-06	0.
~21	DEAD	LinStatic	0.	0.	-0.000018	0.	1.965E-06	0.
~22	DEAD	LinStatic	0.	0.	-0.000021	0.	5.166E-07	0.
~23	DEAD	LinStatic	0.	0.	-0.000022	0.	-1.422E-06	0.
~24	DEAD	LinStatic	0.	0.	-0.000022	0.	-3.578E-06	0.
~25	DEAD	LinStatic	0.	0.	-0.000019	0.	-5.680E-06	0.
~26	DEAD	LinStatic	0.	0.	-0.000014	0.	-7.456E-06	0.
~27	DEAD	LinStatic	0.	0.	-7.854E-06	0.	-8.634E-06	0.

Table: Joint Reactions

Table: Joint Reactions								
Joint	OutputCase	CaseType	F1 Kip	F2 Kip	F3 Kip	M1 Kip-ft	M2 Kip-ft	M3 Kip-ft
2	DEAD	LinStatic	0.	0.	19.442	0.	0.	0.
3	DEAD	LinStatic	0.	0.	45.369	0.	0.	0.
4	DEAD	LinStatic	0.	0.	45.369	0.	0.	0.
5	DEAD	LinStatic	0.	0.	19.442	0.	0.	0.

GEOTECHNICAL REPORT



GEOTECHNOLOGY

A Universal Engineering Sciences Company

**GEOTECHNICAL EXPLORATION
I-70 CORRIDOR IMPROVEMENTS
MoDOT PROJECT No. J6I0624
WENTZVILLE, MISSOURI**

Prepared for:

**HDR ENGINEERING, INC.
ST. LOUIS, MISSOURI**

Prepared by:

**GEOTECHNOLOGY, LLC
ST. LOUIS, MISSOURI**

Date:

APRIL 6, 2022

Geotechnology Project No.:

J032438.03

SAFETY
QUALITY
INTEGRITY
PARTNERSHIP
OPPORTUNITY
RESPONSIVENESS



April 6, 2022

Mr. Kevin Kriete, P.E.
HDR Engineering, Inc.
401 South 18th Street, Suite 300
St. Louis, Missouri 63103

Re: Geotechnical Exploration
I-70 Corridor Improvements
MoDOT Project No. J6I0624
Wentzville, Missouri
Geotechnology Project No. J032438.03

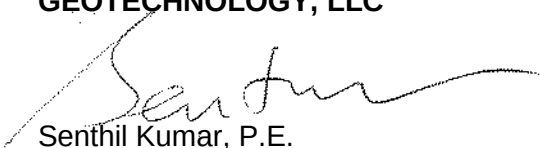
Dear Mr. Kriete:

Presented in this report are the results of a geotechnical exploration conducted for the referenced project. This report includes our project understanding, observed site conditions, conclusions and/or recommendations, and support data as given in the Table of Contents.

It has been our pleasure to provide geotechnical services to you, and we would welcome the opportunity to provide other services during the course of the project. Please contact us if you need further information or clarification about this document.

Very truly yours,

GEOTECHNOLOGY, LLC


Senthil Kumar, P.E.
Principal Engineer




Anthony W. Roth, P.E.
Senior Project Manager

SK/AWR/CKK:sk/jf

Copies submitted: (1) pdf



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**GEOTECHNICAL EXPLORATION
I-70 CORRIDOR IMPROVEMENTS
MODOT PROJECT NO. J610624
WENTZVILLE, MISSOURI
April 6, 2022 | Geotechnology Project No. J032438.03**

1.0 INTRODUCTION

The services documented in this report were provided in accordance with the February 5, 2022 amendment to subconsultant agreement between Geotechnology and HDR Engineering, Inc.

The purpose of the geotechnical exploration was to develop a general subsurface profile at the site and prepare recommendations for the geotechnical aspects of the design and construction of the project as defined in our proposal. Our scope of services included site reconnaissance, review of existing geotechnical data, geotechnical borings and test pits, laboratory testing, engineering analyses, preparing interim design memoranda, and preparing this report.

A copy of "Important Information about This Geotechnical-Engineering Report," published by the Geotechnical Business Council (GBC) of the Geoprofessional Business Association (GBA), is included in Appendix A for your review. The publication discusses report limitations and ways to manage risk associated with subsurface conditions.

2.0 PROJECT INFORMATION

The project includes improvements to Interstate I-70 between Wentzville Parkway and Route Z in Wentzville, Missouri. The site location and general topography of the area as per the 2017 USGS map of the vicinity are shown on Figure 1 included in Appendix B. The improvements will include a new Norfolk-Southern Railroad (NSRR) overpass at I-70, temporary NSRR shoofly bridge, safety improvements and additional lanes in each direction of I-70, widening of the east and west bound I-70 bridge overpasses at Route Z by 20 feet to accommodate the new lanes and realignment of an approximately 1,500 feet of Mar-Le Drive. The proposed layout of the planned improvements is shown on Figures 2 through 7. Brief descriptions of the planned structures are given below.

- **I-70** – Road improvements will include relocating the centerline of I-70 approximately 65 feet southwest of its existing location in the vicinity of the NSRR Bridge and widening I-70 to three lanes in each direction including 12-foot wide inside and outside shoulders. Safety improvements will include improving horizontal curvature, increased sight distance and standard shoulder widths. In addition, the I-70 profile beneath the NSRR alignment will be lowered to provide a standard vertical clearance of 16.5 feet. Ramps at the Route Z interchange are planned to be improved or reconstructed.



- **I-70 Bridges** - The existing eastbound (A4320) and westbound (A4323) I-70 bridges over Route Z will be widened to the outside by approximately 20 feet to facilitate an additional 12-foot lane and a 12-foot shoulder in each direction.
- **Shoofly Bridge** - An approximately 2,500-foot-long shoofly alignment is planned to maintain rail and I-70 traffic throughout construction. The approximately 338-foot long, seven-span, shoofly bridge will be located just south of the existing NSRR tracks.
- **Main Track Bridge** – The proposed four-span, main track bridge over I-70 at mile post S-45.2 will be approximately 387 feet long and will be located approximately along the same horizontal and vertical alignment as the current bridge.
- **Mar-Le Drive** – An approximately 1,500-foot section of Mar-Le Drive will be realigned adjacent to I-70. The realignment will include design and construction of an approximately 1,050 feet long retaining wall along Mar-Le Drive.

3.0 PREVIOUS STUDY

MoDOT performed a geotechnical exploration for the existing eastbound (A4320) and westbound (A4323) I-70 bridges in April 1985. Eight borings were drilled during the geotechnical exploration. Soil stratigraphy generally consist of gravelly, lean clay, occasionally fat clay mixed with boulders to the depths of auger refusal. Auger refusal occurred between 1 and 46 feet (El 551¹ to 590) in the borings. Auger refusal was deeper to the west. Rock was cored in four borings and generally consist of very hard, medium to coarse grained, thin bedded limestone. Relevant data from this exploration are incorporated into this report. Boring locations and associated logs shown in the MoDOT drawings are included in Appendix C.

4.0 GEOTECHNICAL EXPLORATION

The field exploration consisted of drilling twelve borings (Borings B-9 through B-21, except B-17) for NSRR main and shoofly alignments, six borings (Borings B-22 through B-27) for I-70 widening, eight borings (Borings B-101, B-102, B-201, B-202, B-301, B-302, B-401, and B-402) for I-70 bridge widening at Route Z, and 39 borings (Borings B-59 through B-98, except B-97) for Mar-Le Drive realignment and retaining wall design. The Mar-Le Drive borings were generally probe borings to auger refusal with no soil sampling, except for six borings (Borings B-62, B-69, B-70, B-78, B-86 and B-94), where sampling was performed. In addition, three test pits designated as TP-1 through TP-3 were excavated in an anticipated borrow area. The boring and test pit locations are shown on Figures 2 through 7 in Appendix B. The borings and test pits were located in the field by Geotechnology by measuring distances from existing site features and

¹ Elevations herein are in units of feet and refer to North American Vertical Datum (NAVD) 1988.



subsequently surveyed by the project surveyor. The elevations at the boring and test pit locations, as shown on the boring/test pit logs, were provided by the project surveyor.

The borings were drilled to auger refusal using CME 55LC, 85, 550X and 750Y rotary drill rigs equipped with hollow stem augers. Standard Penetration Tests (SPTs) were performed using an automatic hammer. A memorandum of drill rig SPT hammer efficiencies is included as Appendix D. Split-spoon samples and relatively undisturbed Shelby tube samples were obtained at the depths indicated on the boring logs presented in Appendix E. Rock was cored in 28 borings using double-tube NQ2 wireline methods. Rock core photographs are included in Appendix F. Photographs of recovered pavement core samples are included in Appendix G. A legend of the terms and symbols used on the boring logs and rock core descriptions are included in Appendix E.

The test pits were excavated with a backhoe to depths of approximately 15 to 19 feet. Representative grab samples of soils were collected from the backhoe bucket at the depths indicated on the test pit logs presented in Appendix E. In addition, representative bulk samples were obtained for laboratory compaction testing. Photographs of the excavations are included as Appendix H.

Engineers and geologists from Geotechnology provided direction during field exploration, observed drilling, sampling and test pit excavation, assisted in obtaining samples and prepared logs of the recovered material. The boring and test pit logs represent conditions observed at the time of exploration, and have been edited to incorporate results of the laboratory tests.

Unless noted on the boring and test pit logs, the lines designating the changes between various strata represent approximate boundaries. The transition between materials could be gradual or could occur between recovered samples. The stratification given on the boring and test pit logs, or described herein, is for use by Geotechnology in its analyses and should not be used as the basis of design or construction cost estimates without realizing that there can be variation from that shown or described.

The boring and test pit logs and related information depict subsurface conditions only at the specific locations and times where sampling was conducted. The passage of time could result in changes in conditions, interpreted to exist, at or between the locations where sampling was conducted.

5.0 LABORATORY TESTING

Laboratory testing was performed on the soil samples to estimate engineering and index properties. Moisture contents and Atterberg limits tests were performed on selected cohesive samples. Unconfined compression, unconsolidated-undrained (UU) and consolidated -undrained (CU) triaxial, direct shear and consolidation tests were performed on selected Shelby tube samples. Grain size analyses and wash sieve testing were performed on representative samples. Standard Proctor (ASTM D 698) tests were performed on a representative bulk sample. Fertility testing on selected bulk samples, was performed and reported separately by MoDOT.



Compressive strength tests were performed on representative rock core samples. Rock core compressive strength results are summarized in Table 1. Laboratory test results are presented on the boring logs in Appendix E and/or in Appendix I.

Table 1. Limestone Rock Compressive Strength Data

Boring No.	Sample		Unit Weight (pcf)	Compressive Strength	
	Depth (ft)	Elevation (ft)		(psi)	(ksf)
B-9	18.0	604.0	161	14,090	2,029
	22.5	599.5	162	13,581	1,956
	26.5	595.5	165	17,180	2,474
	32.0	590.0	161	17,878	2,574
	37.3	584.8	161	19,196	2,764
B-10	22.0	598.5	164	14,045	2,022
	27.0	593.5	166	15,752	2,268
B-11	17.3	604.4	160	7,790	1,122
	21.5	600.1	161	14,547	2,095
	25.5	596.1	166	13,405	1,930
	31.3	590.4	150	11,074	1,595
	37.0	584.6	167	15,828	2,279
B-12	22.8	605.2	157	9,222	1,328
	27.8	600.2	162	18,247	2,628
	33.5	594.4	162	11,388	1,640
	39.3	588.7	164	15,010	2,161
	44.0	583.9	164	12,052	1,735
B-14	34.3	604.3	163	12,484	1,798
	40.1	598.5	166	16,593	2,389
	44.4	594.2	166	15,987	2,302
	49.2	589.4	156	12,916	1,860
	54.7	583.9	166	14,795	2,131
B-15	27.8	603.7	155	6,430	926
	33.4	598.1	165	18,824	2,711
	40.8	590.7	150	9,769	1,407
	44.8	586.7	154	11,528	1,660
	50.8	580.7	161	15,557	2,240
B-16	22.0	605.0	160	10,546	1,519
	26.5	600.5	161	13,556	1,952
	31.5	595.5	166	14,251	2,052
	36.5	590.5	149	14,575	2,099
	43.5	583.5	166	11,531	1,660
B-23	17.3	606.1	162	13,948	2,009
	24.5	598.8	164	15,890	2,288
	27.0	596.3	163	15,544	2,238
B-25	13.3	600.9	165	18,490	2,663
	19.5	594.6	162	16,761	2,414



Boring No.	Sample		Unit Weight (pcf)	Compressive Strength	
	Depth (ft)	Elevation (ft)		(psi)	(ksf)
B-26	27.0	583.2	153	14,048	2,023
	31.0	579.2	163	12,658	1,823
B-27	15.5	590.9	164	18,448	2,657
	19.5	586.9	161	11,552	1,663
B-101	7.0	592.6	163	14,745	2,123
	23.5	576.1	162	13,261	1,910
	33.8	565.9	163	13,511	1,946
B-201	12.0	566.0	149	13,553	1,952
	23.3	554.8	137	4,219	608
	27.0	551.0	149	6,987	1,006
B-202	13.5	558.8	154	6,182	890
	18.0	554.3	152	11,035	1,589
	26.5	545.8	139	6,691	963
	31.5	540.8	165	15,065	2,169
	36.0	536.3	155	8,243	1,187
B-301	6.0	572.4	157	7,909	1,139
	11.5	566.9	154	9,162	1,319
	16.5	561.9	153	4,552	655
	20.0	558.4	153	6,938	999
	24.0	554.4	154	7,519	1,083
B-302	7.5	566.0	150	9,416	1,356
	12.0	561.5	148	5,052	727
	16.0	557.5	147	5,042	726
	19.5	554.0	159	25,650	3,694
	28.0	545.5	131	6,248	900
B-401	9.2	590.0	165	12,508	1,801
	13.5	585.7	166	16,377	2,358
	17.5	581.7	158	13,814	1,989
B-402	19.0	580.3	152	24,180	3,482
	22.0	577.3	161	5,174	745

6.0 SUBSURFACE CONDITIONS

6.1 Stratigraphy

6.1.1 NSRR Shoofly and Main Track Bridges

Borings B-9 through B-21 were drilled for the proposed shoofly and main track bridges and alignment. Borings B-9, B-10 and B-11 were drilled within the pavement of I-70. The pavement generally consists of 2 to 6 inches of asphalt underlain by 8 to 15 inches of concrete. The soil stratigraphy in the borings generally consists of fill, lean clay/silt, fat clay, and sand to auger refusal. A generalized subsurface profile is shown on Figure 8.



Fill. Fill is present in Borings B-9, B-13, B-19 and B-20 to depths of 3 to 12 feet. Fill generally consists of lean and fat clays mixed with occasional sand, gravel and asphalt.

Lean Clay/Silt. Approximately 3 to 23 feet of lean clay/silt is present in all borings except Borings B-13, B-18 and B-21. In Borings B-9 and B-10, the silt extends to the depths of auger refusal. The consistency of the lean clay/silt varies from very soft to very stiff, but typically is soft to stiff.

Fat Clay. In all borings other than Borings B-9 and B-10, fat clay is present. The thickness of the fat clay varies between 2.5 to 44 feet. The consistency of the fat clay varies from medium stiff to hard, occasionally soft.

Sand. In Borings B-12, B-13, B-19 and B-20, medium dense to dense, occasionally loose silty sand is present. The thickness of the sand layer varies between 4 and 15 feet.

Limestone. Auger refusal occurred in all borings at approximate depths of 13 to 44 feet (El 599 to 609). Auger refusal elevations at the boring locations are shown on Figure 3 in Appendix B. Drill rig augers can often penetrate several feet into soft or broken rock, and therefore these elevations do not necessarily represent top of rock.

Bedrock was cored in Borings B-9 through B-16 and consists generally of medium strong to very strong, gray, aphanitic to finely crystalline limestone. The rock is thin to thick bedded and slightly weathered to unweathered. Bedrock core samples had recoveries of 100 percent and rock quality designation (RQD)² values of 47 to 94 percent, but typically above 75 percent indicating a good to excellent quality rock. Unconfined compressive strength tests in the limestone ranged from 6,430 to 19,196 pounds per square inch (psi).

6.1.2 I-70/Route Z Interchange Bridges

Borings B-101, B-102, B-201, B-202, B-301, B-302, B-401 and B-402 were drilled in the vicinity of the proposed I-70/Route Z interchange bridges. Asphalt/concrete pavement occurs to approximate depths of 10.5 to 13 inches at each boring location. In Borings B-201, B-202, B-301 and B-302, no soil stratum is present. In Borings B-102 and B-402 below the pavement, fill is present to depths of 2 to 4 feet. The fill in Boring B-102 and B-402 consists of crushed rock and clay, and fat clay with trace asphalt and gravel, respectively. In Boring B-102 the fill is underlain by 3 feet of stiff, gravelly clay. Below the fill in Boring B-402 and below the pavement in Borings B-101 and B-401, 6 to 8 feet of fat clay is present. The consistency of the fat clay varies between soft and stiff.

Auger refusal occurred the borings between approximate depths of 3.5 and 13 feet (El 560 to 592). Auger refusal elevations at the boring locations are shown on Figure 5 in Appendix B. In several borings the drill rig augers penetrated through the weathered limestone before encountering

² Rock quality designation is the ratio of the sum of the pieces of core measuring 4 inches or longer to the total length of the cored interval, expressed as a percentage.



auger refusal. Rock generally consists of medium strong to very strong, aphanitic to finely crystalline limestone and occasional dolomite. In Borings B-101 and B-102, in the upper 11 to 28 feet RQD values ranged from 0 to 35 percent, indicating a very poor to poor quality rock. In other borings the poor-quality rock occurs within the upper 2 to 5 feet (RQD less than 25 percent) and generally improves with increasing depth. Unconfined compressive strength tests in the limestone ranged from 4,219 to 24,180 psi.

Generalized subsurface profiles along the bridges are shown on Figures 9 and 10.

6.1.3 Mar-Le Drive

Thirty-nine borings were drilled along the proposed retaining wall alignment along Mar-Le Drive. In Borings B-62, B-69, B-70, B-78, B-86 and B-94 soil samples were collected. The remaining borings were drilled to auger refusal without sampling. In all borings, concrete pavement occurs to depths of 9 to 10 inches underlain by approximately 12 inches of base rock. Pavement thicknesses are summarized in Table 2 and pavement core photos are included Appendix G. Based on data from the six sampled borings, the stratigraphy generally consists of random fill, underlain by fat clay to the depths of auger refusal. An exception is Boring B-94, where 3 feet of lean clay is present below the concrete pavement.

Auger refusal occurred in the borings at approximate depths of 2 to 15 (El 604 to 592). Auger refusal elevations at the boring locations are shown on the Figures 6 and 7 and are summarized in Table 2. Drill rig augers can often penetrate several feet into soft or broken rock, and therefore the provided elevations do not necessarily represent top of rock. Bedrock was cored in five borings and consists generally of medium strong to strong, gray and tan, very finely crystalline limestone. The rock is medium to thick bedded and slightly weathered to unweathered. Bedrock core samples had recoveries of 50 to 100 percent and RQD values of 0 to 100 percent, but typically above 50 percent, indicating fair quality rock.

Table 2. Summary of Boring Data along Mar-Le Drive.

Boring No.	Pavement Thickness (in)		Auger Refusal	
	Concrete	Base Rock	Depth (ft)	Elevation (ft)
B-59	10	12	10	596.8
B-60	10	12	6	601.1
B-61	10	12	4.5	602.9
B-62	9	12	3	604.4
B-63	10	12	8	599.8
B-64	10	12	8.5	599.5
B-65	10	12	8	600.1
B-66	10	12	9	599.1
B-67	10	12	7	600.9
B-68	10	12	6	601.7
B-69	10	12	6	601.6
B-70	9	12	6	601.3
B-71	10	12	5	602.2



Boring No.	Pavement Thickness (in)		Auger Refusal	
	Concrete	Base Rock	Depth (ft)	Elevation (ft)
B-72	10	12	5	601.8
B-73	10	12	4	602.4
B-74	10	12	4	602.1
B-75	10	12	5	600.9
B-76	10	12	5	600.6
B-77	10	12	6	599.4
B-78	9	12	9	596.3
B-79	10	12	7	598.4
B-80	10	12	7	598.4
B-81	10	12	7	598.6
B-82	10	12	6.5	599.3
B-83	10	12	6	599.4
B-84	10	12	3	602.6
B-85	10	12	2	603.8
B-86	9.5	12	3	603.0
B-87	10	12	6	600.1
B-88	10	12	4	602.3
B-89	10	12	7	599.4
B-90	10	12	7	599.5
B-91	10	12	7	600.2
B-92	10	12	7	600.3
B-93	10	12	8	599.3
B-94	9.5	12	9	598.3
B-95	10	12	11	596.4
B-96	10	12	15	592.2
B-98	10	12	13	593.4

6.1.4 I-70 Pavement

Six borings designated as Borings B-22 through B-27 were drilled along the proposed I-70 alignment. The borings were drilled to auger refusal and rock was cored. Auger refusal elevations at the boring locations are shown on Figures 2 through 5 in Appendix B. The soil stratigraphy consists generally of fill and natural lean clay underlain by fat clay and occasionally clayey sand. The soils are very soft to hard, but typically soft to medium stiff in consistency. Drill rig auger refusal occurred in the borings between 6 and 31 feet (EI 588 to 609). More specific descriptions of the soil and rock layers are provided below and on the boring logs.

Fill. Approximately 4 feet of fill is present in Boring B-27. The fill consists generally of fat clay with variable amounts of asphalt, crushed rock and wood. Field SPT N-values in the fill range from 18 to 29 blows per foot (bpf).

Lean Clay Soil. Lean clay is present in all borings, except Boring B-24. In Borings B-26 and B-27, the lean clay is interlayered with fat clay. The thickness of the lean clay varies from 2 to 5.5 feet.



The lean clay soil is very soft to very stiff, but typically is medium stiff in consistency. Moisture content percentages in the soils range from mid-teens to upper-twenties.

Fat Clay Soil. Fat clay soil occurs at the surface in Boring B-24 and at various depths in other borings except Boring B-23. The fat clay is soft to medium stiff, occasionally hard in consistency, based on SPT N60-values. Moisture content percentages in the fat clay range from mid-teens to mid-twenties, occasionally higher.

Sand. Random medium dense, clayey sand occurs within the fine-grained soils in Boring B-23. The percentage of fines from sieve analyses was 32 percent.

Limestone. Bedrock generally consists of strong to very strong, occasionally weak limestone. The limestone is aphanitic to finely crystalline and is thin to thick bedded. Bedrock core samples obtained recoveries of 100 percent and RQD values of 14 to 100 percent, but typically above 75 percent indicating a good to excellent quality rock.

6.1.5 Borrow Area Test Pits

Three test pits were performed on the MoDOT property north of the Norfolk Southern Railroad, south of I-70. The locations of the test pits are shown on Figure 3 in Appendix B.

Fill occurs to approximate depths of at least 15 to 18.5 feet. The fill consists of brown and gray, lean and fat clay with various amounts of sand, gravel, cobbles, boulders and asphalt. Test Pits TP-2 and TP-3 were terminated in the fill at an approximate depth of 15 feet. Moisture content percentages in the soil portion of fill ranged from upper single digits to mid-twenties. In Test Pit TP-1, fill is underlain by natural, brown and gray, fat clay with trace amounts of sand at an approximate depth of 18.5 feet.

6.2 Groundwater

Groundwater was observed while drilling/excavating in Borings B-9, B-10, B-13, B-21 and TP-1 between the depths of approximately 6.5 to 34 feet. Water was observed in a perched condition at a depth of approximately 15 feet in B-19. In other borings and test pits, groundwater was not observed while drilling. Groundwater levels shown on the boring and test pit logs might not have stabilized before backfilling, which is typical in less permeable cohesive soil. Consequently, the indicated or/lack of observed groundwater levels might not represent present or future levels. Groundwater levels could vary over time due to the effects of seasonal variation in precipitation, recharge, presence of creeks or lakes nearby, or other factors not evident at the time of exploration. Free water could be trapped in permeable zones of fill, in pavement base rock, and in utility trenches backfilled with clean rock. Excavations that remain open might collect water.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Recommendations given herein for the NSRR bridges were developed in general accordance with American Railway Engineering and Maintenance-of-Way Association's (AREMA) design guidelines. The recommendations for the remaining structures were developed in accordance



with AASHTO LRFD Bridge Design Specifications and MoDOT's Engineering Policy Guide (EPG).

7.1 NSRR Shoofly and Main Track Bridges

7.1.1 Embankments

Based on the provided section drawings, we anticipate approximately 5 to 12 feet of fill will be placed at the end bents of the shoofly bridge. The weight of the new fill will induce consolidation of the underlying natural soils. We anticipate that the weight of the new fill will induce approximately 1 to 2 inches of settlement as the underlying compressible lean and fat clay strata consolidates. Consolidation of the saturated natural cohesive soils will occur relatively slowly. Based on time rate of settlement estimates, the initial 1 inch is estimated to occur within two years of fill placement. The remaining settlement is estimated to occur approximately within 9 years after fill placement. As the compressible stratum consolidates, downdrag forces will be mobilized on the piles planned for the shoofly bridge end bents. Recommendations to determine the downdrag loads are provided herein.

7.1.2 Driven Piles – Shoofly Bridge

Axial Capacity. We recommend supporting the shoofly bridge on Grade 50 end-bearing steel H-piles at a design allowable compressive stress of 16 kips per square inch (ksi), provided the pile capacity is verified through dynamic testing. Therefore, the allowable loads for HP14x89 and HP14x73 sections are 418 and 342 kips, respectively. Piles driven to rock must be fitted with a cast steel driving shoe or point. The pile, with the protective tip, can usually be driven through relatively thin ledges of weathered rock with little or no damage.

Settlement. Settlement of pile foundations, designed and constructed in accordance with the recommendations given in this memorandum, is expected to be 0.5-inch or less. However, elastic compression of the piles should be evaluated by the structural engineer.

Uplift. The allowable uplift resistance for a single steel H-pile, based on the α -method, is 0.3 kips per square foot (ksf) applied over the perimeter or "box" area. The weight of the pile may be used to resist the uplift loads, but buoyant weights should be used below the water table. The upper 30 inches of the pile or the depth of predrilling should be ignored when determining the uplift resistance.

Downdrag. Negative skin friction (i.e., downdrag) on piles will occur due to settlement of subgrade soils resulting from the weight of the new filled embankments. Downdrag occurs as the soil strata move downward relative to the foundations due to settlement of the surrounding soil layers. The AASHTO Bridge Design Specifications suggest that settlement of 0.4-inch or greater could produce downdrag on deep foundations. MoDOT EPG 751.37.1.4 states that downward movements of 0.1- to 0.5-inch are enough to mobilize full downdrag.



To reduce downdrag load, we recommend predrilling through the embankments and backfilling with loose sand after pile driving. The predrilled portion of the pile must subsequently be ignored for uplift resistance. Predrilling deeper may be considered to further reduce the downdrag load. Downdrag loads to be included in the design of piles may be determined using a load of 1 ksf applied over the perimeter or “box” area of the pile below the predrilled depth to the top of rock.

Additional Design Considerations. Pile caps installed in cohesive soil should be embedded at least 30 inches below the lowest adjacent exterior grade to reduce transient loads from seasonal moisture variations and frost penetration.

Construction Considerations. We anticipate the piles will be driven to refusal on limestone bedrock. A summary of the anticipated pile refusal elevations is presented by boring in Table 3.

Table 3. Anticipated Pile Refusal Elevations – Shoofly Bridge.

Shoofly Pier No.	Boring Number	Approximate Thickness of Soil (Feet)	Approximate Top of Rock Elevation (ft)	Anticipated Pile Refusal Elevation (ft)
East Abutment	B-20	36.0	605.8	605.8
Pier 1 and 2	B-10	15.0	605.5	605.5
Pier 3	B-11	14.0	607.6	607.6
Pier 4	B-16	17.0	610.0	608.0
Pier 5 and 6	B-12	21.0	606.9	606.9
West Abutment	B-19	37.0	606.0	606.0

7.1.3 Drilled Shafts – Main Track Bridge

Axial Capacity. Drilled shafts bearing on competent limestone can be designed for a net allowable bearing pressure of 80 ksf. These design pressures are based on rock over a depth of two times the shaft diameter below the tip of the shaft having an RQD value of greater than 75 percent. Rock capable of supporting these design bearing pressures generally occur at a depth of about 5 to 10 feet below the rock surface. Considerable variation in the final elevation and quantity of rock excavation should be anticipated. For planning purposes, we recommend assuming 7 feet of rock excavation per shaft (i.e., shaft bearing elevations of El 598 to 603). It must be realized that the actual quantity may vary. Appropriate contingency fees should be allocated for removal of rock.

Probe holes and rock socket inspection should be performed for rock bearing shafts. Since it is likely the shafts may require rock removal for a substantial depth, it may be more economical to design the shafts for additional capacity from skin friction of a rock socket in sound rock rather than constructing large diameter shafts for end-bearing capacity only. An allowable side friction of 12 ksf may be assigned to the sides of the shafts in contact with competent bedrock below weathered rock (i.e., rock with an RQD value greater than 75 percent). In the moderately



weathered zone (RQD generally between 25 and 75 percent), an allowable skin friction of 6 ksf may be used. The resistance capacities should be determined for each shaft by drilling probe holes prior to construction. The sides of the rock socket must be free of soil smear and loose rock.

Uplift. The shafts can be designed to withstand uplift load provided appropriate reinforcing steel is installed. Resistance to uplift forces on drilled shafts is provided by the weight of shaft concrete, the allowable adhesion force that develops between the concrete and weathered rock (4 ksf), and sound rock (8 ksf) in the sidewall of the shaft. The buoyant unit weight of concrete should be used in computing uplift resistance, based on the anticipated maximum groundwater level.

Settlement. Settlement of drilled shafts, designed in accordance with the recommendations given in this report, should be approximately 1/2 inch or less.

7.1.4 Lateral Resistance of Piles and Shafts

Based on the laboratory results and our experience on similar projects, soil and rock parameters for use in the lateral load analysis program LPILE are given below in Tables 4 and 5, respectively. Geotechnology can perform such a nonlinear lateral load analysis, if necessary. Excavation, which would remove the lateral resistance, cannot occur while the lateral load is in place.



Table 4. Soil Parameters for Static Lateral Load Analysis.

Soil Type	Soil Model	Undrained Shear Strength (psf)	Strain Parameter (E50)	Soil Modulus (pci)	Internal Friction Angle (deg)	Effective Unit Weight (pcf)	Moist Unit Weight (pcf)
Predrill	Sand	-	-	25	20	48	110
Uncontrolled Fill	Soft Clay	500	0.02	30	-	48	110
Cohesive Soil	Stiff Clay without Free Water	1,500	0.005	1,500	-	58	120

Table 5. Rock Parameters for Static Lateral Load Analysis.

Rock Type	Soil Model	Effective Unit Weight (pcf)	Moist Unit Weight (pcf)	Young's Modulus, E_r (psi)	Uniaxial Compressive Strength		RQD (Percent)	k_{rm}
					(psi)	(ksf)		
Weathered Rock	Weak Rock	83	145	1,000,000	1,000	144	30	0.0005
Moderately Weathered to Fresh Rock	Strong Rock	98	160	n/a	10,000	1,440	n/a	n/a

The effects of group interaction must be taken into account when evaluating lateral movement of pile/shaft groups. P-multipliers may be used to reduce the lateral resistance of single pile/shaft to account for group effects. P-multipliers should be applied to pile/shaft assemblages with spacings less than five pile/shaft diameters. P-multipliers are provided in Table 10.7.2.4-1 in the AASHTO LRFD Bridge Design Specifications (2012). Alternatively, the lateral resistance of drilled shaft assemblages may be evaluated using the GROUP software using the soil and rock parameters provided in Tables 4 and 5.

7.1.5 Seismicity and Liquefaction

In accordance with AREMA Bridge Design Specifications, the bridge site, can be classified as Site Class C (Very Dense Soil and Soft Rock Profile).

The stratigraphy at this site consists primarily of cohesive soils underlain by bedrock, with silty and sandy clay occurring in some of the borings. Silty and clayey sands occur above the groundwater level and/or contain sufficient amounts of fines to resist liquefaction. These strata are not considered susceptible to liquefaction during a seismic event.



7.1.6 Global Stability Analysis

Global stability slope analyses were performed for a representative section of the shoofly bridge using the proposed slope geometries shown on the railroad section plans provided by the client on July 26, 2021. Generally, when the factor of safety is 1 or less, the slope is considered to be unstable. The accepted standard in AREMA is a factor of safety of 1.5 for long term stability of a slope.

Three typical cross-sections were considered in our analysis for the embankment. The locations of the typical cross-sections represented by Sections AA' (Sta 103+22), BB' (Sta 91+00) and CC' (Sta 99+00) are shown on Figure 3. Subsurface conditions used for the analysis were based on the conditions in Borings B-12, B-13, B-19, B-20 and B-21. Embankment fill is anticipated to be compacted soil.

The proposed 1V:2H slope at Sta 103+22 was modified to 1V:2.5H in our analysis to achieve the minimum recommended factor of safety. Also, as discussed in Section 7.1.6.1, the existing fill below the proposed shoofly track embankment at Sta 99+00 was removed and replaced with compacted fill as shown on Figure 5 included in Appendix J. Both short- and long-term conditions using total and effective stress properties, respectively, were analyzed. The soil properties used in our analyses are based on laboratory consolidated-undrained triaxial compressive tests and our experience, and are summarized in Table 6.

Table 6. Soil Properties for Global Stability Analysis

Soil Type	Density (pcf)	Effective Stress		Total Stress (phi=0 analysis)
		Cohesion (psf)	Friction Angle (°)	Cohesion (psf)
Existing Fill	100	10	20	300
Compacted Fill	120	50	30	2,000
Crushed Rock	140	0	40	0
Lean Clay	120	20	29	1,000
Fat Clay	120	40	26	1,500
Sand	120	0	38	0
Bedrock	140	Infinite Strength		

A surcharge load of 1,800 pounds per square foot (psf) was included to account for the anticipated rail traffic load. The Morgenstern-Price procedure was used to compute the factor of safety. The computer program Slide was used to perform the computations. The calculated resultant factors of safety are given in Table 7. The analyzed sections with critical failure arcs are presented in Appendix J.



Table 7. Global Stability Analysis Results

Section ^a	Analysis Condition	Calculated Factor of Safety	Figure No. ^b
AA' (Sta 103+22) 1V:2H	Long-Term	1.4	1
AA' (Sta 103+22) Modified to 1V:2.5H	Long-Term	1.6	2
	Short-Term	2.5	3
BB' (Sta 91+00)	Long-Term	1.5	4
	Short-Term	3.2	5
CC' (Sta 99+00) Remediated Slope	Long-Term	1.5	6
	Short-Term	3.1	7

^a Refer to Figure 3 in Appendix B for section locations.

^b Refer to Slope Stability Analysis Results in Appendix J.

Seismic effects on the slope were not considered. Minor sloughing on the face of the slope may occur and should be repaired immediately.

7.1.6.1 Slope Remediation

Global stability analysis for the shoofly bridge west approach embankment results a factor of safety less than 1.5 for the planned 1V:2H configuration (Figure 1 in Appendix J). We recommend the slope be flattened to a 1V:2.5H configuration to achieve a satisfactory factor of safety. A slope using a 1V:2H configuration may be used west of station 105+00.

The presence of existing fill at the planned east approach for the shoofly bridge is considered uncontrolled. Uncontrolled fill can present weak zones in foundation materials and promote slope failure. We recommend the existing fill be removed from beneath the east approach shoofly bridge embankment slope to a distance of at least 32 feet south of the shoofly track centerline. Fill removal is anticipated to reach El 631, but could be lower based on field conditions. Fill should be removed north of the shoofly track centerline approximately 15 feet such that a 1V:2V slope remains on the south of the mainline track. The recommended section of fill removal is shown on Figures 6 and 7 in Appendix J.

7.1.7 Site Grading

In general, fill materials for the shoofly embankment should consist of low-plastic, cohesive soils or well-graded crushed rock. Acceptable fill soils include non-organic materials designated CL, ML, CL-ML, SW, GP, GW, and GM by ASTM D 2487.

Fill should be placed in maximum 8-inch-thick loose lifts and compacted to the levels given in Table 8, Compaction Summary. The soil should be placed at a moisture content compatible with the required unit weight. Depending on the soil moisture at the time of construction, aeration or wetting might be required to achieve compaction. Deleterious material should not be included in fill, and the fill should not be placed on soft materials or frozen ground.



Table 8. Compaction Summary

Category	Minimum Compaction ^a Standard
General soil fill	95 ^b
Crushed Rock backfill	100

^a Measured as a percent of the maximum dry unit weight as determined by the standard Proctor test (ASTM D698 or D1557, respectively).

^b Moisture content within 3% of optimum moisture content.

7.2 I-70/Route Z Interchange Bridges

Based on the boring data, the soil strata appears to be interlayered with rock ledges and boulders at the west end of both bridges (e.g., Borings B-101 and B-102). Rock is present at depths of approximately 3 to 13 feet at the proposed intermediate and end bents. Current plans are to support the end bents on driven piles and intermediate bents on drilled shafts.

7.2.1 Drilled Shafts

Axial and Uplift Resistances. The intermediate bents of both bridges may be supported on drilled shafts bearing on competent limestone bedrock. Drilled shaft construction and testing shall be performed in accordance with Missouri Standard Specifications for Highway Construction Section 701 - Drilled Shafts. In accordance with EPG 751.37.1.3, permanent casing is required the casing should be socketed 1 foot into rock. At shaft locations where end-bearing and side resistance will be considered, the factored shaft resistance would be equal to the summation of the following: (1) the rock socket surface area multiplied by the factored side friction value and (2) the end area of the shaft multiplied by the factored end-bearing resistance. Uplift resistance for drilled shafts bearing in underlying bedrock can be computed considering the following: (1) buoyant weight of concrete, (2) factored side resistance between the concrete and the rock. A drilled shaft design summary is presented in Table 9. Resistance factors are based on a classification of “major bridge costing less than \$100 million” per EPG 751.37.



Table 9. Drill Shaft Design Summary

Nominal Side Resistance (ksf)	Geotechnical Side Resistance Factors	Nominal End-Bearing Axial Resistance (ksf)	Geotechnical End-Bearing Resistance Factors	Nominal Uplift Resistance (ksf)	Geotechnical Uplift Resistance Factors
35	0.41	400	0.41	35	0.31

A summary of the approximate elevation ranges for the recommended design values is presented in Table 10.

Table 10. Drilled Shaft Design Elevation Summary.

Bridge	Bent	Boring Number	Elevation of Anticipated Tip of Casing (feet)	Elevation Range for End-Bearing (feet)	Elevation Range for Side Friction (feet)*
Westbound	West Intermediate Bent	B-201	573	573 - 559	573 - 549
	East Intermediate Bent	B-301	572	573 - 559	573 - 549
Eastbound	West Intermediate Bent	B-202	559	559 - 545	559 - 535
	East Intermediate Bent	B-302	567	567 - 553	567 - 543

* Based on field socket inspection, side friction should not be counted in areas where voids are present and/or where rock is only partially present along the sidewall of the shaft.

Settlement. Settlement of drilled shafts can be approximated using the magnitude of factored loads relative to the magnitude of factored side and tip resistance. EPG 751.37.4.1 provides guidance on estimation of drilled shaft settlement based on the shaft diameter, factored load, factored side and end-bearing resistances, and factored elastic compression. Alternatively, the “t-z” numerical method (Reese et al., 2006) can be used to model the axial load-displacement response of drilled shafts per EPG 751.37.4.2.

7.2.2 Driven Piles

Axial Resistance. Rock bearing H-piles can be used to support the intermediate bents. Since the rock elevation and quality of rock is not well defined, we recommend high-strain dynamic testing be performed to confirm the required nominal axial resistance. A preliminary wave



equation analysis was performed for HP12X53 and HP14X73 piles to estimate the nominal axial resistance that can be mobilized using a Delmag D19 pile hammer. The resulting bearing graphs are presented in Appendix K and the results are summarized in Table 11.

Table 11. Pile Resistance Summary.

Bridge	Bent	Pile Type	Steel Yield Strength (ksi)	Maximum Nominal Axial Resistance ⁺ (kips)	Tip Elevation (feet)	Pile Length (feet)	Sand Backfill Depth (feet)
Westbound I-70	West Abutment	HP12X53	50	425	550.5	50	49
		HP14X73		500			
	East Abutment	HP12X53		400	586	15*	13.5
		HP14X73		500			
Eastbound I-70	West Abutment	HP12X53		425	550.5	50	49
		HP14X73		500			
	East Abutment	HP12X53		400	584	16	15.5
		HP14X73		500			

* Minimum pile length of 15 feet required per MoDOT EPG for abutments.

+ Maximum required nominal axial resistances are driving stress limited.

If fewer than five piles are in a group, the resistance factor might need to be reduced by 20 percent. Additional considerations for applying a 20 percent geotechnical redundancy reduction are presented in EPG 751.36.1.5. If the pile cap is not in contact with the ground, the individual nominal resistance of each pile shall be multiplied by an efficiency factor based on pile spacing per LRFD 10.7.3.9. We recommend the center-to-center spacing of piles not be less than 30 inches or 2.5 pile diameters, whichever is greater.

Settlement. Settlement of pile foundations, designed and constructed in accordance with MoDOT EPG 751.36 and the recommendations given in this report, is expected to be 1/2-inch or less. However, elastic compression of the piles should be evaluated by the structural engineer.

Uplift Resistance. The nominal uplift resistance (R_s) for a single steel H-pile, based on the α -method, is 0.5 ksf applied over the perimeter or "box" area. The factored uplift resistance can be determined using a resistance factor (ϕ_{up}) of 0.25. The upper 3 feet of the pile should be ignored when determining the uplift resistance. If less than five piles are in the group, the resistance should be reduced by an additional 20 percent.

Additional Design Considerations. Pile caps installed in cohesive soil should be embedded at least 30 inches below the lowest adjacent exterior grade to reduce transient loads from seasonal moisture variations and frost penetration.

Construction Considerations. Because of the presence of rock ledges and boulders, we recommend that pile installation should include pre-boring holes for the piles to anticipated refusal



elevations. Pre-bored holes should be backfilled with sand. A summary of the anticipated pile refusal elevations is presented by boring in the following Table 12. Previous boring data for existing bridges were used for establishing refusal elevations.

Table 12. Anticipated Pile Refusal Elevations.

Bridge	Bent	Boring Number	Approximate Thickness of Soil, boulders and rock ledges (ft)	Approximate Top of Rock Elevation (ft)	Pre-bore Base Elevation (ft)	Anticipated Pile Refusal Elevation (ft)
Westbound	West Abutment	B-101	49.6	550	550	550
	East Abutment	B-401	7	592.2	584.2	584.2
Eastbound	West Abutment	B-102	48.6	551	551	551
	East Abutment	B-402	15.5	584.3	584	584.3

7.2.3 Lateral Resistance of Deep Foundations

Based on the laboratory results and our experience, soil and rock parameters for use in the lateral load analysis program LPILE are given below in Tables 13 and 14, respectively. Excavation, which would remove the lateral resistance, cannot occur while the lateral load is in place.



Table 13. Soil Parameters for Static Lateral Load Analysis.

Soil Type	Soil Model	Undrained Shear Strength (psf)	Strain Parameter (E50)	Soil Modulus (pci)	Internal Friction Angle (deg)	Effective Unit Weight (pcf)	Moist Unit Weight (pcf)
Predrill	Sand	-	-	25	20	48	110
Uncontrolled Fill	Soft Clay	500	0.02	30	-	48	110
Cohesive Soil	Stiff Clay without Free Water	1,500	0.005	1,500	-	58	120

Table 14. Rock Parameters for Static Lateral Load Analysis.

Rock Type	Soil Model	Effective Unit Weight (pcf)	Moist Unit Weight (pcf)	Young's Modulus, E_r (psi)	Uniaxial Compressive Strength		RQD (Percent)	k_{rm}
					(psi)	(ksf)		
Weathered Rock	Weak Rock	83	145	1,000,000	900	130	30	0.0005
Moderately Weathered to Fresh Rock	Strong Rock	98	160	n/a	2,500	360	n/a	n/a

The effects of group interaction must be taken into account when evaluating lateral movement of pile groups. P-multipliers may be used to reduce the lateral resistance of single pile to account for group effects. P-multipliers should be applied to pile assemblages with spacings less than five pile diameters. P-multipliers are provided in Table 10.7.2.4-1 in the AASHTO LRFD Bridge Design Specifications. Alternatively, the lateral resistance of pile assemblages may be evaluated using the GROUP software using the soil and rock parameters provided in Tables 13 and 14.

7.2.4 Slopes

The stability of a slope depends on many factors, including slope geometry, slope height, soil type, and surface pressures. Based on MoDOT's Table 321.1 Guide for Selection of Slope Inclination for Routine Design, fill side slopes can be as steep as 1V:2.5H for lean clay.

7.2.5 Seismicity and Liquefaction

Design recommendations for seismicity and liquefaction are provided in accordance with AASHTO LRFD Bridge Design Specifications and EPG 751.9.



Site Class. In accordance with the general procedures of the AASHTO LRFD Bridge Design Specifications, the bridge site can be classified as Site Class C.

Seismic Design Response Spectrum. In accordance with AASHTO LRFD Bridge Design Specifications, a summary of the seismic site class, mapped peak ground acceleration (PGA), mapped acceleration coefficients (i.e., S_s and S_1), design response spectrum coefficients (i.e., A_s , S_{DS} and S_{D1}), and seismic zone are provided in the following Table 15. The accelerations given herein correspond to a seismic event with a seven percent probability exceedance in 75 years.

Table 15. Seismic Design Parameter Summary

Bridge	Bent	Seismic Site Class	PGA (g)	S_s (g)	S_1 (g)	A_s (g)	S_{DS} (g)	S_{D1} (g)	Seismic Design Category*
Westbound	All Bents	B (Rock)	0.106	0.234	0.076	0.106	0.234	0.076	A
Eastbound	West Abutment and Intermediate Bents	B (Rock)	0.106	0.234	0.076	0.106	0.234	0.076	A
	East Abutment	C (Very Dense Soil and Soft Rock)	0.106	0.234	0.076	0.127	0.28	0.13	A

* Based on MoDOT's LRFD Bridge Seismic Design Flowchart

Liquefaction. The stratigraphy at this site consists of cohesive soils underlain by bedrock. These strata are not considered susceptible to liquefaction during a seismic event.

7.3 Mar-Le Drive

7.3.1 Rock Excavation

Bedrock along Mar-Le Drive is approximately 3 to 15 feet below existing grade. We anticipate approximately 1 to 7 feet of rock excavation to achieve the planned grades of I-70 pavement. The rock cuts are generally at Sta 1311+00 and east thereof. Possible occasional pinnacled rock at other sections along the proposed road should be anticipated. Physical characteristics of the bedrock that affect rippability include stratification, bedding, rock compressive strength, degree of weathering, and the frequency and spacing of planes of weakness (joints, fractures, and faults). The limestone in the borings is generally medium strong to strong, medium to thick-bedded, and slightly weathered to unweathered, and likely not amenable to ripping. Hard rock excavating techniques such as line drilling, chipping with a hydraulic hoe ram, or blasting could be required



along the road alignment. This excavation may be considered as MoDOT Class C excavation. A contingency should be included in the project budget to cover the cost of hard rock excavation.

7.3.2 MSE Walls

MSE walls are planned along Mar-Le Drive for grade separation between Mar-Le Drive and I-70. Based on provided data, the maximum height of the MSE retaining wall will be on the order of 8 to 12 feet. It is our understanding that the MSE wall design will be performed by others.

The following geotechnical parameters may be used for design of the MSE wall.

- Walls approximately from Sta 1311+00 and east thereof will be bearing on rock. Footings for walls bearing on rock can be designed using a nominal bearing resistance of 118,000 psf. A resistance factor (ϕ_b) of 0.38 can be applied to the nominal bearing resistances. A nominal sliding resistance of one half the normal stress may be used for design for walls bearing on rock. A sliding resistance factor (ϕ_T) of 0.85 must be applied to the nominal sliding resistance.
- MSE walls bearing on soil may be designed using a nominal bearing resistance of 2,800 psf. A resistance factor (ϕ_b) of 0.45 can be applied to the nominal bearing resistances. A nominal sliding resistance of 1,000 psf or one half the normal stress, whichever is less, may be used for retaining wall footing design. A sliding resistance factor (ϕ_T) of 0.85 must be applied to the nominal sliding resistances.
- For the foundation and retained soils, friction angles of 25 and 20 degrees, respectively and cohesion of 10 psf may be used for long term conditions. An undrained shear strength of 500 psf, may be used for short term conditions.

7.3.3 Retaining Wall Stability

The retaining wall along Mar-Le Drive is anticipated to be supported on rock or on a thin layer of clay over rock. Thus, the stability of the proposed retaining wall will be determined by the internal stability of the wall. The retaining wall designer is responsible for the internal stability of the wall. An evaluation of the internal stability is beyond our scope of services.

8.0 LIMITATIONS

This report has been prepared on behalf of, and for the exclusive use of, the client for specific application to the named project as described herein. If this report is provided to other parties, it should be provided in its entirety with all supplementary information. In addition, the client should make it clear that the information is provided for factual data only, and not as a warranty of subsurface conditions presented in this report.

Geotechnology has attempted to conduct the services reported herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions. The recommendations and



conclusions contained in this report are professional opinions. The report is not a bidding document and should not be used for that purpose.

Our scope for this phase of the project did not include any environmental assessment or investigation for the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater, or air, on or below or around this site. Any statements in this report or on the boring logs regarding odors noted or unusual or suspicious items or conditions observed are strictly for the information of our client. Our scope did not include an assessment of the effects of flooding and erosion of creeks or rivers adjacent to or on the project site.

The analyses, conclusions, and recommendations contained in this report are based on the data obtained from the geotechnical exploration. The field exploration methods used indicate subsurface conditions only at the specific locations where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Consequently, subsurface conditions could vary gradually, abruptly, and/or nonlinearly between sample locations and/or intervals.

The conclusions or recommendations presented in this report should not be used without Geotechnology's review and assessment if the nature, design, or location of the facilities is changed, if there is a lapse in time between the submittal of this report and the start of work at the site, or if there is a substantial interruption or delay during work at the site. If changes are contemplated or delays occur, Geotechnology must be allowed to review them to assess their impact on the findings, conclusions, and/or design recommendations given in this report. Geotechnology will not be responsible for any claims, damages, or liability associated with any other party's interpretations of the subsurface data or with reuse of the subsurface data or engineering analyses in this report.

The recommendations included in this report have been based in part on assumptions about variations in site stratigraphy that can be evaluated further during earthwork and foundation construction. Geotechnology should be retained to perform construction observation and continue its geotechnical engineering service using observational methods. Geotechnology cannot assume liability for the adequacy of its recommendations when they are used in the field without Geotechnology being retained to observe construction.



APPENDIX A – IMPORTANT INFORMATION ABOUT THIS GEOTECHNICAL-ENGINEERING REPORT

Important Information about This Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a constructor — a construction contractor — or even another civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you — should apply this report for any purpose or project except the one originally contemplated.*

Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

Geotechnical Engineers Base Each Report on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical-engineering report that was:

- not prepared for you;
- not prepared for your project;
- not prepared for the specific site explored; or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an

assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the geotechnical engineer performed the study. *Do not rely on a geotechnical-engineering report whose adequacy may have been affected by:* the passage of time; man-made events, such as construction on or adjacent to the site; or natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Contact the geotechnical engineer before applying this report to determine if it is still reliable.* A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ — sometimes significantly — from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide geotechnical-construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are Not Final

Do not overrely on the confirmation-dependent recommendations included in your report. *Confirmation-dependent recommendations are not final*, because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's confirmation-dependent recommendations if that engineer does not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

A Geotechnical-Engineering Report Is Subject to Misinterpretation

Other design-team members' misinterpretation of geotechnical-engineering reports has resulted in costly

problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical-engineering report. Confront that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical-engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time to perform additional study.* Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help

others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Environmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold-prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical-engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; *none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.*

Rely, on Your GBC-Member Geotechnical Engineer for Additional Assistance

Membership in the Geotechnical Business Council of the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you GBC-Member geotechnical engineer for more information.



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APPENDIX B – FIGURES

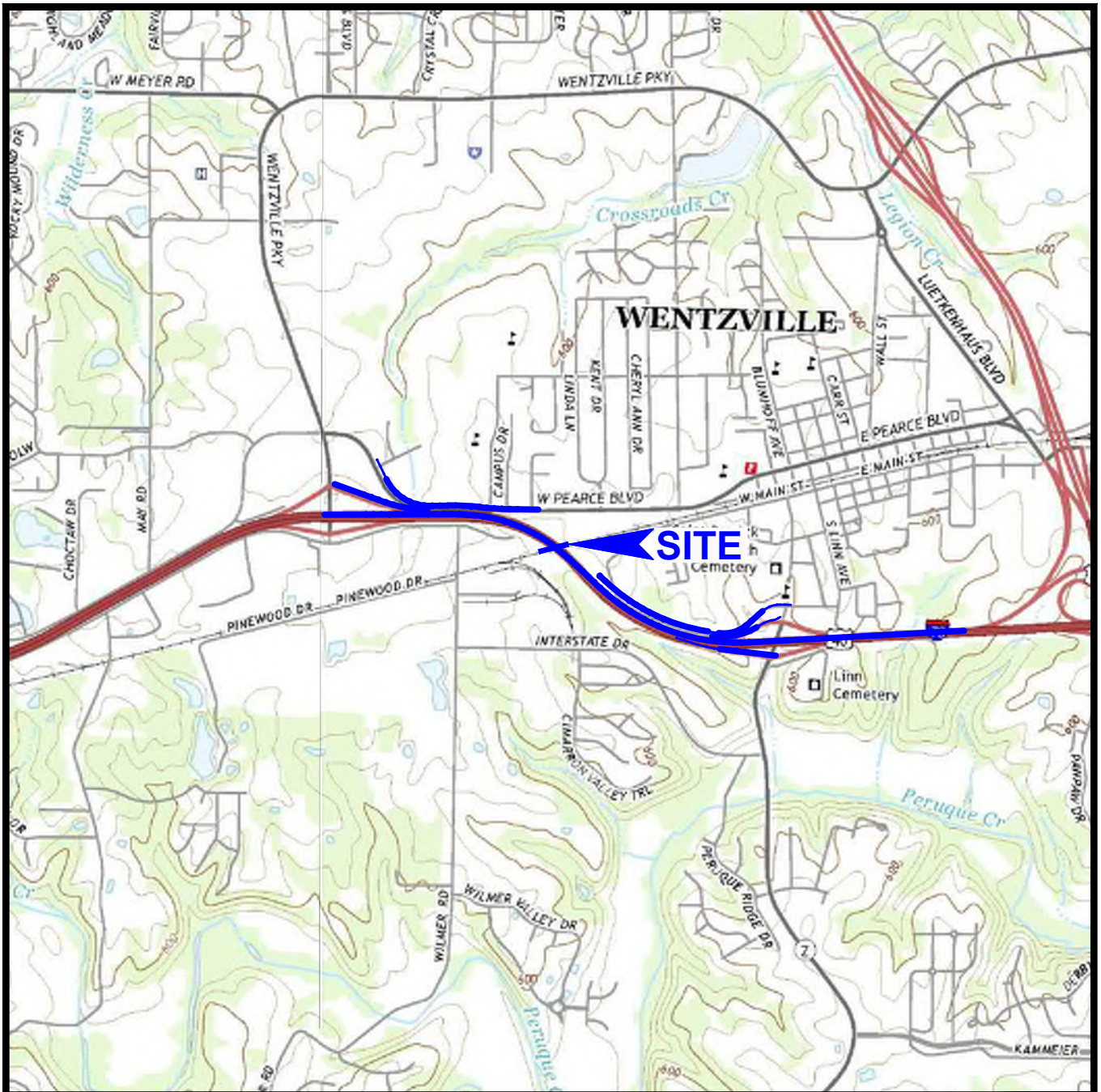
Figure 1 - Site Location and Topography

Figure 2 - Aerial Photograph of Site, Boring and Test Pit Locations

Figures 3 through 7 – Detail Areas 1 through 5

Figure 8 – Generalized Subsurface Profile along NSRR Bridge

Figures 9 and 10 – Generalized Subsurface Profiles along I-70 over Route Z Bridge



NOTES

1. Plan adapted from 7.5 minute U.S.G.S. maps for Wentzville and Foristell, Missouri quadrangles, last revised in 2017.

0 2,000 4,000



SCALE IN FEET



Drawn By: WAH	Ck'd By: SK	App'vd By: AWR
Date: 2-3-22	Date: 3-22-22	Date: 4-5-22



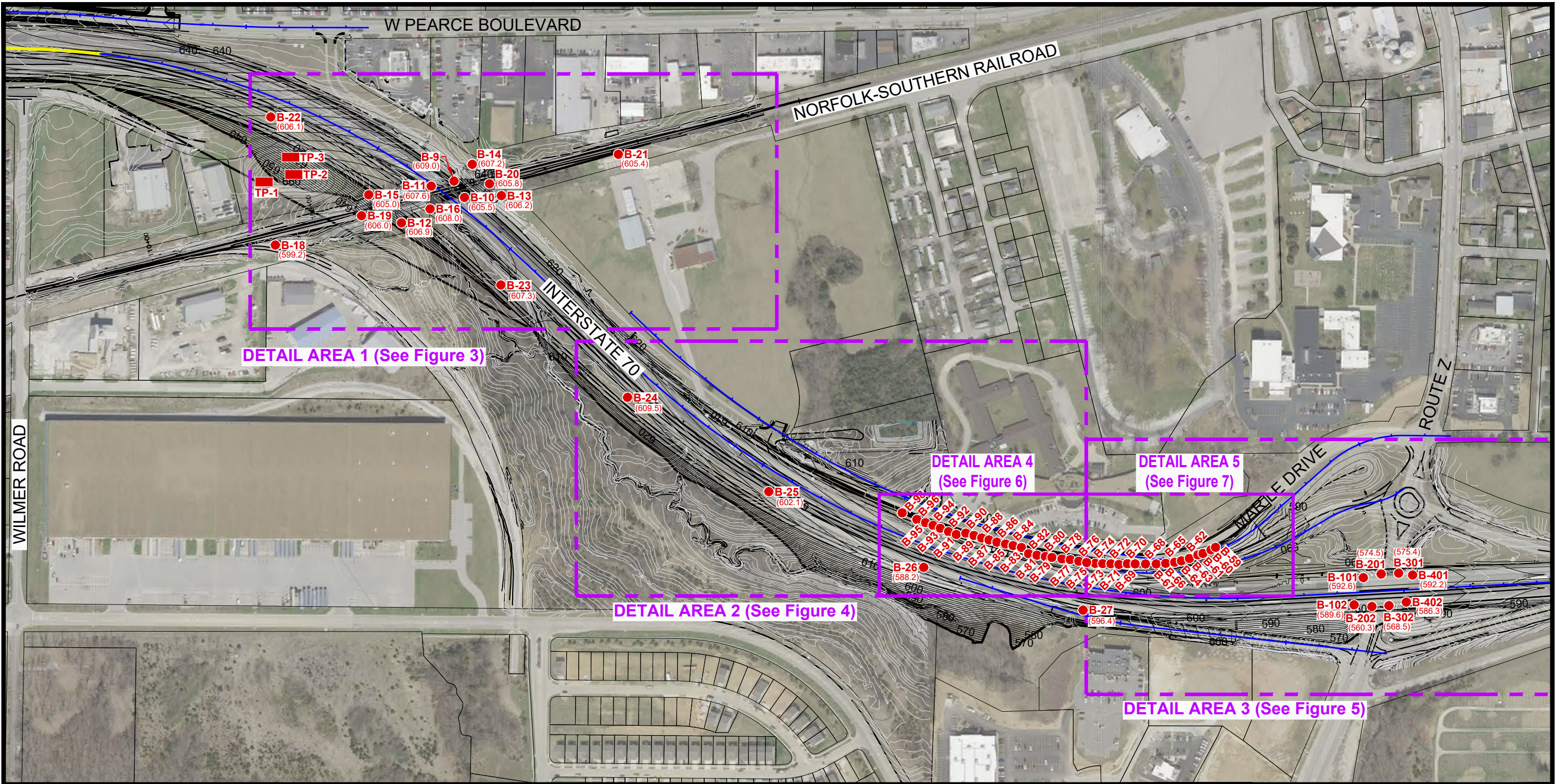
GEOTECHNOLOGY
A Universal Engineering Sciences Company

I-70 Corridor Improvements
MoDOT Project J6I0624
Wentzville, Missouri

SITE LOCATION AND TOPOGRAPHY

Project Number
J032438.03

FIGURE 1



NOTES

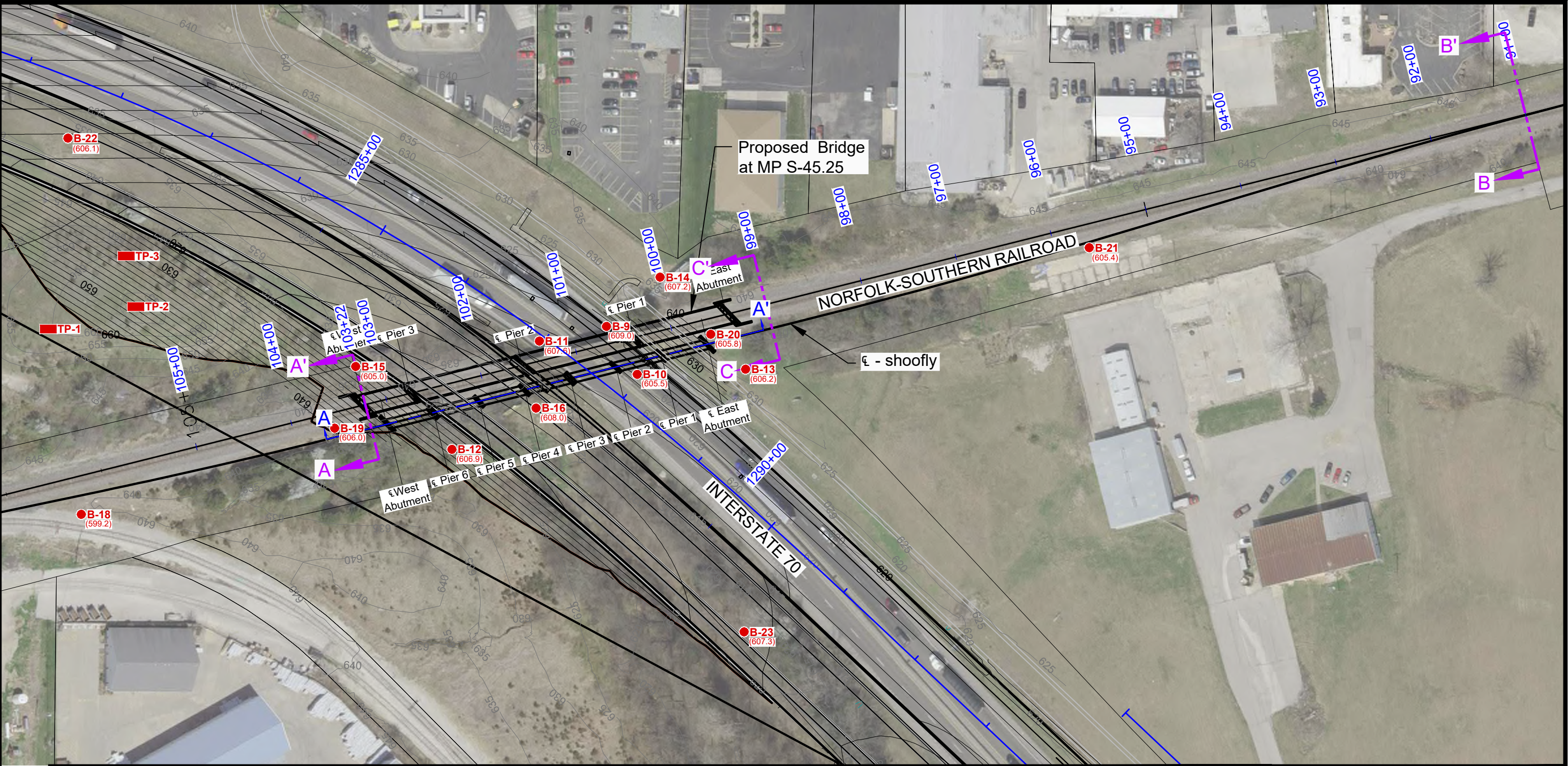
1. Plan adapted from drawings supplied by the client.
2. The borings were located by Geotechnology and were subsequently surveyed by the project surveyor.

LEGEND

- Test Pit Location
- Boring Location
- (xxx.x) Approximate Auger Refusal Elevation (Feet)



Drawn By: WAH	Ck'd By: SK	App'd By: AWR
Date: 2-3-22	Date: 3-22-22	Date: 4-5-22
 I-70 Corridor Improvements MoDOT Project J6I0624 Wentzville, Missouri		
AERIAL PHOTOGRAPH OF SITE, BORING AND TEST PIT LOCATIONS		
Project Number J032438.03		FIGURE 2

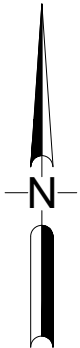


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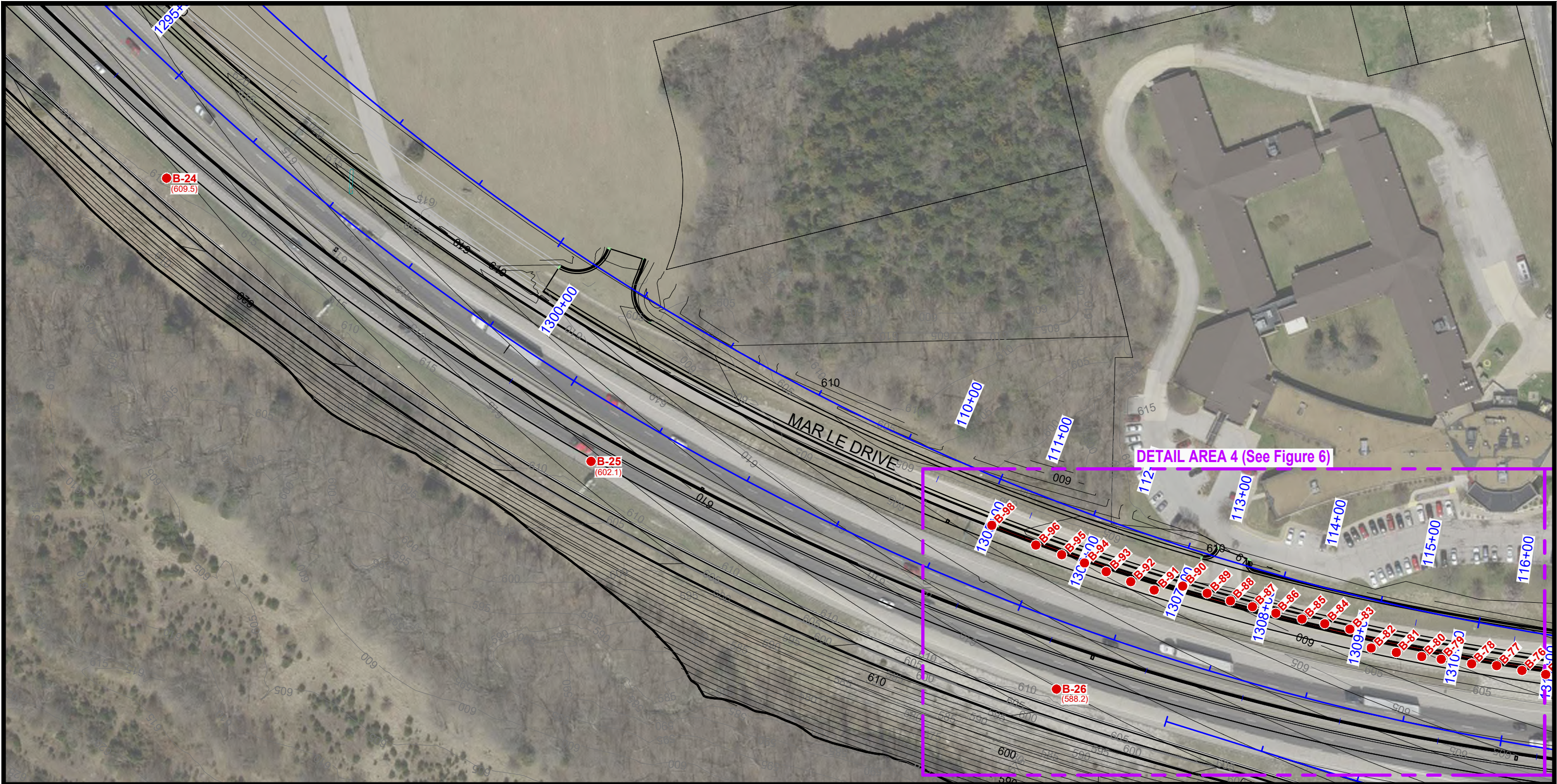
1. Plan adapted from "2015 Aerial Imagery for the St. Louis Region" supplied by East-West Gateway Council of Governments.
2. The borings and test pits were located by Geotechnology and were subsequently surveyed by the project surveyor.

LEGEND

- Test Pit Location
- Boring Location
- (XXX.X) Approximate Auger Refusal Elevation, feet
- Slope Stability Section Location
- Generalized Subsurface Profile (See Figure 8 for Cross-Section A-A')



Drawn By: WAH	Ck'd By: SK	App'vd By: AWR
Date: 2-3-22	Date: 3-22-22	Date: 4-5-22
GEOTECHNOLOGY A Universal Engineering Sciences Company		
I-70 Corridor Improvements MoDOT Project J6I0624 Wentzville, Missouri		
DETAIL AREA 1, BORING AND TEST PIT LOCATIONS		
Project Number J032438.03		FIGURE 3

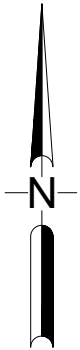
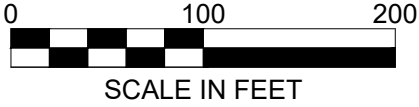


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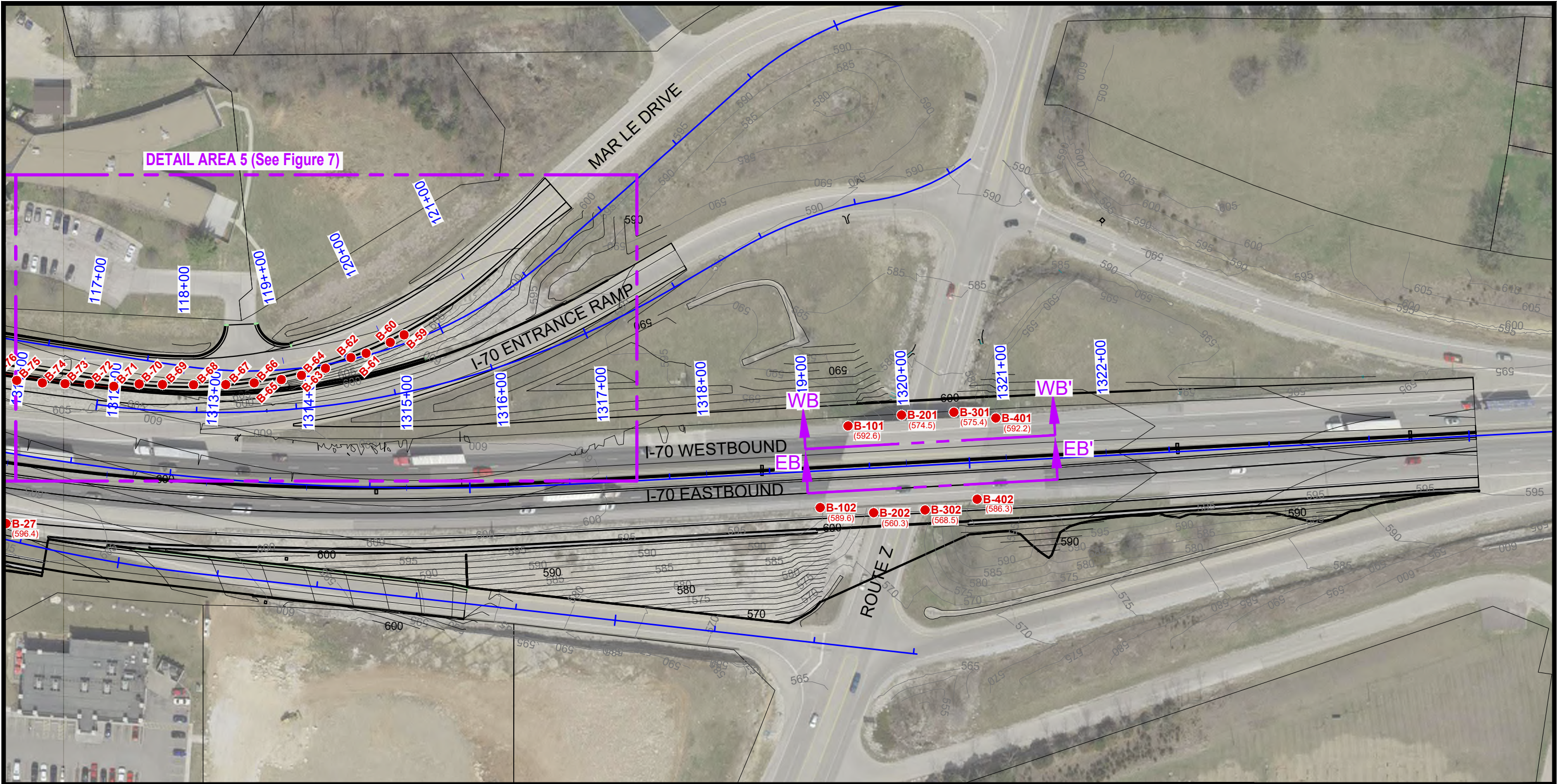
- 1. Plan adapted from "2015 Aerial Imagery for the St. Louis Region" supplied by East-West Gateway Council of Governments.
- 2. The borings were located by Geotechnology and were subsequently surveyed by the project surveyor.

LEGEND

- Boring Location
- (xxx.x) Approximate Auger Refusal Elevation, feet



Drawn By: WAH	Ck'd By: SK	App'd By: AWR
Date: 2-3-22	Date: 3-22-22	Date: 4-5-22
		
I-70 Corridor Improvements MoDOT Project J6I0624 Wentzville, Missouri		
DETAIL AREA 2 AND BORING LOCATIONS		
Project Number J032438.03		FIGURE 4

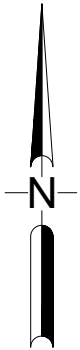


NOTES

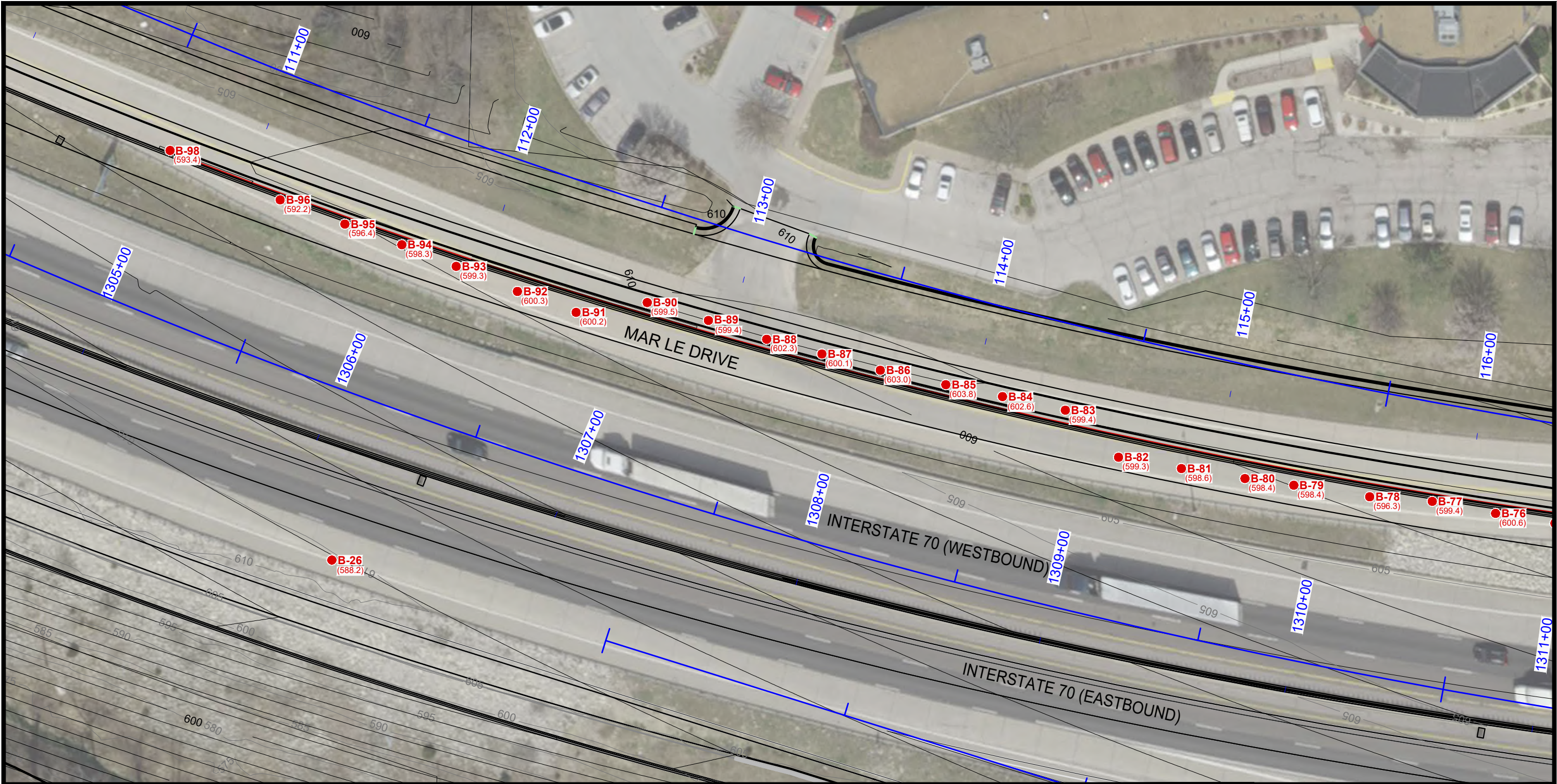
1. Plan adapted from "2015 Aerial Imagery for the St. Louis Region" supplied by East-West Gateway Council of Governments.
2. The borings were located by Geotechnology and were subsequently surveyed by the project surveyor.

LEGEND

- Boring Location
- (XXX.X) Approximate Auger Refusal Elevation, feet
- ↑ Generalized Subsurface Profile Location
(See Figures 9 & 10 for Cross Sections WB-WB' and EB-EB', respectively)



Drawn By: WAH	Ck'd By: SK	App'vd By: AWR
Date: 2-3-22	Date: 3-22-22	Date: 4-5-22
 GEOTECHNOLOGY A Universal Engineering Sciences Company		
I-70 Corridor Improvements MoDOT Project J6I0624 Wentzville, Missouri		
DETAIL AREA 3 AND BORING LOCATIONS		
Project Number J032438.03		FIGURE 5

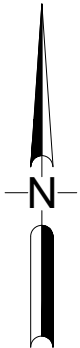


NOTES

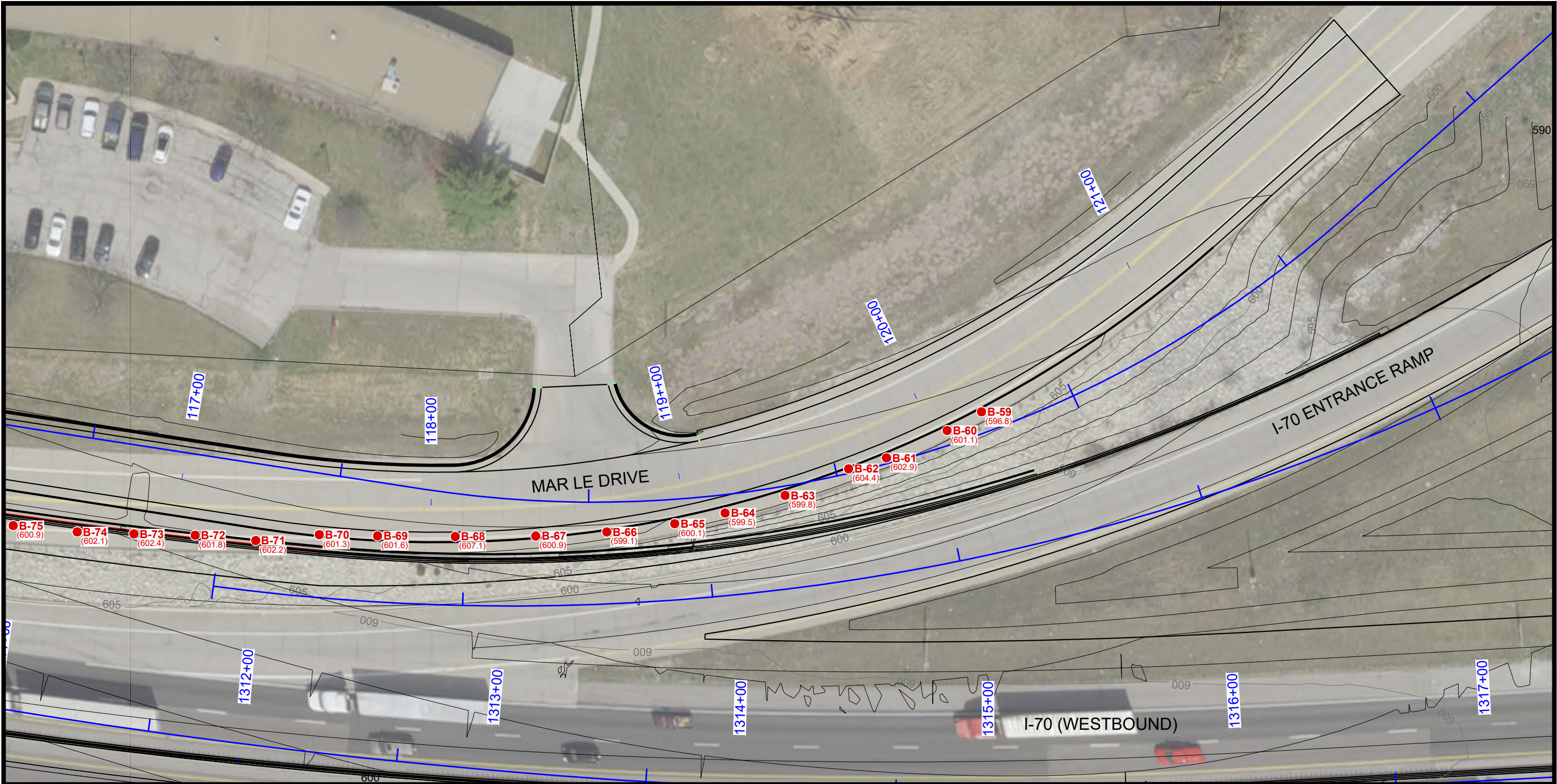
1. Plan adapted from "2015 Aerial Imagery for the St. Louis Region" supplied by East-West Gateway Council of Governments.
2. The borings were located by Geotechnology and were subsequently surveyed by the project surveyor.

LEGEND

- Boring Location
- (XXX.X) Approximate Auger Refusal Elevation, feet



Drawn By: WAH	Ck'd By: SK	App'vd By: AWR
Date: 2-3-22	Date: 3-22-22	Date: 4-5-22
 I-70 Corridor Improvements MoDOT Project J6I0624 Wentzville, Missouri		
DETAIL AREA 4 AND BORING LOCATIONS		
Project Number J032438.03		FIGURE 6

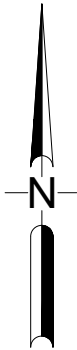


NOTES

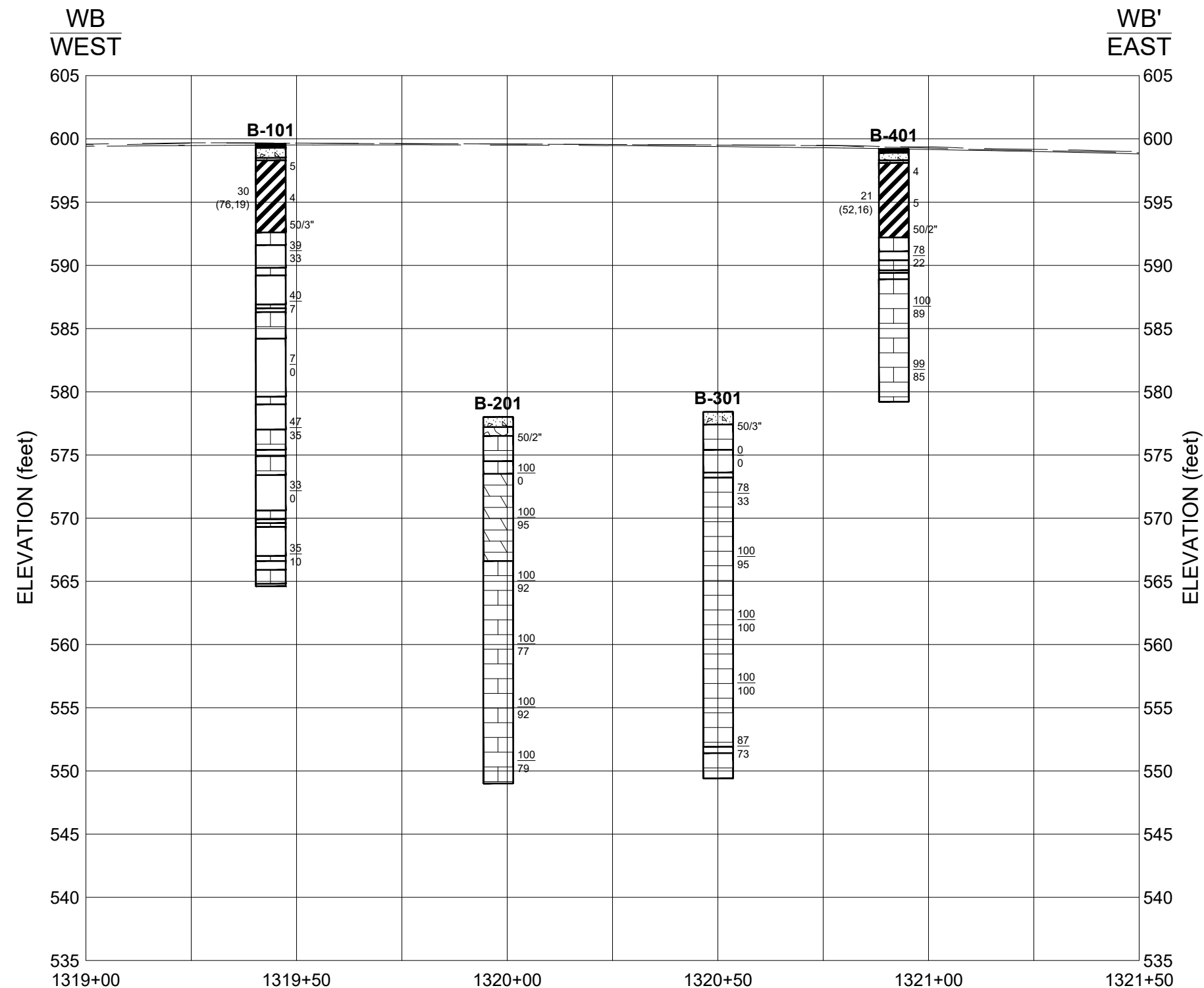
1. Plan adapted from "2015 Aerial Imagery for the St. Louis Region" supplied by East-West Gateway Council of Governments.
2. The borings were located by Geotechnology and were subsequently surveyed by the project surveyor.

LEGEND

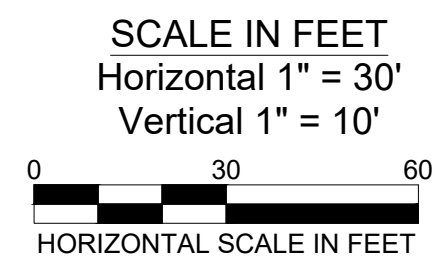
- Boring Location
- (XXX.X) Approximate Auger Refusal Elevation, feet



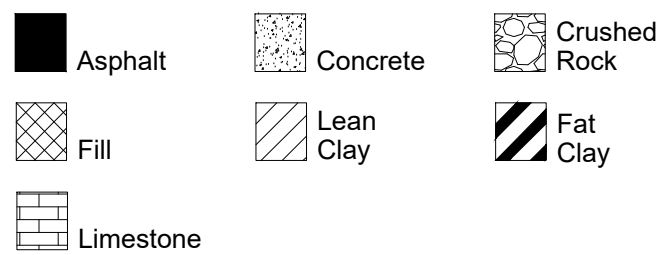
Drawn By: WAH	Ck'd By: SK	App'vd By: AWR
Date: 2-3-22	Date: 3-22-22	Date: 4-5-22
 I-70 Corridor Improvements MoDOT Project J6I0624 Wentzville, Missouri		
DETAIL AREA 5 AND BORING LOCATIONS		
Project Number J032438.03		FIGURE 7



- NOTES
1. See Figure 5 for location of Cross Section WB-WB'.
 2. Data concerning subsurface conditions were obtained at boring locations only.



KEY TO BOREHOLE SYMBOLS



KEY TO TEST DATA

Natural Water Content in Percent

Liquid and Plastic Limits

Standard Penetration Test Resistance (No. of Blows of a 140-lb. Hammer Dropping 30-in. Required to Drive a 2-in. O.D. Split Spoon One Foot or Indicated Depth - "S" Denotes Seating)

Percent Core Recovery

R.Q.D.*

*R.Q.D. Denotes Modified Core Recovery Percentage in Which Only Pieces of Sound Core Over 4 Inches Long are Counted as Recovery

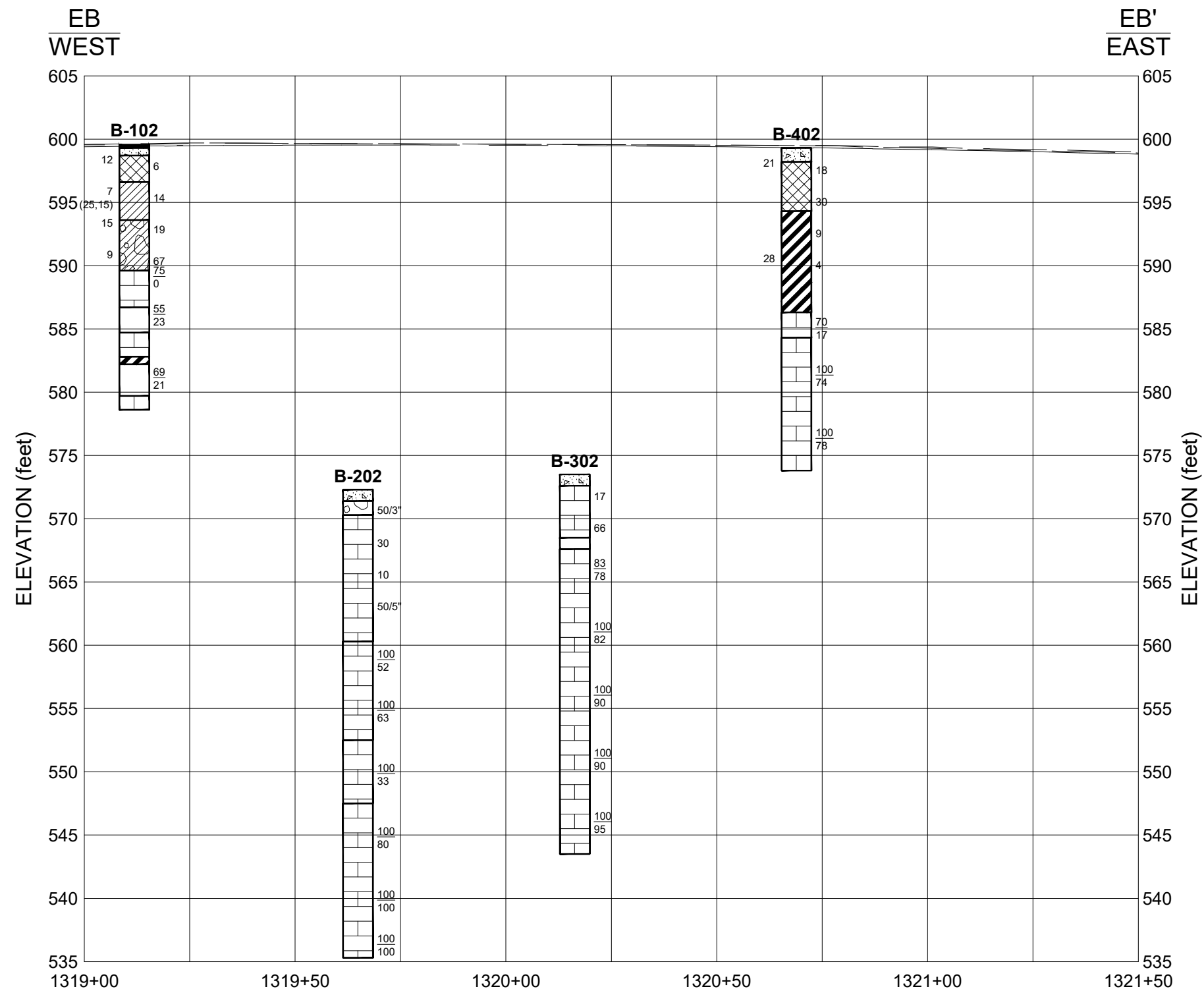
Drawn By: WAH	Ck'd By: SK	App'vd By: AWR
Date: 2-7-22	Date: 3-22-22	Date: 4-5-22

GEOTECHNOLOGY
A Universal Engineering Sciences Company

I-70 Corridor Improvements
MoDOT Project J6I0624
Wentzville, Missouri

**GENERALIZED SUBSURFACE PROFILE
ALONG I-70 BRIDGE OVER ROUTE Z
CROSS-SECTION WB-WB'**

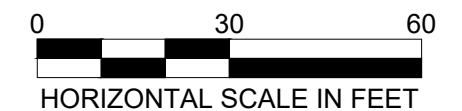
Project Number J032438.03	FIGURE 9
------------------------------	-----------------



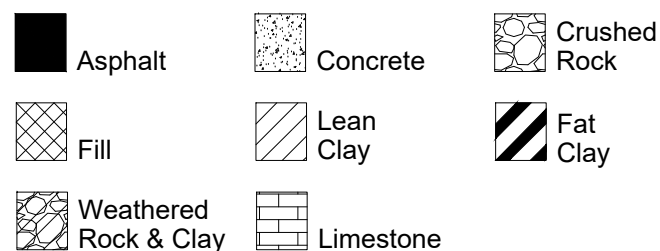
NOTES

1. See Figure 5 for location of Cross Section EB-EB'.
2. Data concerning subsurface conditions were obtained at boring locations only.

SCALE IN FEET
Horizontal 1" = 30'
Vertical 1" = 10'



KEY TO BOREHOLE SYMBOLS



KEY TO TEST DATA

Natural Water Content in Percent
Liquid and Plastic Limits

Standard Penetration Test Resistance (No. of Blows of a 140-lb. Hammer Dropping 30-in. Required to Drive a 2-in. O.D. Split Spoon One Foot or Indicated Depth - "S" Denotes Seating)

Percent Core Recovery
R.Q.D.*

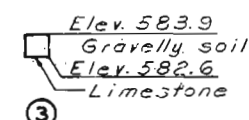
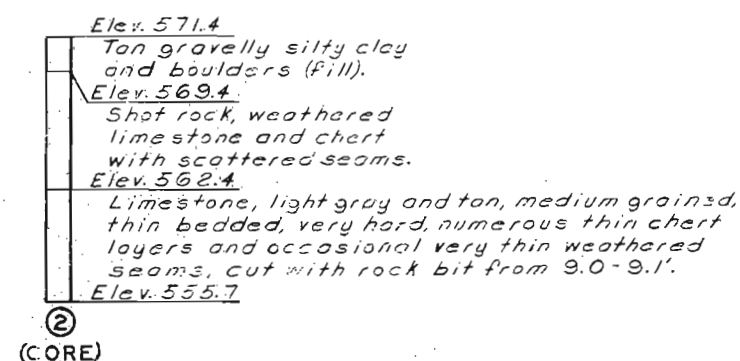
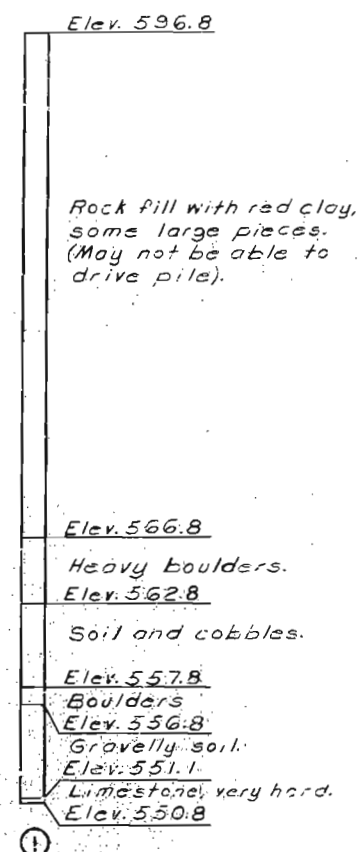
*R.Q.D. Denotes Modified Core Recovery Percentage in Which Only Pieces of Sound Core Over 4 Inches Long are Counted as Recovery

Drawn By: WAH	Ck'd By: SK	App'vd By: AWR
Date: 2-7-22	Date: 3-22-22	Date: 4-5-22
 I-70 Corridor Improvements MoDOT Project J6I0624 Wentzville, Missouri		
GENERALIZED SUBSURFACE PROFILE ALONG I-70 BRIDGE OVER ROUTE Z CROSS-SECTION EB-EB'		
Project Number J032438.03		FIGURE 10

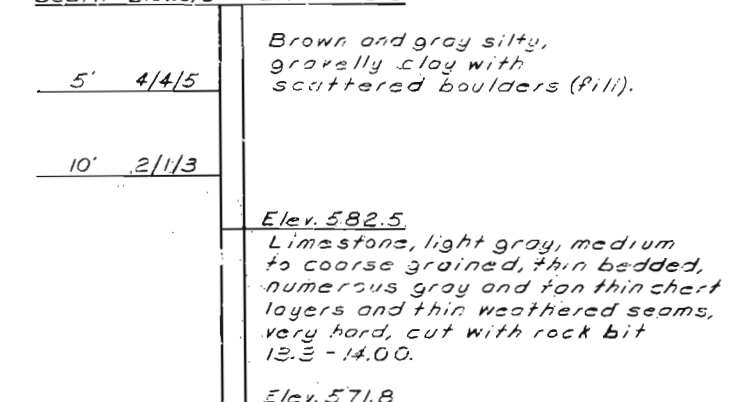


APPENDIX C – PREVIOUS BORINGS

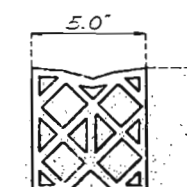
FED. ROAD DIST. NO.	STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
5	MO.		82	38	



Standard Penetration Test
Depth Blows/6" Elev. 595.8

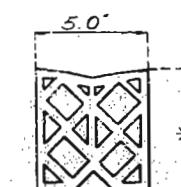


Seal top surface of Preformed Compression Joint Seal



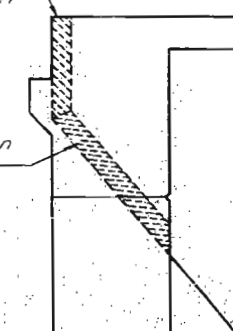
TYPE A1

* Not less than width
Note: Max. limit of compressibility 40%
Gap 2% @ 60°F



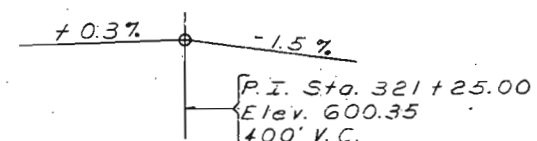
TYPE B3

Compression Joint Seal



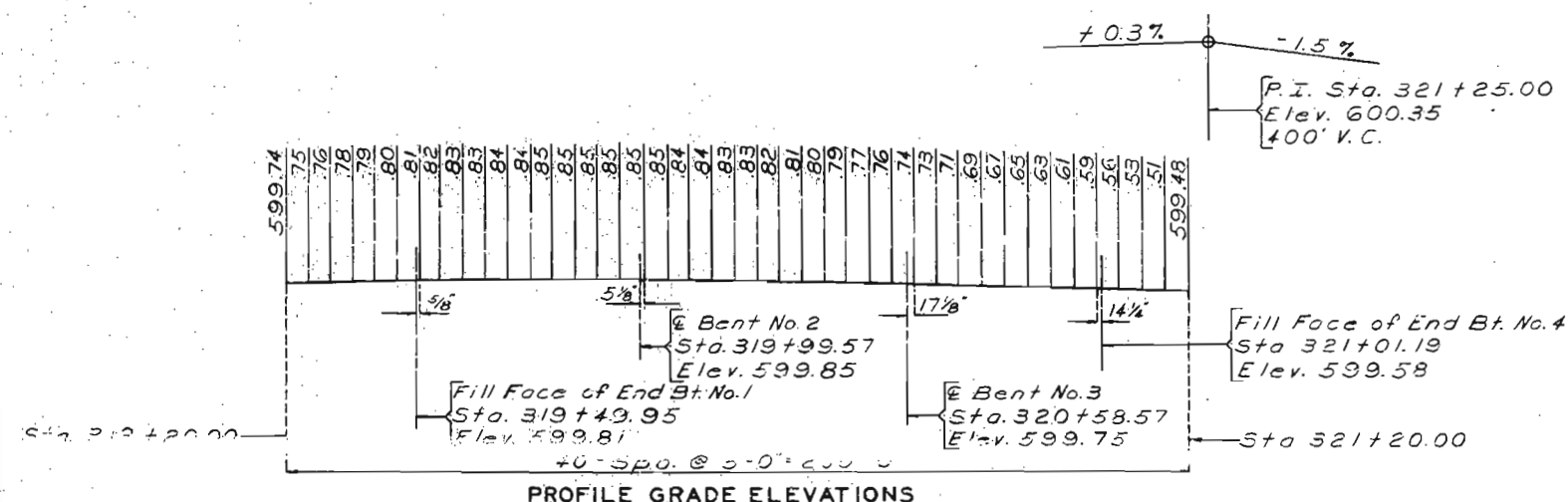
PART ELEVATION SHOWING COMPRESSION JOINT SEAL

BORING DATA



COMPRESSION JOINT SEAL AT END BENTS NO. 1 & NO. 4

Note: Cost of Preformed Compression Joint Seal in place to be included in contract unit price for other items.



PILE & FOOTING DATA					
BENT NO.		1	2	3	4
BEARING PILE	Pile Type and Size	HP10X42			HP10X
	Number	5			5
	Approximate Length	Ft. 20			17
	Design Bearing	Tons 45			42
	Hammer Energy required	Ft. Lbs. 10,100			9,400
SPREAD FOOTING	Foundation Material		Rock	Rock	
	Unit on Bearing	Tons/Sq. Ft.	8.5	8.8	

Note: Minimum energy requirement of hammer based on pile length and design bearing value of piles.
All pile shall be driven to practical refusal.
Prebore for piles at Bents 1 and 4 to elevation 577.0.
Manufactured pile point reinforcement shall be used on piles at bent No. 1. See Special Provisions.

MISSOURI HIGHWAY AND TRANSPORTATION COMMISSION

(44'-59'-37') Prestressed Concrete I Girder Spans

FEED. ROAD DIST. NO.	STREET	FEED. AND PROJ. NO.	FEED. YEAR	SHEET NO.	TOTAL SHEETS
1	ML	10	55		
SEC./SUR. 25 TWP. 47 N RGE. 1 E					

GENERAL NOTES:

Design Specifications: A.A.S.H.T.O.-1977 and Interim thru 1982 Load Factor Design.

Design Loading:

HS20-44 Modified 24,000* Tandem Axle 15% sq. ft. Future Wearing Surface Earth 120% cu. ft., Equivalent Fluid Pressure 30% cu. ft.
Superstructure: Simply supported non-composite for Dead Loads.
Continuous composite for Live Loads.

Design Unit Stresses:

Class B Concrete (Substructure) $f'_c = 3,000$ psi.
Class B1 Concrete (Safety Barrier Curb) $f'_c = 4,000$ psi.

Class B2 Concrete (Superstructure except Prestressed Girders and Safety Barrier Curb) $f'_c = 4,000$ psi.

Reinforcing Steel (Grade 60) $f_y = 60,000$ psi.

Steel Pile $f_b = 3,000$ psi.

For Prestressed Girder Stresses see Girder Sheets.

Reinforcing Steel:

Minimum clearance to reinforcing steel shall be $1\frac{1}{2}$ " unless otherwise shown.

Joint Filler:

All Joint Filler shall meet the requirements of Std. Spec. 1057.2.4 except as noted.

Bearings:

Bearings shall be 60 durometer Neoprene Pads.

ESTIMATED QUANTITIES

ITEM	SUBSTR.	SUPERSTR.	TOTAL
Removal of Bridge (No. L-192) (W.B. Lane) Lump Sum			1
Class I Excavation Cu.Yd.	75		75
Structural Steel Pile (HP10x42) Lin.Ft.	100		100
Pile Bore For Piling Lin.Ft.	78		78
Class B Concrete Cu.Yd.	90.6		90.6
Slab on Concrete I-Gdr. see Special Prov. Sq.Yd.		661	661
Safety Barrier Curb Lin.Ft.		309	309
Pile Point Reinforcement Each	5		5
Plain Neoprene Bearing Pads Each		30	30
Prestressed Concrete I-Girder (44' Span) Each		5	5
Prestressed Concrete I-Girder (59' Span) Each		5	5
Prestressed Concrete I-Girder (37' Span) Each		5	5
Reinforcing Steel Lbs.	11,120		11,120
Slab Drains Each		18	18

Note: All concrete between the upper and lower construction joints in end bents is included in the estimated superstructure quantities for Slab on Concrete I-Girder, see Special Provisions.

All reinforcement in the end bent No.1 and above footing in end bent No.4 is included with superstructure quantities.

Cost of furnishing, fabricating and installing Neoprene Bearing Pads complete in place, will be paid for at the contract unit price for Plain Neoprene Bearing Pads per each.

B.M. Elev. 595.63 "D" on N. leg of "New Melle 8" sign 21' N. of N. edge Off Ramp to Rte. Z.

BRIDGE OVER ROUTE Z

STATE ROAD IN WENTZVILLE

ABOUT 1.3 MILES WEST OF RTE. 61

PROJECT NO. I-IR-70-4(65) STA. 319+68.77

JOB NO. 6-1070-336

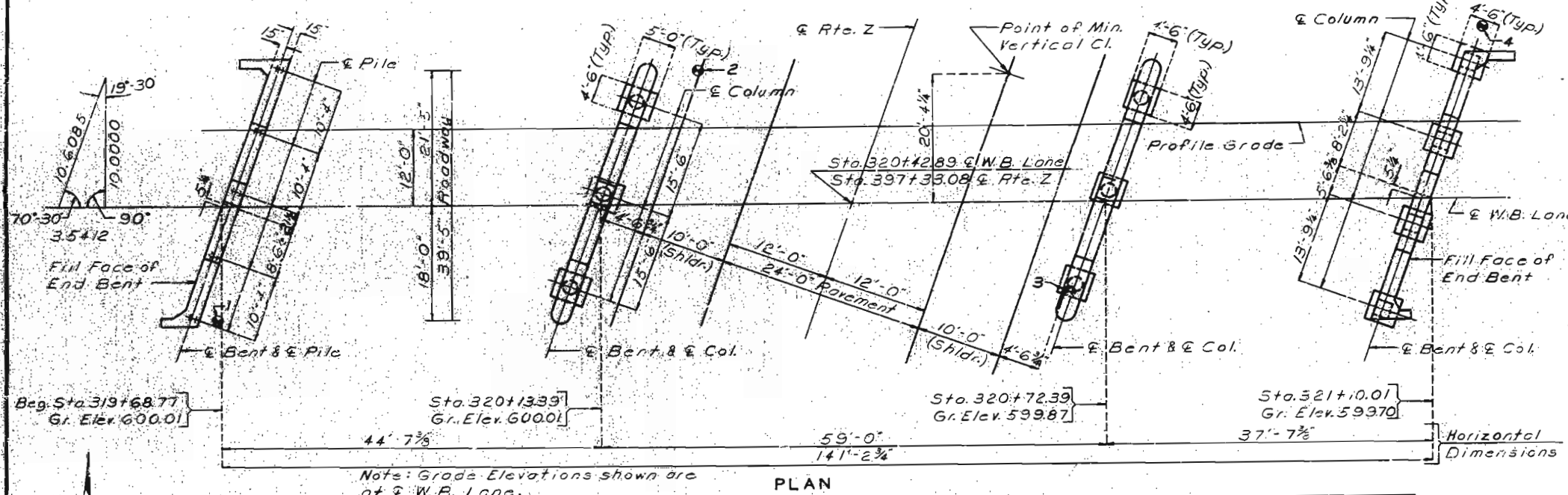
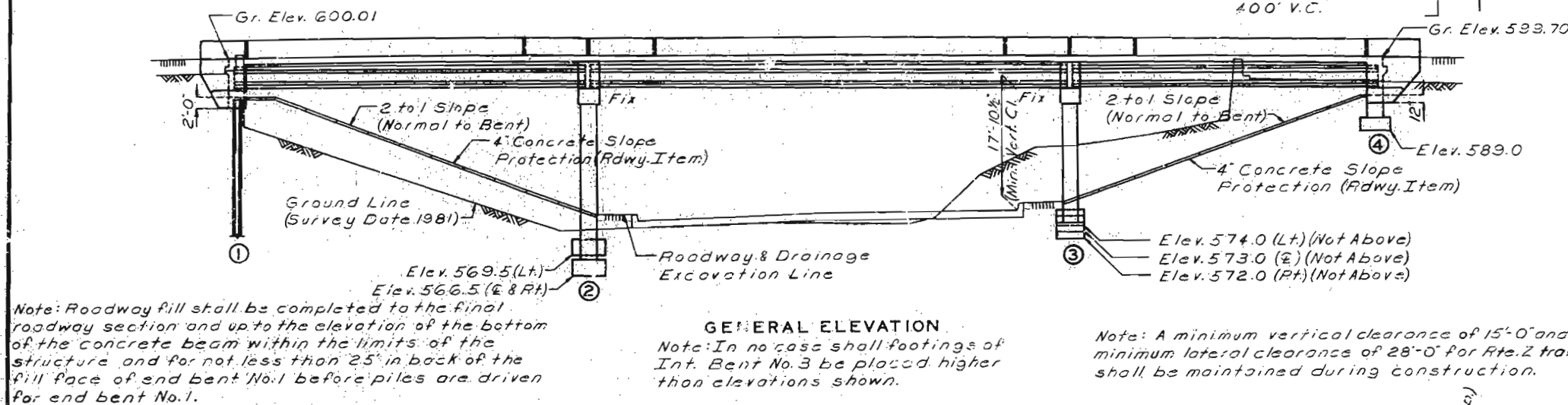
RTE. I-70

ST. CHARLES

COUNTY

DATE April 2, 1985

STD. 611.60
STD. 706.35
A-4323



ESTIMATED QUANTITIES FOR ALTERNATE SLABS

TYPE OF SLAB	REINF. EPOXY	(LBS.) PLAIN	CONC. (CU. YD.)
Cast-In-Place Conventional Forms	25,200	25,780	220.3
Precast Panel Forms	23,860	10,120	181.5
Stay-In-Place Forms	** 25,200	25,780	212.5 *

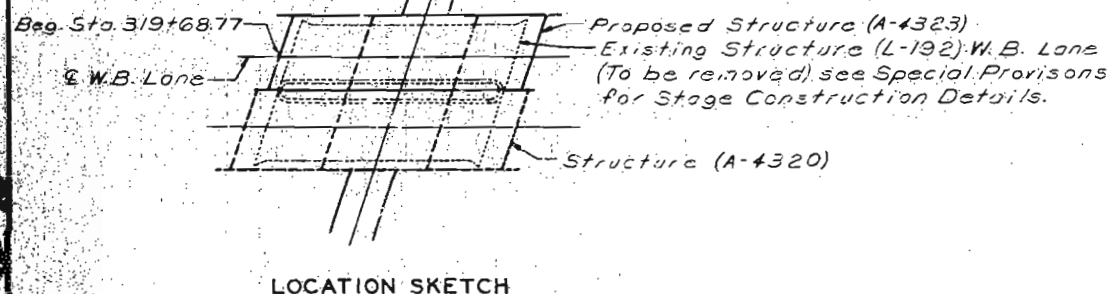
Note: The table of Estimated Quantities for Alternate Slabs represents the quantities used by the state in preparing the cost estimate for concrete slabs. Variations may be encountered in the estimated quantities but these variations cannot be used for an adjustment in the Contract Unit Price per square yard or Alternate Slab used.

See Special Provisions for alternate methods of forming slabs.

* Does not include concrete required to fill corrugation of S-I-P forms.

** Does not include reinforcing bars used as bar supports.

Excavation at End Bents No.1 and No.4 shall be included in price bid for other items.



DESIGNED Aug. 1983
CHECKED Feb. 1984
CHECKED Mar. 1984

Note: This drawing is not to scale. Follow dimensions.

Sheet No. 1 of 19.

FED. ROAD DIST. NO.	STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
5	MO.		80	56	

Elev. 596.9
Concrete
Elev. 596.5

Heavy boulders with some intermixed clay.

Elev. 584.9
Gravelly soil.
Elev. 583.0
Limestone

Elev. 576.2
Tan silty gravelly, clay and cobbles.
Elev. 573.2
Heavy boulders (shot rock) and some clay seams.
Elev. 570.5
Limestone, light gray and tan, medium grained, thin bedded, pitted or slightly ruggy, cherty.
Elev. 566.9
Limestone, light gray, medium grained, thin bedded, numerous tan and gray thin chert layers and very thin weathered seams.
Elev. 560.7

②
(CORE)

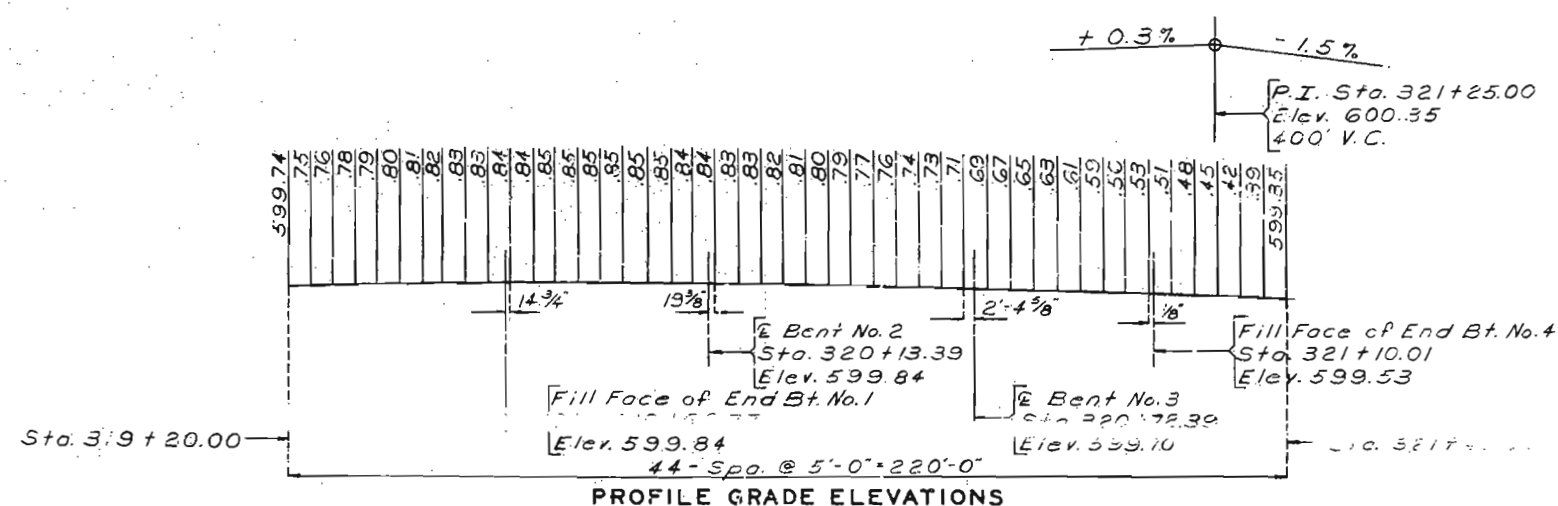
Elev. 593.4
Brown rocky residual clay with scattered boulders.
Elev. 591.9
Brown and reddish-brown residual clay.
Elev. 590.9
Boulders and some clay layers
Elev. 590.5
Limestone, light gray, medium to coarse grained, thin bedded, thin gray & tan chert layers and scattered tan clay seams 0.1-0.2' thick, cut with rock bit from 2.9-3.0'.
Elev. 582.4

④
(CORE)

Elev. 550.5
Limestone
Elev. 547.7

①

BORING DATA



PROFILE GRADE ELEVATIONS

PILE & FOOTING DATA				
BENT NO		1	2	3
BEARING PILE	Pile Type and Size	HP10X42		
	Number	5		
	Approximate Length	Ft. 20		
	Design Bearing	Tons 42		
	Hammer Energy required	Ft. Lbs. 9,400		
FOOTING		Rock	Rock	Rock
Design Bearing		Tons 8	8.8	5

Note: Minimum energy requirement of hammer based on plan length and design bearing value of piles.
All pile shall be driven to practical refusal.
Prebore for piles at Bent No. 1 to elevation 577.0.
Manufactured pile point reinforcement shall be used on all piles in this structure. See Special Provisions.



APPENDIX D – MEMORANDUM OF DRILL RIG SPT HAMMER EFFICIENCIES



MEMORANDUM

TO: Geotechnology Exploration, LLC
FROM: Craig K. Kaibel, P.E., Specialty Testing Manager
DATE: April 5, 2022
SUBJECT: CME 55LC (S/N 390755), CME 85 (S/N 254736), CME 750Y (S/N 404788)
and CME 550X (S/N 343063) Drill Rig SPT Hammer Efficiencies

Presented in this memo are the results of dynamic measurements performed on the subject drill rigs. The purpose of testing was to measure the average transferred energy from the automatic standard penetration test (SPT) hammer to the drill rods and calculate the average hammer efficiency. The testing was performed in accordance with ASTM D4633.

DRILL RIG AND SPT HAMMER INFORMATION

The drill rigs are equipped with a CME automatic SPT hammer which utilizes a mechanical drop system to create a 30-inch free fall condition of a 140-lb hammer. In general, the hammer is designed to be operated at a rate around 50 to 55 blows per minute. AWJ drill rods and a standard 2-inch diameter split spoon sampler were used for testing. The distance from the hammer impact surface to the gages was constant during testing.

DATA COLLECTION AND EVALUATION

A summary of the test dates and drill rig operators is presented below.

SUMMARY OF TESTING		
Drill Rig	Test Date	Operator
CME 55LC	March 12, 2021	Mr. Nick Gonzalez
CME 85	February 3, 2021	Mr. Thomas Dwyer
CME 750Y	February 5, 2021	
CME 550X	March 12, 2021	Mr. Cody Norbeck

SPT energy measurements were collected at 5-foot centers between depths of approximately 28.5 and 70 feet below the ground surface. The dynamic measurements were obtained using an instrumented AWJ rod, piezoresistive accelerometers, and a Pile Driving Analyzer (PDA) Model PAX

manufactured by Pile Dynamics, Inc. A copy of the calibration certificates for the piezoresistive accelerometers and strain gauges is presented as Appendix A.

Mr. Paul Bess, P.E. operated the PDA and observed the associated drilling and sampling. The recorded force and velocity curves were viewed on screen to determine the data quality. Data were digitally stored on the PDA for subsequent processing and analysis. The PDA data are presented as Appendix B and representative force and velocity records are presented in Appendix C. The following data are included in the PDA data summaries.

- FMX – the maximum compressive force at the sensor location
- VMX – the maximum downward velocity at the sensor location
- EFV – energy transfer at the sensor location
- ETR – energy transfer ratio (EMX divided by maximum rated energy)
- BPM – hammer operating rate in blows per minute
- EMX – maximum energy transfer at the sensor location
- EF2 – energy transfer value at time equals $2L/c$, where L is the rod length and c is the stress wave speed in steel (i.e., 16,807.9 feet per second)
- DFN – the final calculated downward displacement at the sensor location
- FVP – force versus velocity proportionality at first peak

RESULTS

A summary of the field measurements are presented in the following tables. Data from the initial 6-inch interval (i.e., seating blows) were removed from the data files and are not included in Table 1.

CME 55LC – SUMMARY OF SPT ENERGY MEASUREMENTS							
Sample Depth (feet)	Effective Rod Length (feet)	Blow Count (blows/6 in)	SPT Field N Value ¹	Average Energy Transferred ² (ft-kips)	Average Energy Transfer Ratio ³ (%)	Energy Transfer Ratio Standard Deviation	Blow per Minute (bpm)
33.5 to 35	38.88	5-7-11	18	0.319	91.1	1.4	52.3
38.5 to 40	43.88	3-5-4	9	0.319	91.2	0.8	53.4
43.5 to 45	48.88	5-5-5	10	0.328	93.7	1.1	53.2
48.5 to 50	53.88	7-8-8	16	0.325	93.0	1.2	53.3
50.5 to 52	55.88	9-11-10	21	0.332	94.8	1.4	53.2
53.5 to 55	58.88	12-15-14	29	0.327	93.5	1.3	53.2
55.5 to 57	60.88	5-10-25	25	0.324	92.7	0.9	53.2
58.5 to 60	63.88	6-23-15	38	0.333	95.2	1.1	53.0
Average ⁴				0.327	93.4	NA	53.2
Standard Deviation ⁴				0.006	1.7	NA	0.3

¹ The standard penetration resistance, or N-value, is defined as the number of blows required to drive the split-spoon sampler 12 inches with a 140-pound hammer falling 30 inches. Since the split spoon sampler is driven 18 inches or until refusal, the blows for the first 6 inches are for seating the sampler, and the number of blows for the final 12 inches is the N-value.

² Average energy transferred is calculated using the FV method (i.e., EMX or EFV calculation).

³ Energy transfer ratio (ETR) is the measured average energy transferred divided by the potential energy of the SPT hammer (i.e., 140-lb hammer multiplied by a 2.5-foot drop height or 0.350 ft-kips) presented as a percent.

⁴ Overall average and standard deviation are calculated from the full dataset prior to rounding.

CME 85 – SUMMARY OF SPT ENERGY MEASUREMENTS							
Sample Depth (feet)	Effective Rod Length (feet)	Blow Count (blows/6 in)	SPT Field N Value ¹	Average Energy Transferred ² (ft-kips)	Average Energy Transfer Ratio ³ (%)	Energy Transfer Ratio Standard Deviation	Blow per Minute (bpm)
33.5 to 35	38.88	8-7-5	12	0.250	71.5	1.0	41.1
38.5 to 40	43.88	4-7-6	13	0.251	71.7	1.5	41.0
43.5 to 45	48.88	4-4-5	9	0.262	74.8	1.6	40.9
48.5 to 50	53.88	4-3-4	7	0.248	70.8	1.9	40.9
53.5 to 55	58.88	11-12-16	28	0.254	72.5	1.7	41.3
58.5 to 60	63.88	11-16-17	33	0.256	73.3	1.8	41.4
63.5 to 65	68.88	15-18-14	32	0.263	75.1	1.3	41.5
68.5 to 70	73.88	13-11-9	20	0.254	72.6	1.6	41.5
Average ⁴				0.256	73.3	NA	41.3
Standard Deviation ⁴				0.007	2.1	NA	0.3

¹ The standard penetration resistance, or N-value, is defined as the number of blows required to drive the split-spoon sampler 12 inches with a 140-pound hammer falling 30 inches. Since the split spoon sampler is driven 18 inches or until refusal, the blows for the first 6 inches are for seating the sampler, and the number of blows for the final 12 inches is the N-value.

² Average energy transferred is calculated using the FV method (i.e., EMX or EFV calculation).

³ Energy transfer ratio (ETR) is the measured average energy transferred divided by the potential energy of the SPT hammer (i.e., 140-lb hammer multiplied by a 2.5-foot drop height or 0.350 ft-kips) presented as a percent.

⁴ Overall average and standard deviation are calculated from the full dataset prior to rounding.

CME 750Y – SUMMARY OF SPT ENERGY MEASUREMENTS							
Sample Depth (feet)	Effective Rod Length (feet)	Blow Count (blows/6 in)	SPT Field N Value ¹	Average Energy Transferred ² (ft-kips)	Average Energy Transfer Ratio ³ (%)	Energy Transfer Ratio Standard Deviation	Blow per Minute (bpm)
28.5 to 30	33.71	7-4-6	10	0.297	84.9	0.8	56.2
33.5 to 35	38.71	9-7-11	18	0.299	85.5	0.7	54.5
38.5 to 40	43.71	7-6-7	13	0.306	87.5	0.7	54.3
43.5 to 45	48.71	5-6-8	14	0.302	86.3	0.6	54.2
48.5 to 50	53.71	19-14-16	30	0.316	90.2	0.9	54.0
53.5 to 55	58.71	15-12-14	26	0.310	88.6	0.7	54.5
58.5 to 60	63.71	16-15-22	37	0.316	90.3	0.8	53.1
63.5 to 65	68.71	29-27-31	58	0.321	91.7	2.1	54.1
Average ⁴				0.314	89.7	NA	54.1
Standard Deviation ⁴				0.009	2.5	NA	0.6

¹ The standard penetration resistance, or N-value, is defined as the number of blows required to drive the split-spoon sampler 12 inches with a 140-pound hammer falling 30 inches. Since the split spoon sampler is driven 18 inches or until refusal, the blows for the first 6 inches are for seating the sampler, and the number of blows for the final 12 inches is the N-value.

² Average energy transferred is calculated using the FV method (i.e., EMX or EFV calculation).

³ Energy transfer ratio (ETR) is the measured average energy transferred divided by the potential energy of the SPT hammer (i.e., 140-lb hammer multiplied by a 2.5-foot drop height or 0.350 ft-kips) presented as a percent.

⁴ Overall average and standard deviation are calculated from the full dataset prior to rounding.

CME 550X – SUMMARY OF SPT ENERGY MEASUREMENTS							
Sample Depth (feet)	Effective Rod Length (feet)	Blow Count (blows/6 in)	SPT Field N Value ¹	Average Energy Transferred ² (ft-kips)	Average Energy Transfer Ratio ³ (%)	Energy Transfer Ratio Standard Deviation	Blow per Minute (bpm)
28.5 to 30	33.88	7-7-6	13	0.281	80.4	0.8	48.2
38.5 to 40	43.88	5-7-5	12	0.288	82.2	1.1	48.1
43.5 to 45	48.88	6-8-9	17	0.293	83.6	1.3	48.2
48.5 to 50	53.88	10-16-14	30	0.294	84.1	1.9	47.4
53.5 to 55	58.88	9-15-16	31	0.293	83.8	1.0	47.3
58.5 to 60	63.88	6-10-11	21	0.298	85.2	1.4	48.0
63.5 to 65	68.88	15-28-30	58	0.294	83.9	1.4	48.0
Average ⁴				0.293	83.6	NA	47.8
Standard Deviation ⁴				0.006	1.7	NA	0.5

¹ The standard penetration resistance, or N-value, is defined as the number of blows required to drive the split-spoon sampler 12 inches with a 140-pound hammer falling 30 inches. Since the split spoon sampler is driven 18 inches or until refusal, the blows for the first 6 inches are for seating the sampler, and the number of blows for the final 12 inches is the N-value.

² Average energy transferred is calculated using the FV method (i.e., EMX or EFV calculation).

³ Energy transfer ratio (ETR) is the measured average energy transferred divided by the potential energy of the SPT hammer (i.e., 140-lb hammer multiplied by a 2.5-foot drop height or 0.350 ft-kips) presented as a percent.

⁴ Overall average and standard deviation are calculated from the full dataset prior to rounding.

Attachments: Appendix A – Calibration Certificates
Appendix B – PDA Data Summaries
Appendix C – Representative Force and Velocity Records

ADP/CKK:adp/ckk

APPENDIX A

CALIBRATION CERTIFICATES

Accelerometer Calibration Certificate

Pile Dynamics, Inc.



Calibrated by Pile Dynamics, Inc.
Calibration performed on 15Feb2021

Serial No: K2491 Temperature: 20.0 °C

Model: PR Humidity: 30%

Calibrated on: Channel 4 on 8G 5161 LE

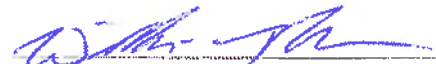
PDA CALIBRATION FACTOR

309.6 mv/5000g
(61.9 μ v/g)
R²: 0.999952 [Chip programmed]

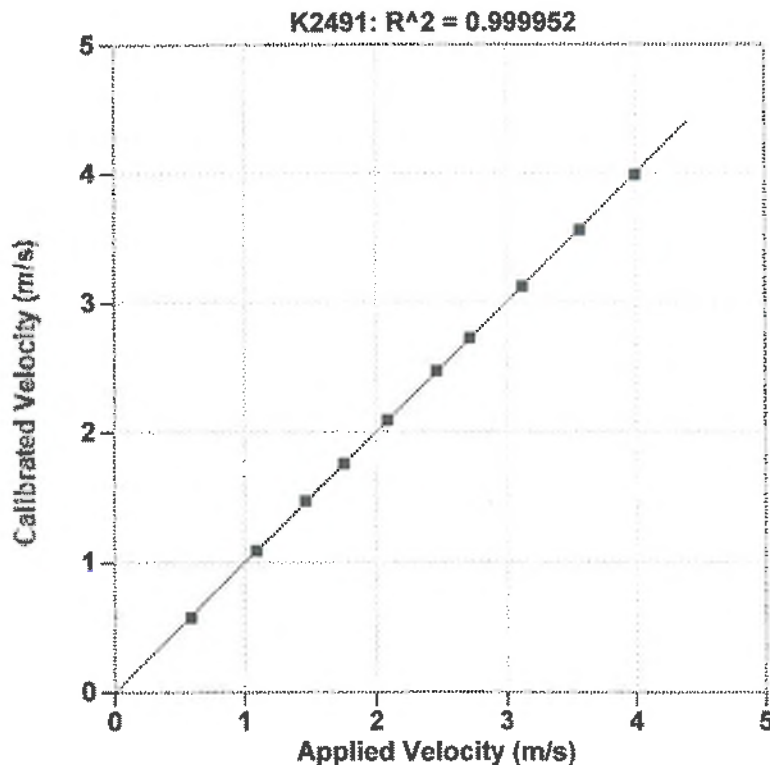
Operator: William Johnson

Ref Acc 1: 69096! Cal on: 27Jan2021
978 g's/volt

Ref Acc 2: 69132! Cal on: 09Feb2021
960 g's/volt


Signed

Reference accelerometer calibrations are traceable to
the United States National Institute of Standards and
Technology (NIST).



Reference Velocity	S/N K2491 Velocity
m/s	m/s
0.579	0.573
1.087	1.085
1.459	1.469
1.753	1.757
2.085	2.089
2.465	2.473
2.715	2.725
3.124	3.124
3.567	3.559
3.996	3.985
Maximum Acceleration: 870 g's	

Accelerometer Calibration Certificate

Pile Dynamics, Inc.



Calibrated by Pile Dynamics, Inc.
Calibration performed on 15Feb2021

Serial No: K2492 Temperature: 20.0 °C

Model: PR Humidity: 30%

Calibrated on: Channel 4 on 8G 5161 LE

PDA CALIBRATION FACTOR

310.9 mv/5000g
(62.2 μ v/g)
R²: 0.999675 [Chip programmed]

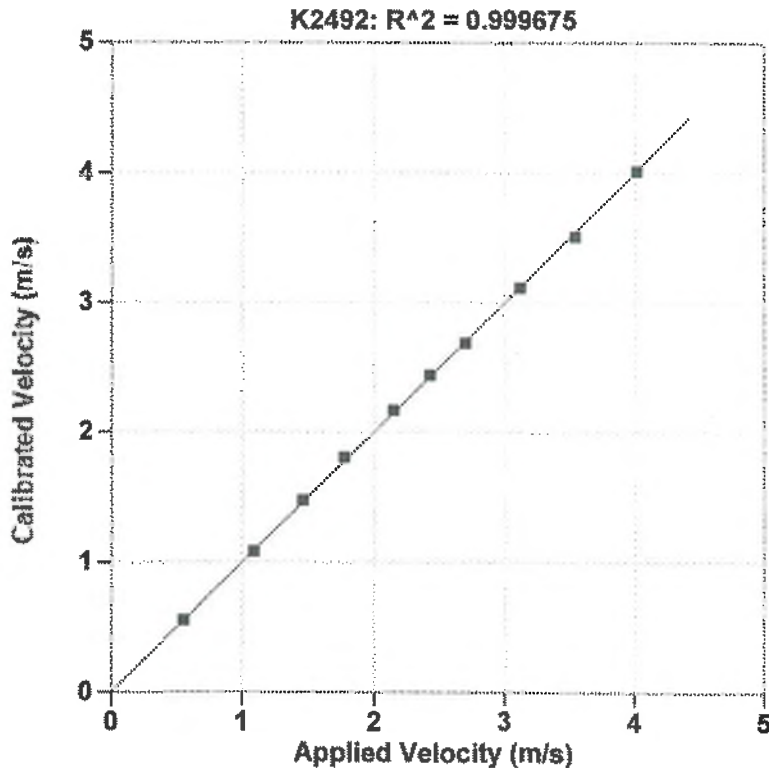
Operator: William Johnson

Ref Acc 1: 69096I Cal on: 27Jan2021
978 g's/volt

Ref Acc 2: 69132I Cal on: 09Feb2021
960 g's/volt

William Johnson
Signed

Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).



Reference Velocity	S/N K2492 Velocity
m/s	m/s
0.545	0.551
1.087	1.085
1.458	1.475
1.768	1.806
2.146	2.167
2.425	2.438
2.698	2.689
3.120	3.115
3.542	3.510
4.016	4.013
Maximum Acceleration: 875 g's	

QSTA: ON [ALT-F1/88=60]

File Dynamics, Inc.

TG F2 DPF

File Dynamics
2020-01-08 14:43FS —
10BN 2521/12520
SL 470/ 3440/ 99PJ:
PN: HOPBARA 4 -- US
F 2 3.3LE 39.6 ft
AR 1.7 in2
EM 30000 Ksi
SP 0.492 K/ft3
WS 16815 ft/s
WC 16851 ft/sJC 0.40
FM 1.00
UM 1.00EA/C 30.3 Ks/ft
UN KIPS X0.1
FR 20000 NB 90DL -36
UT -1 IP 0.00
PK 1 TM-PEAKF1/2 500/ 213
F3/4 213/ 213
A1/2 999/ 999
A3/4 999/ 373TS 12
TB 8.0E B PD: K1220
T1 9.6 2L/C 4.7VA 1000 UE 1024 LP 0.00 ft
LI 1.0

ACCEPT SQ-OFF FL-OFF PR-OFF

ACCEPT



ACCELEROMETER CALIBRATION

N.I.S.T. Traceable

SERIAL NUMBER:

K1220

CALIBRATION FACTOR:

.0746 mV/g

PAK (*5000):

373

DATE:

9 JAN 20

PDA OPERATOR:

<-AI:PIEZORESISTIVE

OP: LAINE [ver:5.01]

AI:PIEZOELECTRIC->

Smart Sensor

Programmed By:

CRC Value

9392

QBTA: ON [ALT-F1/BB=60]

Pile Dynamics, Inc.

TG F2 DPF

Pile Dynamics 2018-02-01 10:11		FS — DN 628 10 SI 660/ 3440/ 99	PJ: PN: HOPBAR	A 4 -- US F 2 3.3
LE 17.0 ft AR 1.7 in2 EM 30000 Ksi SP 0.492 K/ft3 WS 16810 ft/s WC 7234 ft/s				
JC 0.40 FM 1.00 UM 1.00				
EA/C 30.3 Ks/ft UN KIPS±0.1 FR 20000 MB 90				
DL -44 UT -1 IP 0.00 PK 1 TM-PEAK				
F1/2 500/ 213 F3/4 213/ 213 A1/2 999/ 999 A3/4 999/ 338	TS 12 TB 8.0	E B PD: k2127 T1 9.5 2L/C 4.7	VA 1000	UE 1024 LP 0.00 ft LI 1.0
ACCEPT SQ-OFF FL-OFF PR-OFF		UMX= 4.3 FMX= 66 AMX= 139 EMX= 0.3 MEX= 129 FUP= 1.00		
ACCEPT		ACCELEROMETER CALIBRATION N.I.S.T. Traceable		
		SERIAL NUMBER: K2127		
		CALIBRATION FACTOR: .0676 MV/G		
		PAK (*5000): 338 DATE: 1FEB18		
PDA OPERATOR: [Signature]				
← AT: PIEZORESISTIVE		OP: laine [ver:5.011		AT: PIEZOELECTRIC →

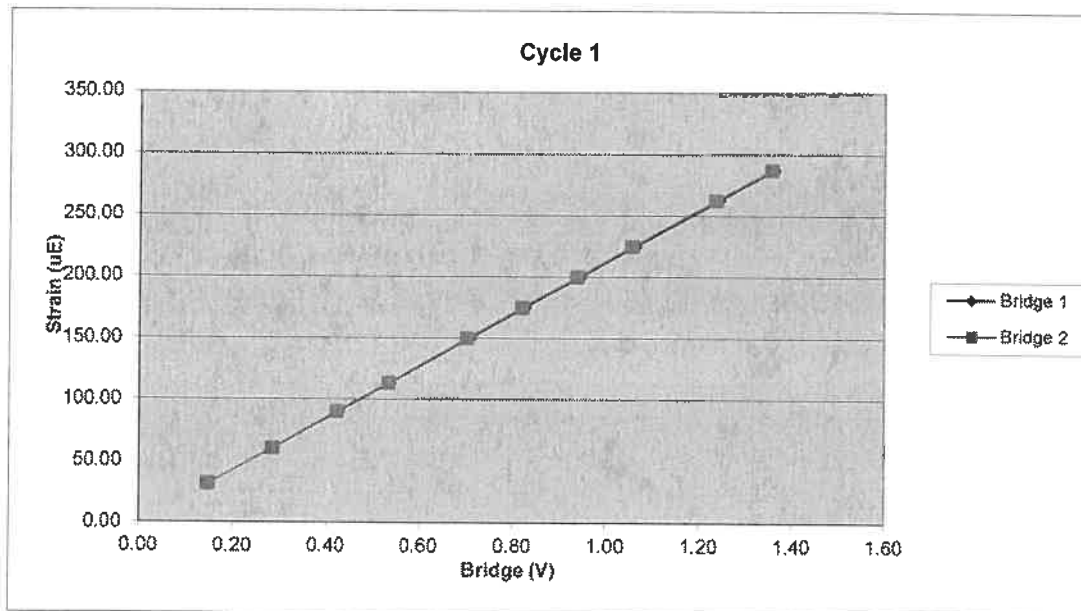
Smart Sensor

Smart Chip Programmed By Z.M.W. on 1FEB18 CRC Value 9054

405AWJ		Cycle 1		
Sample	Force (lb)	Strain (μE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	1099.88	31.07	0.15	0.15
3	2128.61	60.06	0.28	0.28
4	3176.01	90.16	0.43	0.42
5	4012.04	113.39	0.54	0.53
6	5290.36	149.89	0.71	0.70
7	6184.14	175.04	0.83	0.82
8	7076.94	199.84	0.94	0.94
9	7953.33	224.58	1.06	1.06
10	9303.87	262.49	1.24	1.24
11	10208.99	287.30	1.36	1.36

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7501.40	Force Calibration (lb/V)	7535.01
Offset	-6.59	Offset	-4.03
Correlation	0.999998	Correlation	0.999999
Strain Calibration ($\mu\text{E/V}$)	211.24	Strain Calibration ($\mu\text{E/V}$)	212.19
Offset	0.28	Offset	0.35
Correlation	0.999996	Correlation	0.999988

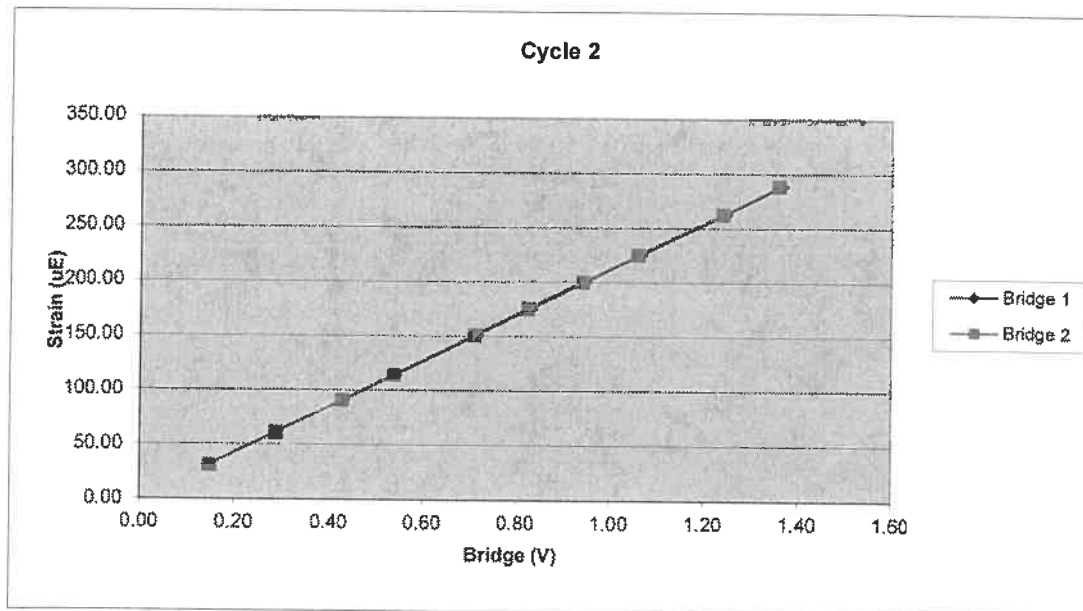
Force Strain Calibration	
EA (Kips)	35510.44
Offset	-16.30
Correlation	0.999991



405AWJ		Cycle 2		
Sample	Force (lb)	Strain (μE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	1085.81	30.90	0.15	0.15
3	2112.88	60.70	0.28	0.29
4	3184.61	91.07	0.43	0.43
5	4019.17	114.23	0.54	0.54
6	5328.38	151.06	0.71	0.71
7	6201.05	175.39	0.83	0.83
8	7074.79	200.08	0.95	0.94
9	7975.71	225.46	1.07	1.06
10	9327.03	263.01	1.25	1.24
11	10220.23	288.70	1.36	1.36

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7508.10	Force Calibration (lb/V)	7550.49
Offset	-28.25	Offset	-36.32
Correlation	0.999998	Correlation	0.999998
Strain Calibration ($\mu\text{E/V}$)	211.24	Strain Calibration ($\mu\text{E/V}$)	212.43
Offset	0.22	Offset	-0.01
Correlation	0.999996	Correlation	0.999996

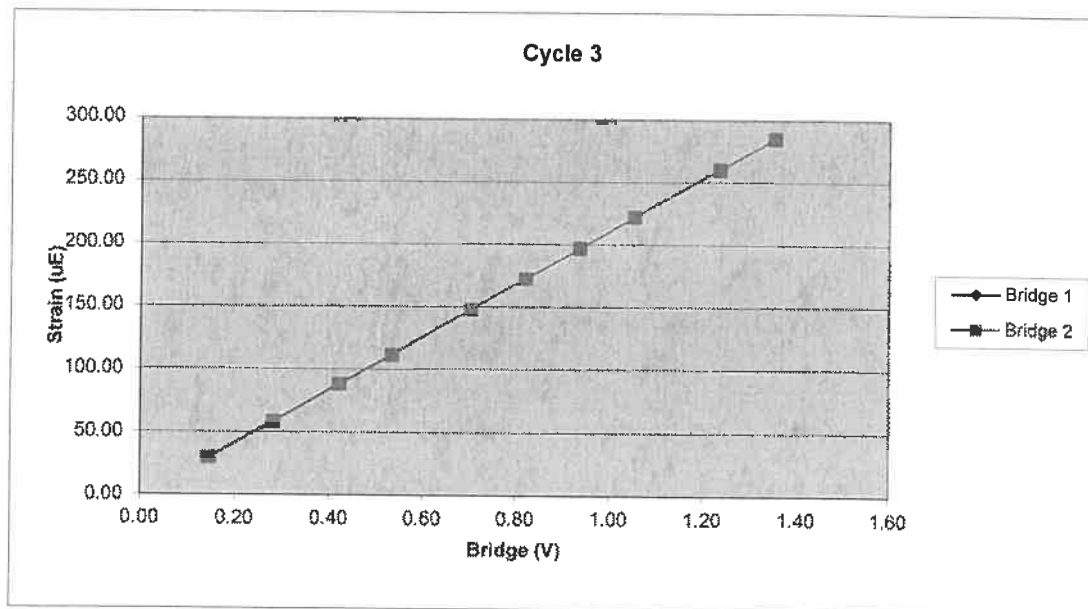
Force Strain Calibration	
EA (Kips)	35543.08
Offset	-36.06
Correlation	0.999993



405AWJ		Cycle 3		
Sample	Force (lb)	Strain (μE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	1087.56	29.76	0.14	0.15
3	2113.17	57.96	0.28	0.28
4	3185.69	87.88	0.42	0.42
5	4037.84	111.24	0.53	0.53
6	5321.73	147.73	0.70	0.70
7	6208.57	172.40	0.82	0.82
8	7096.78	196.97	0.94	0.94
9	7971.02	222.00	1.05	1.05
10	9342.18	259.99	1.23	1.23
11	10239.48	285.07	1.35	1.35

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7564.43	Force Calibration (lb/V)	7573.64
Offset	3.42	Offset	-6.92
Correlation	0.999999	Correlation	0.999999
Strain Calibration ($\mu\text{E/V}$)	211.33	Strain Calibration ($\mu\text{E/V}$)	211.59
Offset	-0.94	Offset	-1.23
Correlation	0.999998	Correlation	0.999996

Force Strain Calibration	
EA (Kips)	35793.86
Offset	37.16
Correlation	0.999995



Bridge Excitation (V) 5
Shunt Resistor (ohm) 60.4k

Calibration Factors	405AWJ		
Bridge 1 ($\mu\text{E/V}$)	211.27	Bridge 2 ($\mu\text{E/V}$)	212.07
EA Factor (Kips)	35615.79	Area (in^2)	1.19

Calibrated by: 

Calibrated Date: 1/21/2020

Pile Dynamics Inc
30725 Aurora Rd
Solon, OH 44139

Traceable to N.I.S.T.

APPENDIX B

PDA DATA SUMMARIES

ST LOUIS 2021 - CME 55LC 33.5-35.0

S/N 390755

OP: PDB

Date: 12-March-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 38.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	28.5	19.3	0.311	89.0	53.6	0.311	0.265	1.10	0.66
2	29.3	19.7	0.323	92.3	53.4	0.323	0.272	1.18	0.66
3	29.0	19.6	0.318	90.9	53.3	0.318	0.270	1.00	0.65
4	28.7	19.6	0.318	90.8	53.5	0.318	0.269	0.91	0.65
5	29.2	19.9	0.325	92.8	53.3	0.325	0.273	0.92	0.65
6	28.8	19.6	0.318	90.8	53.4	0.318	0.270	0.86	0.65
7	28.7	19.7	0.319	91.2	53.4	0.319	0.266	0.94	0.65
8	29.7	20.1	0.325	93.0	53.3	0.325	0.274	0.66	0.65
9	29.3	19.7	0.323	92.4	53.1	0.323	0.272	0.85	0.63
10	29.0	19.9	0.328	93.7	53.5	0.328	0.269	0.85	0.63
11	28.8	19.5	0.316	90.2	53.4	0.316	0.267	0.68	0.64
12	29.1	19.8	0.319	91.3	53.1	0.319	0.269	0.71	0.63
13	28.1	19.1	0.314	89.8	53.4	0.314	0.265	0.83	0.65
14	29.7	20.1	0.326	93.0	53.3	0.326	0.270	0.74	0.61
15	27.9	19.6	0.314	89.7	53.1	0.314	0.265	0.71	0.61
16	27.2	19.2	0.309	88.3	53.3	0.309	0.263	0.54	0.63
17	29.0	19.8	0.318	90.7	53.4	0.318	0.270	0.67	0.61
18	28.7	19.9	0.317	90.6	52.8	0.317	0.268	0.80	0.61
Average	28.8	19.7	0.319	91.1	53.3	0.319	0.269	0.83	0.64
Std. Dev.	0.6	0.3	0.005	1.4	0.2	0.005	0.003	0.16	0.02
Maximum	29.7	20.1	0.328	93.7	53.6	0.328	0.274	1.18	0.66
@ Blow#	14	8	10	10	1	10	8	2	1

Total number of blows analyzed: 18

BL# Sensors

1-18 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K2491] 310.0 (1.00); A4: off

Time Summary

Drive 19 seconds 11:00 AM - 11:01 AM BN 1 - 18

ST LOUIS 2021 - CME 55LC 38.5-40.0

S/N 390755

OP: PDB

Date: 12-March-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 43.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	25.9	20.7	0.315	90.0	53.5	0.315	0.262	1.56	0.59
2	26.8	20.2	0.317	90.5	53.6	0.317	0.267	1.26	0.63
3	26.5	20.6	0.323	92.3	53.0	0.323	0.271	1.43	0.60
4	26.9	20.3	0.322	92.1	53.2	0.322	0.269	1.68	0.62
5	26.7	20.2	0.322	92.1	53.5	0.322	0.269	1.73	0.62
6	26.8	20.0	0.318	90.9	53.5	0.318	0.267	1.67	0.63
7	27.1	19.8	0.319	91.2	53.5	0.319	0.268	1.68	0.64
8	26.5	19.4	0.322	91.9	53.3	0.322	0.269	1.86	0.64
9	27.5	18.4	0.316	90.2	53.3	0.316	0.268	1.74	0.70
Average	26.7	19.9	0.319	91.2	53.4	0.319	0.268	1.62	0.63
Std. Dev.	0.4	0.7	0.003	0.8	0.2	0.003	0.002	0.17	0.03
Maximum	27.5	20.7	0.323	92.3	53.6	0.323	0.271	1.86	0.70
@ Blow#	9	1	3	3	2	3	3	8	9

Total number of blows analyzed: 9

BL# Sensors

1-9 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K2491] 310.0 (1.00); A4: off

Time Summary

Drive 8 seconds 11:17 AM - 11:17 AM BN 1 - 9

ST LOUIS 2021 - CME 55LC 43.5-45.0

S/N 390755

OP: PDB

Date: 12-March-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 48.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	26.5	20.9	0.326	93.2	53.2	0.326	0.263	1.30	0.59
2	26.6	20.7	0.327	93.4	53.4	0.327	0.263	1.44	0.60
3	27.1	21.0	0.327	93.3	53.3	0.327	0.264	1.38	0.61
4	26.1	21.4	0.325	92.8	53.1	0.325	0.262	1.38	0.57
5	26.7	22.2	0.338	96.6	53.6	0.338	0.270	1.39	0.56
6	26.6	21.0	0.327	93.3	53.3	0.327	0.263	1.15	0.60
7	27.1	21.3	0.330	94.2	52.9	0.330	0.268	1.13	0.59
8	26.5	22.0	0.330	94.3	53.0	0.330	0.266	1.20	0.57
9	26.2	21.5	0.325	92.9	53.4	0.325	0.264	1.10	0.57
10	26.9	20.9	0.327	93.4	53.2	0.327	0.265	1.05	0.61
Average	26.6	21.3	0.328	93.7	53.2	0.328	0.265	1.25	0.59
Std. Dev.	0.3	0.5	0.004	1.1	0.2	0.004	0.002	0.13	0.02
Maximum	27.1	22.2	0.338	96.6	53.6	0.338	0.270	1.44	0.61
@ Blow#	7	5	5	5	5	5	5	2	3

Total number of blows analyzed: 10

BL# Sensors

1-10 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K2491] 310.0 (1.00); A4: off

Time Summary

Drive 10 seconds 11:26 AM - 11:26 AM BN 1 - 10

ST LOUIS 2021 - CME 55LC 48.5-50.0

S/N 390755

OP: PDB

Date: 12-March-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 53.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	28.5	18.8	0.325	92.8	53.3	0.325	0.274	0.80	0.70
2	29.3	19.3	0.327	93.4	53.3	0.327	0.273	0.87	0.70
3	28.3	18.7	0.323	92.4	53.3	0.323	0.271	0.85	0.68
4	28.9	19.6	0.328	93.8	53.5	0.328	0.274	0.87	0.68
5	28.0	18.7	0.325	92.8	53.0	0.325	0.270	0.86	0.68
6	28.0	18.4	0.322	92.1	53.3	0.322	0.272	0.77	0.69
7	27.8	18.4	0.318	90.7	52.8	0.318	0.272	0.58	0.70
8	28.3	19.0	0.324	92.5	53.4	0.324	0.274	0.74	0.68
9	28.1	18.7	0.326	93.1	53.5	0.326	0.273	0.79	0.69
10	29.5	19.7	0.333	95.1	53.0	0.333	0.279	0.73	0.66
11	29.4	19.4	0.332	95.0	53.3	0.332	0.279	0.77	0.68
12	28.6	18.7	0.324	92.6	53.7	0.324	0.275	0.78	0.68
13	28.3	19.0	0.329	94.0	53.0	0.329	0.278	0.73	0.69
14	28.2	18.8	0.326	93.1	53.1	0.326	0.274	0.76	0.69
15	28.8	19.0	0.328	93.6	53.3	0.328	0.278	0.66	0.68
16	27.6	18.3	0.318	90.7	53.5	0.318	0.276	0.62	0.69
Average	28.5	18.9	0.325	93.0	53.3	0.325	0.274	0.76	0.69
Std. Dev.	0.6	0.4	0.004	1.2	0.2	0.004	0.003	0.08	0.01
Maximum	29.5	19.7	0.333	95.1	53.7	0.333	0.279	0.87	0.70
@ Blow#	10	10	10	10	12	10	11	4	7

Total number of blows analyzed: 16

BL# Sensors

1-16 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K2491] 310.0 (1.00); A4: off

Time Summary

Drive 16 seconds 11:36 AM - 11:36 AM BN 1 - 16

ST LOUIS 2021 - CME 55LC 50.5-52.0

S/N 390755

OP: PDB

Date: 12-March-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 55.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	29.2	19.3	0.326	93.0	53.3	0.326	0.289	0.66	0.71
2	29.0	19.4	0.328	93.7	53.1	0.328	0.291	0.65	0.71
3	29.1	18.5	0.331	94.7	53.0	0.331	0.288	1.07	0.74
4	29.1	19.4	0.324	92.5	53.7	0.324	0.289	0.70	0.70
5	29.6	19.4	0.338	96.6	53.0	0.338	0.291	1.05	0.71
6	29.4	18.9	0.327	93.5	53.3	0.327	0.290	0.72	0.73
7	29.3	18.6	0.324	92.6	53.1	0.324	0.290	0.53	0.74
8	29.4	19.4	0.326	93.0	53.3	0.326	0.291	0.64	0.71
9	29.6	19.6	0.340	97.1	52.8	0.340	0.294	1.02	0.71
10	29.7	19.3	0.331	94.7	53.5	0.331	0.292	0.87	0.72
11	28.6	18.9	0.327	93.5	53.1	0.327	0.295	0.71	0.71
12	29.7	19.7	0.331	94.7	53.3	0.331	0.295	0.82	0.70
13	29.4	19.6	0.336	95.9	52.9	0.336	0.296	0.90	0.70
14	29.5	19.6	0.334	95.5	53.2	0.334	0.294	0.83	0.71
15	29.5	19.7	0.335	95.7	53.3	0.335	0.293	0.80	0.71
16	29.4	19.1	0.330	94.3	53.1	0.330	0.290	0.90	0.72
17	29.7	19.7	0.335	95.6	53.2	0.335	0.295	0.95	0.71
18	29.7	19.7	0.336	95.9	52.9	0.336	0.296	0.86	0.70
19	29.0	19.4	0.332	94.8	53.5	0.332	0.293	0.80	0.70
20	29.8	19.5	0.339	97.0	52.8	0.339	0.298	0.99	0.72
21	29.4	19.5	0.335	95.8	53.4	0.335	0.292	0.96	0.70
Average	29.4	19.3	0.332	94.8	53.2	0.332	0.292	0.83	0.71
Std. Dev.	0.3	0.3	0.005	1.4	0.2	0.005	0.003	0.15	0.01
Maximum	29.8	19.7	0.340	97.1	53.7	0.340	0.298	1.07	0.74
@ Blow#	20	12	9	9	4	9	20	3	7

Total number of blows analyzed: 21

BL# Sensors

1-21 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K2491] 310.0 (1.00); A4: off

Time Summary

Drive 22 seconds 11:42 AM - 11:43 AM BN 1 - 21

ST LOUIS 2021 - CME 55LC 53.5-55.0

S/N 390755

OP: PDB

Date: 12-March-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 58.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	25.9	18.3	0.319	91.1	53.4	0.319	0.268	0.69	0.66
2	26.6	17.9	0.314	89.8	53.3	0.314	0.266	0.55	0.68
3	27.5	19.0	0.326	93.1	52.9	0.326	0.269	0.45	0.65
4	27.9	19.0	0.323	92.2	53.3	0.323	0.266	0.47	0.65
5	28.0	19.6	0.329	94.0	52.9	0.329	0.273	0.47	0.64
6	28.6	19.5	0.331	94.6	53.1	0.331	0.276	0.55	0.65
7	28.3	19.1	0.321	91.6	53.0	0.321	0.272	0.44	0.66
8	28.2	20.6	0.329	94.0	53.2	0.329	0.271	0.57	0.59
9	28.2	19.4	0.330	94.2	53.1	0.330	0.276	0.59	0.66
10	28.4	18.5	0.324	92.6	53.5	0.324	0.271	0.62	0.69
11	28.0	19.2	0.329	93.9	53.1	0.329	0.274	0.60	0.67
12	28.7	19.8	0.331	94.7	53.2	0.331	0.275	0.59	0.64
13	28.8	19.3	0.334	95.4	53.2	0.334	0.275	0.58	0.67
14	28.7	20.5	0.324	92.6	53.2	0.324	0.270	0.42	0.60
15	28.2	18.6	0.328	93.6	53.5	0.328	0.270	0.65	0.69
16	28.7	18.4	0.326	93.2	53.2	0.326	0.268	0.68	0.69
17	28.6	19.1	0.333	95.2	53.2	0.333	0.275	0.58	0.68
18	29.2	19.2	0.326	93.2	53.2	0.326	0.273	0.45	0.67
19	28.3	20.7	0.330	94.2	53.4	0.330	0.271	0.50	0.60
20	27.9	20.3	0.330	94.4	53.2	0.330	0.271	0.51	0.62
21	28.4	19.1	0.330	94.3	53.3	0.330	0.274	0.56	0.66
22	29.0	19.8	0.331	94.5	52.9	0.331	0.275	0.46	0.64
23	28.6	20.2	0.329	94.0	53.2	0.329	0.271	0.54	0.62
24	29.0	18.9	0.322	91.9	53.1	0.322	0.264	0.46	0.70
25	29.0	18.6	0.322	92.1	53.2	0.322	0.271	0.50	0.70
26	28.6	19.4	0.331	94.5	53.3	0.331	0.269	0.56	0.66
27	28.8	18.5	0.326	93.2	52.9	0.326	0.267	0.49	0.71
28	29.2	19.1	0.329	93.9	53.1	0.329	0.270	0.41	0.69
29	28.1	20.5	0.331	94.5	53.2	0.331	0.267	0.41	0.62
Average	28.3	19.3	0.327	93.5	53.2	0.327	0.271	0.53	0.66
Std. Dev.	0.7	0.7	0.004	1.3	0.2	0.004	0.003	0.08	0.03
Maximum	29.2	20.7	0.334	95.4	53.5	0.334	0.276	0.69	0.71
@ Blow#	18	19	13	13	10	13	6	1	27

Total number of blows analyzed: 29

BL# Sensors

1-29 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K2491] 310.0 (1.00); A4: off

Time Summary

Drive 42 seconds 11:51 AM - 11:51 AM BN 1 - 29

ST LOUIS 2021 - CME 55LC 55.5-57.0

S/N 390755

OP: PDB

Date: 12-March-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 60.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	28.4	18.7	0.323	92.3	53.2	0.323	0.288	1.07	0.71
2	29.0	18.4	0.319	91.2	53.3	0.319	0.288	0.51	0.73
3	29.1	19.3	0.321	91.8	53.1	0.321	0.287	0.76	0.71
4	28.6	19.3	0.326	93.1	52.9	0.326	0.288	0.66	0.70
5	29.1	19.1	0.321	91.7	53.5	0.321	0.287	0.62	0.71
6	29.5	19.5	0.325	93.0	52.7	0.325	0.290	0.69	0.71
7	29.3	18.9	0.320	91.4	53.5	0.320	0.287	0.61	0.72
8	29.3	19.4	0.326	93.0	53.2	0.326	0.288	0.69	0.71
9	29.7	19.1	0.327	93.5	53.1	0.327	0.288	0.62	0.72
10	29.0	18.7	0.325	93.0	53.5	0.325	0.287	0.76	0.72
11	29.3	19.2	0.327	93.4	52.9	0.327	0.289	0.63	0.72
12	29.4	19.3	0.325	92.9	53.2	0.325	0.288	0.64	0.71
13	29.8	19.0	0.327	93.4	53.2	0.327	0.292	0.54	0.73
14	29.4	19.0	0.329	94.1	53.0	0.329	0.287	0.63	0.72
15	29.1	18.6	0.323	92.3	53.0	0.323	0.291	0.24	0.73
16	28.7	18.3	0.319	91.2	53.5	0.319	0.285	0.51	0.73
17	29.7	19.5	0.331	94.5	53.1	0.331	0.289	0.55	0.69
18	29.5	19.0	0.327	93.3	53.5	0.327	0.286	0.48	0.72
19	28.7	18.5	0.320	91.4	52.8	0.320	0.283	0.60	0.73
20	29.4	19.2	0.326	93.1	53.5	0.326	0.289	0.57	0.71
21	29.5	19.3	0.326	93.2	52.8	0.326	0.289	0.55	0.70
22	29.1	19.0	0.325	93.0	53.1	0.325	0.282	0.48	0.71
23	29.7	19.6	0.324	92.6	53.3	0.324	0.286	0.43	0.70
24	28.4	18.1	0.322	92.1	53.4	0.322	0.276	0.56	0.73
25	29.3	19.5	0.324	92.6	52.8	0.324	0.284	0.44	0.69
Average	29.2	19.0	0.324	92.7	53.2	0.324	0.287	0.59	0.71
Std. Dev.	0.4	0.4	0.003	0.9	0.3	0.003	0.003	0.15	0.01
Maximum	29.8	19.6	0.331	94.5	53.5	0.331	0.292	1.07	0.73
@ Blow#	13	23	17	17	5	17	13	1	15

Total number of blows analyzed: 25

BL# Sensors

1-25 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K2491] 310.0 (1.00); A4: off

Time Summary

Drive 28 seconds 11:59 AM - 11:59 AM BN 1 - 25

ST LOUIS 2021 - CME 55LC 58.5-60.0

S/N 390755

OP: PDB

Date: 12-March-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 63.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	26.6	21.1	0.330	94.2	53.3	0.330	0.264	0.45	0.56
2	26.7	20.9	0.333	95.2	52.5	0.333	0.264	0.60	0.56
3	27.2	21.5	0.332	94.9	53.3	0.332	0.266	0.52	0.53
4	27.1	21.5	0.328	93.8	52.9	0.328	0.265	0.47	0.54
5	28.4	22.5	0.337	96.2	53.3	0.337	0.267	0.50	0.54
6	27.0	21.9	0.330	94.3	52.3	0.330	0.265	0.37	0.55
7	26.6	21.0	0.329	94.1	53.5	0.329	0.264	0.47	0.56
8	27.3	21.8	0.336	95.9	52.9	0.336	0.266	0.60	0.53
9	26.5	21.8	0.330	94.3	52.6	0.330	0.265	0.42	0.53
10	26.7	21.8	0.336	95.9	53.5	0.336	0.265	0.56	0.53
11	26.5	20.6	0.330	94.1	52.8	0.330	0.267	0.42	0.59
12	27.5	22.3	0.333	95.1	53.1	0.333	0.266	0.42	0.53
13	27.8	22.1	0.337	96.3	52.6	0.337	0.266	0.59	0.53
14	26.6	21.6	0.325	93.0	53.2	0.325	0.265	0.28	0.55
15	27.0	21.4	0.338	96.5	52.8	0.338	0.267	0.50	0.57
16	28.1	22.7	0.332	94.8	53.3	0.332	0.265	0.42	0.52
17	26.9	21.9	0.333	95.1	52.7	0.333	0.266	0.37	0.55
18	26.2	20.4	0.332	94.9	53.4	0.332	0.259	0.51	0.58
19	26.7	20.8	0.334	95.5	52.8	0.334	0.264	0.55	0.58
20	27.1	22.3	0.327	93.6	52.9	0.327	0.260	0.35	0.50
21	28.0	22.5	0.330	94.3	52.8	0.330	0.265	0.23	0.49
22	26.6	22.1	0.336	96.0	53.4	0.336	0.265	0.40	0.54
23	26.9	21.2	0.333	95.2	52.9	0.333	0.262	0.67	0.56
24	27.2	22.5	0.339	96.9	52.7	0.339	0.265	0.25	0.53
25	27.4	21.1	0.334	95.5	53.5	0.334	0.264	0.32	0.57
26	27.0	20.8	0.333	95.1	52.3	0.333	0.263	0.48	0.57
27	26.7	21.4	0.334	95.5	52.6	0.334	0.266	0.36	0.55
28	27.8	22.4	0.339	96.8	53.3	0.339	0.267	0.50	0.53
29	26.9	21.2	0.334	95.5	52.9	0.334	0.263	0.46	0.55
30	27.3	22.2	0.335	95.7	53.3	0.335	0.266	0.52	0.51
31	26.2	21.2	0.325	92.8	52.8	0.325	0.261	0.32	0.53
32	27.2	19.9	0.326	93.2	53.1	0.326	0.261	0.42	0.60
33	27.6	20.6	0.338	96.7	52.7	0.338	0.265	0.57	0.60
34	26.8	20.8	0.339	96.8	52.5	0.339	0.267	0.51	0.59
35	27.5	22.4	0.335	95.7	53.1	0.335	0.266	0.36	0.52
36	27.1	21.3	0.335	95.9	53.0	0.335	0.265	0.46	0.57
37	27.2	21.5	0.335	95.6	53.4	0.335	0.263	0.33	0.54
38	27.5	20.5	0.332	95.0	52.7	0.332	0.265	0.35	0.58
Average	27.1	21.5	0.333	95.2	53.0	0.333	0.265	0.44	0.55
Std. Dev.	0.5	0.7	0.004	1.1	0.3	0.004	0.002	0.10	0.03
Maximum	28.4	22.7	0.339	96.9	53.5	0.339	0.267	0.67	0.60
@ Blow#	5	16	24	24	7	24	5	23	32

Total number of blows analyzed: 38

ST LOUIS 2021 - CME 55LC 58.5-60.0
OP: PDB

S/N 390755
Date: 12-March-2021

BL# Sensors

1-38 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K2491] 310.0 (1.00); A4: off

Time Summary

Drive 54 seconds 12:07 PM - 12:08 PM BN 1 - 38

ST LOUIS 2021 - CME 85 33.5-35

S/N 254746

OP: PDB

Date: 03-February-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 38.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	26.7	15.8	0.252	72.1	41.2	0.252	0.212	1.26	0.71
2	27.3	15.8	0.252	72.0	40.6	0.252	0.212	1.30	0.70
3	26.5	15.7	0.249	71.2	41.2	0.249	0.210	1.30	0.69
4	26.9	15.7	0.246	70.2	40.7	0.246	0.206	1.27	0.68
5	26.7	15.8	0.249	71.1	41.2	0.249	0.210	1.32	0.67
6	26.3	15.7	0.247	70.5	40.7	0.247	0.207	1.35	0.68
7	27.1	15.9	0.252	72.1	41.7	0.252	0.213	1.31	0.66
8	26.7	15.6	0.249	71.0	41.1	0.249	0.210	1.23	0.70
9	27.9	16.0	0.258	73.7	40.9	0.258	0.217	1.36	0.66
10	26.9	15.6	0.246	70.4	41.0	0.246	0.209	1.35	0.69
11	27.9	15.9	0.250	71.4	41.5	0.250	0.214	1.70	0.68
12	26.7	16.3	0.253	72.2	41.4	0.253	0.211	2.41	0.65
Average	27.0	15.8	0.250	71.5	41.1	0.250	0.211	1.43	0.68
Std. Dev.	0.5	0.2	0.003	1.0	0.3	0.003	0.003	0.32	0.02
Maximum	27.9	16.3	0.258	73.7	41.7	0.258	0.217	2.41	0.71
@ Blow#	11	12	9	9	7	9	9	12	1

Total number of blows analyzed: 12

BL# Sensors

1-12 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K1220] 373.0 (1.00);
A4: [K2127] 338.0 (1.00)

Time Summary

Drive 16 seconds 11:09 AM - 11:09 AM BN 1 - 12

ST LOUIS 2021 - CME 85 38.5-40

S/N 254746

OP: PDB

Date: 03-February-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 43.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	27.0	15.2	0.245	70.0	40.7	0.245	0.205	1.26	0.74
2	27.9	15.8	0.263	75.1	41.0	0.263	0.220	1.36	0.71
3	27.4	15.3	0.252	71.9	40.8	0.252	0.213	1.18	0.71
4	27.8	15.2	0.248	70.8	40.9	0.248	0.211	1.34	0.72
5	28.6	15.6	0.252	72.1	41.1	0.252	0.217	1.32	0.71
6	27.6	15.2	0.248	70.8	40.4	0.248	0.211	1.30	0.75
7	28.2	15.4	0.251	71.8	41.3	0.251	0.215	1.25	0.72
8	28.6	15.7	0.256	73.0	41.5	0.256	0.215	1.32	0.76
9	27.2	15.2	0.247	70.5	41.3	0.247	0.209	1.23	0.79
10	28.1	15.7	0.257	73.4	40.8	0.257	0.219	1.55	0.71
11	27.0	15.3	0.243	69.5	41.4	0.243	0.206	1.74	0.75
12	27.1	16.0	0.253	72.4	40.5	0.253	0.214	1.98	0.73
13	27.1	15.3	0.249	71.0	41.5	0.249	0.209	1.95	0.78
Average	27.7	15.5	0.251	71.7	41.0	0.251	0.213	1.44	0.74
Std. Dev.	0.6	0.3	0.005	1.5	0.4	0.005	0.005	0.26	0.03
Maximum	28.6	16.0	0.263	75.1	41.5	0.263	0.220	1.98	0.79
@ Blow#	8	12	2	2	8	2	2	12	9

Total number of blows analyzed: 13

BL# Sensors

1-13 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K1220] 373.0 (1.00);
A4: [K2127] 338.0 (1.00)

Time Summary

Drive 17 seconds 11:15 AM - 11:15 AM BN 1 - 13

ST LOUIS 2021 - CME 85 43.5-45

S/N 254746

OP: PDB

Date: 03-February-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 48.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	27.5	15.9	0.259	74.1	41.2	0.259	0.220	1.39	0.71
2	27.6	16.0	0.265	75.6	40.9	0.265	0.224	1.84	0.72
3	26.9	15.9	0.260	74.2	40.9	0.260	0.220	1.84	0.73
4	27.2	16.5	0.275	78.4	41.2	0.275	0.228	2.06	0.72
5	28.0	16.2	0.266	76.0	40.3	0.266	0.222	1.92	0.70
6	27.6	16.2	0.260	74.4	41.0	0.260	0.218	1.77	0.71
7	26.8	15.8	0.257	73.5	41.0	0.257	0.218	1.68	0.71
8	26.9	15.9	0.255	72.8	40.5	0.255	0.215	1.69	0.71
9	27.3	15.8	0.258	73.8	41.4	0.258	0.220	1.87	0.73
Average	27.3	16.0	0.262	74.8	40.9	0.262	0.221	1.78	0.72
Std. Dev.	0.4	0.2	0.006	1.6	0.3	0.006	0.004	0.18	0.01
Maximum	28.0	16.5	0.275	78.4	41.4	0.275	0.228	2.06	0.73
@ Blow#	5	4	4	4	9	4	4	4	3

Total number of blows analyzed: 9

BL# Sensors

1-9 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K1220] 373.0 (1.00);
A4: [K2127] 338.0 (1.00)

Time Summary

Drive 11 seconds 11:21 AM - 11:22 AM BN 1 - 9

ST LOUIS 2021 - CME 85 48.5-50

S/N 254746

OP: PDB

Date: 03-February-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 53.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	27.4	16.0	0.262	74.9	40.9	0.262	0.217	2.29	0.70
2	27.0	15.3	0.246	70.4	40.7	0.246	0.210	1.45	0.75
3	26.4	15.2	0.245	69.9	41.2	0.245	0.205	1.58	0.79
4	26.3	15.4	0.247	70.7	40.9	0.247	0.207	1.84	0.77
5	26.0	15.2	0.240	68.5	40.6	0.240	0.201	1.68	0.78
6	26.6	15.3	0.248	70.9	41.1	0.248	0.208	1.78	0.78
7	26.2	15.1	0.245	70.1	40.7	0.245	0.204	1.59	0.80
Average	26.6	15.4	0.248	70.8	40.9	0.248	0.208	1.74	0.77
Std. Dev.	0.5	0.3	0.006	1.9	0.2	0.006	0.005	0.25	0.03
Maximum	27.4	16.0	0.262	74.9	41.2	0.262	0.217	2.29	0.80
@ Blow#	1	1	1	1	3	1	1	1	7

Total number of blows analyzed: 7

BL# Sensors

1-7 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K1220] 373.0 (1.00);
A4: [K2127] 338.0 (1.00)

Time Summary

Drive 8 seconds 11:28 AM - 11:29 AM BN 1 - 7

ST LOUIS 2021 - CME 85 53.5-55

S/N 254746

OP: PDB

Date: 03-February-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 58.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	25.9	15.4	0.249	71.1	41.1	0.249	0.205	0.89	0.75
2	27.0	15.5	0.253	72.4	41.3	0.253	0.216	0.98	0.70
3	26.5	15.5	0.254	72.5	41.3	0.254	0.210	0.91	0.74
4	25.8	15.3	0.247	70.5	41.1	0.247	0.211	0.79	0.73
5	26.1	15.4	0.245	70.0	41.5	0.245	0.204	0.87	0.73
6	28.3	15.9	0.266	76.1	41.1	0.266	0.229	0.90	0.70
7	25.5	15.4	0.246	70.2	41.2	0.246	0.202	0.83	0.75
8	25.7	15.4	0.252	71.9	41.5	0.252	0.214	0.78	0.74
9	28.2	16.0	0.264	75.4	41.1	0.264	0.227	0.90	0.71
10	27.4	15.7	0.259	74.1	41.4	0.259	0.222	0.80	0.70
11	27.4	16.0	0.256	73.0	41.5	0.256	0.219	0.94	0.70
12	26.3	15.6	0.258	73.7	41.3	0.258	0.220	0.89	0.74
13	28.4	16.2	0.266	75.9	41.2	0.266	0.229	0.92	0.68
14	25.9	15.2	0.247	70.6	41.6	0.247	0.209	0.85	0.75
15	26.8	15.4	0.250	71.4	41.2	0.250	0.206	0.88	0.73
16	26.3	15.6	0.258	73.7	41.2	0.258	0.216	0.74	0.77
17	26.9	15.6	0.256	73.0	41.3	0.256	0.218	0.57	0.73
18	24.5	14.8	0.247	70.6	41.5	0.247	0.208	0.62	0.77
19	25.6	15.2	0.253	72.3	41.6	0.253	0.213	0.62	0.79
20	25.4	15.2	0.254	72.5	41.3	0.254	0.212	0.78	0.78
21	27.6	15.7	0.259	74.0	41.6	0.259	0.212	0.89	0.75
22	25.3	15.2	0.255	72.7	41.1	0.255	0.212	0.57	0.78
23	25.3	15.4	0.258	73.8	41.5	0.258	0.214	0.62	0.77
24	24.9	15.2	0.253	72.3	41.3	0.253	0.211	0.58	0.75
25	25.7	15.5	0.251	71.8	41.6	0.251	0.210	0.87	0.76
26	25.7	15.3	0.250	71.5	41.5	0.250	0.209	0.80	0.79
27	25.4	14.8	0.245	70.1	40.9	0.245	0.207	0.69	0.81
28	26.1	15.4	0.252	72.0	41.5	0.252	0.211	0.85	0.77
Average	26.3	15.5	0.254	72.5	41.3	0.254	0.213	0.80	0.75
Std. Dev.	1.0	0.3	0.006	1.7	0.2	0.006	0.007	0.12	0.03
Maximum	28.4	16.2	0.266	76.1	41.6	0.266	0.229	0.98	0.81
@ Blow#	13	13	6	6	14	6	6	2	27

Total number of blows analyzed: 28

BL# Sensors

1-28 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K1220] 373.0 (1.00);
A4: [K2127] 338.0 (1.00)

Time Summary

Drive 39 seconds 11:37 AM - 11:38 AM BN 1 - 28

ST LOUIS 2021 - CME 85 58.5-60

S/N 254746

OP: PDB

Date: 03-February-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 63.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	27.9	14.8	0.259	73.9	40.9	0.259	0.223	0.93	0.87
2	24.8	15.3	0.255	72.9	41.8	0.255	0.219	0.88	0.75
3	26.3	14.5	0.249	71.1	41.1	0.249	0.213	0.91	0.85
4	25.9	15.2	0.258	73.7	41.5	0.258	0.221	0.89	0.80
5	28.8	15.1	0.261	74.6	41.4	0.261	0.229	0.97	0.90
6	26.2	14.9	0.258	73.7	41.6	0.258	0.221	0.79	0.79
7	27.7	14.6	0.259	74.1	41.3	0.259	0.229	0.82	0.89
8	26.4	14.2	0.245	70.0	41.2	0.245	0.212	0.84	0.87
9	27.6	14.4	0.254	72.5	41.6	0.254	0.224	0.64	0.90
10	26.8	14.0	0.246	70.4	41.1	0.246	0.217	0.56	0.90
11	28.4	14.8	0.270	77.3	41.8	0.270	0.237	0.85	0.89
12	27.7	14.7	0.256	73.0	41.5	0.256	0.224	0.81	0.89
13	27.4	14.2	0.246	70.3	40.9	0.246	0.215	0.85	0.90
14	25.3	15.1	0.255	72.8	41.4	0.255	0.219	0.39	0.78
15	28.8	14.7	0.260	74.4	41.5	0.260	0.232	0.72	0.92
16	28.1	14.5	0.260	74.2	41.7	0.260	0.225	0.77	0.91
17	29.9	15.4	0.269	76.8	41.2	0.269	0.245	0.81	0.89
18	26.8	14.5	0.254	72.7	41.7	0.254	0.220	0.60	0.86
19	25.3	14.8	0.257	73.4	41.3	0.257	0.218	0.68	0.78
20	27.2	14.7	0.257	73.4	41.6	0.257	0.220	0.68	0.87
21	29.1	15.2	0.263	75.1	41.1	0.263	0.230	0.67	0.90
22	25.6	14.1	0.248	71.0	41.8	0.248	0.213	0.66	0.84
23	29.4	15.3	0.261	74.6	41.5	0.261	0.230	0.78	0.87
24	26.7	14.5	0.257	73.5	41.3	0.257	0.223	0.65	0.85
25	27.3	14.8	0.255	72.8	41.2	0.255	0.224	0.80	0.86
26	26.7	14.5	0.248	70.9	41.3	0.248	0.215	0.80	0.87
27	29.0	15.2	0.268	76.5	41.4	0.268	0.236	0.78	0.88
28	26.4	14.2	0.253	72.2	41.7	0.253	0.218	0.67	0.85
29	26.4	14.4	0.250	71.6	41.3	0.250	0.221	0.65	0.85
30	27.3	14.7	0.260	74.3	41.3	0.260	0.227	0.84	0.87
31	27.0	14.9	0.261	74.7	41.6	0.261	0.226	0.72	0.85
32	27.0	14.8	0.254	72.5	41.3	0.254	0.221	0.65	0.85
33	27.6	15.2	0.255	72.9	41.5	0.255	0.218	0.74	0.85
Average	27.2	14.7	0.256	73.3	41.4	0.256	0.223	0.75	0.86
Std. Dev.	1.2	0.4	0.006	1.8	0.2	0.006	0.007	0.12	0.04
Maximum	29.9	15.4	0.270	77.3	41.8	0.270	0.245	0.97	0.92
@ Blow#	17	17	11	11	2	11	17	5	15

Total number of blows analyzed: 33

BL# Sensors

1-33 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K1220] 373.0 (1.00);
A4: [K2127] 338.0 (1.00)

ST LOUIS 2021 - CME 85 58.5-60
OP: PDB

S/N 254746
Date: 03-February-2021

Time Summary

Drive 46 seconds 11:46 AM - 11:47 AM BN 1 - 33

ST LOUIS 2021 - CME 85 63.5-65

S/N 254746

OP: PDB

Date: 03-February-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 68.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	26.9	16.0	0.266	76.0	41.7	0.266	0.232	0.66	0.75
2	26.6	15.8	0.260	74.2	41.1	0.260	0.220	0.71	0.74
3	27.6	16.4	0.267	76.4	41.4	0.267	0.229	0.77	0.72
4	26.0	15.7	0.253	72.4	41.6	0.253	0.217	0.56	0.72
5	26.1	15.9	0.260	74.4	41.3	0.260	0.222	0.58	0.71
6	26.4	16.1	0.268	76.6	41.6	0.268	0.230	0.54	0.73
7	26.0	15.9	0.262	74.7	40.9	0.262	0.223	0.35	0.71
8	26.2	16.0	0.260	74.2	41.2	0.260	0.222	0.58	0.73
9	26.6	16.2	0.270	77.0	41.7	0.270	0.227	0.65	0.73
10	27.2	16.4	0.263	75.1	41.2	0.263	0.227	0.80	0.76
11	26.6	15.9	0.263	75.1	42.1	0.263	0.224	0.74	0.73
12	26.0	15.8	0.257	73.5	41.4	0.257	0.219	0.64	0.73
13	27.0	16.2	0.267	76.2	41.3	0.267	0.226	0.47	0.72
14	26.3	15.9	0.264	75.3	41.5	0.264	0.224	0.47	0.71
15	26.4	15.8	0.258	73.8	41.7	0.258	0.217	0.48	0.71
16	27.0	16.1	0.262	75.0	41.4	0.262	0.220	0.63	0.72
17	26.4	15.8	0.255	73.0	41.6	0.255	0.216	0.65	0.71
18	26.0	15.8	0.261	74.5	41.5	0.261	0.222	0.64	0.72
19	26.6	16.1	0.262	75.0	41.3	0.262	0.223	0.67	0.74
20	26.7	16.2	0.266	76.0	41.8	0.266	0.223	0.77	0.71
21	26.0	16.2	0.268	76.5	41.7	0.268	0.225	0.75	0.74
22	26.7	16.2	0.268	76.5	41.4	0.268	0.227	0.18	0.72
23	26.3	16.1	0.263	75.1	41.4	0.263	0.222	0.54	0.71
24	26.7	16.2	0.261	74.6	41.5	0.261	0.218	0.80	0.71
25	27.4	16.4	0.258	73.9	41.8	0.258	0.225	0.66	0.74
26	26.2	16.0	0.261	74.6	41.3	0.261	0.220	0.73	0.72
27	26.2	16.0	0.269	76.8	41.3	0.269	0.227	0.86	0.75
28	26.7	16.4	0.272	77.6	41.5	0.272	0.232	0.76	0.75
29	27.4	16.7	0.272	77.7	41.5	0.272	0.232	0.87	0.75
30	25.6	15.8	0.261	74.6	41.4	0.261	0.221	0.85	0.73
31	27.8	16.5	0.260	74.4	41.4	0.260	0.222	0.81	0.74
32	26.4	15.9	0.259	74.1	41.3	0.259	0.219	0.86	0.73
Average	26.6	16.1	0.263	75.1	41.5	0.263	0.224	0.66	0.73
Std. Dev.	0.5	0.2	0.004	1.3	0.2	0.004	0.004	0.15	0.01
Maximum	27.8	16.7	0.272	77.7	42.1	0.272	0.232	0.87	0.76
@ Blow#	31	29	29	29	11	29	29	29	10

Total number of blows analyzed: 32

BL# Sensors

1-32 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K1220] 373.0 (1.00);
A4: [K2127] 338.0 (1.00)

ST LOUIS 2021 - CME 85 63.5-65
OP: PDB

S/N 254746
Date: 03-February-2021

Time Summary

Drive 44 seconds 11:56 AM - 11:57 AM BN 1 - 32

ST LOUIS 2021 - CME 85 68.5-70

S/N 254746

OP: PDB

Date: 03-February-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 73.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	28.3	16.0	0.258	73.8	41.5	0.258	0.219	0.86	0.79
2	25.7	15.3	0.243	69.5	41.4	0.243	0.203	0.80	0.76
3	28.3	16.0	0.249	71.1	41.4	0.249	0.215	0.79	0.80
4	26.2	15.7	0.254	72.5	41.3	0.254	0.211	0.78	0.78
5	24.8	16.0	0.248	70.8	41.6	0.248	0.204	0.82	0.72
6	27.5	16.2	0.265	75.8	41.2	0.265	0.225	0.92	0.74
7	26.0	15.5	0.252	72.1	41.5	0.252	0.213	0.82	0.79
8	23.5	16.4	0.250	71.5	41.2	0.250	0.202	0.83	0.67
9	26.4	15.9	0.257	73.5	41.4	0.257	0.217	0.96	0.74
10	24.4	16.1	0.253	72.2	41.5	0.253	0.206	0.87	0.71
11	25.0	15.8	0.253	72.2	41.6	0.253	0.210	0.80	0.74
12	26.4	16.0	0.253	72.4	41.3	0.253	0.212	0.94	0.76
13	24.2	16.1	0.254	72.7	41.4	0.254	0.207	0.89	0.71
14	27.2	16.3	0.265	75.8	41.8	0.265	0.223	0.98	0.73
15	26.8	16.2	0.256	73.0	41.7	0.256	0.216	0.92	0.75
16	24.8	15.7	0.248	70.9	41.5	0.248	0.204	0.82	0.73
17	24.4	15.9	0.252	71.9	41.8	0.252	0.207	0.83	0.73
18	26.8	16.1	0.255	72.9	41.3	0.255	0.216	0.94	0.78
19	24.8	15.9	0.260	74.3	41.5	0.260	0.212	0.79	0.73
20	27.2	15.9	0.259	74.1	41.4	0.259	0.216	0.93	0.76
Average	25.9	15.9	0.254	72.6	41.5	0.254	0.212	0.87	0.75
Std. Dev.	1.4	0.3	0.005	1.6	0.2	0.005	0.006	0.06	0.03
Maximum	28.3	16.4	0.265	75.8	41.8	0.265	0.225	0.98	0.80
@ Blow#	1	8	6	6	14	6	6	14	3

Total number of blows analyzed: 20

BL# Sensors

1-20 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K1220] 373.0 (1.00);
A4: [K2127] 338.0 (1.00)

Time Summary

Drive 27 seconds 12:06 PM - 12:07 PM BN 1 - 20

ST LOUIS 2021 - CME 750Y 28.5-30

S/N 404788

OP: PDB

Date: 05-February-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 33.71 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	28.8	16.6	0.297	84.9	56.0	0.297	0.254	1.26	0.75
2	28.5	16.6	0.294	84.1	56.6	0.294	0.251	1.21	0.78
3	29.1	16.6	0.300	85.7	55.8	0.300	0.254	1.22	0.77
4	29.6	16.5	0.298	85.1	56.3	0.298	0.256	1.23	0.76
5	29.2	16.5	0.301	85.9	55.9	0.301	0.254	1.50	0.75
6	28.9	16.4	0.298	85.0	56.3	0.298	0.250	1.87	0.79
7	28.9	16.8	0.301	86.1	56.3	0.301	0.250	1.11	0.74
8	28.8	16.5	0.295	84.2	56.4	0.295	0.250	1.57	0.78
9	29.0	16.4	0.293	83.7	56.3	0.293	0.248	2.39	0.77
10	29.3	16.2	0.296	84.5	56.1	0.296	0.250	2.05	0.79
Average	29.0	16.5	0.297	84.9	56.2	0.297	0.252	1.54	0.77
Std. Dev.	0.3	0.1	0.003	0.8	0.2	0.003	0.002	0.41	0.02
Maximum	29.6	16.8	0.301	86.1	56.6	0.301	0.256	2.39	0.79
@ Blow#	4	7	7	7	2	7	4	9	6

Total number of blows analyzed: 10

BL# Sensors

1-10 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K1220] 373.0 (1.00);
A4: [K2127] 338.0 (1.00)

Time Summary

Drive 22 seconds 10:22 AM - 10:23 AM BN 1 - 10

ST LOUIS 2021 - CME 750Y 33.5-35

S/N 404788

OP: PDB

Date: 05-February-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 38.71 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	26.3	17.4	0.298	85.1	54.2	0.298	0.247	1.27	0.69
2	26.3	17.6	0.299	85.3	54.8	0.299	0.245	1.26	0.68
3	26.3	17.6	0.298	85.1	54.4	0.298	0.243	1.25	0.69
4	26.2	17.6	0.299	85.4	54.5	0.299	0.243	1.22	0.70
5	26.3	17.5	0.299	85.3	54.4	0.299	0.245	1.18	0.71
6	26.2	17.5	0.299	85.5	54.4	0.299	0.245	1.11	0.71
7	26.0	17.3	0.296	84.6	54.6	0.296	0.243	0.90	0.71
8	26.2	17.3	0.299	85.3	54.5	0.299	0.245	0.96	0.69
9	26.3	17.6	0.302	86.2	54.3	0.302	0.245	0.97	0.69
10	25.8	17.5	0.301	85.9	54.5	0.301	0.245	0.90	0.70
11	26.0	17.5	0.299	85.5	54.6	0.299	0.243	0.81	0.70
12	25.8	17.5	0.299	85.5	54.5	0.299	0.243	0.77	0.69
13	25.5	17.4	0.295	84.3	54.6	0.295	0.241	0.71	0.68
14	25.8	17.5	0.301	86.1	54.1	0.301	0.245	0.68	0.68
15	25.6	17.5	0.298	85.0	54.8	0.298	0.242	0.63	0.68
16	26.4	17.8	0.306	87.3	54.2	0.306	0.245	0.69	0.67
17	25.7	17.6	0.302	86.2	54.4	0.302	0.243	0.70	0.67
18	25.8	17.7	0.301	85.9	54.6	0.301	0.243	0.65	0.66
Average	26.0	17.5	0.299	85.5	54.5	0.299	0.244	0.93	0.69
Std. Dev.	0.3	0.1	0.002	0.7	0.2	0.002	0.001	0.23	0.01
Maximum	26.4	17.8	0.306	87.3	54.8	0.306	0.247	1.27	0.71
@ Blow#	16	16	16	16	2	16	1	1	7

Total number of blows analyzed: 18

BL# Sensors

1-18 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K1220] 373.0 (1.00);
A4: [K2127] 338.0 (1.00)

Time Summary

Drive 18 seconds 10:29 AM - 10:29 AM BN 1 - 18

ST LOUIS 2021 - CME 750Y 38.5-40

S/N 404788

OP: PDB

Date: 05-February-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 43.71 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	28.6	16.3	0.307	87.6	54.4	0.307	0.257	1.25	0.83
2	28.3	16.3	0.304	86.8	54.2	0.304	0.255	1.26	0.79
3	28.1	16.2	0.304	87.0	54.3	0.304	0.254	1.23	0.81
4	28.4	16.4	0.302	86.4	54.3	0.302	0.257	1.19	0.79
5	28.8	16.6	0.309	88.3	54.3	0.309	0.260	1.34	0.81
6	28.7	16.6	0.307	87.9	54.3	0.307	0.258	1.34	0.82
7	28.3	16.4	0.304	86.8	54.4	0.304	0.258	1.26	0.79
8	28.9	16.8	0.307	87.8	54.2	0.307	0.259	1.37	0.81
9	28.7	16.6	0.305	87.1	54.3	0.305	0.258	1.44	0.78
10	28.8	16.5	0.305	87.1	54.3	0.305	0.260	1.40	0.80
11	29.0	16.7	0.308	88.0	54.4	0.308	0.261	1.62	0.79
12	28.9	16.7	0.310	88.5	54.3	0.310	0.261	1.70	0.80
13	28.7	16.8	0.310	88.5	54.4	0.310	0.261	1.68	0.81
Average	28.6	16.5	0.306	87.5	54.3	0.306	0.258	1.39	0.80
Std. Dev.	0.3	0.2	0.002	0.7	0.1	0.002	0.002	0.17	0.01
Maximum	29.0	16.8	0.310	88.5	54.4	0.310	0.261	1.70	0.83
@ Blow#	11	13	12	12	1	12	11	12	1

Total number of blows analyzed: 13

BL# Sensors

1-13 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K1220] 373.0 (1.00);
A4: [K2127] 338.0 (1.00)

Time Summary

Drive 13 seconds 10:35 AM - 10:35 AM BN 1 - 13

ST LOUIS 2021 - CME 750Y 43.5-45

S/N 404788

OP: PDB

Date: 05-February-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 48.71 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	28.5	16.5	0.301	86.1	54.2	0.301	0.266	1.18	0.81
2	28.6	16.4	0.301	86.0	54.1	0.301	0.263	1.84	0.82
3	28.1	16.3	0.302	86.4	54.1	0.302	0.265	1.53	0.81
4	28.1	16.5	0.304	87.0	54.1	0.304	0.266	1.56	0.79
5	28.0	16.7	0.305	87.2	54.2	0.305	0.263	1.78	0.77
6	28.6	16.8	0.304	87.0	54.2	0.304	0.264	1.69	0.80
7	27.9	16.4	0.304	86.9	54.1	0.304	0.264	1.81	0.79
8	27.6	16.5	0.302	86.3	54.3	0.302	0.261	1.82	0.79
9	27.8	16.4	0.301	85.9	54.2	0.301	0.261	1.78	0.80
10	27.9	16.3	0.301	86.0	54.1	0.301	0.260	1.78	0.79
11	28.0	16.3	0.298	85.1	54.3	0.298	0.257	1.77	0.81
12	28.0	16.4	0.300	85.7	54.2	0.300	0.260	1.63	0.80
13	28.2	16.5	0.300	85.7	54.1	0.300	0.258	1.43	0.80
14	28.7	16.5	0.302	86.4	54.0	0.302	0.262	1.25	0.82
Average	28.1	16.5	0.302	86.3	54.2	0.302	0.262	1.63	0.80
Std. Dev.	0.3	0.1	0.002	0.6	0.1	0.002	0.003	0.21	0.01
Maximum	28.7	16.8	0.305	87.2	54.3	0.305	0.266	1.84	0.82
@ Blow#	14	6	5	5	8	5	1	2	2

Total number of blows analyzed: 14

BL# Sensors

1-14 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K1220] 373.0 (1.00);
A4: [K2127] 338.0 (1.00)

Time Summary

Drive 20 seconds 10:42 AM - 10:43 AM BN 1 - 14

ST LOUIS 2021 - CME 750Y 48.5-50
OP: PDB

S/N 404788
Date: 05-February-2021

AR: 1.19 in²
LE: 53.71 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft³
EM: 30,000 ksi
JC: 0.00

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated
BPM: Blows/Minute

EMX: Maximum Energy
EF2: Energy of F² (ASTM D4633)
DFN: Final Displacement
FVP: Force/Velocity Proportionality

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	27.2	17.7	0.312	89.3	54.0	0.312	0.261	0.91	0.68
2	29.0	17.9	0.317	90.5	54.0	0.317	0.266	0.98	0.67
3	28.5	17.8	0.313	89.5	54.0	0.313	0.262	0.98	0.66
4	28.6	18.1	0.313	89.4	54.1	0.313	0.262	0.64	0.68
5	27.8	17.9	0.311	88.7	53.8	0.311	0.260	1.03	0.68
6	26.5	18.3	0.315	90.1	54.4	0.315	0.259	1.09	0.63
7	26.6	17.9	0.315	90.0	53.8	0.315	0.261	0.90	0.67
8	28.2	18.3	0.318	91.0	54.1	0.318	0.264	1.07	0.69
9	26.5	17.9	0.313	89.4	54.1	0.313	0.259	0.81	0.68
10	27.2	18.6	0.322	92.0	53.9	0.322	0.262	1.12	0.66
11	26.6	18.6	0.319	91.2	54.0	0.319	0.262	1.16	0.65
12	28.0	18.1	0.316	90.4	54.0	0.316	0.262	0.92	0.67
13	27.4	18.6	0.321	91.6	54.1	0.321	0.265	1.05	0.65
14	26.4	18.3	0.316	90.3	54.1	0.316	0.261	1.11	0.66
15	27.2	18.3	0.317	90.6	54.0	0.317	0.261	1.10	0.68
16	28.1	18.7	0.324	92.6	53.9	0.324	0.267	1.22	0.65
17	26.6	18.3	0.318	90.7	54.1	0.318	0.261	1.06	0.66
18	28.3	18.4	0.318	90.9	54.0	0.318	0.264	1.15	0.68
19	26.8	18.1	0.318	90.9	54.1	0.318	0.262	1.09	0.68
20	27.9	17.9	0.312	89.2	54.0	0.312	0.261	1.08	0.67
21	27.5	18.0	0.314	89.6	54.1	0.314	0.260	1.26	0.67
22	28.4	18.5	0.320	91.3	54.1	0.320	0.265	1.03	0.68
23	27.8	18.1	0.316	90.2	53.9	0.316	0.262	0.88	0.70
24	28.2	17.9	0.313	89.5	54.1	0.313	0.259	0.93	0.66
25	28.4	17.9	0.312	89.2	54.1	0.312	0.258	1.04	0.67
26	26.1	18.2	0.314	89.6	53.8	0.314	0.255	1.00	0.67
27	27.5	18.0	0.315	90.1	53.9	0.315	0.261	0.96	0.67
28	29.2	17.9	0.312	89.3	54.3	0.312	0.260	0.97	0.67
29	26.9	18.3	0.315	89.9	54.1	0.315	0.257	1.07	0.66
30	27.9	17.8	0.311	88.9	54.2	0.311	0.258	0.96	0.70
Average	27.6	18.1	0.316	90.2	54.0	0.316	0.261	1.02	0.67
Std. Dev.	0.8	0.3	0.003	0.9	0.1	0.003	0.003	0.12	0.01
Maximum	29.2	18.7	0.324	92.6	54.4	0.324	0.267	1.26	0.70
@ Blow#	28	16	16	16	6	16	16	21	30

Total number of blows analyzed: 30

BL# Sensors

1-30 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K1220] 373.0 (1.00);
A4: [K2127] 338.0 (1.00)

ST LOUIS 2021 - CME 750Y 48.5-50
OP: PDB

S/N 404788
Date: 05-February-2021

Time Summary

Drive 32 seconds 10:50 AM - 10:50 AM BN 1 - 30

ST LOUIS 2021 - CME 750Y 53.5-55

S/N 404788

OP: PDB

Date: 05-February-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 58.71 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	29.9	16.9	0.316	90.3	54.5	0.316	0.285	1.03	0.83
2	29.7	16.8	0.316	90.1	54.5	0.316	0.286	0.98	0.82
3	29.4	16.7	0.312	89.0	54.7	0.312	0.286	0.95	0.83
4	29.6	16.7	0.315	90.1	54.5	0.315	0.286	1.02	0.83
5	29.5	16.6	0.314	89.6	54.6	0.314	0.285	1.06	0.84
6	29.4	16.4	0.309	88.4	54.6	0.309	0.281	1.04	0.85
7	29.5	16.3	0.308	88.0	54.6	0.308	0.282	1.06	0.83
8	29.7	16.5	0.313	89.3	54.4	0.313	0.284	1.06	0.85
9	29.5	16.5	0.308	88.1	54.6	0.308	0.284	0.93	0.84
10	29.8	16.7	0.310	88.5	54.5	0.310	0.284	0.98	0.84
11	29.3	16.4	0.311	88.8	54.5	0.311	0.286	0.94	0.84
12	29.7	16.6	0.310	88.7	54.6	0.310	0.284	0.80	0.84
13	29.4	16.4	0.311	88.9	54.5	0.311	0.283	0.83	0.84
14	29.5	16.6	0.311	88.9	54.5	0.311	0.281	0.82	0.84
15	29.5	16.6	0.308	87.9	54.8	0.308	0.281	0.73	0.84
16	29.0	16.3	0.308	87.9	54.5	0.308	0.283	0.80	0.84
17	29.6	16.6	0.309	88.3	54.6	0.309	0.282	0.78	0.84
18	29.2	16.3	0.307	87.8	54.5	0.307	0.281	0.71	0.84
19	28.7	16.3	0.308	88.1	54.5	0.308	0.280	0.78	0.83
20	29.2	16.5	0.310	88.6	54.3	0.310	0.280	0.73	0.83
21	29.3	16.2	0.309	88.3	54.8	0.309	0.280	0.72	0.83
22	29.1	16.3	0.308	88.0	54.4	0.308	0.279	0.81	0.83
23	29.2	16.5	0.311	88.8	54.5	0.311	0.279	0.75	0.83
24	29.1	16.3	0.308	88.0	54.7	0.308	0.282	0.68	0.83
25	29.5	16.4	0.307	87.6	54.5	0.307	0.277	0.72	0.84
26	29.3	16.4	0.309	88.2	54.4	0.309	0.280	0.73	0.85
Average	29.4	16.5	0.310	88.6	54.5	0.310	0.282	0.86	0.84
Std. Dev.	0.3	0.2	0.003	0.7	0.1	0.003	0.003	0.13	0.01
Maximum	29.9	16.9	0.316	90.3	54.8	0.316	0.286	1.06	0.85
@ Blow#	1	1	1	1	15	1	3	7	8

Total number of blows analyzed: 26

BL# Sensors

1-26 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K1220] 373.0 (1.00);
A4: [K2127] 338.0 (1.00)

Time Summary

Drive 27 seconds 11:24 AM - 11:24 AM BN 1 - 26

ST LOUIS 2021 - CME 750Y 58.5-60

S/N 404788

OP: PDB

Date: 05-February-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 63.71 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	28.5	17.6	0.316	90.2	53.0	0.316	0.264	1.09	0.73
2	28.6	17.6	0.316	90.3	53.1	0.316	0.265	1.08	0.75
3	28.8	17.6	0.316	90.2	52.9	0.316	0.265	0.98	0.75
4	28.6	17.6	0.317	90.4	53.2	0.317	0.264	1.06	0.75
5	28.9	17.5	0.317	90.5	53.0	0.317	0.267	1.02	0.74
6	28.4	17.7	0.319	91.2	53.1	0.319	0.265	1.10	0.72
7	28.4	17.4	0.313	89.4	52.9	0.313	0.265	0.97	0.76
8	28.5	17.6	0.318	90.8	53.1	0.318	0.267	1.08	0.72
9	28.9	17.9	0.320	91.5	52.8	0.320	0.267	1.04	0.72
10	28.6	17.7	0.317	90.6	53.1	0.317	0.266	1.00	0.73
11	29.1	17.7	0.319	91.1	53.1	0.319	0.266	1.01	0.74
12	28.7	17.8	0.321	91.7	53.1	0.321	0.265	1.13	0.72
13	28.6	17.6	0.318	90.9	53.1	0.318	0.265	1.06	0.75
14	28.7	17.6	0.318	91.0	53.1	0.318	0.265	1.07	0.75
15	29.1	17.5	0.320	91.4	53.1	0.320	0.267	1.05	0.75
16	28.2	17.6	0.318	90.8	53.0	0.318	0.263	1.04	0.75
17	29.2	17.4	0.318	90.8	53.1	0.318	0.265	1.11	0.76
18	29.1	17.6	0.319	91.2	53.1	0.319	0.265	1.07	0.75
19	29.0	17.4	0.317	90.6	53.1	0.317	0.263	1.14	0.76
20	29.2	17.3	0.318	90.7	53.1	0.318	0.266	1.22	0.76
21	29.0	17.2	0.316	90.3	53.0	0.316	0.264	1.13	0.74
22	29.0	17.3	0.317	90.5	53.1	0.317	0.267	1.06	0.74
23	28.7	17.2	0.315	90.0	53.3	0.315	0.261	0.83	0.76
24	29.3	17.4	0.320	91.4	53.1	0.320	0.265	1.20	0.75
25	28.8	17.3	0.317	90.4	53.0	0.317	0.262	1.14	0.74
26	28.5	17.1	0.314	89.6	53.2	0.314	0.260	1.05	0.75
27	28.9	17.1	0.318	90.9	53.0	0.318	0.259	1.25	0.74
28	28.1	17.1	0.314	89.8	53.1	0.314	0.261	1.04	0.75
29	28.2	16.9	0.314	89.7	53.1	0.314	0.259	1.17	0.76
30	28.0	17.1	0.315	89.9	53.1	0.315	0.258	1.03	0.74
31	28.4	17.1	0.314	89.8	53.0	0.314	0.258	1.07	0.75
32	28.4	17.0	0.309	88.2	53.3	0.309	0.256	0.91	0.74
33	28.4	17.1	0.314	89.6	53.0	0.314	0.262	0.85	0.73
34	28.4	17.0	0.313	89.4	53.2	0.313	0.256	1.09	0.74
35	28.2	17.1	0.312	89.1	53.0	0.312	0.260	1.05	0.73
36	28.2	17.2	0.311	88.9	53.1	0.311	0.259	1.03	0.73
37	28.2	17.0	0.312	89.0	53.3	0.312	0.257	1.09	0.76
Average	28.6	17.4	0.316	90.3	53.1	0.316	0.263	1.06	0.74
Std. Dev.	0.3	0.3	0.003	0.8	0.1	0.003	0.003	0.08	0.01
Maximum	29.3	17.9	0.321	91.7	53.3	0.321	0.267	1.25	0.76
@ Blow#	24	9	12	12	23	12	22	27	23

Total number of blows analyzed: 37

ST LOUIS 2021 - CME 750Y 58.5-60
OP: PDB

S/N 404788
Date: 05-February-2021

BL# Sensors

1-37 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K1220] 373.0 (1.00);
A4: [K2127] 338.0 (1.00)

Time Summary

Drive 40 seconds 12:01 PM - 12:01 PM BN 1 - 37

ST LOUIS 2021 - CME 750Y 63.5-65

S/N 404788

OP: PDB

Date: 05-February-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 68.71 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	29.6	17.2	0.318	90.8	54.1	0.318	0.256	0.68	0.76
2	30.1	17.8	0.319	91.3	54.2	0.319	0.259	0.70	0.71
3	29.9	17.4	0.316	90.2	54.1	0.316	0.254	0.66	0.74
4	29.7	17.0	0.313	89.4	54.1	0.313	0.252	0.67	0.74
5	29.6	17.1	0.316	90.3	54.1	0.316	0.252	0.68	0.73
6	29.6	17.3	0.314	89.7	54.2	0.314	0.255	0.62	0.74
7	29.3	17.2	0.314	89.6	54.1	0.314	0.254	0.57	0.76
8	30.4	17.7	0.318	90.9	54.3	0.318	0.261	0.68	0.75
9	29.3	17.0	0.312	89.1	54.1	0.312	0.253	0.61	0.74
10	29.3	17.3	0.317	90.5	54.0	0.317	0.255	0.55	0.74
11	30.1	17.6	0.319	91.0	54.2	0.319	0.260	0.60	0.75
12	29.9	17.4	0.313	89.5	54.4	0.313	0.251	0.66	0.75
13	29.7	17.4	0.315	90.0	53.9	0.315	0.256	0.53	0.77
14	29.7	17.4	0.315	89.9	54.2	0.315	0.254	0.55	0.76
15	30.2	17.5	0.313	89.6	54.4	0.313	0.253	0.65	0.77
16	30.0	17.4	0.315	90.0	54.0	0.315	0.254	0.64	0.75
17	29.6	17.4	0.312	89.2	54.3	0.312	0.253	0.53	0.76
18	29.8	17.4	0.311	88.8	54.1	0.311	0.251	0.55	0.75
19	29.8	17.4	0.314	89.7	54.1	0.314	0.255	0.51	0.76
20	30.5	17.8	0.320	91.5	54.1	0.320	0.258	0.69	0.76
21	29.3	17.2	0.311	88.8	54.1	0.311	0.253	0.49	0.76
22	29.9	17.6	0.315	89.9	54.1	0.315	0.255	0.62	0.74
23	29.7	17.5	0.313	89.4	54.1	0.313	0.254	0.59	0.77
24	29.5	17.5	0.315	89.9	54.1	0.315	0.254	0.52	0.76
25	29.5	17.6	0.315	90.0	54.2	0.315	0.257	0.54	0.74
26	29.9	17.7	0.320	91.3	54.1	0.320	0.260	0.62	0.74
27	29.6	17.5	0.316	90.3	54.2	0.316	0.255	0.53	0.75
28	29.9	17.8	0.321	91.9	54.2	0.321	0.260	0.63	0.76
29	29.3	17.4	0.314	89.8	54.3	0.314	0.253	0.57	0.76
30	29.3	17.5	0.313	89.5	53.8	0.313	0.255	0.54	0.74
31	29.6	17.5	0.319	91.1	54.2	0.319	0.257	0.58	0.76
32	29.6	17.6	0.321	91.8	54.0	0.321	0.257	0.57	0.73
33	29.7	17.7	0.319	91.3	54.2	0.319	0.255	0.55	0.74
34	29.3	17.6	0.321	91.8	54.0	0.321	0.256	0.58	0.74
35	29.8	17.7	0.321	91.7	54.1	0.321	0.257	0.53	0.74
36	29.6	17.7	0.324	92.7	54.3	0.324	0.255	0.67	0.75
37	30.2	17.8	0.323	92.3	53.9	0.323	0.260	0.60	0.72
38	29.9	17.8	0.330	94.2	54.2	0.330	0.259	0.71	0.72
39	30.2	17.8	0.325	92.9	54.1	0.325	0.260	0.61	0.71
40	30.0	18.2	0.332	94.9	54.2	0.332	0.264	0.63	0.71
41	30.0	18.2	0.332	94.9	53.9	0.332	0.265	0.65	0.69
42	30.0	18.2	0.327	93.4	54.1	0.327	0.265	0.62	0.69
43	30.3	18.6	0.333	95.2	54.0	0.333	0.269	0.65	0.72
44	30.4	18.6	0.332	94.8	54.2	0.332	0.267	0.67	0.73
45	30.2	18.6	0.329	94.0	54.0	0.329	0.266	0.65	0.72

ST LOUIS 2021 - CME 750Y 63.5-65

S/N 404788

OP: PDB

Date: 05-February-2021

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
46	30.3	18.6	0.332	94.9	54.0	0.332	0.267	0.70	0.71
47	30.0	18.5	0.332	94.7	54.3	0.332	0.268	0.69	0.68
48	30.1	18.5	0.327	93.4	54.0	0.327	0.265	0.70	0.71
49	30.1	18.8	0.333	95.2	53.9	0.333	0.270	0.78	0.71
50	31.2	18.9	0.334	95.3	54.2	0.334	0.268	0.76	0.73
51	30.9	18.8	0.331	94.5	54.0	0.331	0.266	0.75	0.70
52	30.5	18.8	0.327	93.6	54.1	0.327	0.264	0.69	0.74
53	30.8	19.1	0.335	95.7	53.9	0.335	0.269	0.82	0.71
54	30.3	18.8	0.330	94.2	54.2	0.330	0.266	0.71	0.74
55	30.4	18.6	0.326	93.2	53.9	0.326	0.264	0.74	0.74
56	30.5	18.8	0.328	93.7	54.5	0.328	0.262	0.86	0.73
57	30.0	18.2	0.322	92.1	53.7	0.322	0.264	0.72	0.70
58	29.7	18.3	0.322	91.9	54.2	0.322	0.262	0.78	0.70
Average	29.9	17.8	0.321	91.7	54.1	0.321	0.259	0.64	0.74
Std. Dev.	0.4	0.6	0.007	2.1	0.1	0.007	0.005	0.08	0.02
Maximum	31.2	19.1	0.335	95.7	54.5	0.335	0.270	0.86	0.77
@ Blow#	50	53	53	53	56	53	49	56	13

Total number of blows analyzed: 58

BL# Sensors

1-58 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K1220] 373.0 (1.00);
A4: [K2127] 338.0 (1.00)

Time Summary

Drive 1 minute 3 seconds 12:41 PM - 12:42 PM BN 1 - 58

ST LOUIS 2021 - CME 550X 28.5-30.0

S/N 343063

OP: PDB

Date: 12-March-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 33.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	25.8	16.4	0.284	81.3	48.2	0.284	0.247	0.86	0.72
2	25.8	15.4	0.285	81.3	48.5	0.285	0.247	0.83	0.79
3	25.9	15.5	0.281	80.4	48.2	0.281	0.245	0.79	0.78
4	26.1	16.0	0.284	81.2	48.2	0.284	0.247	0.88	0.76
5	25.0	17.0	0.279	79.7	48.3	0.279	0.242	0.93	0.68
6	25.1	16.4	0.281	80.4	48.0	0.281	0.248	1.17	0.72
7	25.2	15.8	0.283	81.0	47.9	0.283	0.243	1.19	0.75
8	25.2	15.5	0.282	80.6	48.3	0.282	0.247	1.20	0.76
9	25.2	15.0	0.277	79.1	48.1	0.277	0.243	1.17	0.79
10	24.9	15.5	0.277	79.1	48.2	0.277	0.241	1.04	0.76
11	24.8	15.0	0.280	80.1	47.2	0.280	0.246	1.09	0.75
12	24.9	17.2	0.280	80.1	49.1	0.280	0.244	1.12	0.67
13	25.0	17.1	0.284	81.3	48.1	0.284	0.246	1.44	0.69
Average	25.3	16.0	0.281	80.4	48.2	0.281	0.245	1.05	0.74
Std. Dev.	0.4	0.7	0.003	0.8	0.4	0.003	0.002	0.18	0.04
Maximum	26.1	17.2	0.285	81.3	49.1	0.285	0.248	1.44	0.79
@ Blow#	4	12	2	2	12	2	6	13	9

Total number of blows analyzed: 13

BL# Sensors

1-13 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K2491] 310.0 (1.00); A4: off

Time Summary

Drive 14 seconds 10:33 AM - 10:33 AM BN 1 - 13

ST LOUIS 2021 - CME 550X 38.5-40.0

S/N 343063

OP: PDB

Date: 12-March-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 43.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	25.2	15.4	0.279	79.7	48.2	0.279	0.239	0.84	0.76
2	25.4	16.3	0.287	81.9	48.0	0.287	0.243	0.83	0.72
3	26.0	17.0	0.288	82.3	48.3	0.288	0.244	0.89	0.71
4	26.5	17.1	0.292	83.4	48.0	0.292	0.250	0.86	0.71
5	26.7	17.3	0.294	84.0	47.9	0.294	0.251	0.87	0.70
6	26.2	16.9	0.287	82.0	48.1	0.287	0.244	0.79	0.73
7	25.7	16.3	0.290	82.8	48.2	0.290	0.250	0.85	0.74
8	26.0	16.2	0.291	83.2	48.2	0.291	0.249	0.88	0.75
9	25.7	16.2	0.286	81.8	47.9	0.286	0.244	0.87	0.74
10	25.5	15.7	0.287	82.1	48.7	0.287	0.245	1.18	0.76
11	25.5	15.3	0.283	80.9	47.2	0.283	0.245	1.48	0.78
12	25.0	18.2	0.290	82.9	48.6	0.290	0.243	1.32	0.64
Average	25.8	16.5	0.288	82.2	48.1	0.288	0.246	0.97	0.73
Std. Dev.	0.5	0.8	0.004	1.1	0.4	0.004	0.003	0.22	0.04
Maximum	26.7	18.2	0.294	84.0	48.7	0.294	0.251	1.48	0.78
@ Blow#	5	12	5	5	10	5	5	11	11

Total number of blows analyzed: 12

BL# Sensors

1-12 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K2491] 310.0 (1.00); A4: off

Time Summary

Drive 13 seconds 10:56 AM - 10:56 AM BN 1 - 12

ST LOUIS 2021 - CME 550X 43.5-45.0

S/N 343063

OP: PDB

Date: 12-March-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 48.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	24.2	18.8	0.292	83.4	48.0	0.292	0.241	0.78	0.60
2	24.2	19.0	0.291	83.1	48.7	0.291	0.240	0.75	0.60
3	23.6	19.2	0.286	81.7	48.1	0.286	0.232	0.73	0.58
4	25.1	19.9	0.290	82.7	47.9	0.290	0.239	0.72	0.56
5	25.1	20.3	0.294	84.0	48.2	0.294	0.240	0.70	0.54
6	25.3	20.2	0.294	84.1	48.3	0.294	0.242	0.74	0.55
7	25.4	18.8	0.288	82.2	48.9	0.288	0.236	0.72	0.62
8	24.9	18.9	0.294	84.0	47.4	0.294	0.239	0.76	0.61
9	24.8	19.1	0.293	83.6	48.7	0.293	0.236	0.80	0.60
10	24.7	18.3	0.281	80.3	48.1	0.281	0.231	0.68	0.62
11	25.4	20.2	0.300	85.7	47.7	0.300	0.242	0.79	0.56
12	25.1	19.1	0.293	83.8	48.3	0.293	0.238	0.78	0.60
13	26.2	19.8	0.294	84.0	48.5	0.294	0.240	0.73	0.58
14	24.8	19.6	0.294	83.9	48.2	0.294	0.236	0.75	0.57
15	25.3	19.1	0.294	83.9	48.0	0.294	0.238	0.75	0.60
16	25.5	20.0	0.298	85.2	47.9	0.298	0.242	0.85	0.56
17	25.0	20.0	0.298	85.2	48.2	0.298	0.238	0.76	0.57
Average	25.0	19.4	0.293	83.6	48.2	0.293	0.238	0.75	0.58
Std. Dev.	0.6	0.6	0.004	1.3	0.4	0.004	0.003	0.04	0.02
Maximum	26.2	20.3	0.300	85.7	48.9	0.300	0.242	0.85	0.62
@ Blow#	13	5	11	11	7	11	16	16	10

Total number of blows analyzed: 17

BL# Sensors

1-17 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K2491] 310.0 (1.00); A4: off

Time Summary

Drive 19 seconds 11:11 AM - 11:11 AM BN 1 - 17

ST LOUIS 2021 - CME 550X 48.5-50.0

S/N 343063

OP: PDB

Date: 12-March-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 53.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	26.1	18.3	0.298	85.0	46.4	0.298	0.247	0.57	0.66
2	25.6	18.1	0.300	85.6	47.9	0.300	0.250	0.52	0.66
3	26.4	18.2	0.299	85.5	47.6	0.299	0.248	0.48	0.66
4	26.4	18.4	0.300	85.8	47.1	0.300	0.246	0.43	0.66
5	26.1	18.2	0.292	83.6	48.0	0.292	0.242	0.27	0.66
6	26.5	18.5	0.300	85.7	46.9	0.300	0.245	0.34	0.66
7	26.0	19.0	0.303	86.7	47.1	0.303	0.247	0.55	0.62
8	26.4	19.3	0.302	86.3	47.6	0.302	0.246	0.57	0.61
9	26.8	19.0	0.300	85.9	47.6	0.300	0.246	0.55	0.64
10	26.9	18.6	0.306	87.3	47.3	0.306	0.251	0.46	0.65
11	25.8	18.3	0.293	83.6	47.6	0.293	0.241	0.42	0.65
12	26.4	18.7	0.303	86.5	47.7	0.303	0.247	0.55	0.64
13	26.1	17.7	0.297	84.8	47.1	0.297	0.244	0.37	0.68
14	24.4	17.8	0.297	84.7	47.3	0.297	0.244	0.37	0.64
15	25.7	18.3	0.302	86.1	46.9	0.302	0.248	0.47	0.64
16	25.6	18.2	0.292	83.3	48.1	0.292	0.242	0.36	0.64
17	25.5	18.3	0.290	82.9	47.1	0.290	0.237	0.43	0.63
18	25.1	15.6	0.284	81.1	47.4	0.284	0.237	0.31	0.76
19	24.9	16.6	0.291	83.2	47.4	0.291	0.242	0.36	0.70
20	25.4	17.1	0.301	86.0	47.5	0.301	0.244	0.53	0.69
21	25.8	17.6	0.290	82.9	47.3	0.290	0.235	0.58	0.69
22	24.8	17.1	0.286	81.6	47.3	0.286	0.237	0.49	0.68
23	24.8	18.4	0.290	82.9	47.5	0.290	0.233	0.66	0.63
24	26.8	18.3	0.285	81.5	47.4	0.285	0.239	0.30	0.66
25	26.7	18.5	0.297	84.9	47.2	0.297	0.241	0.79	0.65
26	26.5	18.7	0.293	83.6	47.4	0.293	0.242	0.54	0.65
27	24.7	18.2	0.282	80.7	47.4	0.282	0.229	0.53	0.64
28	25.5	18.2	0.291	83.2	47.1	0.291	0.239	0.61	0.65
29	25.5	18.5	0.284	81.2	48.0	0.284	0.233	0.45	0.64
30	25.3	18.8	0.285	81.5	46.9	0.285	0.234	0.41	0.62
Average	25.8	18.1	0.294	84.1	47.4	0.294	0.242	0.48	0.66
Std. Dev.	0.7	0.7	0.007	1.9	0.4	0.007	0.005	0.11	0.03
Maximum	26.9	19.3	0.306	87.3	48.1	0.306	0.251	0.79	0.76
@ Blow#	10	8	10	10	16	10	10	25	18

Total number of blows analyzed: 30

BL# Sensors

1-30 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K2491] 310.0 (1.00); A4: off

ST LOUIS 2021 - CME 550X 48.5-50.0
OP: PDB

S/N 343063
Date: 12-March-2021

Time Summary

Drive 36 seconds 11:23 AM - 11:23 AM BN 1 - 30

ST LOUIS 2021 - CME 550X 53.5-55.0

S/N 343063

OP: PDB

Date: 12-March-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 58.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	25.9	17.9	0.291	83.1	47.8	0.291	0.246	0.64	0.67
2	26.0	17.5	0.293	83.7	47.3	0.293	0.243	0.56	0.70
3	25.9	17.9	0.297	85.0	47.2	0.297	0.248	0.62	0.68
4	25.8	17.2	0.293	83.8	47.7	0.293	0.245	0.66	0.70
5	25.5	18.0	0.294	84.1	47.3	0.294	0.243	0.66	0.66
6	26.2	18.5	0.290	83.0	47.3	0.290	0.247	0.53	0.64
7	26.6	18.3	0.300	85.8	47.6	0.300	0.249	0.60	0.67
8	25.9	18.0	0.294	84.1	47.1	0.294	0.246	0.64	0.67
9	26.1	18.4	0.300	85.8	47.0	0.300	0.249	0.64	0.66
10	26.1	18.6	0.296	84.6	47.2	0.296	0.246	0.63	0.64
11	26.1	17.4	0.293	83.8	47.4	0.293	0.242	0.61	0.71
12	26.3	18.5	0.294	83.9	47.6	0.294	0.248	0.60	0.64
13	25.9	17.9	0.293	83.8	47.5	0.293	0.242	0.65	0.68
14	26.1	18.6	0.294	84.0	47.3	0.294	0.244	0.62	0.63
15	26.2	17.8	0.292	83.4	47.5	0.292	0.243	0.57	0.69
16	26.0	18.4	0.292	83.5	47.2	0.292	0.244	0.55	0.65
17	26.1	18.2	0.293	83.6	47.5	0.293	0.241	0.57	0.67
18	26.3	18.7	0.292	83.4	47.2	0.292	0.244	0.54	0.63
19	26.8	18.9	0.299	85.5	47.3	0.299	0.249	0.54	0.64
20	26.3	18.7	0.289	82.7	47.1	0.289	0.246	0.44	0.63
21	25.3	17.7	0.285	81.4	47.5	0.285	0.238	0.44	0.67
22	25.4	18.1	0.287	82.1	47.2	0.287	0.240	0.46	0.64
23	25.4	18.0	0.292	83.6	46.9	0.292	0.243	0.56	0.66
24	26.0	18.5	0.295	84.3	47.7	0.295	0.245	0.47	0.64
25	25.8	16.6	0.289	82.6	46.9	0.289	0.241	0.45	0.73
26	25.4	17.6	0.291	83.2	47.4	0.291	0.250	0.55	0.68
27	25.1	18.0	0.294	83.9	47.6	0.294	0.244	0.54	0.65
28	25.7	16.8	0.293	83.8	47.3	0.293	0.241	0.66	0.72
29	25.3	17.3	0.291	83.2	47.4	0.291	0.244	0.54	0.69
30	25.5	17.5	0.297	84.8	47.1	0.297	0.245	0.67	0.69
31	25.7	17.2	0.297	84.8	47.5	0.297	0.244	0.58	0.70
Average	25.9	18.0	0.293	83.8	47.3	0.293	0.245	0.57	0.67
Std. Dev.	0.4	0.6	0.003	1.0	0.2	0.003	0.003	0.07	0.03
Maximum	26.8	18.9	0.300	85.8	47.8	0.300	0.250	0.67	0.73
@ Blow#	19	19	7	7	1	7	26	30	25

Total number of blows analyzed: 31

BL# Sensors

1-31 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K2491] 310.0 (1.00); A4: off

ST LOUIS 2021 - CME 550X 53.5-55.0
OP: PDB

S/N 343063
Date: 12-March-2021

Time Summary

Drive 37 seconds 11:38 AM - 11:39 AM BN 1 - 31

ST LOUIS 2021 - CME 550X 58.5-60.0

S/N 343063

OP: PDB

Date: 12-March-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 63.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	25.0	18.8	0.303	86.7	48.2	0.303	0.243	0.51	0.60
2	25.1	18.8	0.305	87.3	48.0	0.305	0.246	0.53	0.61
3	24.4	18.5	0.294	84.1	47.8	0.294	0.237	0.74	0.60
4	25.7	19.8	0.303	86.7	48.8	0.303	0.242	0.77	0.58
5	25.0	19.6	0.300	85.7	47.4	0.300	0.239	0.80	0.54
6	25.0	19.7	0.301	85.9	48.5	0.301	0.241	0.79	0.57
7	24.5	19.1	0.304	86.9	48.2	0.304	0.246	0.85	0.58
8	25.1	19.7	0.300	85.8	47.4	0.300	0.241	0.79	0.54
9	23.8	18.4	0.302	86.2	47.7	0.302	0.241	0.85	0.59
10	25.0	19.0	0.304	86.8	48.4	0.304	0.242	0.86	0.59
11	24.6	18.7	0.297	84.9	47.5	0.297	0.237	0.84	0.60
12	25.0	18.7	0.298	85.0	48.2	0.298	0.239	0.77	0.60
13	24.5	18.9	0.298	85.0	48.1	0.298	0.236	0.80	0.59
14	24.6	18.8	0.297	84.8	48.0	0.297	0.242	0.54	0.59
15	25.5	19.4	0.293	83.8	48.3	0.293	0.239	0.61	0.58
16	24.9	18.9	0.300	85.7	47.8	0.300	0.240	0.72	0.60
17	24.5	18.5	0.296	84.6	47.7	0.296	0.238	0.84	0.60
18	25.0	19.2	0.295	84.3	48.5	0.295	0.238	0.65	0.57
19	24.3	19.1	0.296	84.6	47.6	0.296	0.237	0.75	0.58
20	23.9	18.4	0.290	82.8	47.8	0.290	0.236	0.48	0.60
21	23.7	18.2	0.286	81.7	48.0	0.286	0.235	0.51	0.60
Average	24.7	19.0	0.298	85.2	48.0	0.298	0.240	0.71	0.59
Std. Dev.	0.5	0.4	0.005	1.4	0.4	0.005	0.003	0.13	0.02
Maximum	25.7	19.8	0.305	87.3	48.8	0.305	0.246	0.86	0.61
@ Blow#	4	4	2	2	4	2	2	10	2

Total number of blows analyzed: 21

BL# Sensors

1-21 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K2491] 310.0 (1.00); A4: off

Time Summary

Drive 24 seconds 11:55 AM - 11:55 AM BN 1 - 21

ST LOUIS 2021 - CME 550X 63.5-65.0

S/N 343063

OP: PDB

Date: 12-March-2021

AR: 1.19 in²

SP: 0.492 k/ft³

LE: 68.88 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

EMX: Maximum Energy

VMX: Maximum Velocity

EF2: Energy of F² (ASTM D4633)

EFV: Maximum Energy

DFN: Final Displacement

ETR: Energy Transfer Ratio - Rated

FVP: Force/Velocity Proportionality

BPM: Blows/Minute

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
1	26.2	19.6	0.305	87.1	48.1	0.305	0.244	0.51	0.59
2	26.3	19.6	0.300	85.8	47.9	0.300	0.238	0.40	0.60
3	25.9	19.0	0.300	85.9	48.0	0.300	0.235	0.45	0.61
4	25.7	19.1	0.296	84.6	48.6	0.296	0.238	0.28	0.61
5	25.5	18.9	0.292	83.4	48.2	0.292	0.233	0.33	0.60
6	26.1	19.3	0.296	84.6	47.7	0.296	0.235	0.40	0.61
7	25.4	19.0	0.294	84.1	47.8	0.294	0.236	0.33	0.60
8	25.8	19.3	0.302	86.2	48.0	0.302	0.241	0.35	0.60
9	25.3	18.6	0.293	83.8	48.2	0.293	0.230	0.33	0.62
10	24.0	19.3	0.300	85.7	48.0	0.300	0.236	0.41	0.58
11	25.7	19.9	0.302	86.3	48.0	0.302	0.239	0.28	0.58
12	26.0	19.7	0.298	85.2	48.8	0.298	0.238	0.24	0.58
13	26.1	19.4	0.301	86.0	48.0	0.301	0.240	0.30	0.61
14	24.9	18.6	0.292	83.3	48.2	0.292	0.235	0.31	0.61
15	25.6	18.7	0.295	84.3	47.5	0.295	0.232	0.38	0.61
16	23.5	19.7	0.300	85.8	48.3	0.300	0.234	0.19	0.55
17	25.5	18.7	0.292	83.3	47.9	0.292	0.231	0.30	0.61
18	25.8	18.9	0.294	84.0	47.9	0.294	0.232	0.29	0.61
19	24.3	18.9	0.291	83.2	48.2	0.291	0.227	0.21	0.59
20	25.7	18.8	0.297	84.8	47.8	0.297	0.234	0.29	0.62
21	25.6	19.0	0.290	82.7	48.3	0.290	0.235	0.15	0.61
22	25.4	19.0	0.290	83.0	48.0	0.290	0.234	0.15	0.61
23	24.1	19.8	0.299	85.5	47.7	0.299	0.235	0.17	0.57
24	24.5	19.5	0.291	83.3	48.0	0.291	0.229	0.16	0.59
25	25.1	18.6	0.291	83.2	48.2	0.291	0.233	0.08	0.62
26	23.6	17.9	0.290	83.0	47.8	0.290	0.231	0.20	0.62
27	24.7	18.2	0.288	82.2	48.4	0.288	0.230	0.10	0.63
28	24.5	18.4	0.292	83.3	48.1	0.292	0.233	0.11	0.62
29	24.1	17.9	0.285	81.5	47.6	0.285	0.231	0.00	0.62
30	24.6	18.7	0.291	83.1	48.5	0.291	0.230	0.13	0.61
31	24.1	18.9	0.294	84.1	48.3	0.294	0.232	0.07	0.60
32	24.5	18.1	0.283	80.8	47.9	0.283	0.225	0.18	0.63
33	22.8	19.8	0.301	85.9	47.9	0.301	0.237	0.17	0.54
34	24.0	17.9	0.294	84.0	48.2	0.294	0.237	0.13	0.63
35	24.3	18.2	0.299	85.3	47.7	0.299	0.238	0.21	0.63
36	24.3	18.1	0.293	83.6	47.7	0.293	0.231	0.19	0.63
37	23.9	18.0	0.288	82.3	47.9	0.288	0.227	0.16	0.62
38	23.7	17.5	0.288	82.3	47.8	0.288	0.228	0.26	0.63
39	23.3	19.1	0.288	82.3	48.5	0.288	0.227	0.19	0.56
40	24.6	18.2	0.291	83.3	48.0	0.291	0.232	0.14	0.63
41	24.9	18.6	0.297	84.8	48.0	0.297	0.234	0.18	0.62
42	23.5	19.7	0.297	85.0	48.1	0.297	0.231	0.18	0.55
43	24.5	18.2	0.294	84.1	48.2	0.294	0.233	0.20	0.64
44	24.5	18.0	0.285	81.3	48.0	0.285	0.227	0.13	0.63
45	24.3	18.3	0.292	83.4	48.0	0.292	0.231	0.19	0.63

ST LOUIS 2021 - CME 550X 63.5-65.0

S/N 343063

OP: PDB

Date: 12-March-2021

BL#	FMX kips	VMX f/s	EFV k-ft	ETR (%)	BPM bpm	EMX k-ft	EF2 k-ft	DFN in	FVP
46	23.4	19.2	0.298	85.3	47.9	0.298	0.235	0.22	0.57
47	25.2	18.8	0.296	84.6	48.2	0.296	0.235	0.24	0.61
48	25.2	19.3	0.298	85.1	47.8	0.298	0.235	0.23	0.59
49	25.4	19.1	0.293	83.6	48.1	0.293	0.231	0.25	0.60
50	25.0	18.6	0.291	83.3	48.3	0.291	0.231	0.24	0.62
51	25.2	18.9	0.290	82.7	47.3	0.290	0.233	0.12	0.61
52	25.2	18.7	0.290	82.8	48.2	0.290	0.232	0.22	0.60
53	24.2	18.5	0.292	83.3	48.1	0.292	0.227	0.28	0.61
54	24.4	18.3	0.288	82.2	47.9	0.288	0.228	0.25	0.61
55	25.0	18.6	0.288	82.4	48.2	0.288	0.229	0.23	0.61
56	24.8	18.6	0.286	81.8	48.2	0.286	0.226	0.15	0.62
57	23.5	19.3	0.290	82.8	47.8	0.290	0.228	0.15	0.57
58	22.6	19.3	0.295	84.3	48.2	0.295	0.230	0.24	0.55
Average	24.8	18.8	0.294	83.9	48.0	0.294	0.233	0.23	0.60
Std. Dev.	0.9	0.6	0.005	1.4	0.3	0.005	0.004	0.10	0.02
Maximum	26.3	19.9	0.305	87.1	48.8	0.305	0.244	0.51	0.64
@ Blow#	2	11	1	1	12	1	1	1	43

Total number of blows analyzed: 58

BL# Sensors

1-58 F3: [405AWJ-1] 211.3 (1.00); F4: [405AWJ-2] 212.1 (1.00); A3: [K2491] 310.0 (1.00); A4: off

Time Summary

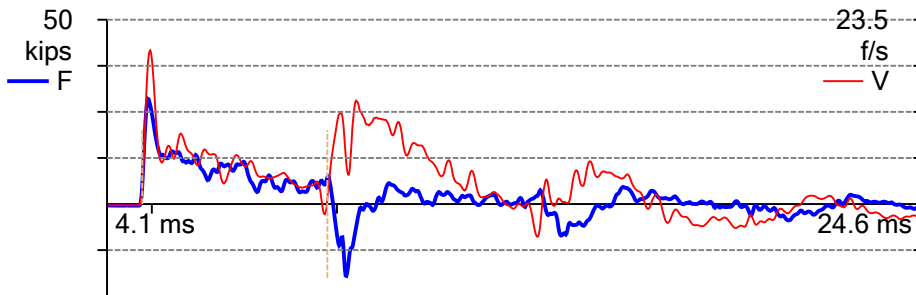
Drive 1 minute 11 seconds 12:14 PM - 12:15 PM BN 1 - 58

APPENDIX C

REPRESENTATIVE FORCE AND VELOCITY RECORDS

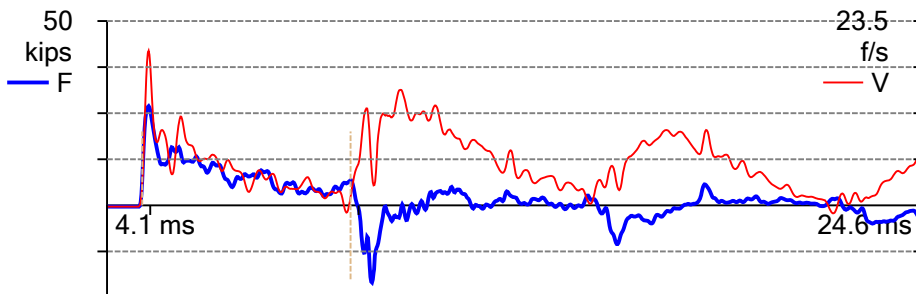
Project: ST LOUIS 2021
Pile: CME 55LC 32.5-35.0 - Description: S/N 390755
Operator: PDB

BN 7
3/12/2021 11:00:55 AM



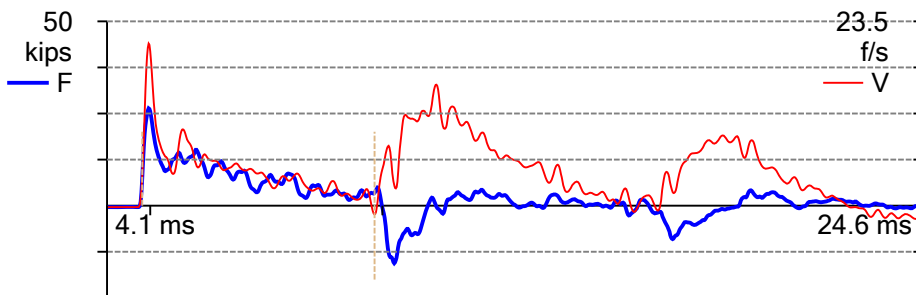
Project: ST LOUIS 2021
Pile: CME 55LC 38.5-40.0 - Description: S/N 390755
Operator: PDB

BN 7
3/12/2021 11:17:32 AM



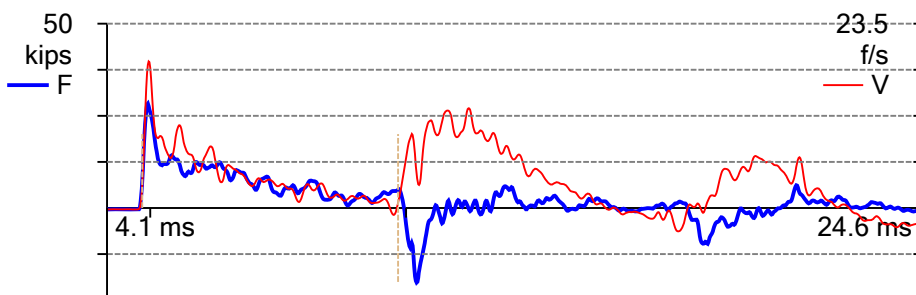
Project: ST LOUIS 2021
Pile: CME 55LC 43.5-45.0 - Description: S/N 390755
Operator: PDB

BN 2
3/12/2021 11:26:39 AM



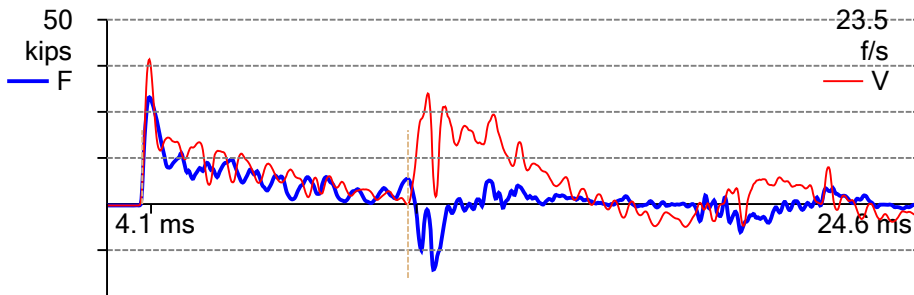
Project: ST LOUIS 2021
Pile: CME 55LC 48.5-50.0 - Description: S/N 390755
Operator: PDB

BN 1
3/12/2021 11:36:38 AM



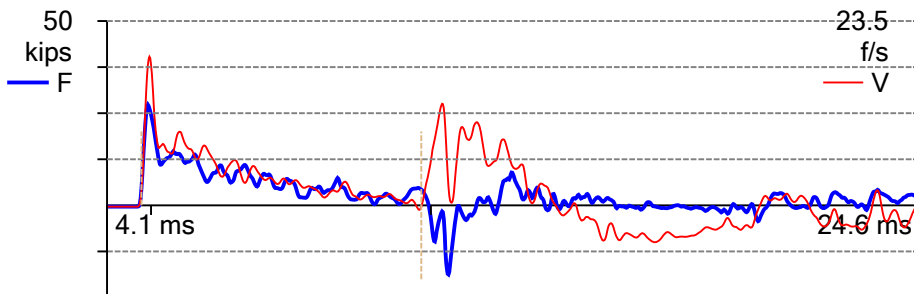
Project: ST LOUIS 2021
Pile: CME 55LC 50.5-52.0 - Description: S/N 390755
Operator: PDB

BN 3
3/12/2021 11:42:57 AM



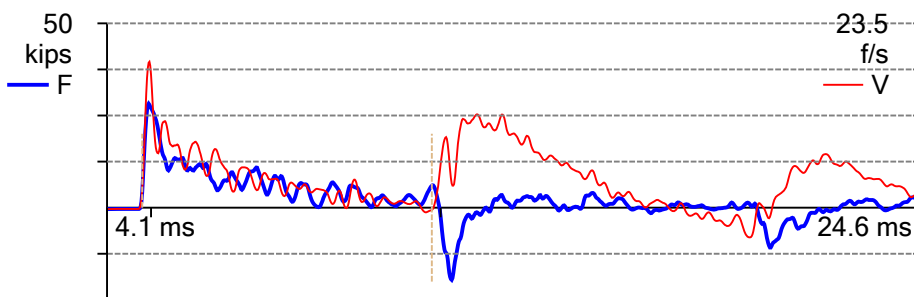
Project: ST LOUIS 2021
Pile: CME 55LC 53.5-55.0 - Description: S/N 390755
Operator: PDB

BN 3
3/12/2021 11:51:11 AM



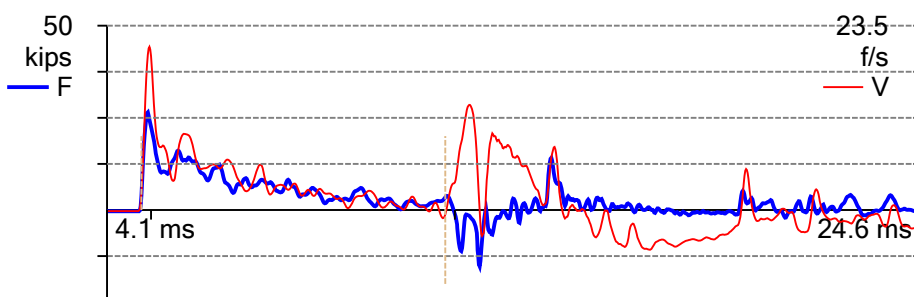
Project: ST LOUIS 2021
Pile: CME 55LC 55.5-57.0 - Description: S/N 390755
Operator: PDB

BN 1
3/12/2021 11:59:10 AM



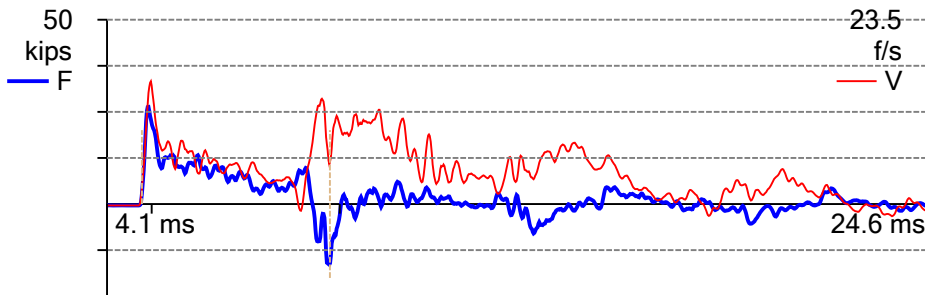
Project: ST LOUIS 2021
Pile: CME 55LC 58.5-60.0 - Description: S/N 390755
Operator: PDB

BN 2
3/12/2021 12:07:41 PM



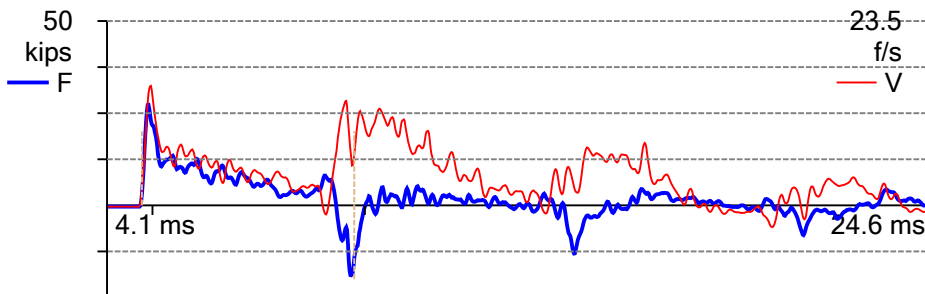
Project: ST LOUIS 2021
Pile: CME 85 33.5-35 - Description: S/N 254746
Operator: PDB

BN 3
2/3/2021 11:09:35 AM



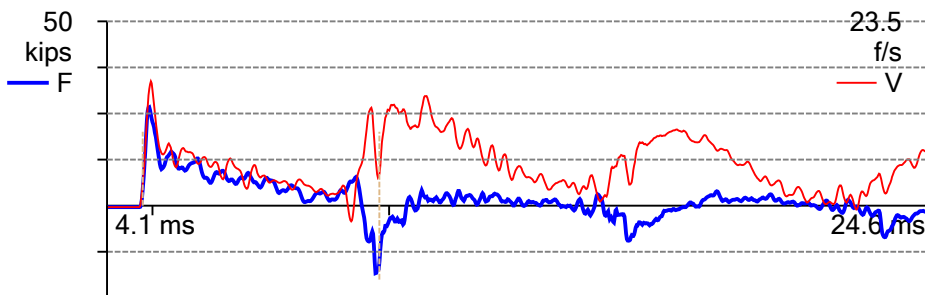
Project: ST LOUIS 2021
Pile: CME 85 38.5-40 - Description: S/N 254746
Operator: PDB

BN 3
2/3/2021 11:15:36 AM



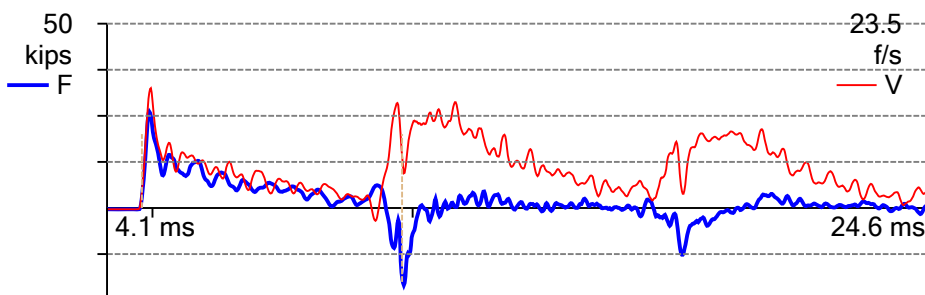
Project: ST LOUIS 2021
Pile: CME 85 43.5-45 - Description: S/N 254746
Operator: PDB

BN 3
2/3/2021 11:22:02 AM



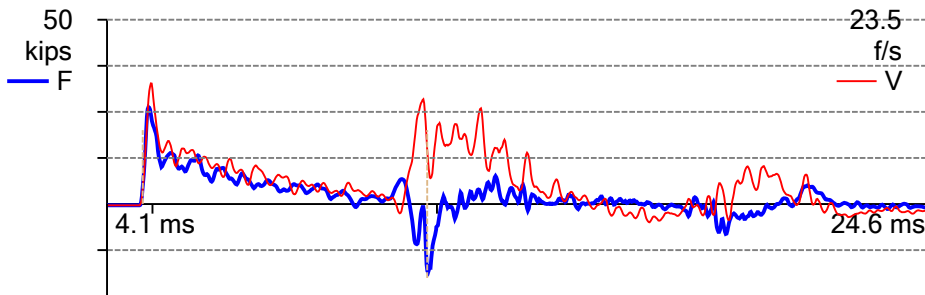
Project: ST LOUIS 2021
Pile: CME 85 48.5-50 - Description: S/N 254746
Operator: PDB

BN 4
2/3/2021 11:28:59 AM



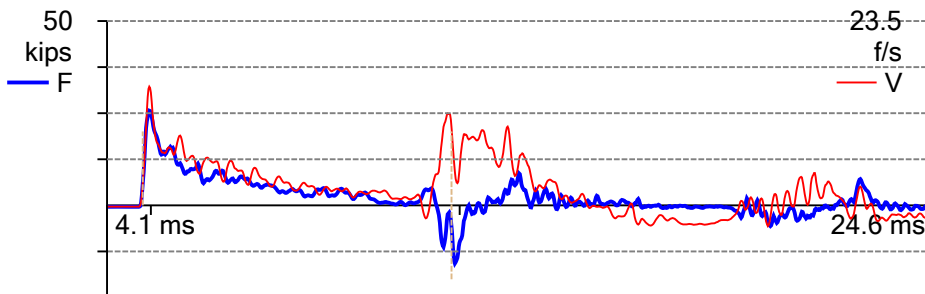
Project: ST LOUIS 2021
Pile: CME 85 53.5-55 - Description: S/N 254746
Operator: PDB

BN 3
2/3/2021 11:37:37 AM



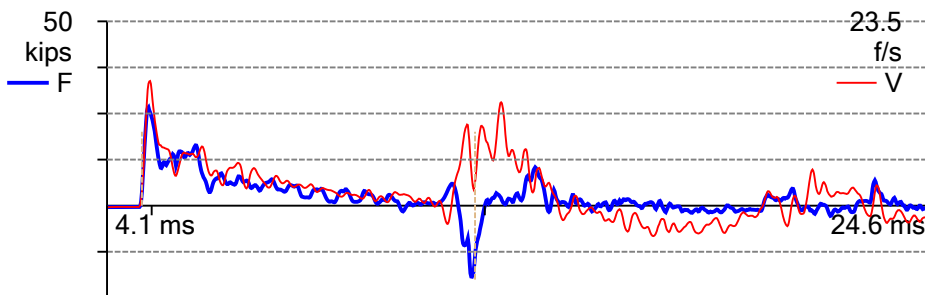
Project: ST LOUIS 2021
Pile: CME 85 58.5-60 - Description: S/N 254746
Operator: PDB

BN 4
2/3/2021 11:46:28 AM



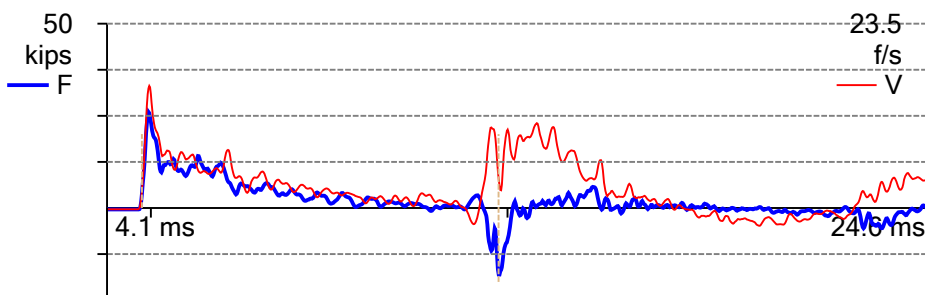
Project: ST LOUIS 2021
Pile: CME 85 63.5-65 - Description: S/N 254746
Operator: PDB

BN 1
2/3/2021 11:56:50 AM



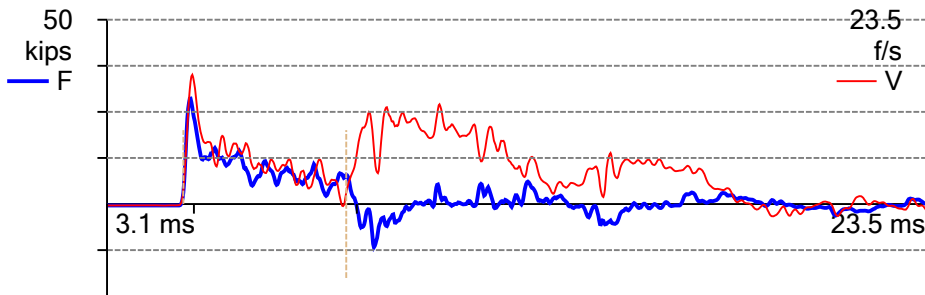
Project: ST LOUIS 2021
Pile: CME 85 68.5-70 - Description: S/N 254746
Operator: PDB

BN 4
2/3/2021 12:06:53 PM



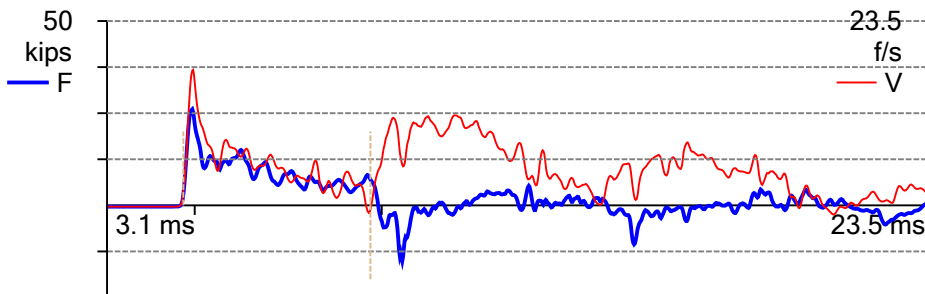
Project: ST LOUIS 2021
Pile: CME 750Y 28.5-30 - Description: S/N 404788
Operator: PDB

BN 1
2/5/2021 10:22:53 AM



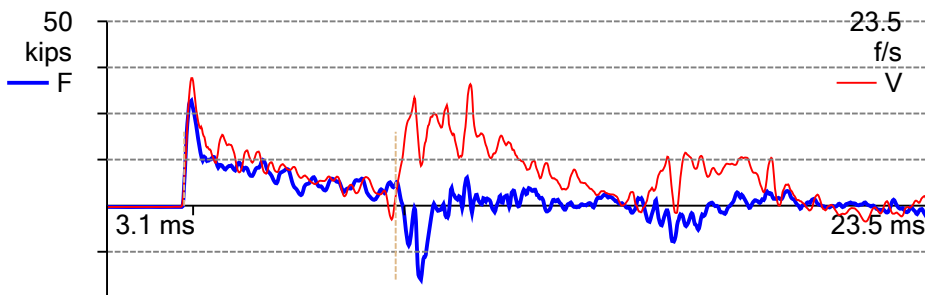
Project: ST LOUIS 2021
Pile: CME 750Y 33.5-35 - Description: S/N 404788
Operator: PDB

BN 1
2/5/2021 10:29:21 AM



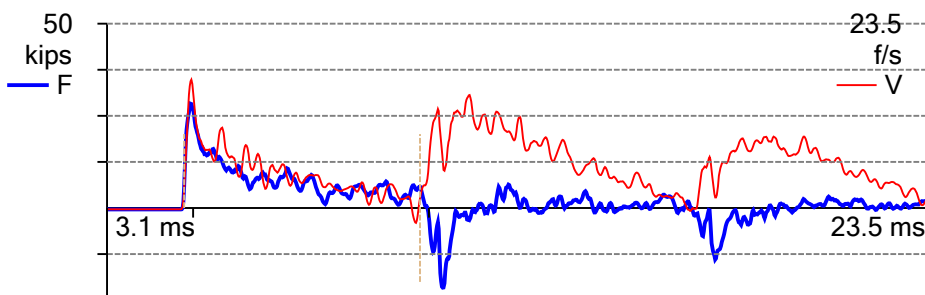
Project: ST LOUIS 2021
Pile: CME 750Y 38.5-40 - Description: S/N 404788
Operator: PDB

BN 1
2/5/2021 10:35:29 AM



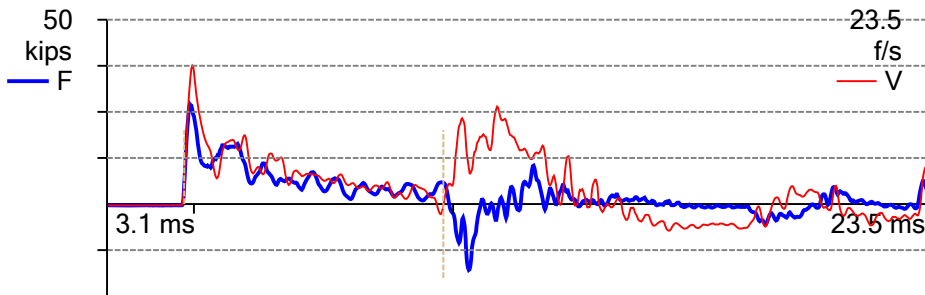
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Pile: CME 750Y 43.5-45 - Description: S/N 404788
Operator: PDB

BN 1
2/5/2021 10:42:48 AM



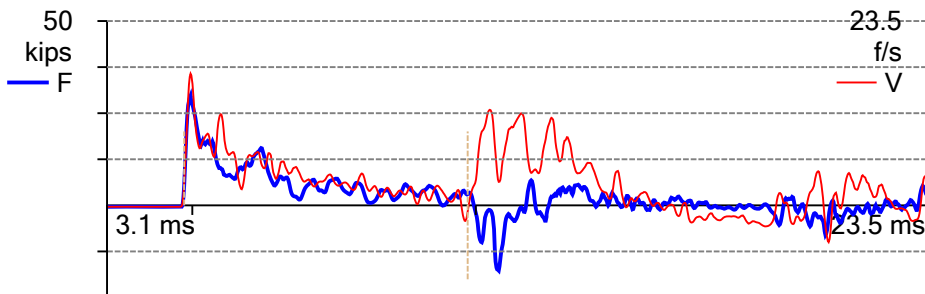
Project: ST LOUIS 2021
Pile: CME 750Y 48.5-50 - Description: S/N 404788
Operator: PDB

BN 1
2/5/2021 10:50:00 AM



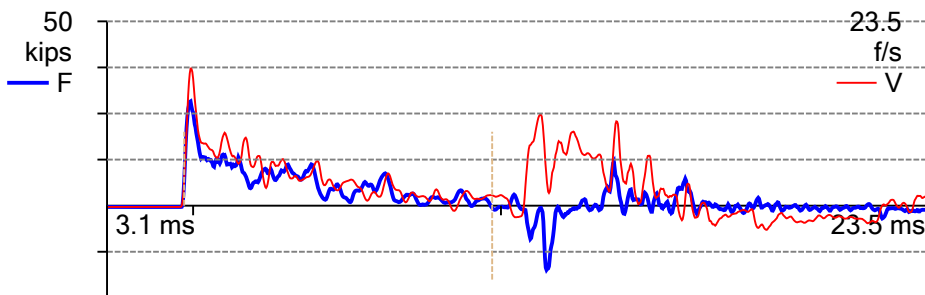
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Pile: CME 750Y 53.5-55 - Description: S/N 404788
Operator: PDB

BN 1
2/5/2021 11:24:01 AM



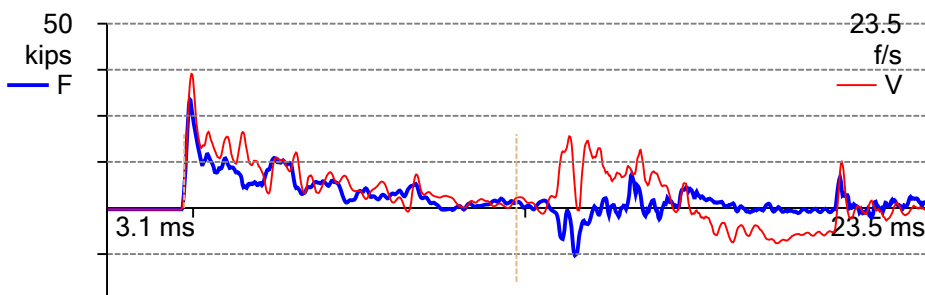
Project: ST LOUIS 2021
Pile: CME 750Y 58.5-60 - Description: S/N 404788
Operator: PDB

BN 1
2/5/2021 12:01:04 PM



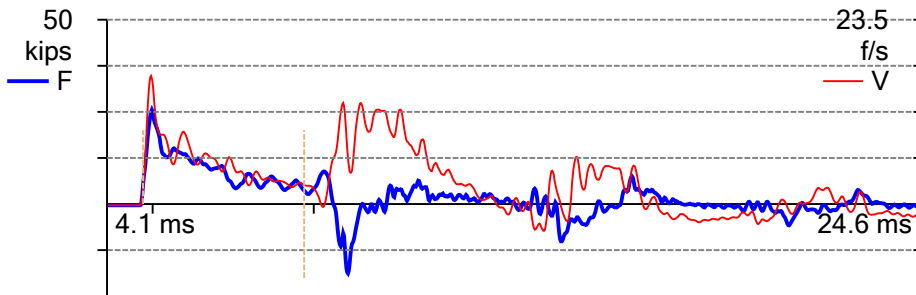
Project: ST LOUIS 2021
Pile: CME 750Y 63.5-65 - Description: S/N 404788
Operator: PDB

BN 1
2/5/2021 12:41:06 PM



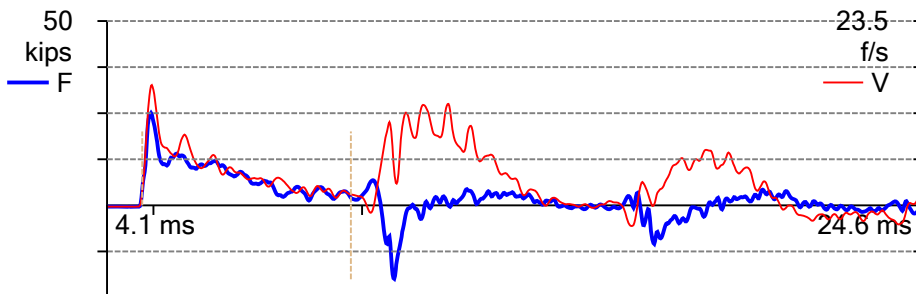
Project: ST LOUIS 2021
Pile: CME 550X 28.5-30.0 - Description: S/N 343063
Operator: PDB

BN 1
3/12/2021 10:33:05 AM



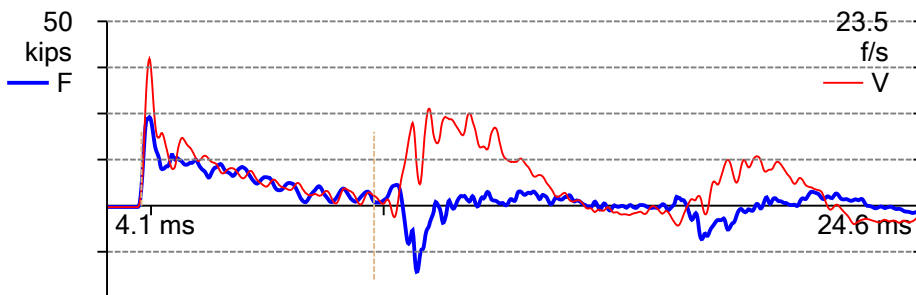
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Pile: CME 550X 38.5-40.0 - Description: S/N 343063
Operator: PDB

BN 1
3/12/2021 10:56:25 AM



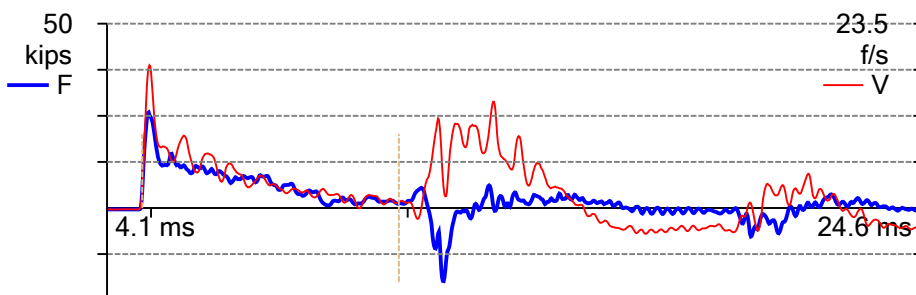
Project: ST LOUIS 2021
Pile: CME 550X 42.5-45.0 - Description: S/N 343063
Operator: PDB

BN 1
3/12/2021 11:11:04 AM



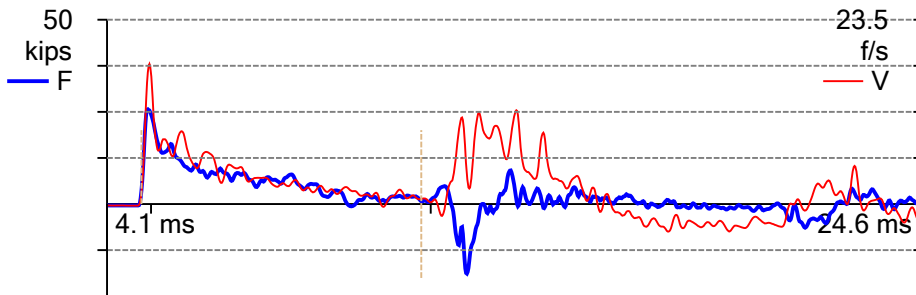
Project: ST LOUIS 2021
Pile: CME 550X 48.5-50.0 - Description: S/N 343063
Operator: PDB

BN 1
3/12/2021 11:23:13 AM



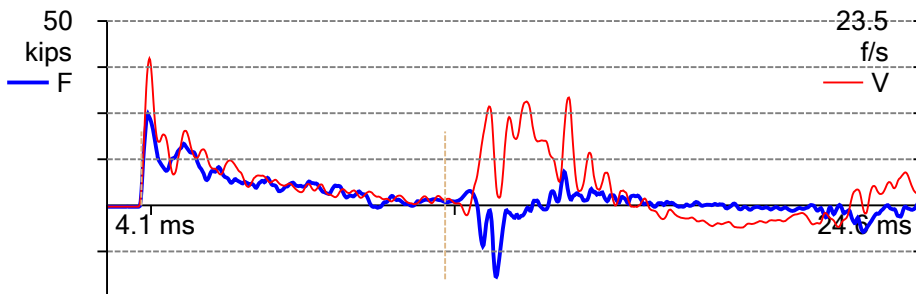
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Pile: CME 550X 53.5-55.0 - Description: S/N 343063
Operator: PDB

BN 1
3/12/2021 11:38:54 AM



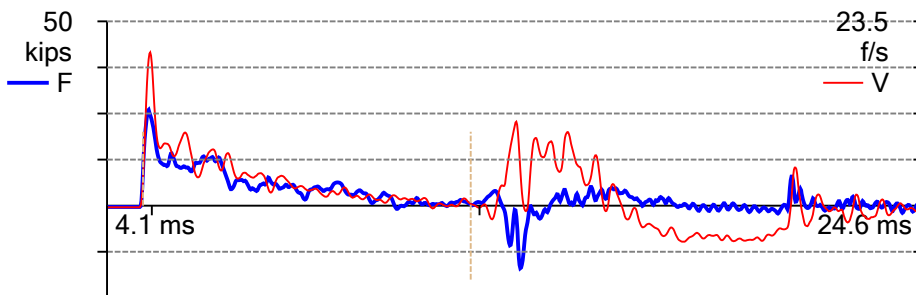
Project: ST LOUIS 2021
Pile: CME 550X 58.5-60.0 - Description: S/N 343063
Operator: PDB

BN 1
3/12/2021 11:55:17 AM



Project: ST LOUIS 2021
Pile: CME 550X 63.5-65.0 - Description: S/N 343063
Operator: PDB

BN 1
3/12/2021 12:14:12 PM





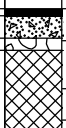
APPENDIX E – BORING AND TEST PIT INFORMATION

Boring/Test Pit Logs

Boring Log Terms and Symbols

Rock Core Descriptions

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
N60 BORING LOG (WITH PAGE #) J032438.03 BORING LOGS.GPJ 00 CLONE ME.GPJ 2/20/2021 THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: <u>622.0</u>		Completion Date: <u>6/4/21</u>		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf				
Datum: <u>NAVD 88</u>		Northing: <u>1083730.43</u> Easting: <u>716413.07</u>					Δ - UU/2	○ - QU/2	□ - SV		
							0.5	1.0	1.5	2.0	2.5
							STANDARD PENETRATION RESISTANCE ▲ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)				
DEPTH IN FEET	ELEVATION IN FEET	DESCRIPTION OF MATERIAL	WATER CONTENT, %								
			PL	10	20	30	40	50	LL		
		Asphalt - 2 inches									
		Concrete - 9 inches									
		Crushed rock - 4 inches									
		Fill: brown and tan clay, trace gravel and fine sand									
5	617.0	Stiff, brown SILT some sand - (ML)									
			4-4-5 (11)	SS1							
			3-6-8 (17)	SS2							
			3-4-7 (13)	SS3							
10	612.0		95	ST4							
		some weathered rock	31-50/1"	SS5							
15	607.0	Brown, weathered LIMESTONE and clay 3-inch core loss	83% 0%	NQ1							
		Strong to very strong, gray, very finely crystalline, thin to thick bedded, slightly weathered to unweathered LIMESTONE with chert nodules and occasional clay seams	100% 78%	NQ2							
		Unconfined compressive strength 2,029 ksf									
20	602.0		100% 85%	NQ3							
		Unconfined compressive strength 1,956 ksf									
25	597.0		100% 90%	NQ4							
		Unconfined compressive strength 2,474 ksf									
30	592.0		100% 88%	NQ5							
		Unconfined compressive strength 2,574 ksf									
35	587.0		100% 86%	NQ6							
		Unconfined compressive strength 2,764 ksf									
		Boring terminated at 38 feet									

GROUNDWATER DATA

ENCOUNTERED AT 7 FEET ▼

DRILLING DATA

___ AUGER 3 3/4" HOLLOW STEM
WASHBORING FROM ___ FEET
TPD DRILLER LAD LOGGER
CME 85 DRILL RIG
HAMMER TYPE Auto
HAMMER EFFICIENCY 73 %

Drawn by: SK Checked by: SK App'd. by: AWR
Date: 7/15/21 Date: 8/2/21 Date: 8/3/21

REMARKS: Rough drilling below 12 feet



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**I-70 Corridor Improvements
MoDOT Project J610624
Wentzville, Missouri**

LOG OF BORING: B-9

Page 1 of 1

Project No. J032438.03

N60 BORING LOG (WITH PAGE #) J032438.03 BORING LOGS.GPJ 00 CLONE ME.GPJ 4/5 AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: <u>621.6</u>		Completion Date: <u>5/24/21</u>		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf		
Datum: <u>NAVD 88</u>		Northing: <u>1083715.42</u> Easting: <u>716344.56</u>					Δ - UU/2 $\bigcirc$ - QU/2 $\square$ - SV		
							0.5 1.0 1.5 2.0 2.5		
DEPTH IN FEET	ELEVATION IN FEET	DESCRIPTION OF MATERIAL	STANDARD PENETRATION RESISTANCE						
			$\blacktriangle$ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)						
			WATER CONTENT, %						
			PL	10	20	30	40	50	LL
		Asphalt - 3.5 inches							
		Concrete - 15 inches							
		Stiff, tan, LEAN CLAY to FAT CLAY, some sand and gravel - (CL-CH)							
5	616.6	Stiff, brown, LEAN CLAY, trace gravel - CL							
		Very stiff, tan, FAT CLAY and gravel - CH							
10	611.6								
15	606.6	Strong to very strong, gray, very finely crystalline to aphanitic, thin to thick bedded, slightly weathered to unweathered LIMESTONE with chert and occasional clay seams							
		Unconfined compressive strength 1,122 ksf							
20	601.6								
		Unconfined compressive strength 2,095 ksf							
25	596.6								
		Unconfined compressive strength 1,930 ksf							
30	591.6								
		Unconfined compressive strength 1,595 ksf							
35	586.6								
		Unconfined compressive strength 2,279 ksf							
		Boring terminated at 39 feet							
GROUNDWATER DATA			DRILLING DATA			Drawn by: SK Checked by: SK App'vd. by: AWR			
☒ FREE WATER NOT ENCOUNTERED DURING DRILLING			☐ AUGER <u>3 3/4"</u> HOLLOW STEM WASHBORING FROM <u> </u> FEET			Date: 7/15/21 Date: 8/2/21 Date: 4/5/22			
REMARKS:			TPD DRILLER <u>ALY</u> LOGGER			 GEOTECHNOLOGY A Universal Engineering Sciences Company			
			<u>CME 85</u> DRILL RIG HAMMER TYPE <u>Auto</u> HAMMER EFFICIENCY <u>73</u> %						
LOG OF BORING: B-11						Page 1 of 1			
Project No. J032438.03									

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: <u>627.9</u>		Completion Date: <u>5/25/21</u>		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf				
Datum: <u>NAVD 88</u>		Northing: <u>1083604.78</u> Easting: <u>716255.13</u>					Δ - UU/2	○ - QU/2	□ - SV		
							0.5	1.0	1.5	2.0	2.5
							STANDARD PENETRATION RESISTANCE ▲ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)				
DEPTH IN FEET	ELEVATION IN FEET	DESCRIPTION OF MATERIAL	WATER CONTENT, %								
			PL	10	20	30	40	50	LL		
		Top soil - 12 inches									
		Soft to very soft, brown, LEAN CLAY - (CL)									
5	622.9										
		Stiff, brown and gray, FAT CLAY - (CH)									
10	617.9										
		Medium dense, brown, silty, clayey SAND, trace gravel - (SC-SM)									
15	612.9										
		Very stiff to stiff, brown, FAT CLAY, trace sand and gravel - CH									
20	607.9										
25	602.9										
		Strong to very strong, tan and gray to gray, very finely crystalline to aphanitic, thin to massive bedded, slightly weathered to unweathered LIMESTONE with chert nodules and occasional clay seams									
		Unconfined compressive strength 1,328 ksf									
		Unconfined compressive strength 2,628 ksf									
30	597.9										
		Unconfined compressive strength 1,640 ksf									
35	592.9										
		Unconfined compressive strength 2,161 ksf									

GROUNDWATER DATA

X FREE WATER NOT ENCOUNTERED DURING DRILLING

DRILLING DATA

___ AUGER 3 3/4" HOLLOW STEM WASHBORING FROM ___ FEET

NJG DRILLER EER LOGGER

CME 550X DRILL RIG

HAMMER TYPE Auto

HAMMER EFFICIENCY 84 %

Drawn by: SK
Date: 7/15/21

Checked by: SK
Date: 8/2/21

App'vd. by: AWR
Date: 4/5/22

REMARKS:

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LOG OF BORING: B-12

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Project No. J032438.03

[illegible]

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: <u>637.2</u>		Completion Date: <u>7/21/21</u>		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf		
Datum: <u>NAVD 88</u>		Northing: <u>1083686.65</u> Easting: <u>716555.23</u>					Δ - UU/2	○ - QU/2	□ - SV
DEPTH IN FEET	ELEVATION IN FEET	DESCRIPTION OF MATERIAL					STANDARD PENETRATION RESISTANCE ▲ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)		
				WATER CONTENT, %					
				PL - 10 20 30 40 50 LL					
		Fill: brown, lean clay			1-1-2 (4)	SS1	▲	●	
5	632.2				1-2-2 (6)	SS2	▲	●	
		Stiff to hard, brown and gray, FAT CLAY - (CH)			114	ST3		○	┘
10	627.2	some sand			3-6-8 (20)	SS4	▲	●	
		some weathered rock			13-18-21 (55)	SS5	●		▲
15	622.2								
		Dense to loose, brown, SILTY SAND - SM			4-16-28 (62)	SS6			▲
20	617.2								
					4-4-5 (13)	SS7	▲		
25	612.2								
		53 percent passing #200 sieve			4-4-50/1" ()	SS8			
30	607.2								
		Medium strong to strong, gray, finely crystalline, slightly weathered LIMESTONE with clay seams			100% 65%	NQ1			
35	602.2				100% 75%	NQ2			

GROUNDWATER DATA

ENCOUNTERED AT 28 FEET ▼

DRILLING DATA

___ AUGER 3 3/4" HOLLOW STEM
WASHBORING FROM ___ FEET
TPD DRILLER LAD LOGGER
CME 550X DRILL RIG
HAMMER TYPE Auto
HAMMER EFFICIENCY 84 %

Drawn by: SK Checked by: SK App'vd. by: AWR

Date: 7/22/21 Date: 8/2/21 Date: 4/5/22

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Wentzville, Missouri

LOG OF BORING: B-13

Page 1 of 2

Project No. J032438.03

REMARKS: Rough drilling at 13 feet.

[illegible]

N60 BORING LOG (WITH PAGE #) J032438.03 BORING LOGS.GPJ 00 CLONE ME.GPJ 4/5/21 NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: <u>638.6</u>		Completion Date: <u>5/26/21</u>		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf		
Datum: <u>NAVD 88</u>		Northing: <u>1083780.69</u> Easting: <u>716467.79</u>					Δ - UU/2	○ - QU/2	□ - SV
							0.5	1.0	1.5
							STANDARD PENETRATION RESISTANCE ▲ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)		
							PLI WATER CONTENT, % LL		
							10 20 30 40 50		
		Top soil - 12 inches							
		Soft to very stiff, brown and gray, FAT CLAY - (CH)							
					1-2-3 (7)	SS1	▲		
					1-1-3 (6)	SS2	▲		84
5	633.6				3-7-9 (22)	SS3		●	
		Stiff, brown, LEAN CLAY - (CL)							
10	628.6				2-5-7 (17)	SS4	▲	●	
		Limestone ledge - 4 inches							
15	623.6	Brown, LEAN CLAY - (CL)				GB5		●	
20	618.6					GB6		●	
25	613.6					GB7		●	
30	608.6								
		Strong to very strong, tan and gray to gray, very finely crystalline to aphanitic, thin to thick bedded, slightly weathered to unweathered LIMESTONE with occasional chert nodules and clay seams							
35	603.6	Unconfined compressive strength 1,798 ksf			100% 54%	NQ1			
					100% 77%	NQ2			

GROUNDWATER DATA

☒ FREE WATER NOT ENCOUNTERED DURING DRILLING

DRILLING DATA

___ AUGER 3 3/4" HOLLOW STEM WASHBORING FROM ___ FEET
NJG DRILLER EER LOGGER
CME 550X DRILL RIG
HAMMER TYPE Auto
HAMMER EFFICIENCY 84 %

Drawn by: SK	Checked by: SK	App'vd. by: AWR
Date: 7/15/21	Date: 8/2/21	Date: 4/5/22

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MoDOT Project J610624
Wentzville, Missouri

LOG OF BORING: B-14
Page 1 of 2

Project No. J032438.03

REMARKS: Auger refusal occurred at 13 feet, and commenced coring. Collected only grab samples of lean clay to a depth of 31 feet.

[illegible]

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: <u>631.5</u>		Completion Date: <u>5/27/21</u>		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf		
Datum: <u>NAVD 88</u>		Northing: <u>1083689.44</u> Easting: <u>716156.83</u>					Δ - UU/2 $\circ$ - QU/2 $\square$ - SV		
							0.5 1.0 1.5 2.0 2.5		
DEPTH IN FEET	ELEVATION IN FEET	DESCRIPTION OF MATERIAL	STANDARD PENETRATION RESISTANCE $\blacktriangle$ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)						
			WATER CONTENT, % PL 10 20 30 40 50 LL						
		Top soil - 30 inches		0-1-1 (3)	SS1	$\blacktriangle$			
		Very soft, brown, LEAN CLAY trace sand - (CL)		0-0-0 (0)	SS2	$\blacktriangle$			
5	626.5	Medium stiff to very stiff, brown, FAT CLAY, trace sand and gravel - CH		1-3-4 (10)	SS3	$\blacktriangle$			
				115	ST4		Δ		
10	621.5								
				3-8-10 (25)	SS5	$\blacktriangle$			
15	616.5								
				3-5-6 (15)	SS6	$\blacktriangle$			
20	611.5								
				2-3-6 (13)	SS7	$\blacktriangle$			
25	606.5								
		Medium strong to very strong, gray, very finely crystalline to aphanitic, thin to thick bedded, slightly weathered to unweathered LIMESTONE with chert nodules and clay seams		100% 90%	NQ1				
30	601.5								
		Unconfined compressive strength 926 ksf		100% 92%	NQ2				
		Unconfined compressive strength 2,711 ksf							
35	596.5			98% 65%	NQ3				
		1-inch core loss							
		1-inch core loss							
GROUNDWATER DATA				DRILLING DATA		Drawn by: SK Checked by: SK App'vd. by: AWR			
☒ FREE WATER NOT ENCOUNTERED DURING DRILLING				___ AUGER <u>3 3/4"</u> HOLLOW STEM WASHBORING FROM ___ FEET		Date: 7/15/21 Date: 8/2/21 Date: 4/5/22			
REMARKS:				NJG DRILLER EER LOGGER		GEOTECHNOLOGY A Universal Engineering Sciences Company			
				CME 550X DRILL RIG					
				HAMMER TYPE <u>Auto</u>		I-70 Corridor Improvements MoDOT Project J610624 Wentzville, Missouri			
				HAMMER EFFICIENCY <u>84</u> %					
						LOG OF BORING: B-15			
						Page 1 of 2			
						Project No. J032438.03			

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
160 BORING LOG (WITH PAGE #) J032438 03 BORING LOGS GPJ 00 CLONE ME GPJ 4/5 AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
 160 BORING LOG (WITH PAGE # 0032438.03 BORING LOGS.GPJ 00 CLONE ME.GPJ 2) AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
160 BORING LOG (WITH PAGE # 0032438.03 BORING LOGS.GPJ 00 CLONE ME.GPJ 2) AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
N60 BORING LOG (WITH PAGE #) J032438.03 BORING LOGS.GPJ 00 CLONE ME.GPJ 2/2/21 THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: <u>641.8</u>		Completion Date: <u>7/2/21</u>		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf				
Datum: <u>NAVD 88</u>		Northing: <u>1083722.34</u> Easting: <u>716519.60</u>					Δ - UU/2	○ - QU/2	□ - SV		
							0.5	1.0	1.5	2.0	2.5
							STANDARD PENETRATION RESISTANCE ▲ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)				
DEPTH IN FEET	ELEVATION IN FEET	DESCRIPTION OF MATERIAL		WATER CONTENT, %							
				PL 10 20 30 40 50 LL							
		Fill: brown, lean to fat clay			2-1-1 (3)	SS1	▲		●		
		Soft, brown, LEAN CLAY - CL			0-1-2 (5)	SS2	▲		●		
5	636.8	Medium stiff to hard, brown and gray, FAT CLAY - (CH)			2-3-4 (11)	SS3	▲		●		
					102	ST4			●		
					115	ST5			●		
					2-4-6 (15)	SS6	▲		●		
15	626.8	some gravel									
		Medium dense, brown, silty SAND - SM			6-12-20 (48)	SS7		●		▲	
20	621.8										
		Medium dense, brown, clayey SAND - SC			6-12-18 (45)	SS8				▲	
25	616.8										
		Medium stiff, brown LEAN CLAY, some sand - CL			4-5-6 (17)	SS9		▲		●	
30	611.8										
		Auger refusal at 36 feet			2-3-4 (11)	SS10	▲		●		
35	606.8										

GROUNDWATER DATA

X FREE WATER NOT ENCOUNTERED DURING DRILLING

DRILLING DATA

___ AUGER 3 3/4" HOLLOW STEM WASHBORING FROM ___ FEET

GS DRILLER DWJ LOGGER

CME 750Y DRILL RIG

HAMMER TYPE Auto

HAMMER EFFICIENCY 90 %

Drawn by: SK
Date: 7/15/21

Checked by: SK
Date: 8/2/21

App'vd. by: AWR
Date: 8/3/21

REMARKS:

GEOTECHNOLOGY
A Universal Engineering Sciences Company

I-70 Corridor Improvements
MoDOT Project J610624
Wentzville, Missouri

LOG OF BORING: B-20

Page 1 of 1

Project No. J032438.03

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
N60 BORING LOG (WITH PAGE #) J032438.03 BORING LOGS.GPJ 00 CLONE ME.GPJ 3/19/22 THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: <u>642.4</u>		Completion Date: <u>7/2/21</u>		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf							
Datum: <u>NAVD 88</u>		Northing: <u>1083810.82</u> Easting: <u>716906.31</u>					Δ - UU/2 $\circ$ - QU/2 $\square$ - SV 0.5 1.0 1.5 2.0 2.5							
							STANDARD PENETRATION RESISTANCE ▲ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)							
DEPTH IN FEET	ELEVATION IN FEET	DESCRIPTION OF MATERIAL					WATER CONTENT, %							
							PL	10	20	30	40	50	LL	
		Soft to very stiff, brown, FAT CLAY - CH			1-1-2 (5)	SS1	▲			●				
					2-5-5 (15)	SS2		▲		●				
5	637.4				109	ST3				●		○		
					2-3-5 (12)	SS4		▲		●				
		Very stiff to hard, brown, FAT CLAY trace gravel - CH												
10	632.4													
		Dense to loose, brown, silty SAND - SM			3-9-15 (36)	SS5			●	▲			├	
15	627.4													
					7-17-20 (56)	SS6				●			▲	
20	622.4													
		Auger refusal at 37 feet			5-17-24 (62)	SS7			●				▲	
25	617.4													
					7-12-13 (38)	SS8					●		▲	
30	612.4													
					2-2-3 (8)	SS9	▲							
35	607.4													

GROUNDWATER DATA

ENCOUNTERED AT 34 FEET ▼

REMARKS:

DRILLING DATA

___ AUGER 3 3/4" HOLLOW STEM
WASHBORING FROM ___ FEET
GS DRILLER DWJ LOGGER
CME 750Y DRILL RIG
HAMMER TYPE Auto
HAMMER EFFICIENCY 90 %

Drawn by: SK	Checked by: SK	App'vd. by: AWR
Date: 7/15/21	Date: 8/2/21	Date: 8/3/21

GEOTECHNOLOGY
A Universal Engineering Sciences Company

**I-70 Corridor Improvements
MoDOT Project J610624
Wentzville, Missouri**

LOG OF BORING: B-21

Page 1 of 1

Project No. J032438.03

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
160 BORING LOG (WITH PAGE #) J032438.03 BORING LOGS GPJ 00 CLONE ME GPJ 4/52 AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
N60 BORING LOG (WITH PAGE #) J032438.03 BORING LOGS.GPJ 00 CLONE ME.GPJ 2000 THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: <u>615.5</u>		Completion Date: <u>7/1/21</u>		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf						
Datum: <u>NAVD 88</u>		Northing: <u>1083081.07</u> Easting: <u>716933.82</u>					Δ - UU/2 $\bigcirc$ - QU/2 $\square$ - SV 0.5 1.0 1.5 2.0 2.5						
							STANDARD PENETRATION RESISTANCE $\blacktriangle$ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)						
DEPTH IN FEET	ELEVATION IN FEET	DESCRIPTION OF MATERIAL					WATER CONTENT, %						
							PL	10	20	30	40	50	LL
5	610.5	Soft to medium stiff, brown, FAT CLAY - CH			0-1-2 (5)	SS1	$\blacktriangle$			$\bullet$			
					1-2-4 (9)	SS2	$\blacktriangle$			$\bullet$			
10	605.5	Strong, tan and brown to gray, finely crystalline, slightly weathered LIMESTONE with clay seams			100% 75%	NQ1							
					100% 56%	NQ2							
15	600.5				100%/100%	NQ3							
20	595.5	Boring terminated at 16 feet											
25	590.5												
30	585.5												
35	580.5												
GROUNDWATER DATA		DRILLING DATA		Drawn by: SK Date: 7/15/21		Checked by: SK Date: 8/2/21		App'vd. by: AWR Date: 8/3/21					
☒ FREE WATER NOT ENCOUNTERED DURING DRILLING		___ AUGER <u>3 3/4"</u> HOLLOW STEM WASHBORING FROM ___ FEET ___ GS DRILLER <u>DWJ</u> LOGGER ___ CME 750Y DRILL RIG ___ HAMMER TYPE <u>Auto</u> HAMMER EFFICIENCY <u>90</u> %		 GEOTECHNOLOGY A Universal Engineering Sciences Company I-70 Corridor Improvements MoDOT Project J610624 Wentzville, Missouri LOG OF BORING: B-24 Page 1 of 1 Project No. J032438.03									
REMARKS:													

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
160 BORING LOG (WITH PAGE # J032438.03 BORING LOGS.GPJ 00 CLONE ME.GPJ 2) AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
N60 BORING LOG (WITH PAGE #) J032438.03 BORING LOGS.GPJ 00 CLONE ME.GPJ 2000 THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: <u>606.4</u>		Completion Date: <u>5/26/21</u>		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf Δ - UU/2 $\bigcirc$ - QU/2 $\square$ - SV 0.5 1.0 1.5 2.0 2.5		
Datum: <u>NAVD 88</u>		Northing: <u>1082441.82</u> Easting: <u>718301.55</u>					STANDARD PENETRATION RESISTANCE $\blacktriangle$ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)		
							WATER CONTENT, % PL 10 20 30 40 50 LL		
DEPTH IN FEET	ELEVATION IN FEET	DESCRIPTION OF MATERIAL							
		Concrete - 16 inches	☼ ☼ ☼						
		Fill: Tan, fat clay some asphalt, crushed rock trace organics and wood	▨ ▨ ▨	10-10-8 (22)	SS1				
				4-4-25 (35)	SS2				
5	601.4	Stiff, brown, FAT CLAY - CH	▨ ▨ ▨	5-5-5 (12)	SS3				
		Very stiff, brown and gray, LEAN CLAY and weathered rock - CL	▨ ▨ ▨	4-13-9 (27)	SS4				
10	596.4	Strong to very strong, gray, very finely crystalline to aphanitic, thin to medium bedded, slightly weathered to unweathered LIMESTONE with chert and occasional clay seams	▨ ▨ ▨	94% 32%	NQ1				
		4-inch core loss							
15	591.4	Unconfined compressive strength 2,657 ksf	▨ ▨ ▨	100% 100%	NQ2				
20	586.4	Unconfined compressive strength 1,663 ksf Boring terminated at 20 feet	▨ ▨ ▨						
25	581.4								
30	576.4								
35	571.4								
GROUNDWATER DATA ☒ FREE WATER NOT ENCOUNTERED DURING DRILLING REMARKS:				DRILLING DATA ___ AUGER <u>3 3/4"</u> HOLLOW STEM WASHBORING FROM ___ FEET TPD DRILLER <u>ALY</u> LOGGER <u>CME 85</u> DRILL RIG HAMMER TYPE <u>Auto</u> HAMMER EFFICIENCY <u>73</u> %				Drawn by: WAH Checked by: SK App'vd. by: AWR Date: 6/2/21 Date: 8/2/21 Date: 8/3/21	
						GEOTECHNOLOGY A Universal Engineering Sciences Company			
						I-70 Corridor Improvements MoDOT Project J610624 Wentzville, Missouri			
						LOG OF BORING: B-27 Page 1 of 1 Project No. J032438.03			

N60 BORING LOG (WITH PAGE #) J032438.03 BORING LOGS.GPJ 00 CLONE ME.GPJ 4/5/21
NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: <u>607.4</u>		Completion Date: <u>6/10/21</u>		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf		
Datum: <u>NAVD 88</u>		Northing: <u>1082607.65</u> Easting: <u>718646.23</u>					Δ - UU/2 $\bigcirc$ - QU/2 $\square$ - SV		
							0.5 1.0 1.5 2.0 2.5		
DEPTH IN FEET	ELEVATION IN FEET	DESCRIPTION OF MATERIAL	STANDARD PENETRATION RESISTANCE			WATER CONTENT, %			
			$\blacktriangle$ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)			PLI 10 20 30 40 50 LL			
		Concrete - 9 inches							
		Crushed rock - 12 inches							
		Fill: brown, fat clay, gravel and asphalt							
		Concrete - 6 inches							
		Core loss - 12 inches							
5	602.4	Medium strong to strong, gray and tan to gray, very finely crystalline, medium bedded, slightly weathered to unweathered LIMESTONE with occasional clay seams		6-12-5 (24)	SS1				
				50% 25%	NQ1				
				100% 70%	NQ2				
10	597.4			100% 89%	NQ3				
		Boring terminated at 13 feet							
15	592.4								
20	587.4								
25	582.4								
30	577.4								
35	572.4								
GROUNDWATER DATA					DRILLING DATA		Drawn by: WAH Checked by: SK App'vd. by: AWR		
☒ FREE WATER NOT ENCOUNTERED DURING DRILLING					4" AUGER 3 3/4" HOLLOW STEM WASHBORING FROM ____ FEET		Date: 6/25/21 Date: 8/2/21 Date: 4/5/22		
REMARKS:					NJG DRILLER DWJ LOGGER		 GEOTECHNOLOGY A Universal Engineering Sciences Company		
					CME 550X DRILL RIG				
					HAMMER TYPE <u>Auto</u>				
					HAMMER EFFICIENCY <u>84</u> %		I-70 Corridor Improvements MoDOT Project J6I0624 Wentzville, Missouri		
							LOG OF BORING: B-62		
							Page 1 of 1		
							Project No. J032438.03		

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
160 BORING LOG (WITH PAGE #) J032438 03 BORING LOGS GPJ 00 CLONE ME GPJ 4/5 AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
160 BORING LOG (WITH PAGE #) J032438 03 BORING LOGS GPJ 00 CLONE ME GPJ 4/5 AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: <u>605.3</u>		Completion Date: <u>6/8/21</u>		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf			
Datum: <u>NAVD 88</u>		Northing: <u>1082595.54</u> Easting: <u>718238.19</u>					Δ - UU/2 $\bigcirc$ - QU/2 $\square$ - SV			
							0.5 1.0 1.5 2.0 2.5			
DEPTH IN FEET	ELEVATION IN FEET	DESCRIPTION OF MATERIAL	STANDARD PENETRATION RESISTANCE							
			$\blacktriangle$ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)							
			WATER CONTENT, %							
			PL 10 20 30 40 50 LL							
		Concrete - 9 inches								
		Crushed rock - 12 inches								
		Soft to stiff, brown, FAT CLAY - (CH)								
5	600.3				3-1-2 (4)	SS1	$\blacktriangle$			62
					97	ST2		Δ		
					1-3-2 (7)	SS3	$\blacktriangle$			
10	595.3	Core loss - 5 inches			50%/0%	NQ1				
		Medium strong, gray to gray and tan, very finely crystalline, thin to medium bedded, moderately weathered LIMESTONE with occasional clay seams			100% 78%	NQ2				
		3 inches highly fractured zone								
15	590.3	Boring terminated at 15 feet								
20	585.3									
25	580.3									
30	575.3									
35	570.3									
GROUNDWATER DATA <u>X</u> FREE WATER NOT ENCOUNTERED DURING DRILLING REMARKS:							DRILLING DATA ___ AUGER <u>3 3/4"</u> HOLLOW STEM WASHBORING FROM ___ FEET <u>NJG</u> DRILLER <u>DWJ</u> LOGGER <u>CME 550X</u> DRILL RIG HAMMER TYPE <u>Auto</u> HAMMER EFFICIENCY <u>84</u> %			
							Drawn by: WAH Checked by: SK App'vd. by: AWR Date: 6/11/21 Date: 8/2/21 Date: 4/5/22			
							 GEOTECHNOLOGY A Universal Engineering Sciences Company			
							I-70 Corridor Improvements MoDOT Project J610624 Wentzville, Missouri			
							LOG OF BORING: B-78 Page 1 of 1 Project No. J032438.03			

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
160 BORING LOG (WITH PAGE #) J032438.03 BORING LOGS GPJ 00 CLONE ME GPJ 4/52 AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: <u>607.3</u>		Completion Date: <u>6/7/21</u>		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf		
Datum: <u>NAVD 88</u>		Northing: <u>1082696.35</u> Easting: <u>717851.22</u>					Δ - UU/2	○ - QU/2	□ - SV
DEPTH IN FEET	ELEVATION IN FEET	DESCRIPTION OF MATERIAL					STANDARD PENETRATION RESISTANCE ▲ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)		
				WATER CONTENT, %					
				PL 10 20 30 40 50 LL					
		Concrete - 9.5 inches		8-3-4 (10)	SS1				
		Crushed rock - 12 inches							
		Very soft, brown, LEAN CLAY - (CL)		97	ST2				
5	602.3	Direct shear cohesion 0.9 psi, phi 33 deg							
		Medium stiff, brown, FAT CLAY - (CH)		0-1-5 (8)	SS3				
10	597.3	Fractured LIMESTONE		100%/0%	NQ1				
		Core loss - 6 inches							
		Fractured LIMESTONE							
		Core loss - 6 inches							
15	592.3	Medium strong, gray and tan, very finely crystalline, medium bedded, slightly weathered LIMESTONE with occasional clay seams		77% 40%	NQ2				
		Boring terminated at 15 feet							
20	587.3								
25	582.3								
30	577.3								
35	572.3								

GROUNDWATER DATA

☒ FREE WATER NOT ENCOUNTERED DURING DRILLING

REMARKS:

DRILLING DATA

___ AUGER 3 3/4" HOLLOW STEM WASHBORING FROM ___ FEET

NJG DRILLER DWJ LOGGER

CME 550X DRILL RIG

HAMMER TYPE Auto

HAMMER EFFICIENCY 84 %

Drawn by: WAH	Checked by: SK	App'vd. by: AWR
Date: 6/11/21	Date: 8/2/21	Date: 4/5/22

GEOTECHNOLOGY
A Universal Engineering Sciences Company

I-70 Corridor Improvements
MoDOT Project J610624
Wentzville, Missouri

LOG OF BORING: B-94
Page 1 of 1

Project No. J032438.03

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
N60 BORING LOG (WITH PAGE #) J032438.03 BORING LOGS.GPJ 00 CLONE ME.GPJ 2000 THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: <u>599.6</u>		Completion Date: <u>6/3/21</u>		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf			
Datum: <u>NAVD 88</u>		Northing: <u>1082533.58</u> Easting: <u>719126.25</u>					Δ - UU/2 ○ - QU/2 □ - SV			
							0.5 1.0 1.5 2.0 2.5			
DEPTH IN FEET	ELEVATION IN FEET	DESCRIPTION OF MATERIAL	STANDARD PENETRATION RESISTANCE ▲ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)							
			WATER CONTENT, %							
			PL	10	20	30	40	50	LL	
		Asphalt - 2.5 inches								
		Concrete - 10.5 inches								
		Crushed rock - 2 inches								
		Medium stiff to soft, brown to gray, FAT CLAY - (CH)								
5	594.6									
		some weathered rock								
		Strong, gray, aphanitic, medium bedded, unweathered LIMESTONE								
		Unconfined compressive strength 2,123 ksf								
10	589.6	Core loss - 22 inches. Probable clay washout.								
		Weathered LIMESTONE								
		Core loss - 28 inches. Void.								
		Weathered LIMESTONE								
		Core loss - 4 inches. Void.								
15	584.6	Fractured LIMESTONE								
		Core loss - 55 inches. Void.								
20	579.6	LIMESTONE								
		Core loss - 24 inches. Probable clay washout.								
		Strong, gray, aphanitic, thin bedded, slightly weathered LIMESTONE								
		Unconfined compressive strength 1,910 ksf								
25	574.6	Core loss - 6 inches. Probable clay washout.								
		Weathered LIMESTONE								
		Core loss - 34 inches. Void.								
30	569.6	Strong, gray, aphanitic, thin bedded, slightly weathered LIMESTONE								
		Core loss - 4 inches. Void.								
		LIMESTONE								
		Core loss - 27 inches. Void.								
		3-inch clay								
		Fractured LIMESTONE								
35	564.6	Core loss - 8 inches. Void.								
		Strong, gray, aphanitic, thin bedded, moderately weathered LIMESTONE								
		Unconfined compressive strength 1,946 ksf								
		Core loss - 2 inches. Void.								
		Boring terminated at 35 feet								
GROUNDWATER DATA			DRILLING DATA			Drawn by: WAH Checked by: SK App'vd. by: AWR Date: 6/10/21 Date: 8/2/21 Date: 8/3/21				
☒ FREE WATER NOT ENCOUNTERED DURING DRILLING			___ AUGER <u>3 3/4"</u> HOLLOW STEM WASHBORING FROM ___ FEET TPD DRILLER LAD LOGGER CME <u>85</u> DRILL RIG HAMMER TYPE <u>Auto</u> HAMMER EFFICIENCY <u>73</u> %			 GEOTECHNOLOGY A Universal Engineering Sciences Company				
REMARKS: Rough drilling below 6.5 feet.			I-70 Corridor Improvements MoDOT Project J610624 Wentzville, Missouri							
			LOG OF BORING: B-101 Page 1 of 1 Project No. J032438.03							

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
160 BORING LOG (WITH PAGE #) J032438 03 BORING LOGS GPJ 00 CLONE ME GPJ 4/5 AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: <u>572.3</u>		Completion Date: <u>6/10/21</u>		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf				
Datum: <u>NAVD 88</u>		Northing: <u>1082451.82</u> Easting: <u>719173.33</u>					Δ - UU/2 $\circ$ - QU/2 $\square$ - SV 0.5 1.0 1.5 2.0 2.5				
DEPTH IN FEET	ELEVATION IN FEET	DESCRIPTION OF MATERIAL	STANDARD PENETRATION RESISTANCE								
			$\blacktriangle$ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)								
			WATER CONTENT, %								
			PL $\left \begin{array}{ccccccc} 10 & 20 & 30 & 40 & 50 & LL \end{array} \right.$								
		Concrete - 11 inches									
		Crushed rock - 13 inches									
		Highly weathered LIMESTONE some clay	4-24 -50/3" ()	SS1							
			8-20-10 (42)	SS2							
5	567.3		10-5-5 (14)	SS3							
10	562.3		10-24 -50/5" ()	SS4							
		Medium strong to strong, gray, finely crystalline, thin to medium bedded, slightly weathered LIMESTONE Unconfined compressive strength 890 ksf	100% 52%	NQ1							
15	557.3		100% 63%	NQ2							
		Unconfined compressive strength 1,589 ksf									
		Medium strong, gray and tan, finely crystalline, thin to medium bedded, moderately weathered LIMESTONE Unconfined compressive strength 963 ksf	100% 33%	NQ3							
20	552.3		100% 80%	NQ4							
		Unconfined compressive strength 2,169 ksf									
		Very strong to strong, gray, very finely crystalline to aphanitic, thin to thick bedded, slightly weathered to unweathered LIMESTONE with chert nodules	100% 100%	NQ5							
25	547.3		100% 100%	NQ6							
		Unconfined compressive strength 1,187 ksf									
30	542.3										
35	537.3										
		Boring terminated at 37 feet									

GROUNDWATER DATA

X FREE WATER NOT ENCOUNTERED DURING DRILLING

DRILLING DATA

4" AUGER 3 3/4" HOLLOW STEM
WASHBORING FROM ___ FEET
NJG DRILLER DWJ LOGGER
CME 550X DRILL RIG
HAMMER TYPE Auto
HAMMER EFFICIENCY 84 %

Drawn by: WAH Checked by: SK App'vd. by: AWR
 Date: 6/25/21 Date: 8/2/21 Date: 4/5/22

REMARKS: Rough drilling below 2 feet.

GEOTECHNOLOGY
A Universal Engineering Sciences Company

**I-70 Corridor Improvements
MoDOT Project J610624
Wentzville, Missouri**

LOG OF BORING: B-202

Page 1 of 1

Project No. J032438.03

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
160 BORING LOG (WITH PAGE #) J032438 03 BORING LOGS GPJ 00 CLONE ME GPJ 4/5 AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
160 BORING LOG (WITH PAGE # J032438.03 BORING LOGS.GPJ 00 CLONE ME.GPJ 2) AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
N60 BORING LOG (WITH PAGE #) J032438.03 BORING LOGS.GPJ 00 CLONE ME.GPJ 2000 THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: <u>599.3</u>		Completion Date: <u>6/1/21</u>		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf						
Datum: <u>NAVD 88</u>		Northing: <u>1082471.27</u> Easting: <u>719291.58</u>					Δ - UU/2 ○ - QU/2 □ - SV	0.5 1.0 1.5 2.0 2.5					
							STANDARD PENETRATION RESISTANCE ▲ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)						
DEPTH IN FEET	ELEVATION IN FEET	DESCRIPTION OF MATERIAL					WATER CONTENT, %						
							PL	10	20	30	40	50	LL
		Concrete - 13 inches											
		Fill: gray and black, fat clay trace asphalt and gravel			1-6-12 (22)	SS1							
					11-21-9 (37)	SS2							
5	594.3	Stiff to soft, reddish brown, FAT CLAY some gravel - CH			3-5-4 (11)	SS3							
10	589.3				2-1-3 (5)	SS4							
		Weathered LIMESTONE											
15	584.3	Core loss - 5 inches. Probable clay washout.			70% 17%	NQ1							
		Weathered LIMESTONE											
		Core loss - 4 inches. Probable clay washout.											
		Weathered LIMESTONE											
20	579.3	Very strong to medium strong, gray, very finely crystalline to aphanitic, thin to medium bedded, moderately weathered to unweathered LIMESTONE with occasional clay seams			100% 74%	NQ2							
		Unconfined compressive strength 3,482 ksf											
		Unconfined compressive strength 745 ksf											
25	574.3				100% 78%	NQ3							
		Boring terminated at 25.5 feet											
30	569.3												
35	564.3												

GROUNDWATER DATA

X FREE WATER NOT ENCOUNTERED DURING DRILLING

DRILLING DATA

___ AUGER 3 3/4" HOLLOW STEM WASHBORING FROM ___ FEET

TPD DRILLER LAD LOGGER

CME 85 DRILL RIG

HAMMER TYPE Auto

HAMMER EFFICIENCY 73 %

Drawn by: WAH Checked by: SK App'vd. by: AWR

Date: 6/10/21 Date: 8/2/21 Date: 8/3/21

REMARKS: Rough drilling from 3 to 5 feet.

GEOTECHNOLOGY
A Universal Engineering Sciences Company

I-70 Corridor Improvements
MoDOT Project J610624
Wentzville, Missouri

LOG OF BORING: B-402

Page 1 of 1

Project No. J032438.03

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

Surface Elevation: 660.1		Completion Date: 9/10/21		GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS (N60) CORE RECOVERY/RQD	SAMPLES	SHEAR STRENGTH, tsf △ - UU/2 ○ - QU/2 □ - SV 0.5 1.0 1.5 2.0 2.5							
Datum: NAVD88		Northing: 1083727.67 Easting: 715842.78					STANDARD PENETRATION RESISTANCE ▲ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)							
							WATER CONTENT, % PL 10 20 30 40 50 LL							
DEPTH IN FEET	ELEVATION IN FEET	DESCRIPTION OF MATERIAL												
		FILL: brown, fat clay, with sand, some gravel and occasional cobbles and boulders	[Hatched Pattern]	[Empty]	[Empty]	[Empty]	GB1 [Empty]							
5	655.1													
10	650.1	FILL: gray, fat clay, with sand, gravel and asphalt	[Hatched Pattern]	[Empty]	[Empty]	[Empty]	GB2 [Empty]							
15	645.1	FILL: gray, lean clay, with sand, some gravel	[Hatched Pattern]	[Empty]	[Empty]	[Empty]	GB3 [Empty]							
20	640.1	Gray to brown, FAT CLAY, trace sand - CH Test pit terminated at 19 feet.	[Hatched Pattern]	[Empty]	[Empty]	[Empty]	GB4 [Empty]							
25	635.1						GB5 [Empty]							
30	630.1						[Empty] [Empty]							
35	625.1						[Empty] [Empty]							

GROUNDWATER DATA

ENCOUNTERED AT 18 FEET ∇

DRILLING DATA

___ AUGER ___ HOLLOW STEM
 WASHBORING FROM ___ FEET
 McFRY DRILLER VTZ LOGGER
 15 GC BACKHOE
 HAMMER TYPE ___

REMARKS:

Bulk sample collected of composite matereial from 0 to 6 feet.
 Large pieces of concrete and asphalt observed.
 Perched water at 18 feet.

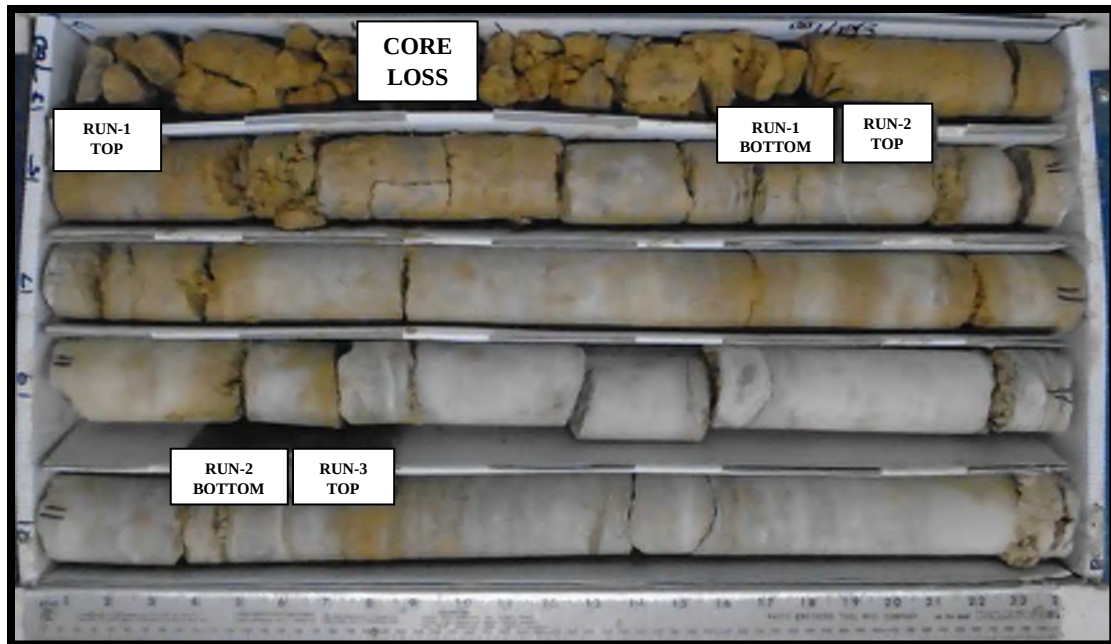
Drawn by: WAH Date: 9/23/21	Checked by: SK Date: 3/22/22	App'vd. by: AWR Date: 4/5/22
GEOTECHNOLOGY A Universal Engineering Sciences Company		
I-70 Corridor Improvments MoDOT Project J610624 Wentzville, Misssouri		
LOG OF TEST PIT: TP-01 Page 1 of 1		
Project No. J032438.03		

[illegible]

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES
 160 BORING LOG (WITH PAGE #) J032438 03 TEST PIT LOGS GPJ 00 CLONE ME GPJ 4#AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

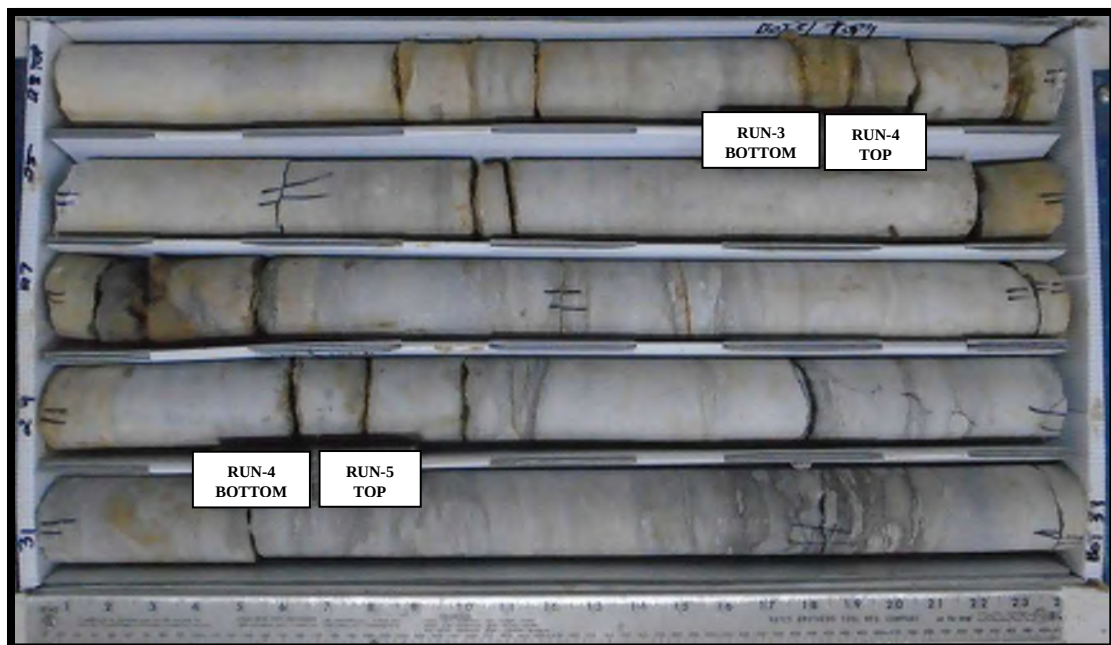


APPENDIX F – ROCK CORE PHOTOGRAPHS



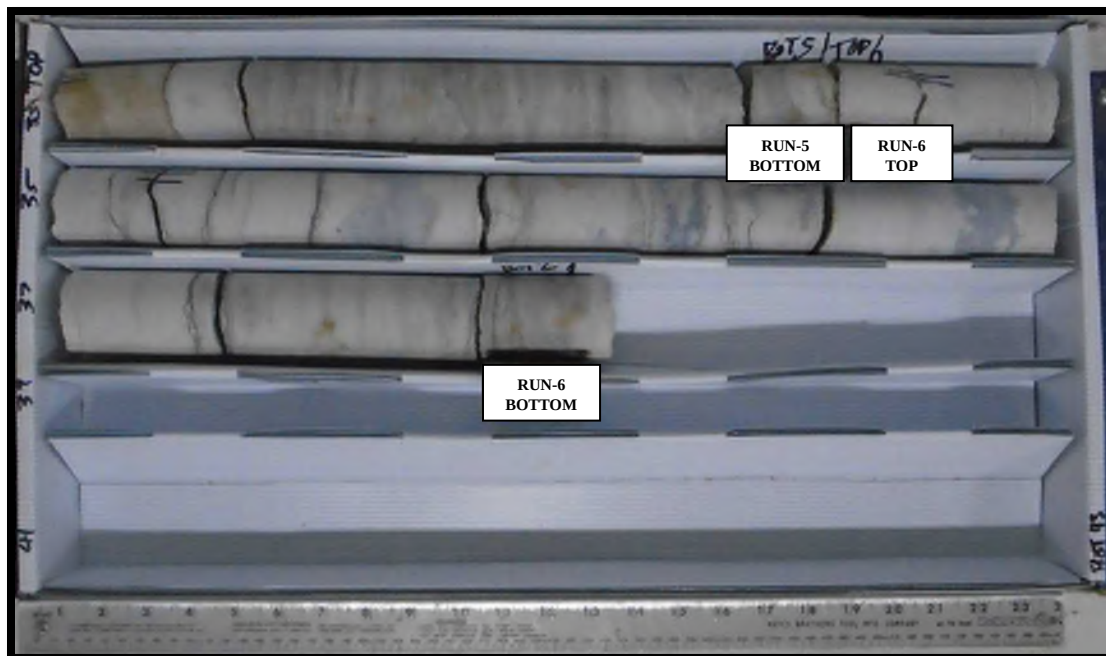
B-9, Box 1 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	13.0-14.5	83	0
2	14.5-19.5	100	78
3	19.5-Cont.	100	85



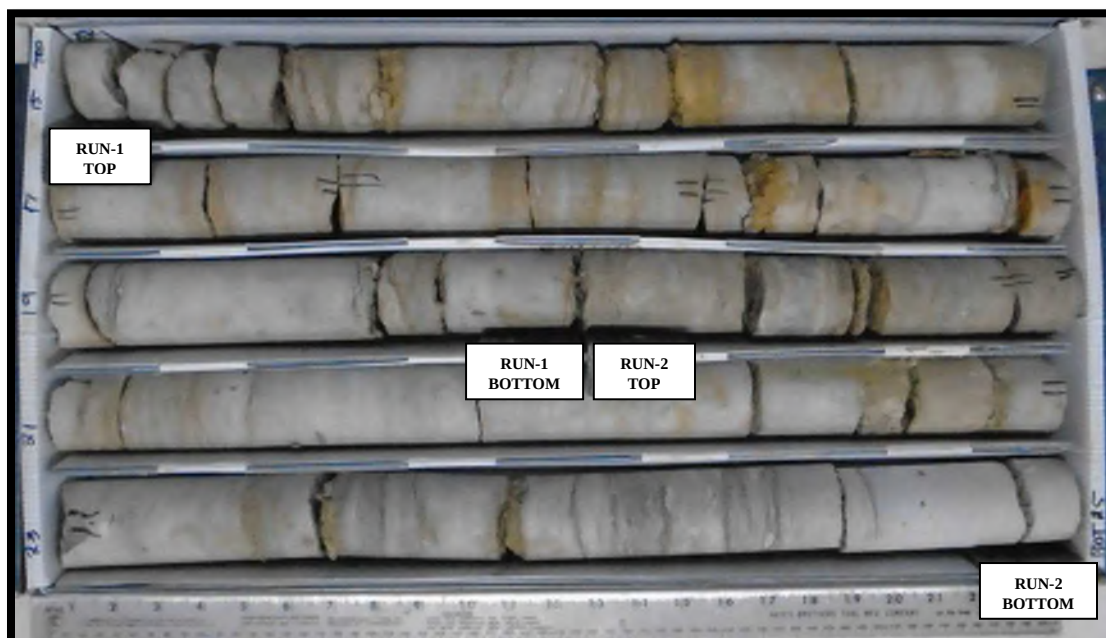
B-9, Box 2 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	Cont.-24.5	100	85
4	24.5-29.5	100	90
5	29.5-Cont.	100	88



B-9, Box 3 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
5	Cont.-34.5	100	88
6	34.5-38.0	100	86



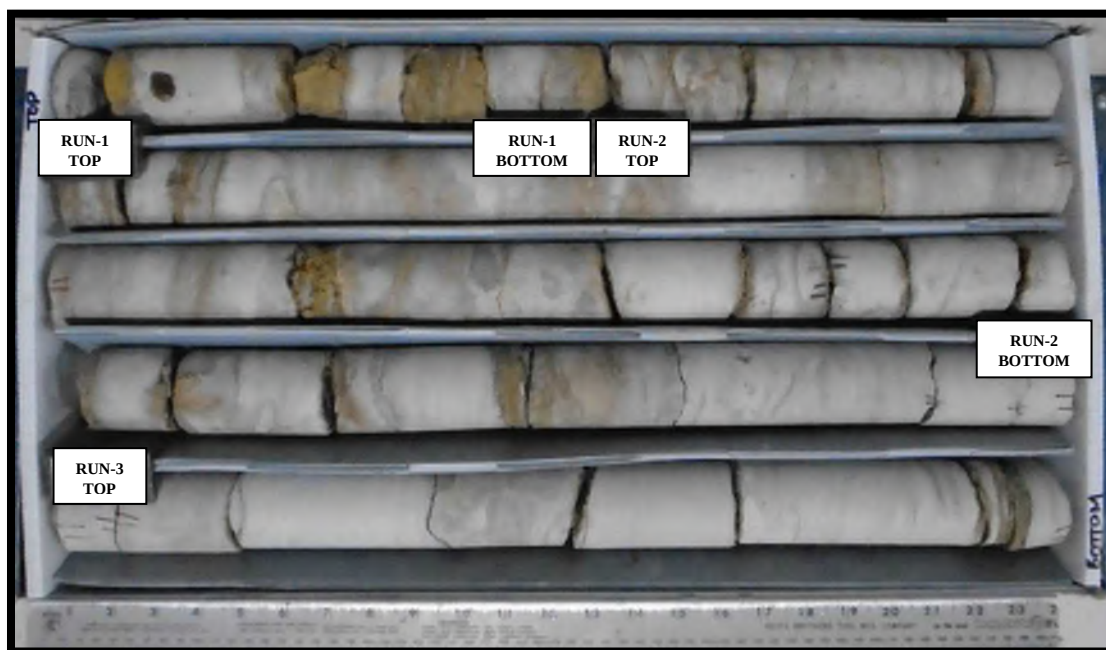
B-10, Box 1 of 2

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	15.0-20.0	100	69
2	20.0-25.0	100	84



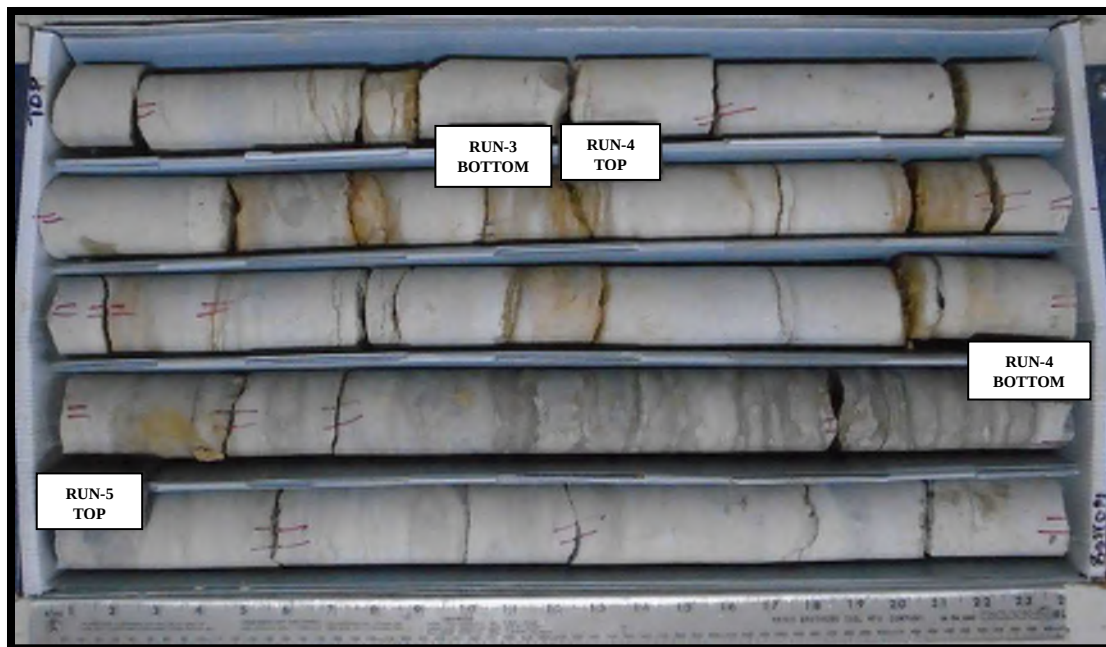
B-10, Box 2 of 2

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	25.0-30.3	97	87



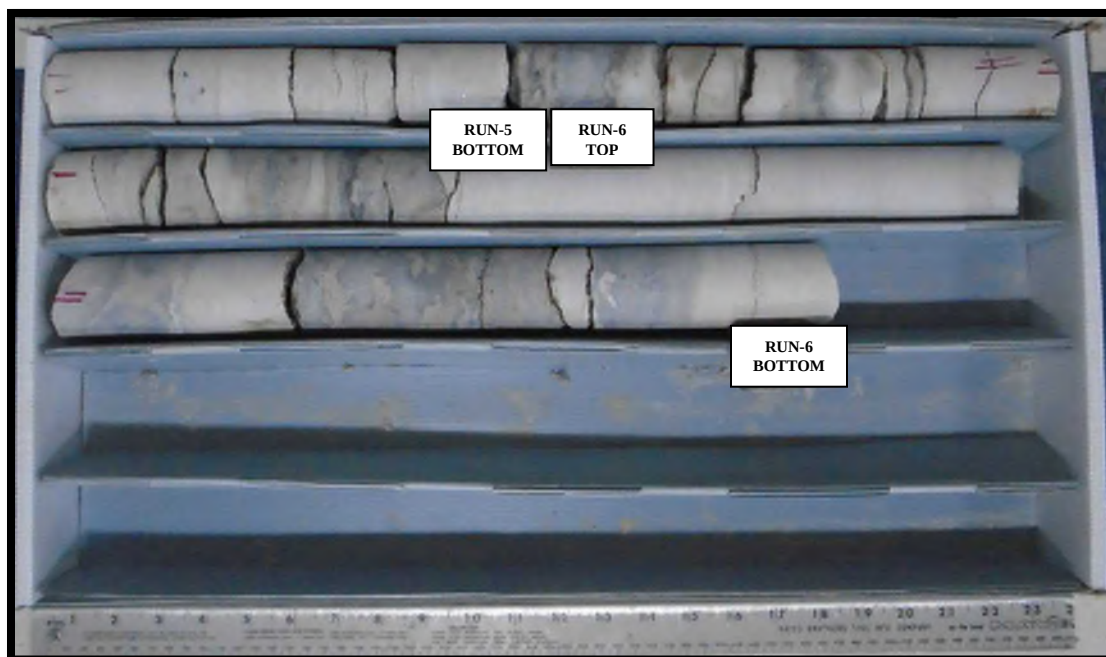
B-11, Box 1 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	14.0-15.0	100	33
2	15.0-20.0	100	73
3	20.0-Cont.	100	78



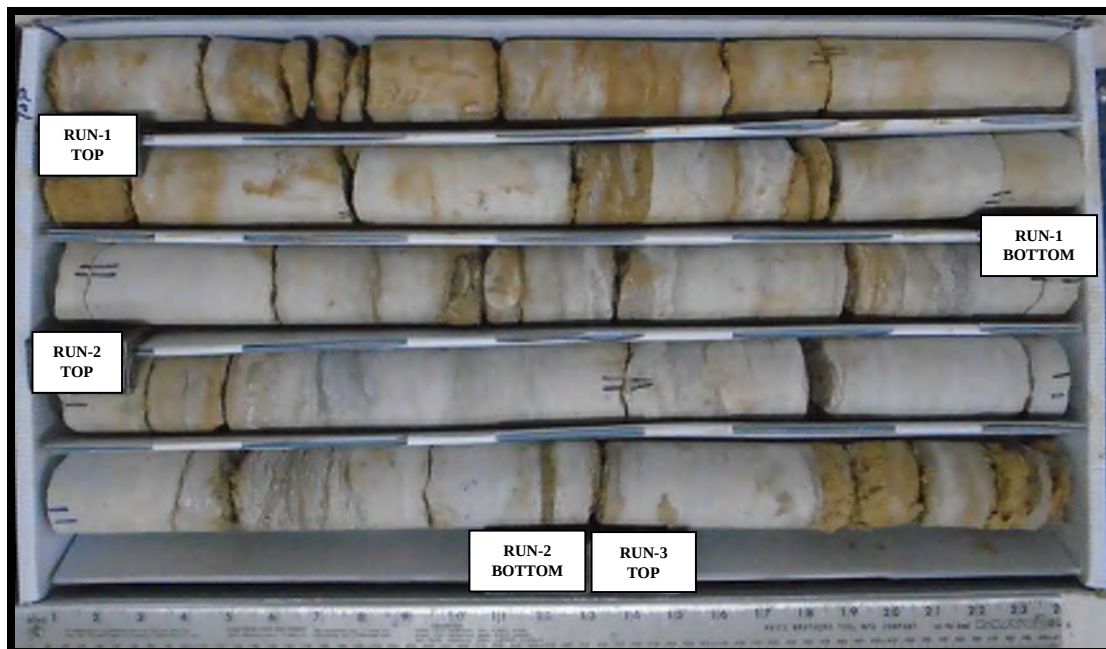
B-11, Box 2 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	Cont.-25.0	100	78
4	25.0-30.0	100	97
5	30.0-Cont.	100	90



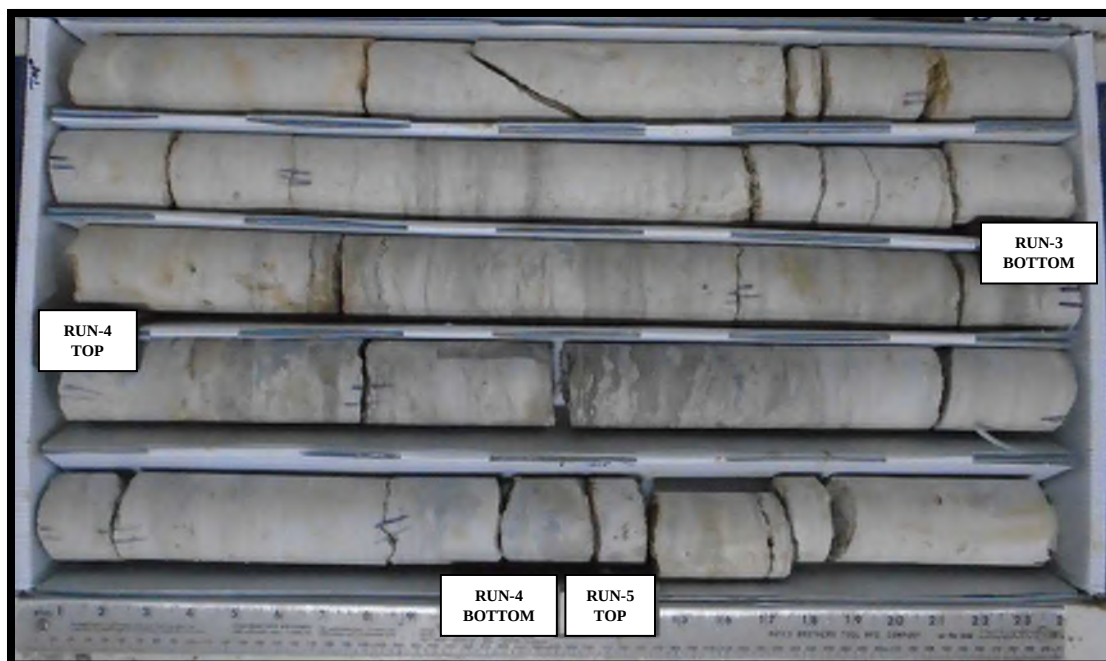
B-11, Box 3 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
5	Cont.-35.0	100	90
6	35.0-39.0	100	80



B-12, Box 1 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	21.0-25.0	100	72
2	25.0-30.0	100	82
3	30.0-Cont.	100	82



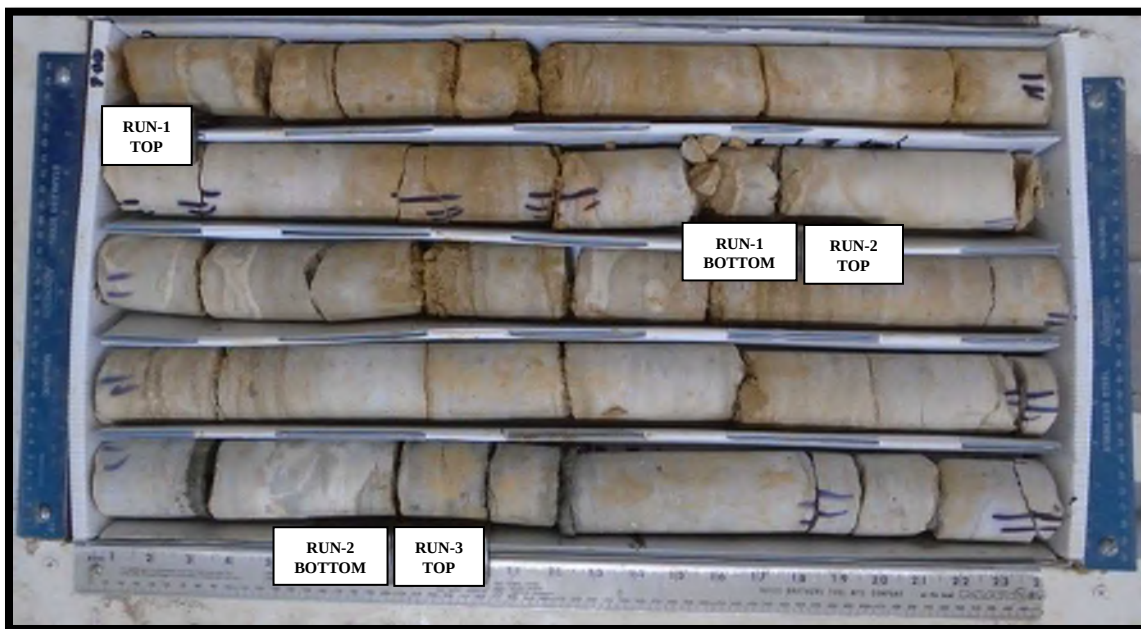
B-12, Box 2 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	Cont.-35.0	100	82
4	35.0-40.0	100	93
5	40.0-Cont.	100	93



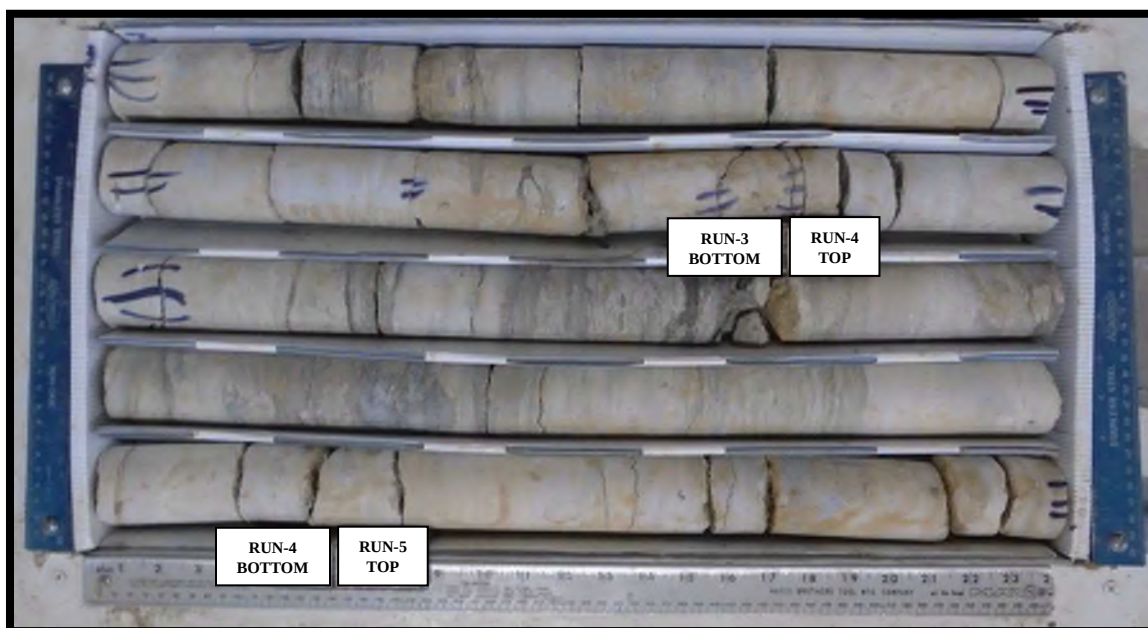
B-12, Box 3 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
5	Cont.-45.0	100	93
6	45.0-46.0	100	83



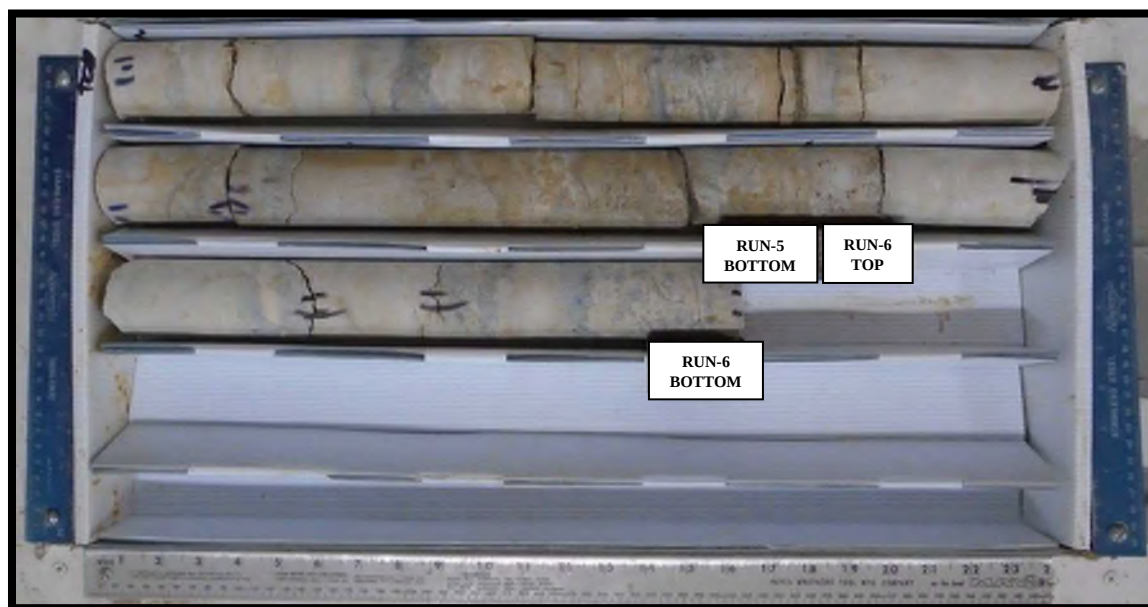
B-13, Box 1 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	31.0-34.9	100	65
2	34.5-39.5	100	75
3	39.5-Cont.	100	87



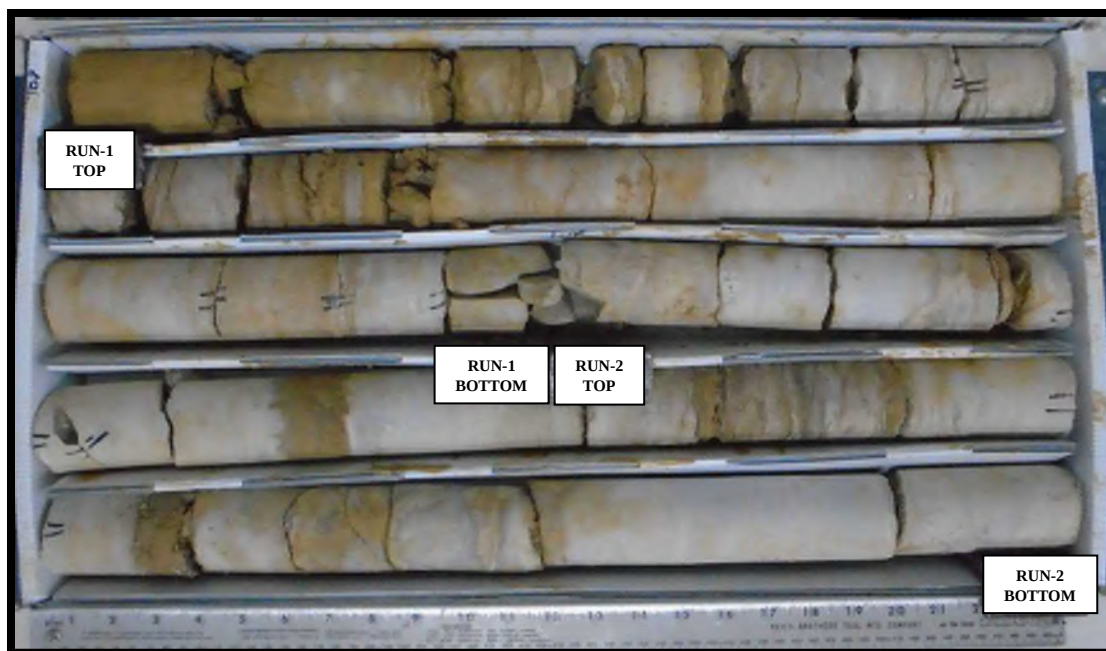
B-13, Box 2 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	Cont.-44.5	100	87
4	44.5-49.5	100	83
5	49.5-Cont.	100	85



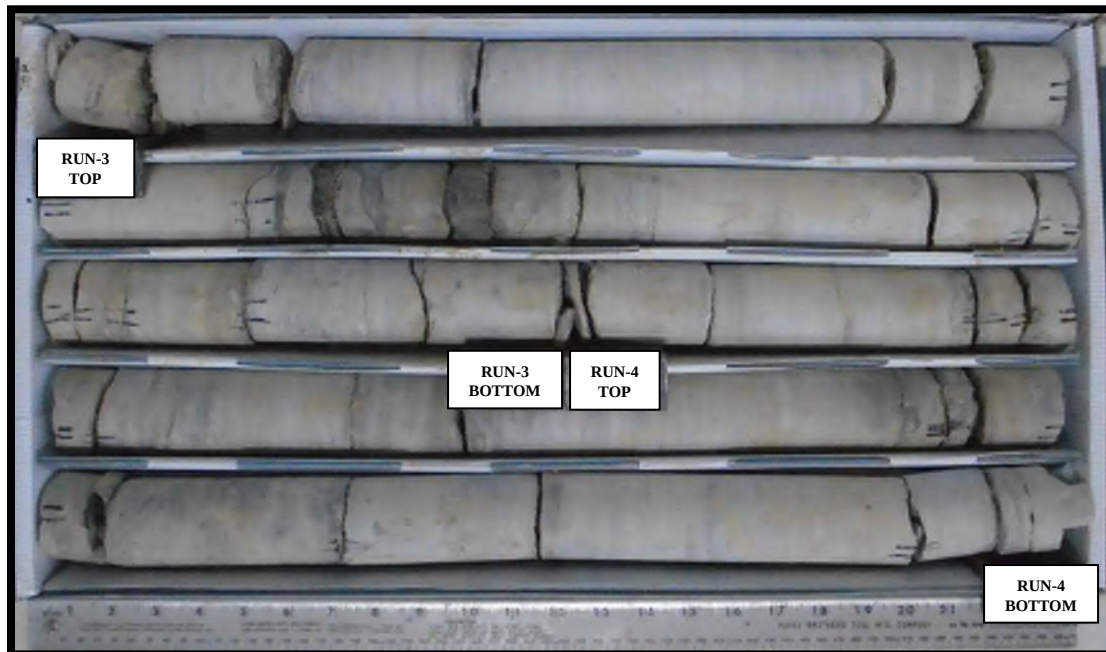
B-13, Box 3 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
5	Cont.-54.5	100	85
6	54.5-56.0	100	100



B-14, Box 1 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	31.0-36.0	100	54
2	36.0-41.0	100	77



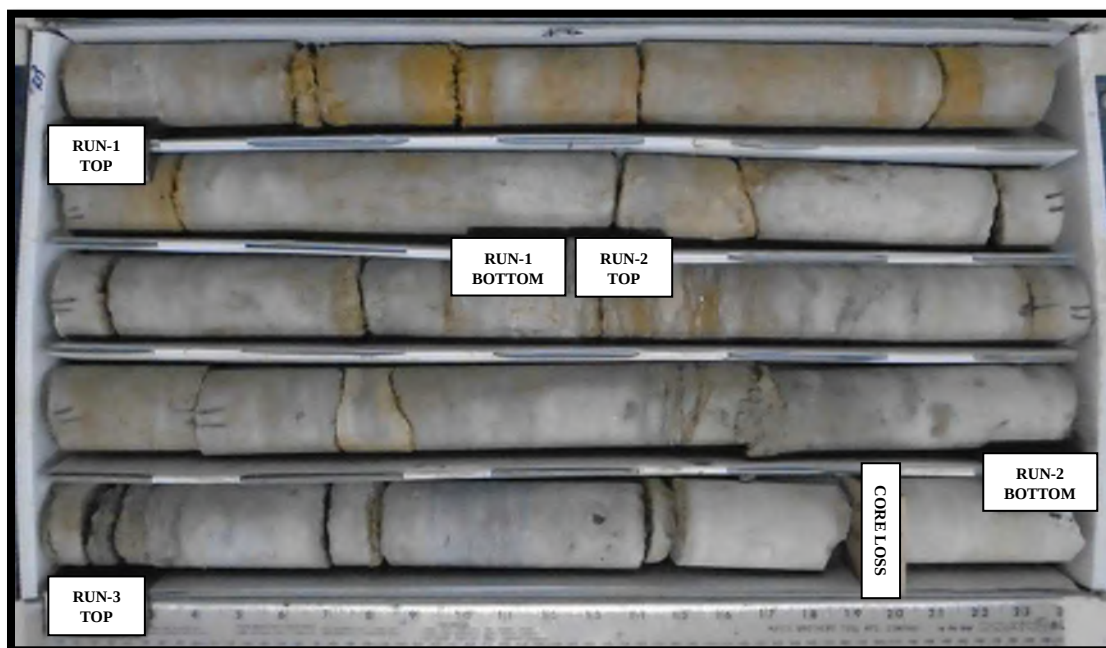
B-14, Box 2 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	41.0-46.0	100	75
4	46.0-51.0	100	83



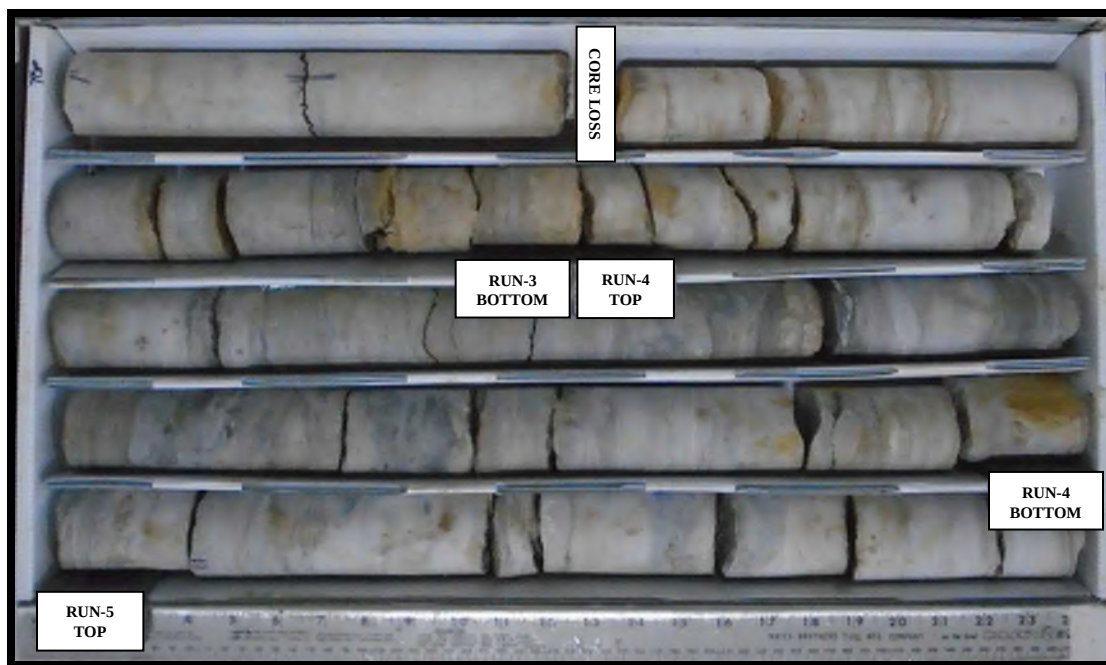
B-14, Box 3 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
5	51.0-56.0	100	92



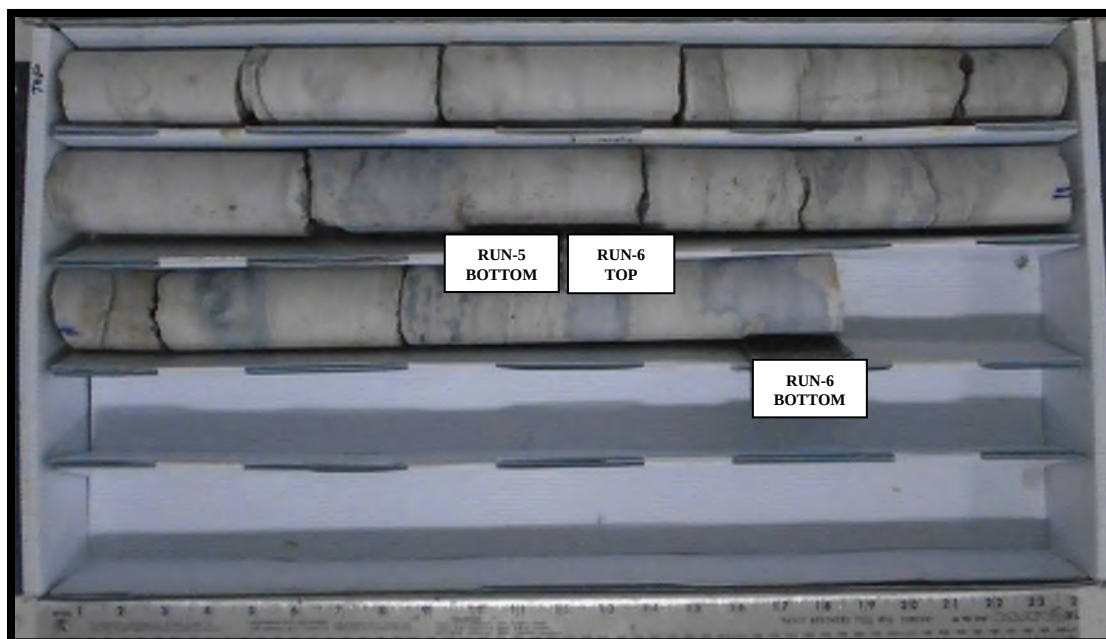
B-15, Box 1 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	26.5-29.5	100	90
2	29.5-34.5	100	92
3	34.5-Cont.	98	65



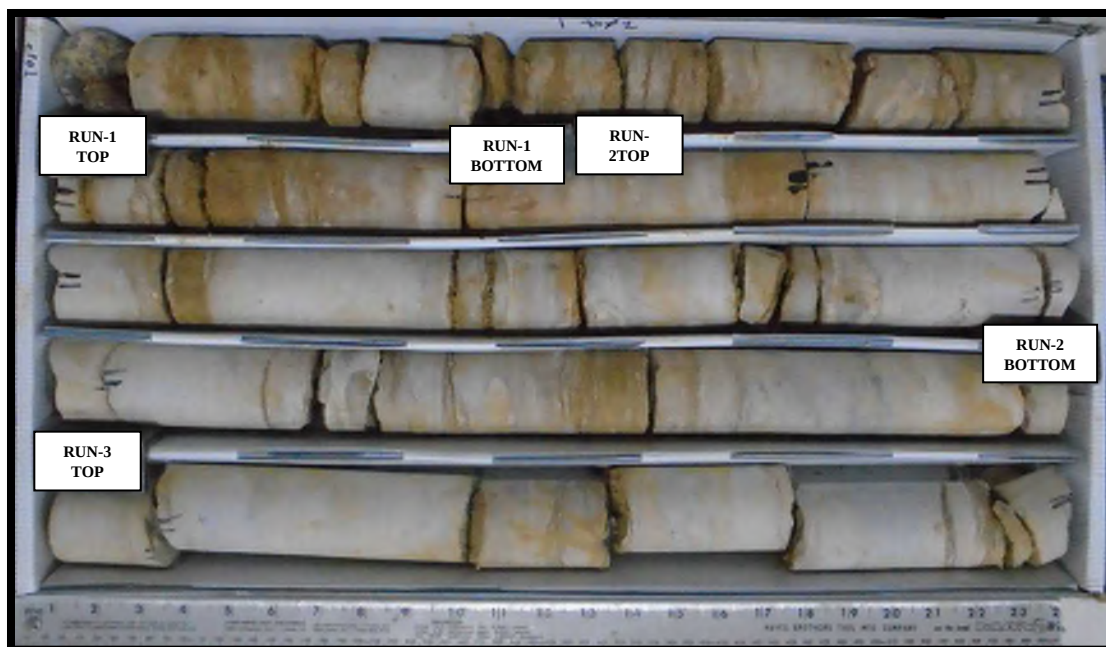
B-15, Box 2 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	Cont.-39.5	98	65
4	39.5-44.5	100	78
5	44.5-Cont.	100	93



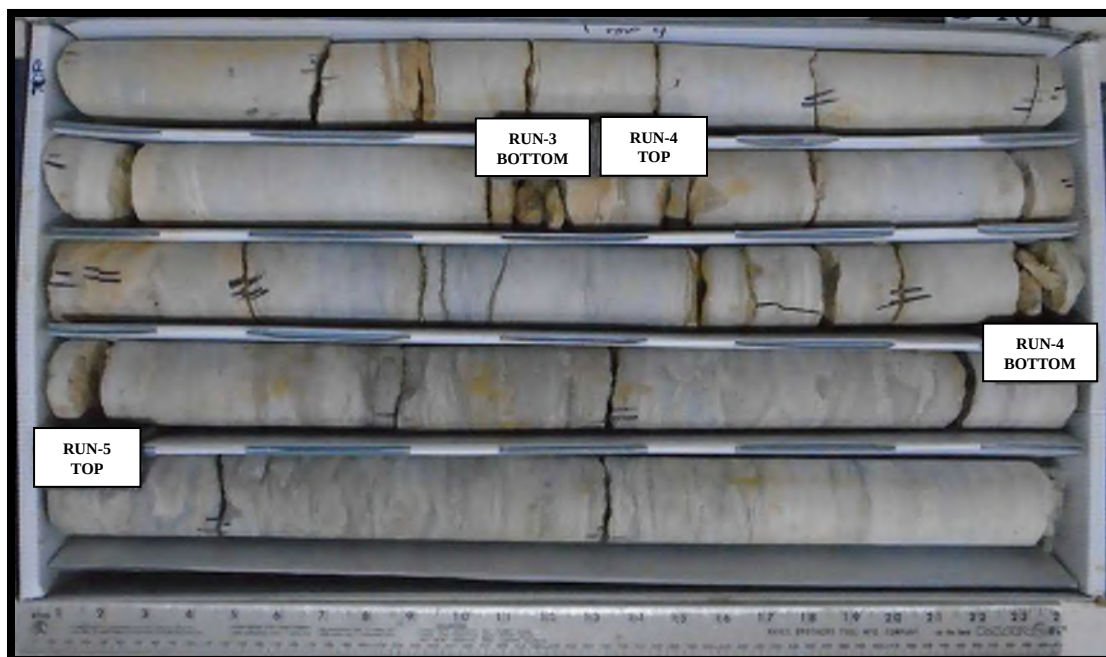
B-15, Box 3 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
5	Cont.-49.5	100	93
6	49.5-52	100	100



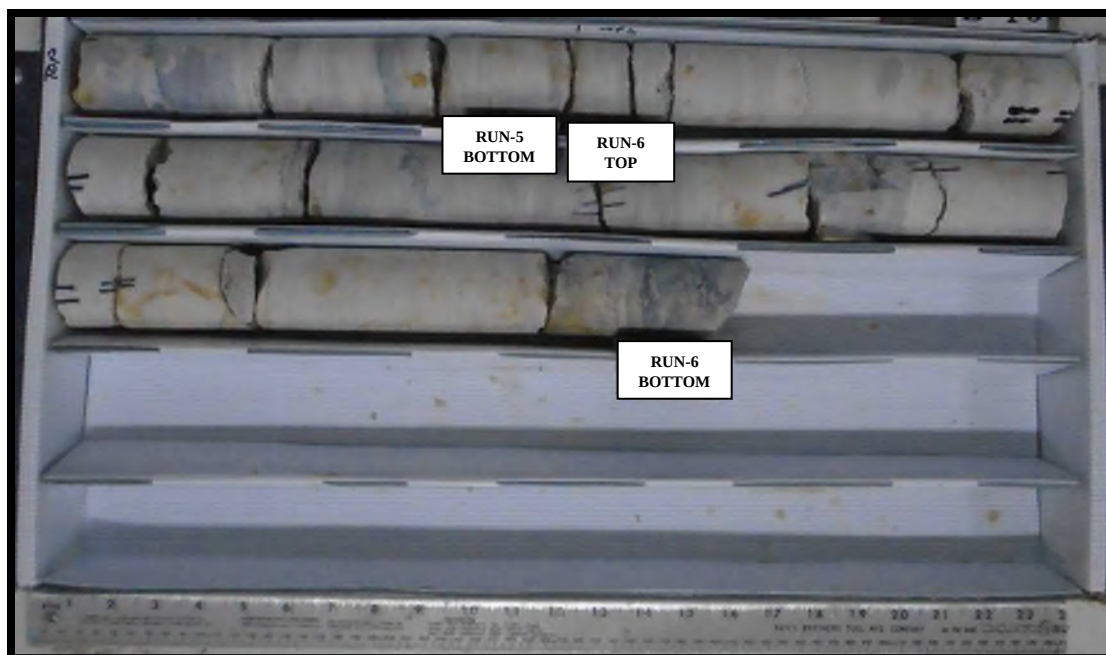
B-16, Box 1 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	19.0-20.0	100	33
2	20.0-25.0	100	70
3	25.0-Cont.	100	82



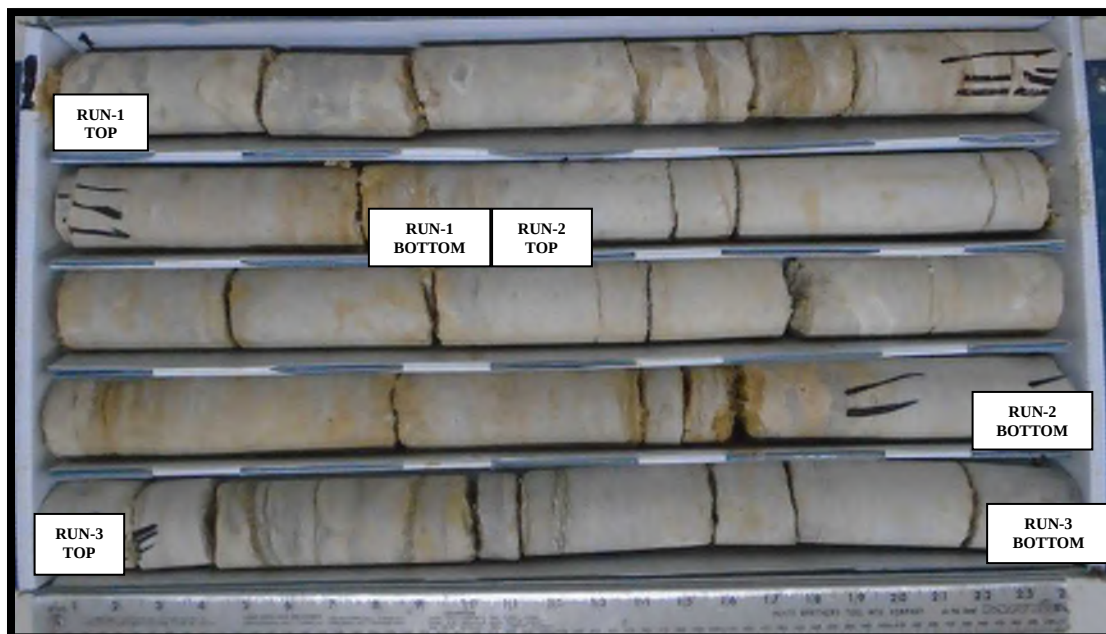
B-16, Box 2 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	Cont.-30.0	100	82
4	30.0-35.0	100	82
5	35.0-Cont.	100	47



B-16, Box 3 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
5	Cont.-40.0	100	47
6	40.0-44.0	100	94



B-22, Box 1 of 1

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	31.0-34.0	100	75
2	34.0-39.0	100	95
3	39.0-41.0	100	75



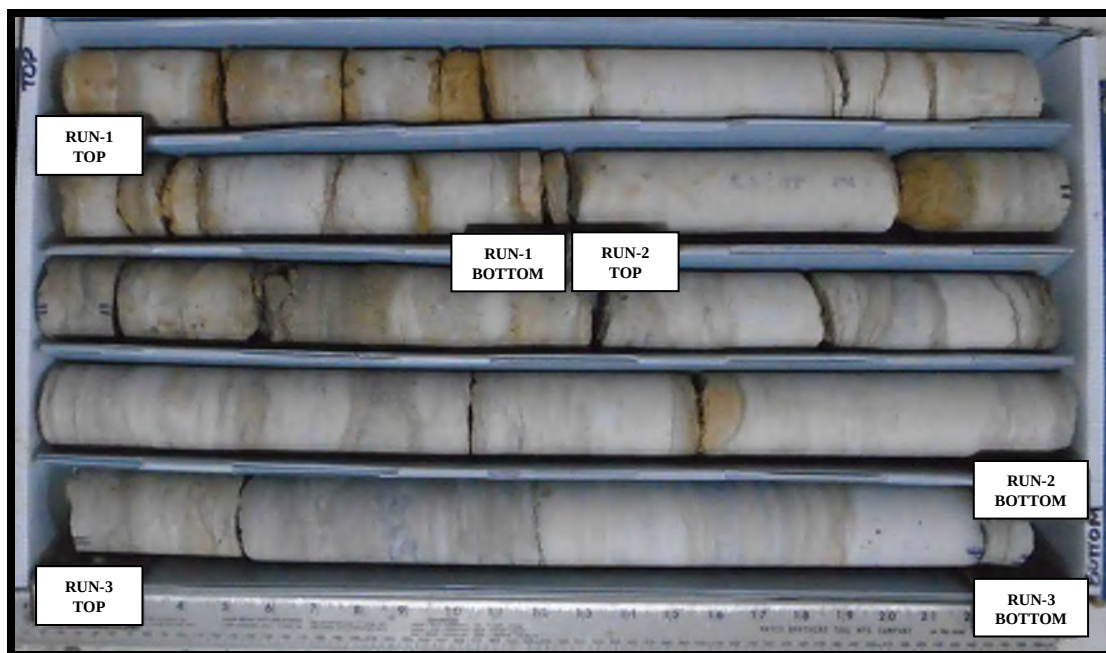
B-23, Box 1 of 2

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	16.0-20.0	100	92
2	20.0-25.0	100	70
3	25.0-Cont.	100	85



B-23, Box 2 of 2

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	Cont.-30.0	100	85



B-25, Box 1 of 1

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	12.0-15.0	100	61
2	15.0-20.0	100	92
3	20.0-22.0	100	100



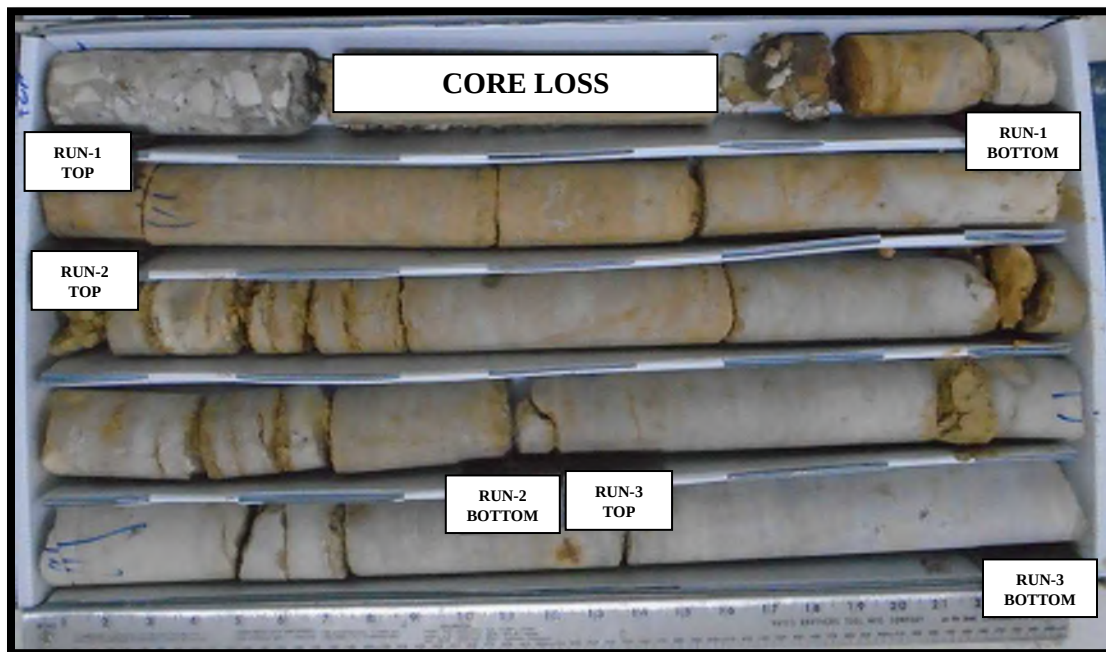
B-26, Box 1 of 1

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	22.0-25.0	100	14
2	25.0-30.0	100	80
3	30.0-32.0	100	79



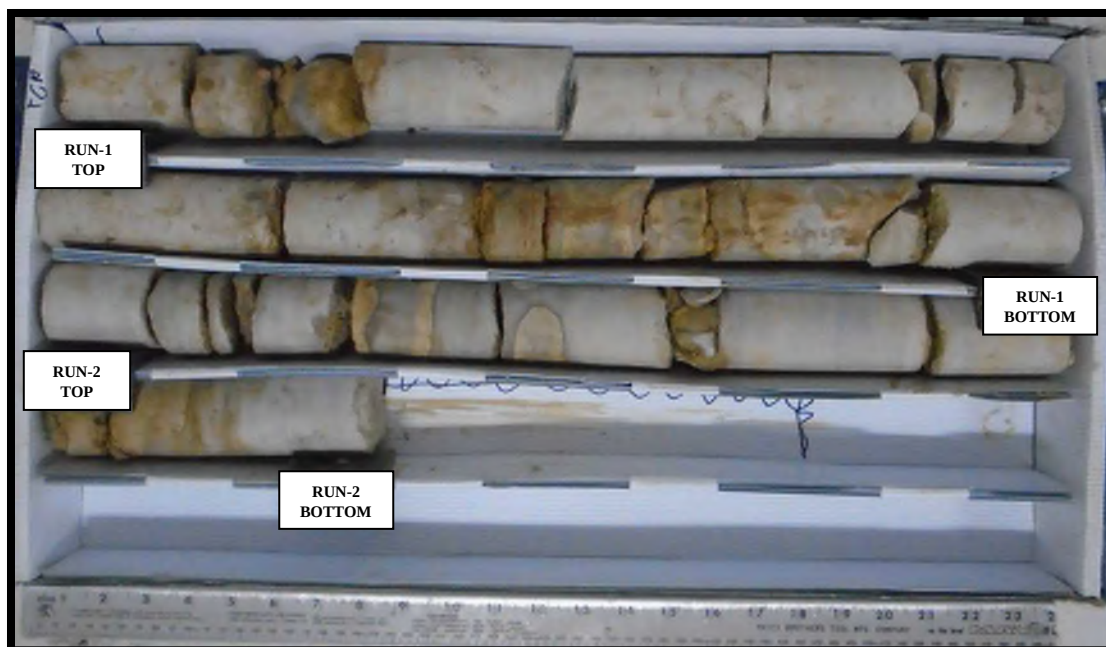
B-27, Box 1 of 1

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	10.0-15.0	94	32
2	15.0-20.0	100	100



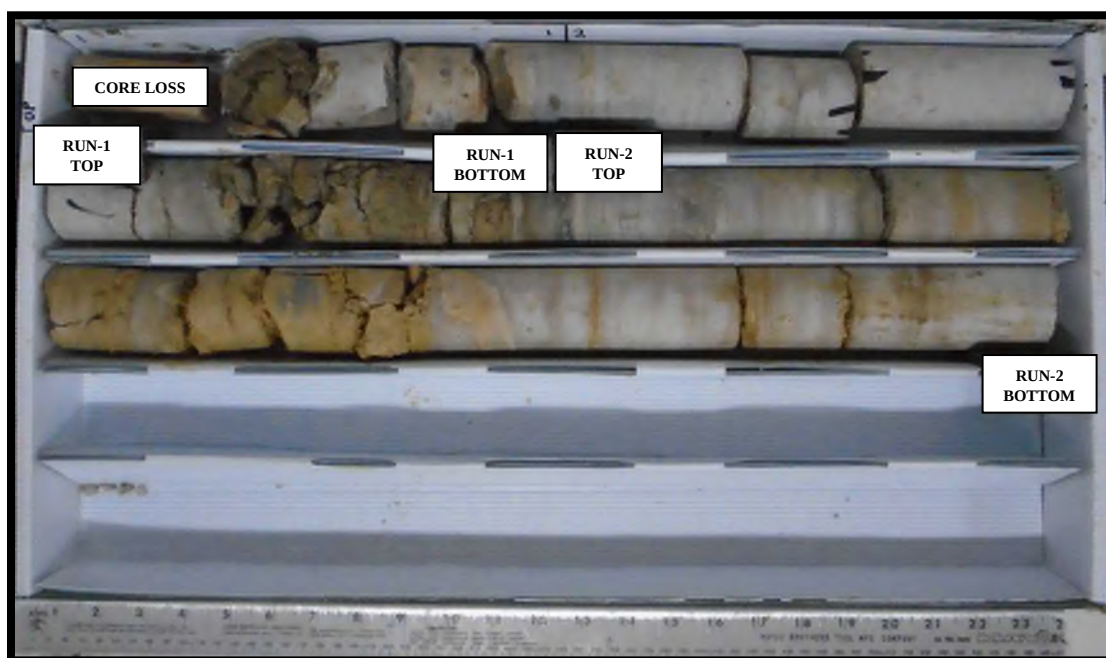
B-62, Box 1 of 1

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	3.0-5.0	50	25
2	5.0-10.0	100	70
3	10.0-13.0	100	89



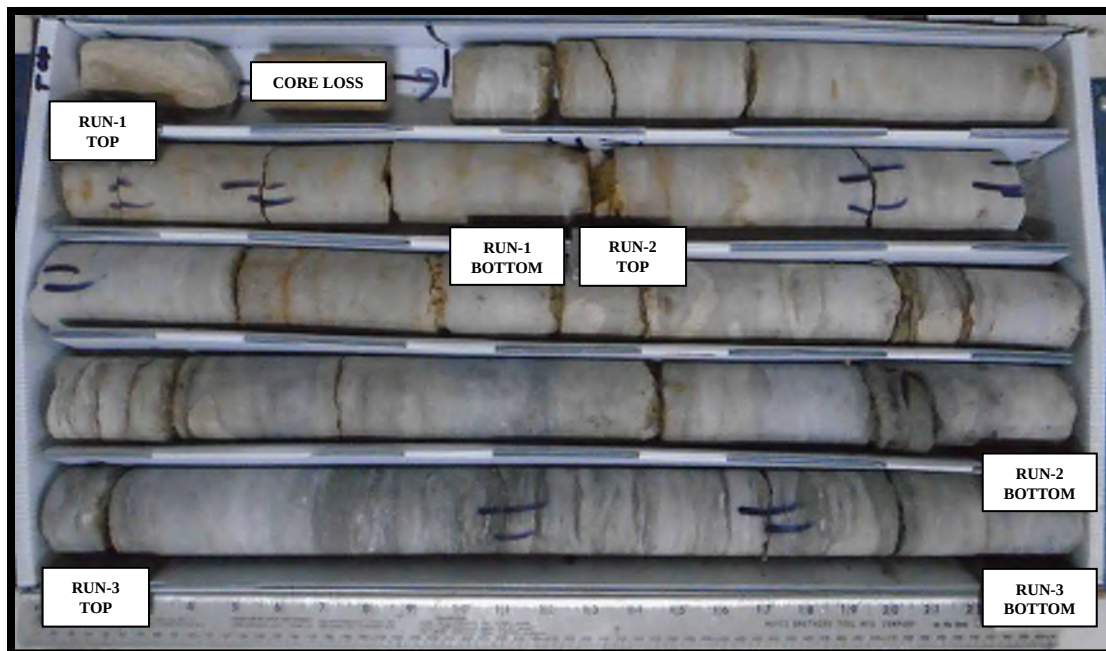
B-70, Box 1 of 1

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	6.0-10.0	100	50
2	10.0-12.8	100	23



B-78, Box 1 of 1

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	9.0-10.0	50	0
2	10.0-15.0	100	78



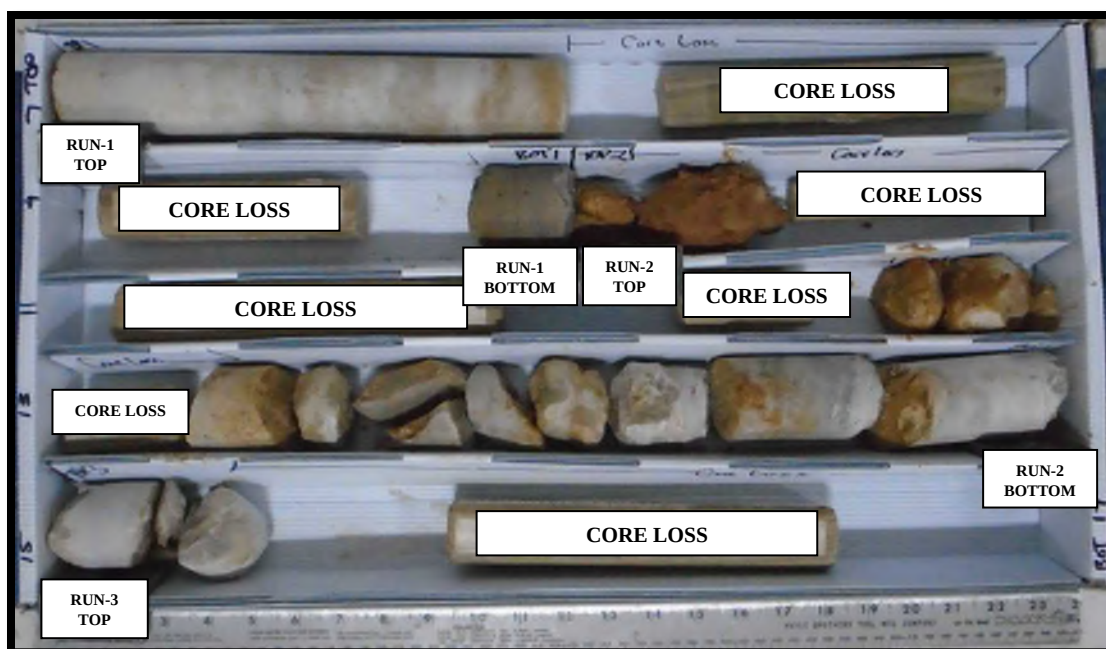
B-86, Box 1 of 1

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	3.0-6.0	72	55
2	6.0-11.0	100	82
3	11.0-13.0	100	100



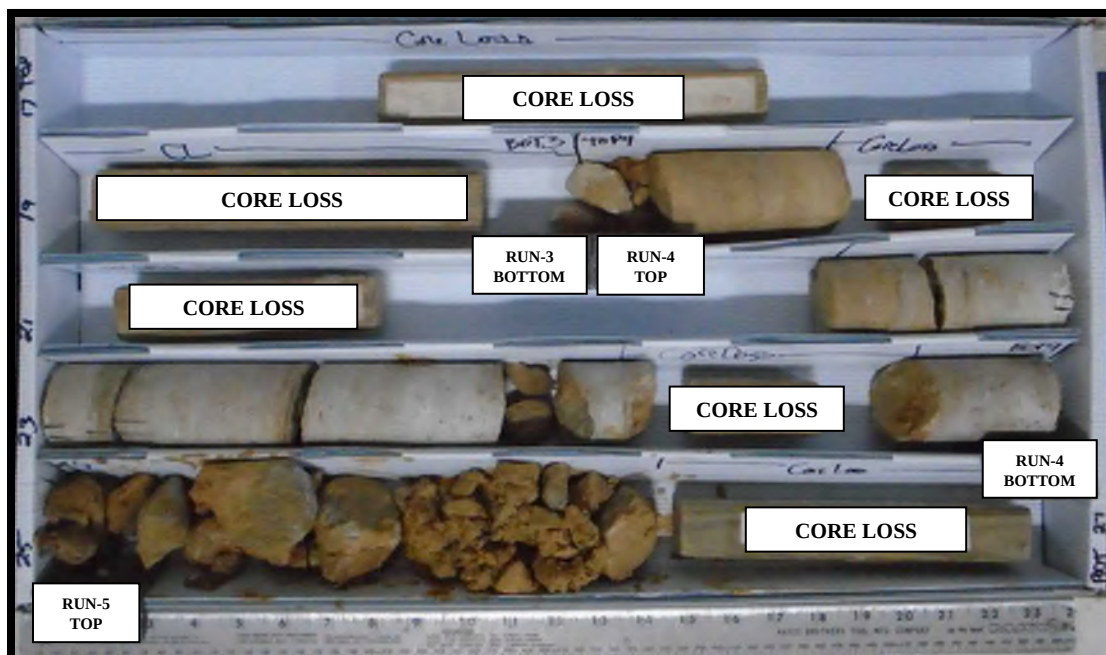
B-94, Box 1 of 1

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	9.0-10.0	100	0
2	10.0-15.0	77	40



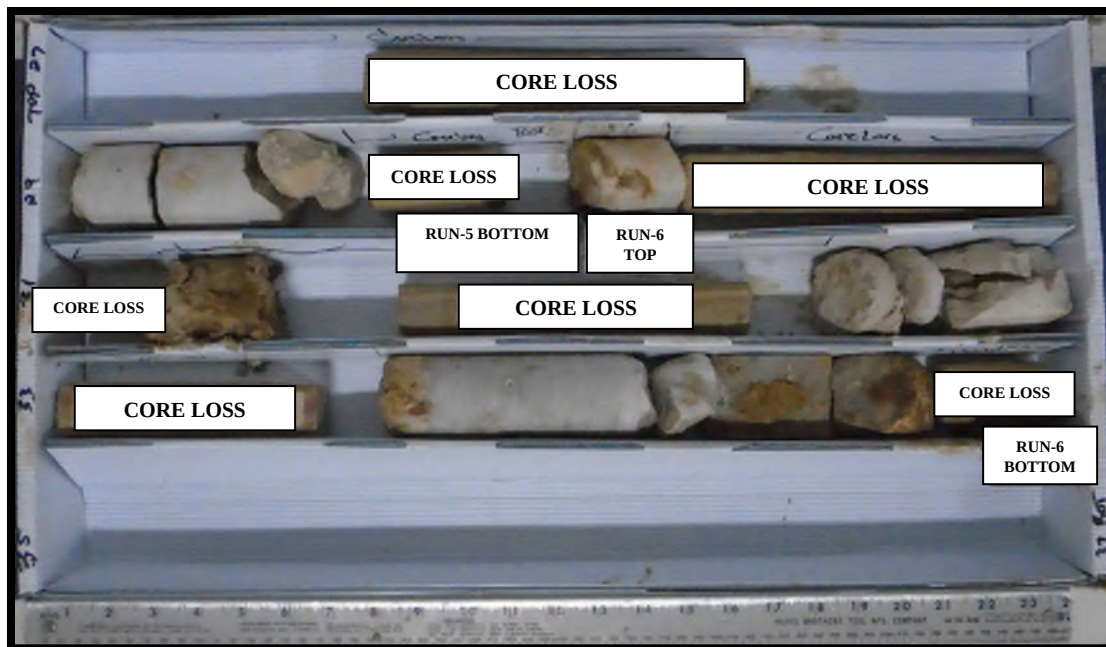
B-101, Box 1 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	7.0-10.0	39	33
2	10.0-15.0	40	7
3	15.0-Cont.	7	0



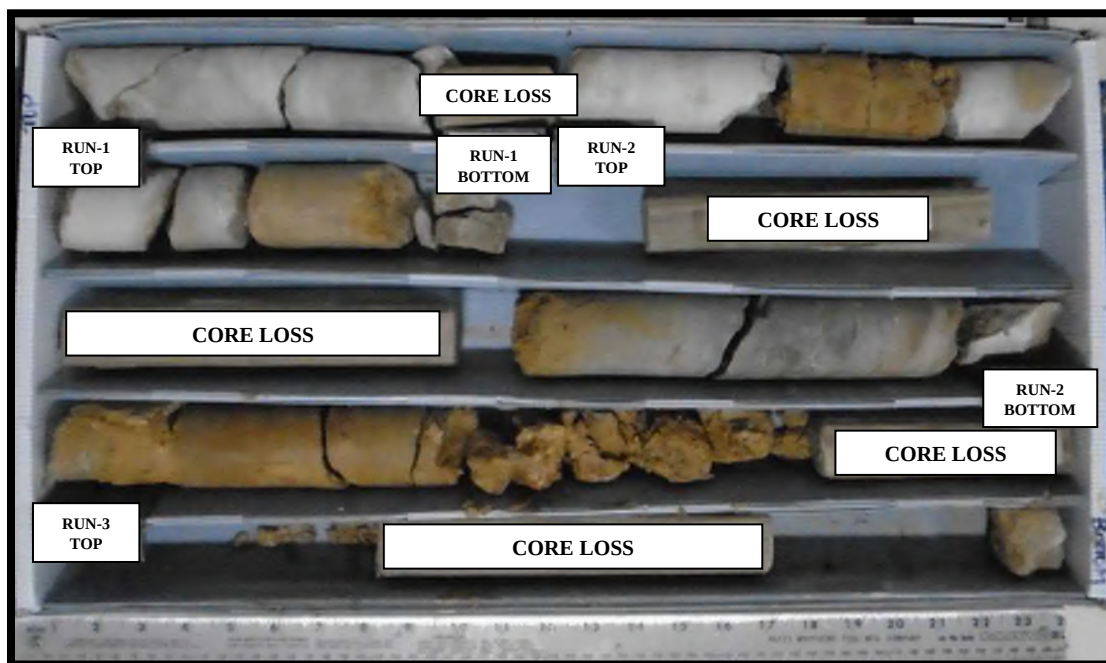
B-101, Box 2 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	Cont.-20.0	7	0
4	20.0-25.0	47	35
5	25.0-Cont.	33	0



B-101, Box 3 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
5	Cont.-30.0	33	0
6	30.0-35.0	35	10



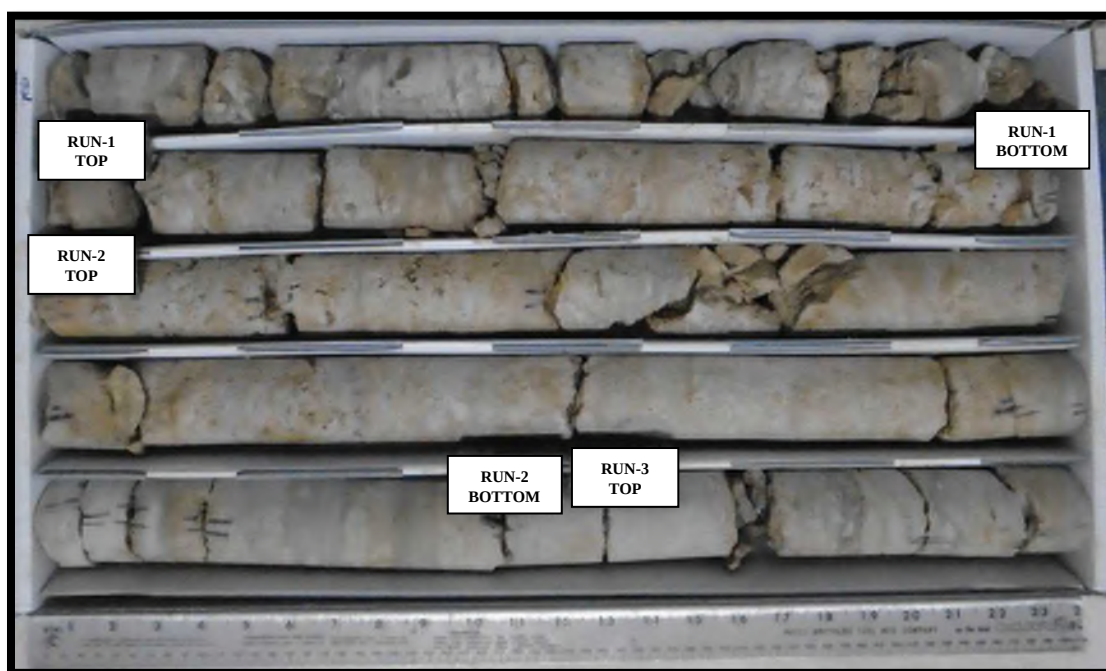
B-102, Box 1 of 2

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	10.0-11.0	75	0
2	11.0-16.0	55	23
3	16.0-Cont.	69	21



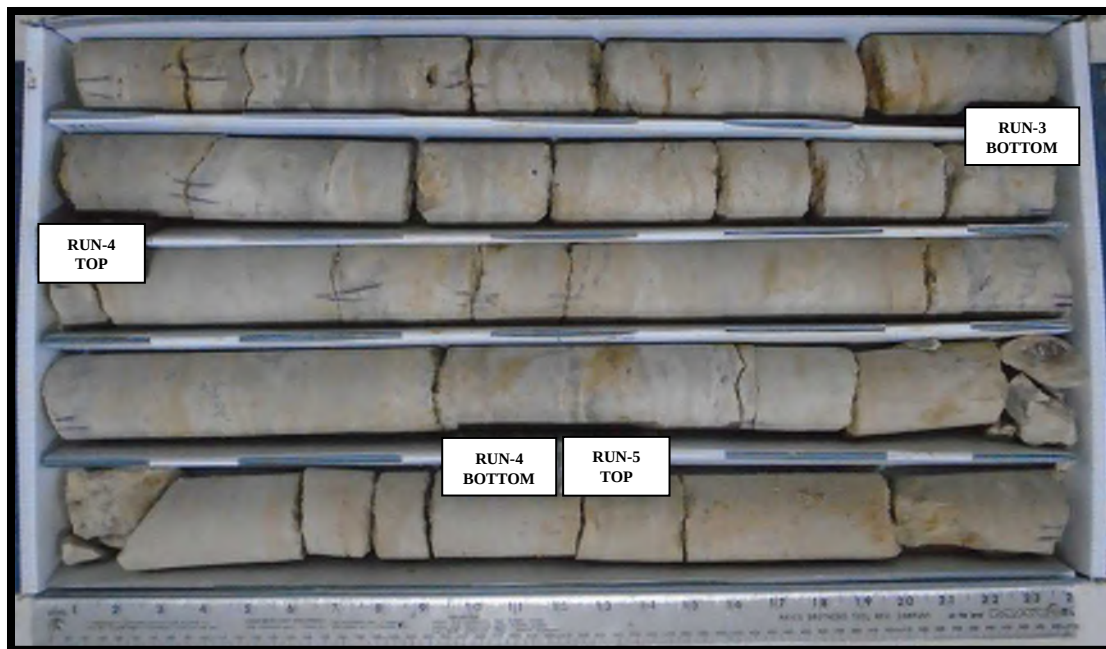
B-102, Box 2 of 2

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	Cont.-21.0	69	21



B-201, Box 1 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	3.5-5.5	100	0
2	5.5-10.5	100	95
3	10.5-Cont.	100	92



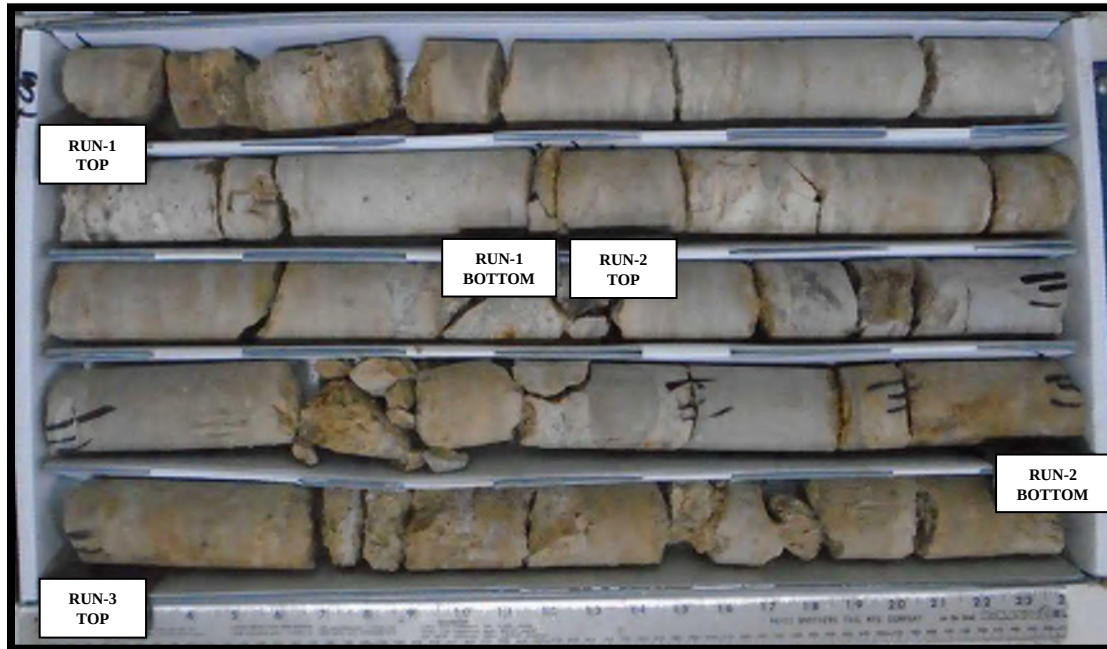
B-201, Box 2 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	Cont.-15.5	100	92
4	15.5-20.5	100	77
5	20.5-Cont.	100	92



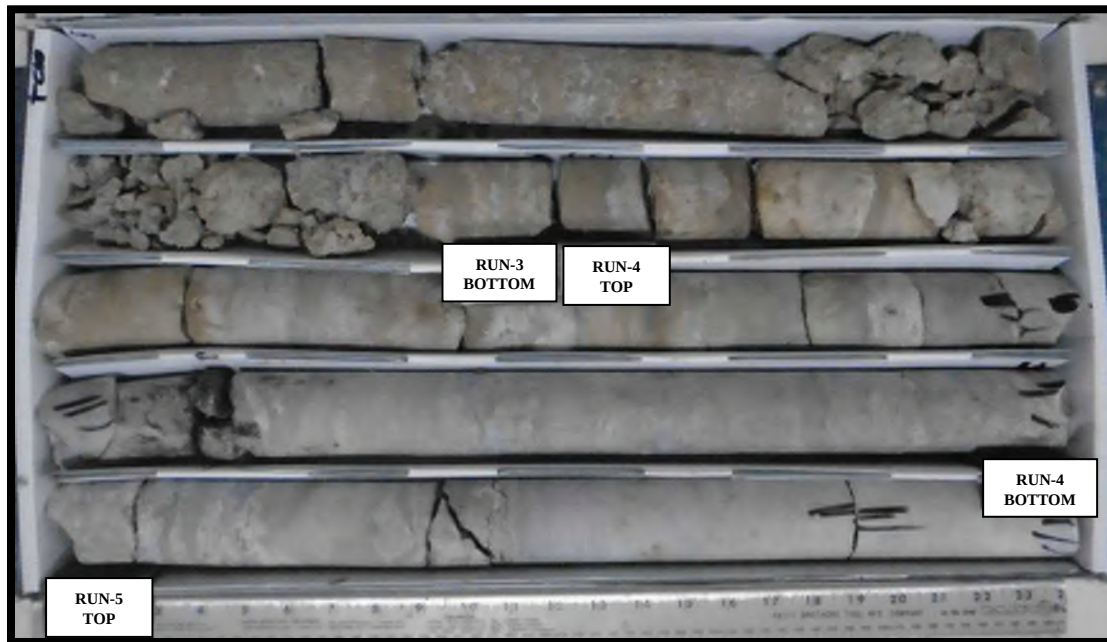
B-201, Box 3 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
5	Cont.-25.5	100	92
6	25.5-29.0	100	79



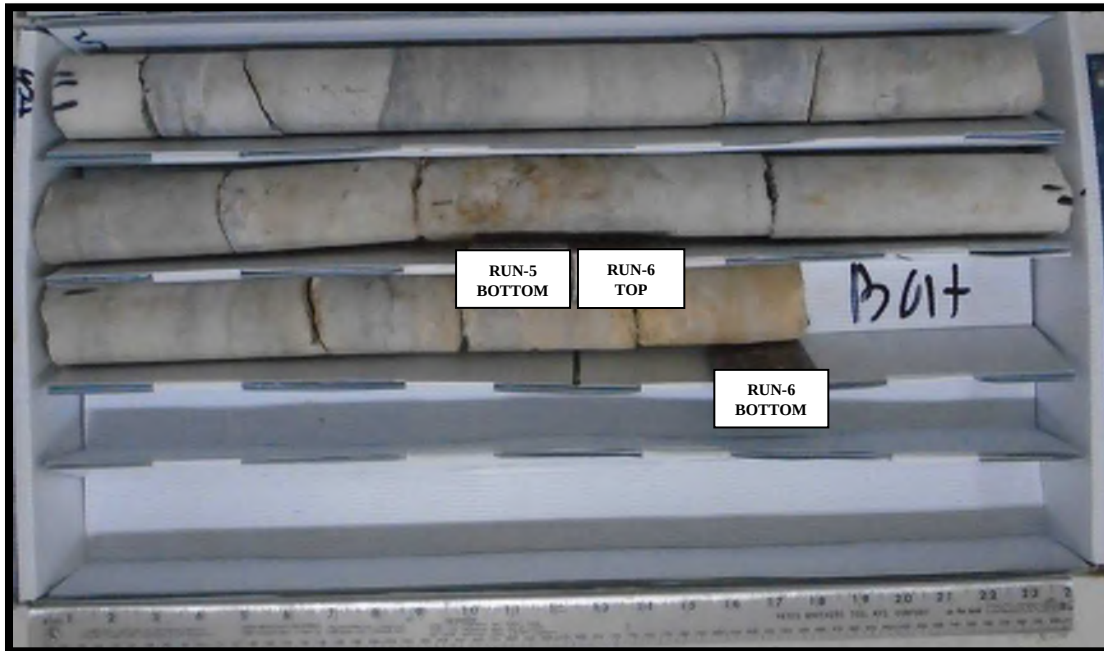
B-202, Box 1 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	12.0-15.0	100	52
2	15.0-20.0	100	63
3	20.0-Cont.	100	33



B-202, Box 2 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	Cont.-25.0	100	33
4	25.0-30.0	100	80
5	30.0-Cont.	100	100



B-202, Box 3 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
5	Cont.-35.0	100	100
6	35.0-37.0	100	100



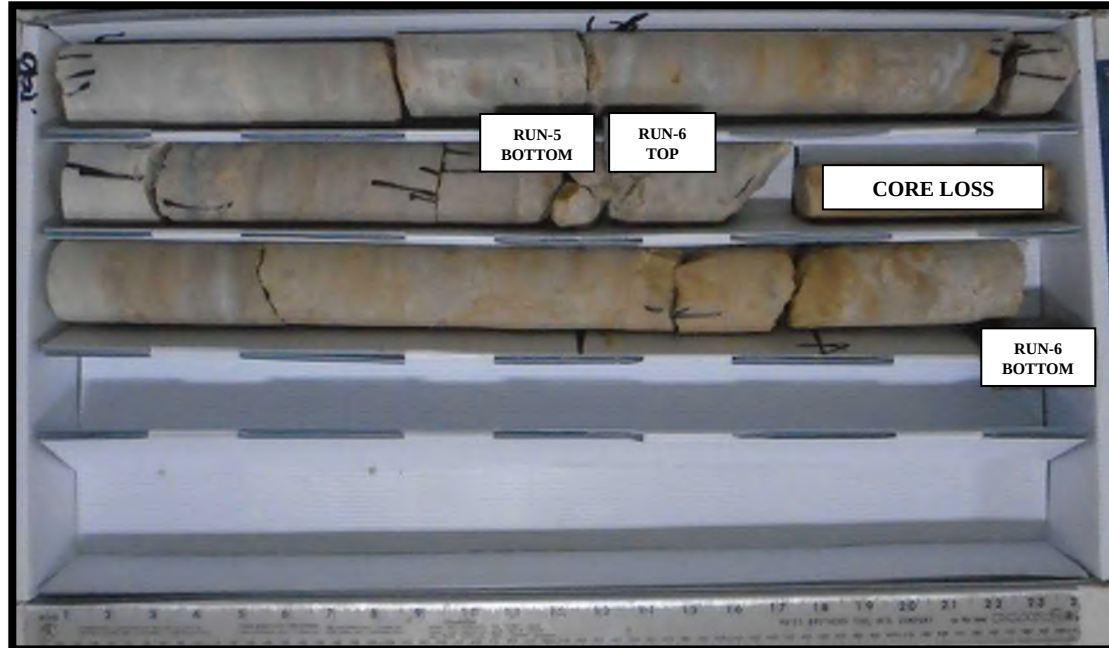
B-301, Box 1 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	3.0-4.0	0	0
2	4.0-9.0	78	33
3	9.0-Cont.	100	95



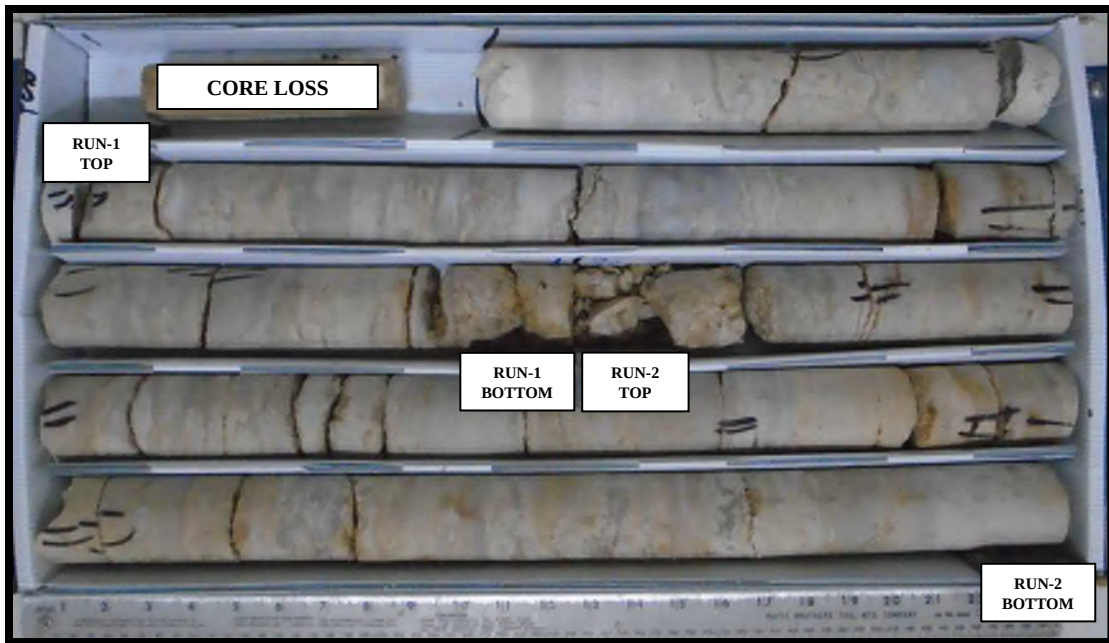
B-301, Box 2 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	Cont.-14.0	100	95
4	14.0-19.0	100	100
5	19.0-Cont.	100	100



B-301, Box 3 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
5	Cont.-24.0	100	100
6	24.0-29.0	87	73



B-302, Box 1 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	5.0-10.0	83	78
2	10.0-15.0	100	82



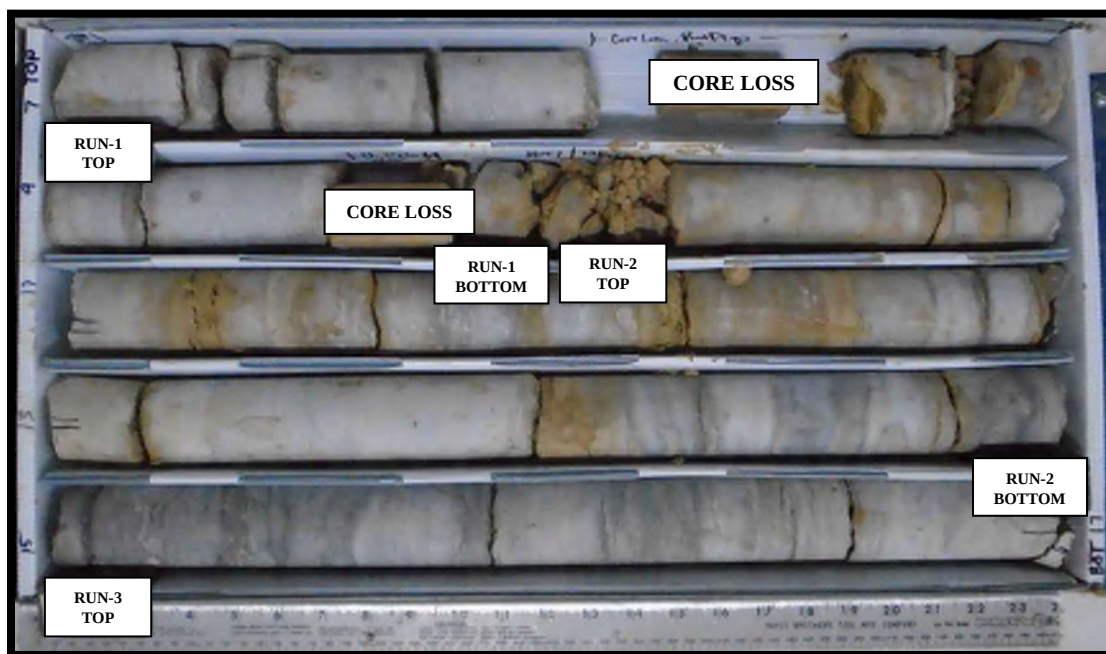
B-302, Box 2 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	15.0-20.0	100	90
4	20.0-25.0	100	90



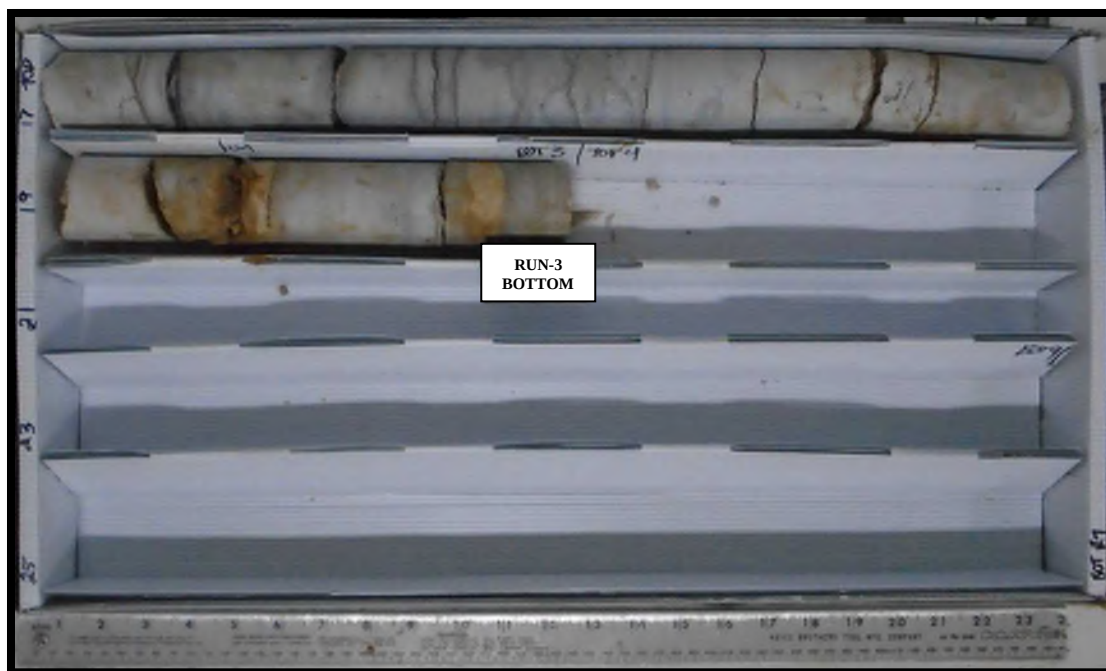
B-302, Box 3 of 3

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
5	25.0-30.0	100	95



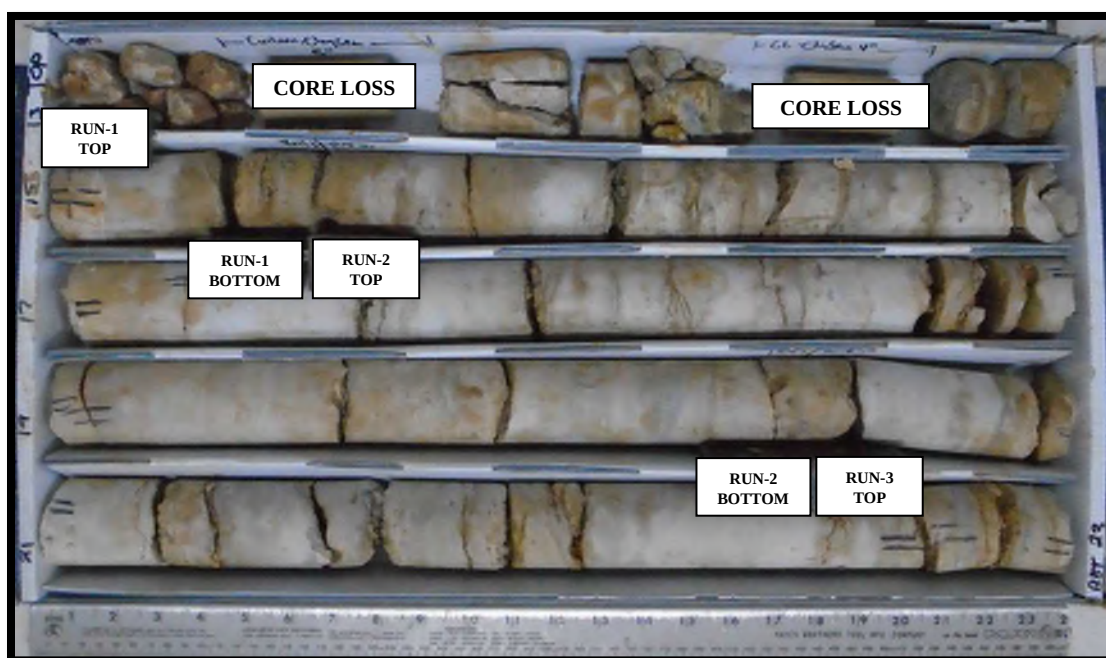
B-401, Box 1 of 2

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	7.0-10.0	78	22
2	10.0-15.0	100	89
3	15.0-Cont.	99	85



B-401, Box 2 of 2

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	Cont.-20.0	99	85



B-402, Box 1 of 2

<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
1	13.0-15.5	70	17
2	15.5-20.5	100	74
3	20.5- Cont.	100	78



<u>B-402, Box 2 of 2</u>			
<u>RUN</u>	<u>DEPTH, FT</u>	<u>RECOVERY, %</u>	<u>RQD, %</u>
3	Cont.-25.5	100	78



APPENDIX G – PAVEMENT CORE PHOTOGRAPHS



B-9



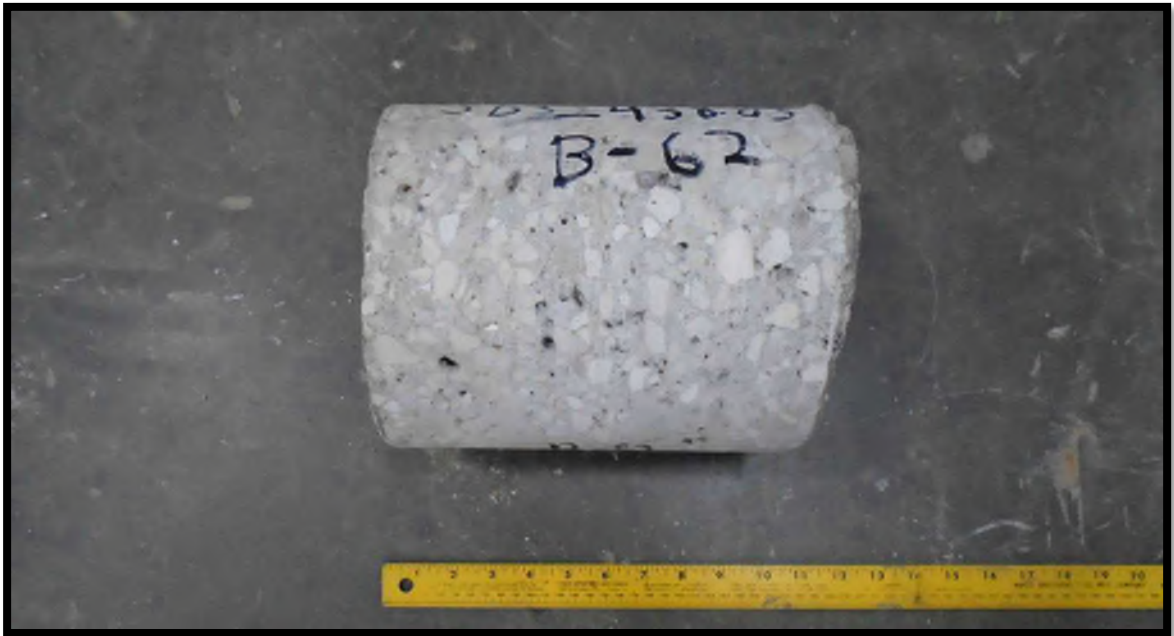
B-10



B-11



B-25



B-62



B-70



B-78



B-86



B-94



B-101



B-102



B-201



B-202



B-302



B-401



B-402



APPENDIX H – TEST PIT PHOTOGRAPHS



Test Pit TP-1



Test Pit TP-1 Spoils



Test Pit TP-2



Test Pit TP-2 Spoils



Test Pit TP-3



Test Pit TP-3 Spoils



APPENDIX I – LABORATORY TEST DATA

Unconsolidated Undrained Triaxial Compression

Consolidated Undrained Triaxial Compression

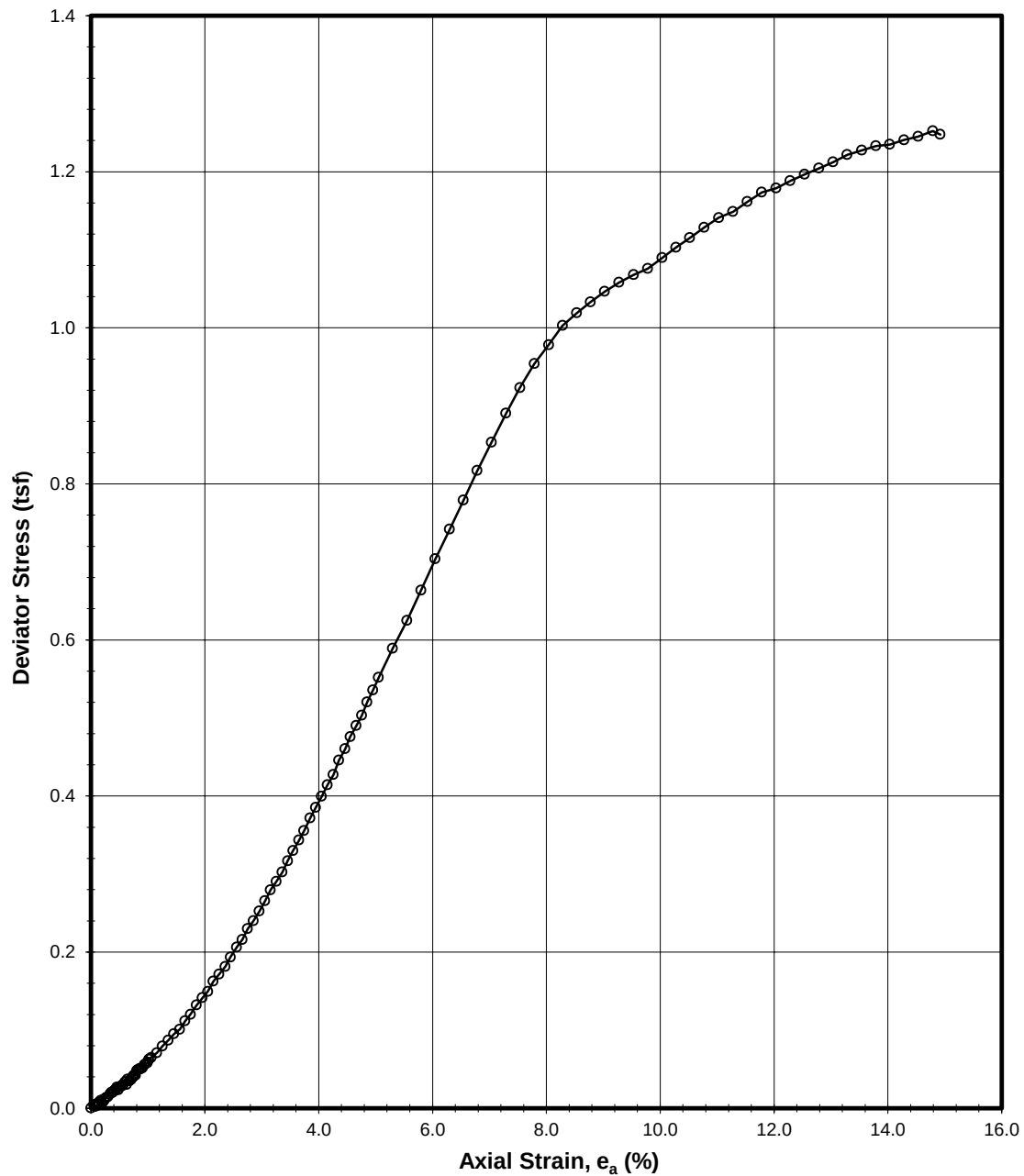
Direct Shear Test

Grain Size Distributions

One-Dimensional Consolidation

Standard Proctor Compaction

Stress Strain Curve



SAMPLE INFORMATION

Boring: B-9 Sample: ST4 Depth: 8-10 feet

SAMPLE DATA

Moisture Content (%): 28.8
 Dry Unit Weight (pcf): 94.8

RESULTS

Undrained Shear Strength (tsf): 0.63
 Failure Strain (%): 14.8
 e_{50} : 0.06

Tested By: AT	Calc'd By: EG	Check'd By: AT
Date: 6/11/2021	Date: 6/25/2021	Date: 6/28/2021

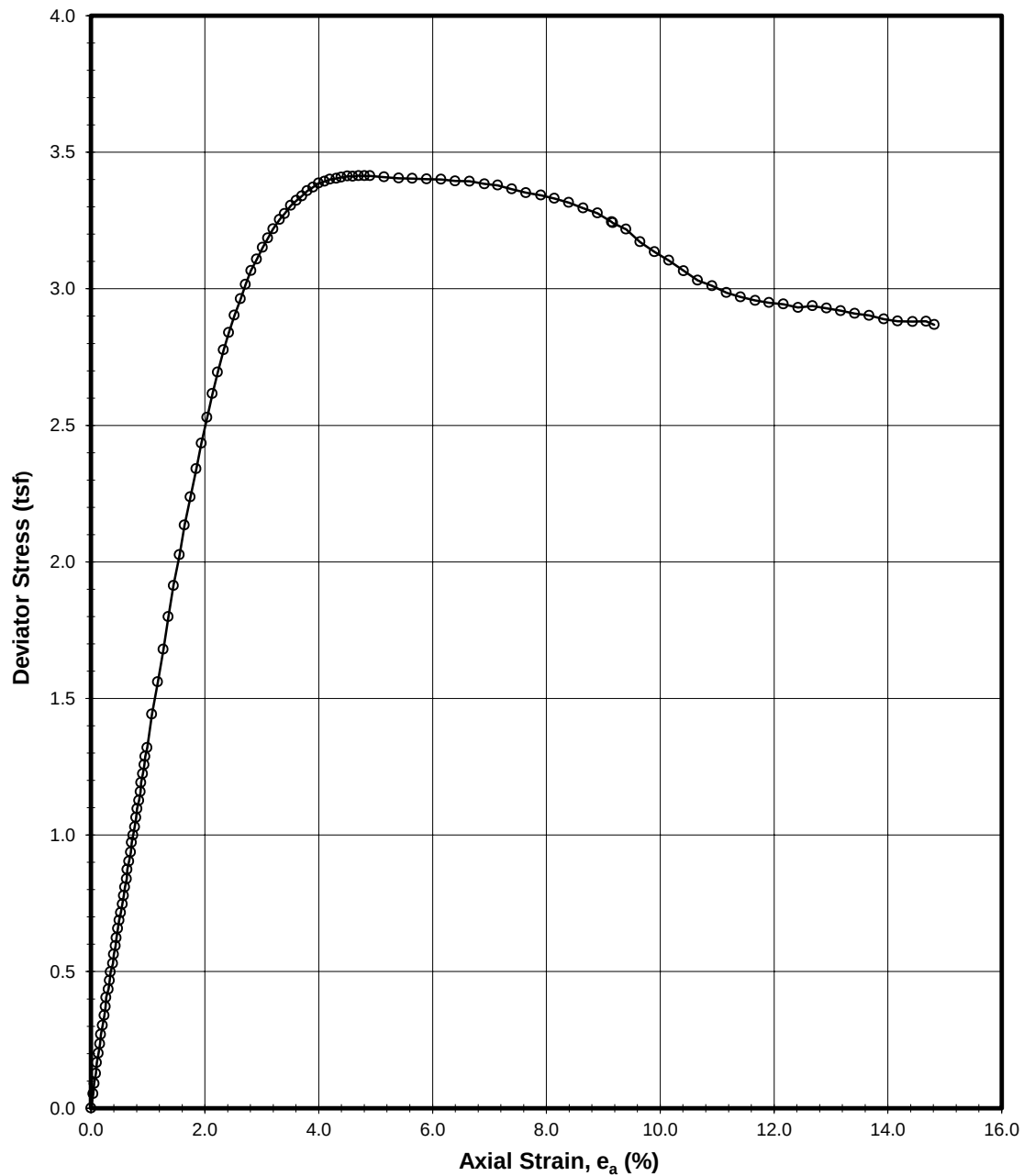


**I-70 Corridor Improvements
 MoDOT Project J6I0624
 Wentzville, Missouri**

**UNCONSOLIDATED-UNDRAINED TRIAXIAL
 COMPRESSION TEST ASTM D2850**

Project Number: J032438.03

Stress Strain Curve



SAMPLE INFORMATION

Boring: B-13 Sample: ST3 Depth: 6-8 feet

SAMPLE DATA

Moisture Content (%): 16.1
 Dry Unit Weight (pcf): 113.9

RESULTS

Undrained Shear Strength (tsf): 1.71
 Failure Strain (%): 4.7
 e_{50} : 0.01

Tested By: AT	Calc'd By: EG	Check'd By: AT
Date: 7/27/2021	Date: 7/29/2021	Date: 7/29/2021

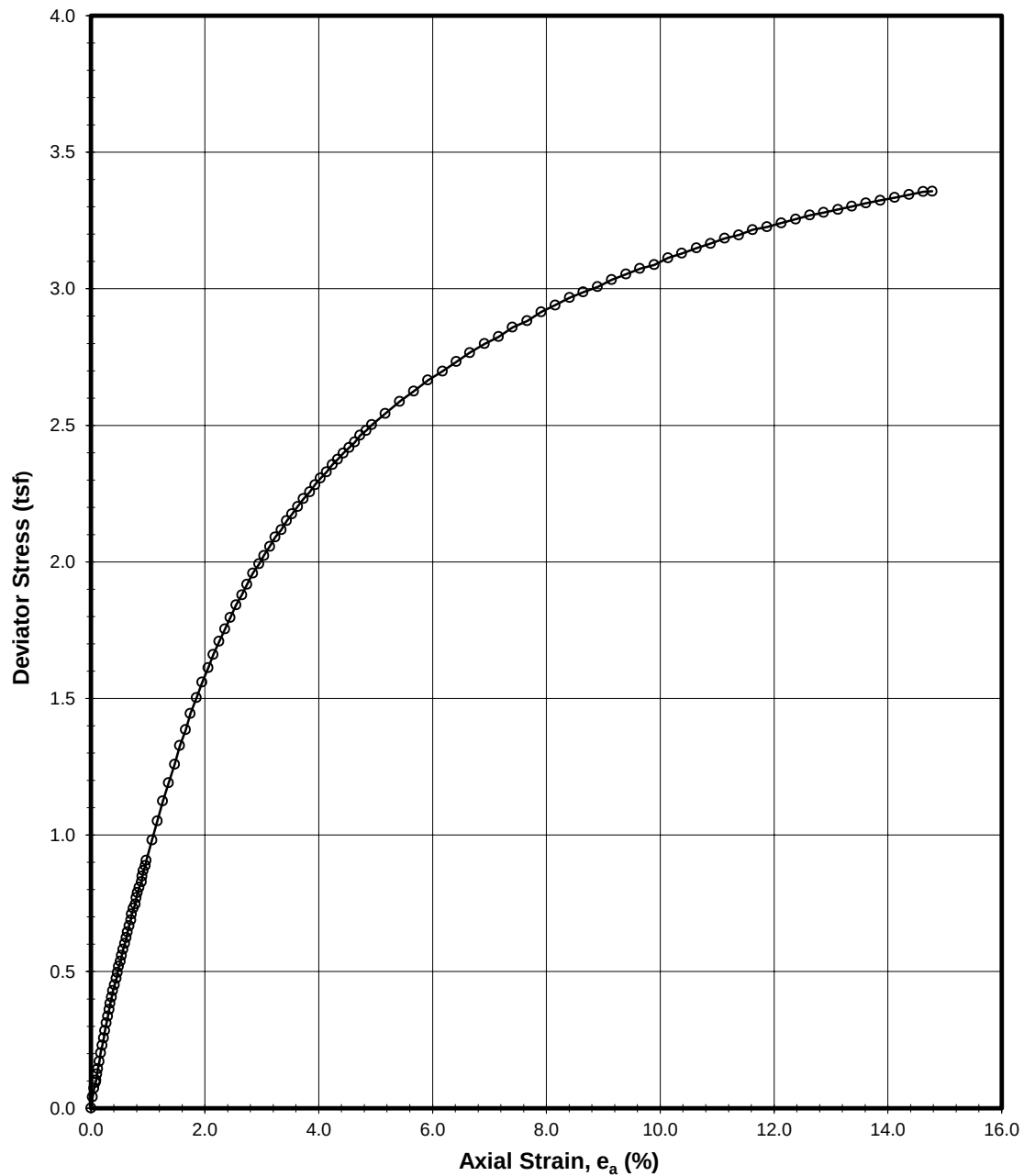


**I-70 Corridor Improvements
 MoDOT Project J6I0624
 Wentzville, Missouri**

**UNCONSOLIDATED-UNDRAINED TRIAXIAL
 COMPRESSION TEST ASTM D2850**

Project Number: J032438.03

Stress Strain Curve



SAMPLE INFORMATION

Boring: B-15 Sample: ST4 Depth: 8-10 feet

SAMPLE DATA

Moisture Content (%): 16.4

Dry Unit Weight (pcf): 115.0

RESULTS

Undrained Shear Strength (tsf): 1.68

Failure Strain (%): 14.8

e_{50} : 0.02

Tested By: AT	Calc'd By: EG	Check'd By: AT
Date: 6/15/2021	Date: 6/25/2021	Date: 6/28/2021



I-70 Corridor Improvements

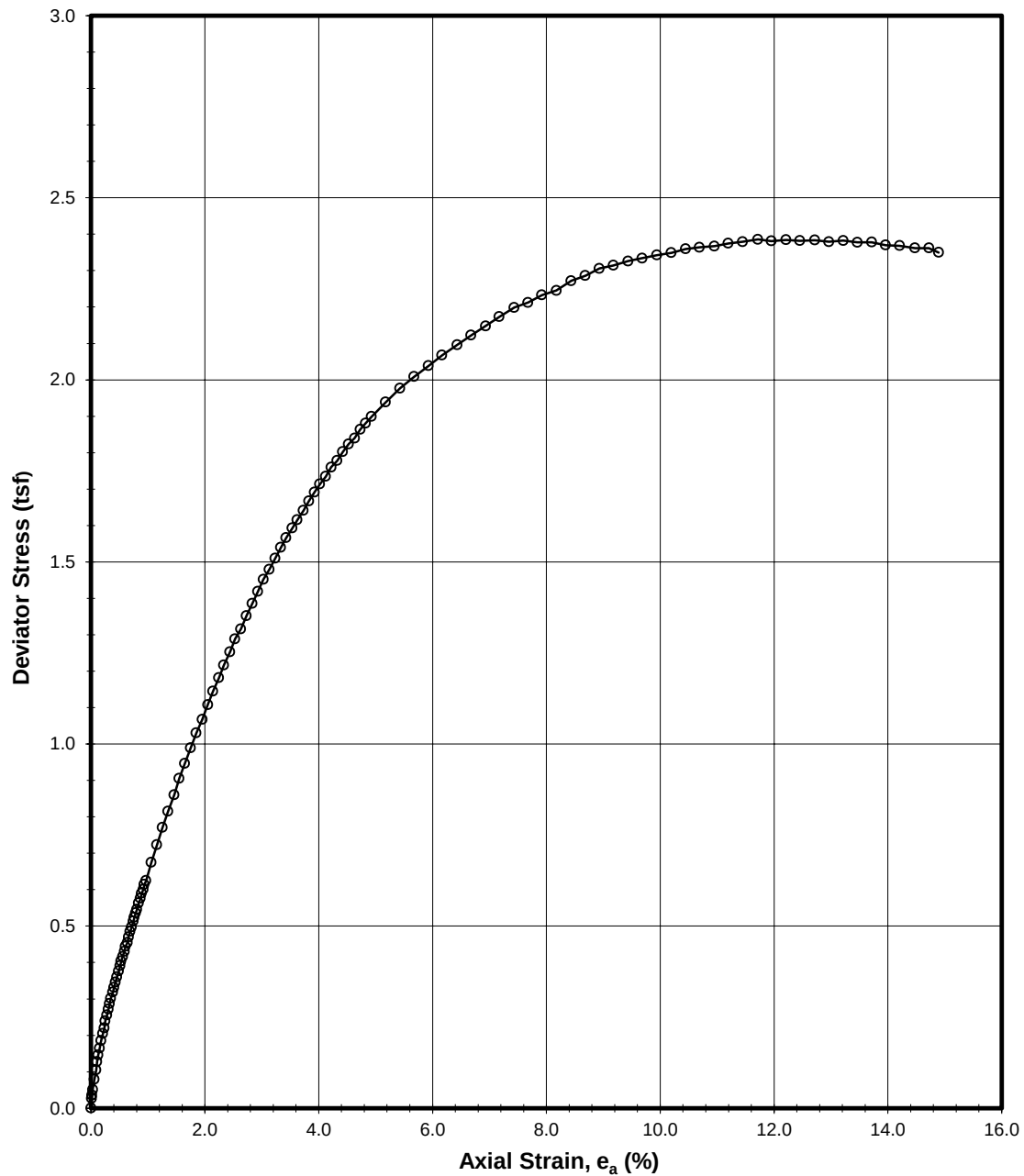
MoDOT Project J6I0624

Wentzville, Missouri

**UNCONSOLIDATED-UNDRAINED TRIAXIAL
COMPRESSION TEST ASTM D2850**

Project Number: J032438.03

Stress Strain Curve



SAMPLE INFORMATION

Boring: B-23 Sample: ST3 Depth: 6-8 feet

SAMPLE DATA

Moisture Content (%): 17.3
 Dry Unit Weight (pcf): 109.5

RESULTS

Undrained Shear Strength (tsf): 1.19
 Failure Strain (%): 2.4
 e_{50} : 0.02

Tested By: AT	Calc'd By: EG	Check'd By: AT
Date: 6/15/2021	Date: 6/25/2021	Date: 6/28/2021

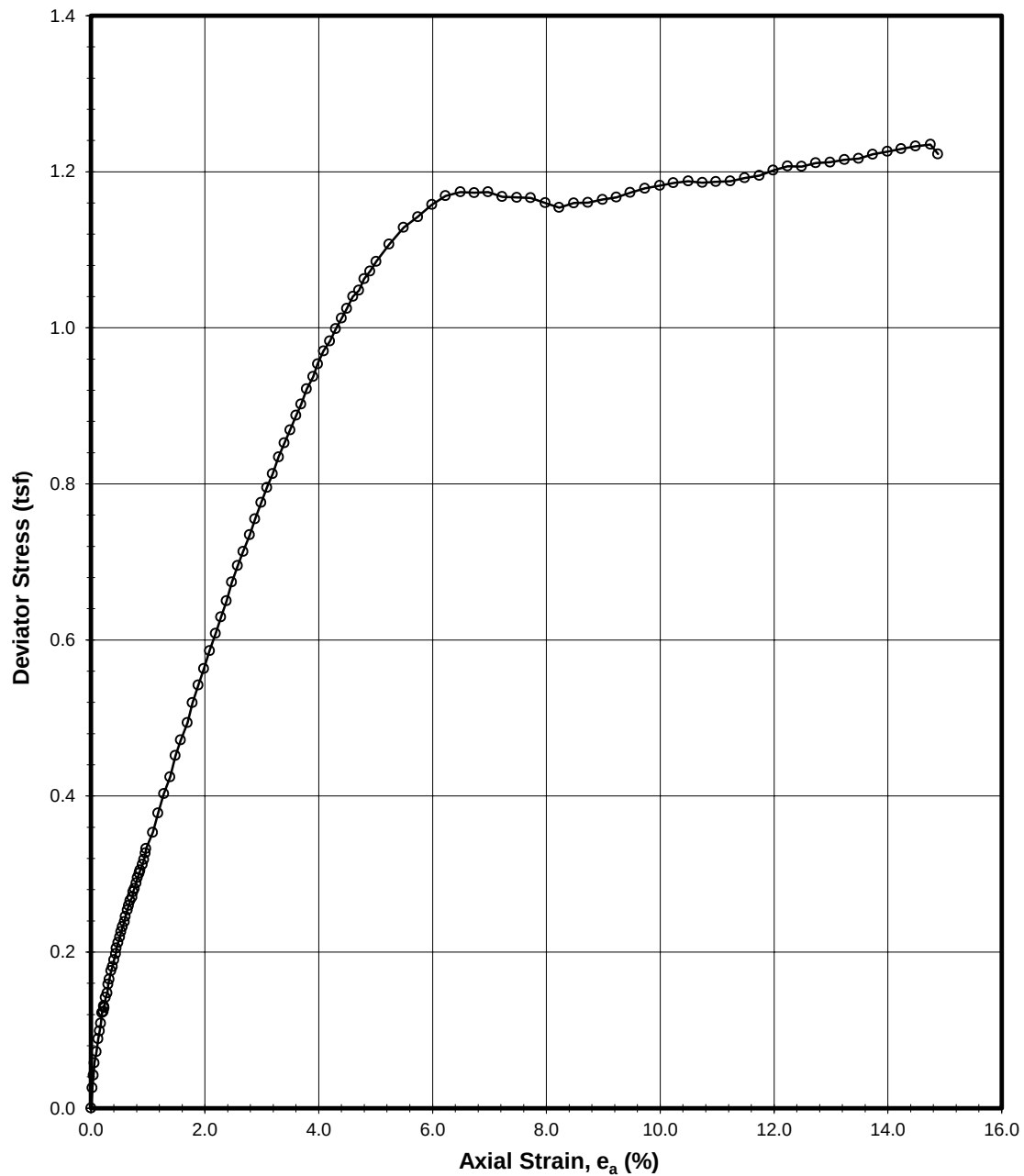


**I-70 Corridor Improvements
 MoDOT Project J6I0624
 Wentzville, Missouri**

**UNCONSOLIDATED-UNDRAINED TRIAXIAL
 COMPRESSION TEST ASTM D2850**

Project Number: J032438.03

Stress Strain Curve



SAMPLE INFORMATION

Boring: B-78 Sample: ST2 Depth: 3-5 feet

SAMPLE DATA

Moisture Content (%): 24.7
 Dry Unit Weight (pcf): 96.6

RESULTS

Undrained Shear Strength (tsf): 0.62
 Failure Strain (%): 14.8
 e_{50} : 0.02

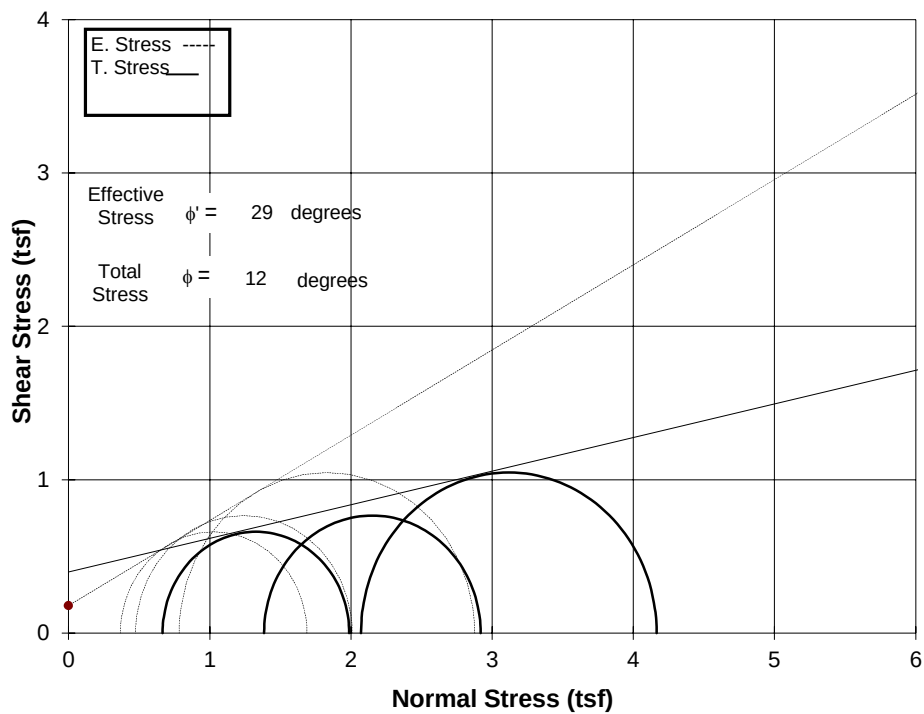
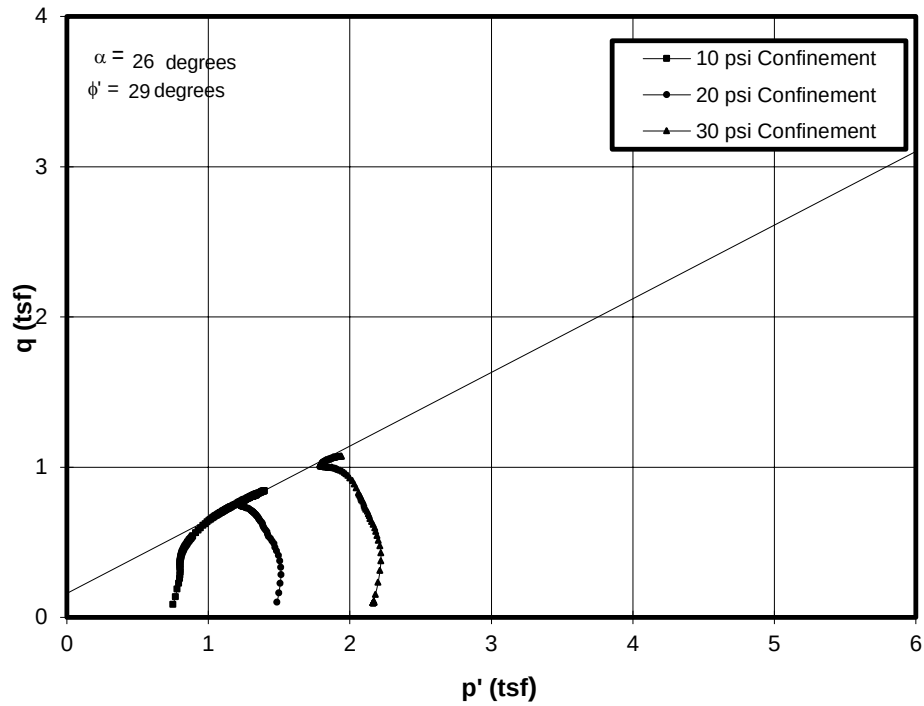
Tested By: AT	Calc'd By: EG	Check'd By: AT
Date: 6/15/2021	Date: 6/25/2021	Date: 6/28/2021



**I-70 Corridor Improvements
 MoDOT Project J6I0624
 Wentzville, Missouri**

**UNCONSOLIDATED-UNDRAINED TRIAXIAL
 COMPRESSION TEST ASTM D2850**

Project Number: J032438.03



SAMPLE INFORMATION

Boring: B-19 Sample: ST5 Depth: 13 to 15 feet

SAMPLE DATA

Average Moisture Content (%): 24.5
 Average Dry Unit Weight (pcf): 98.5

RESULTS

Total Friction Angle (degrees): 12
 Effective Friction Angle (degrees): 29
 Effective Cohesion (tsf): 0.1

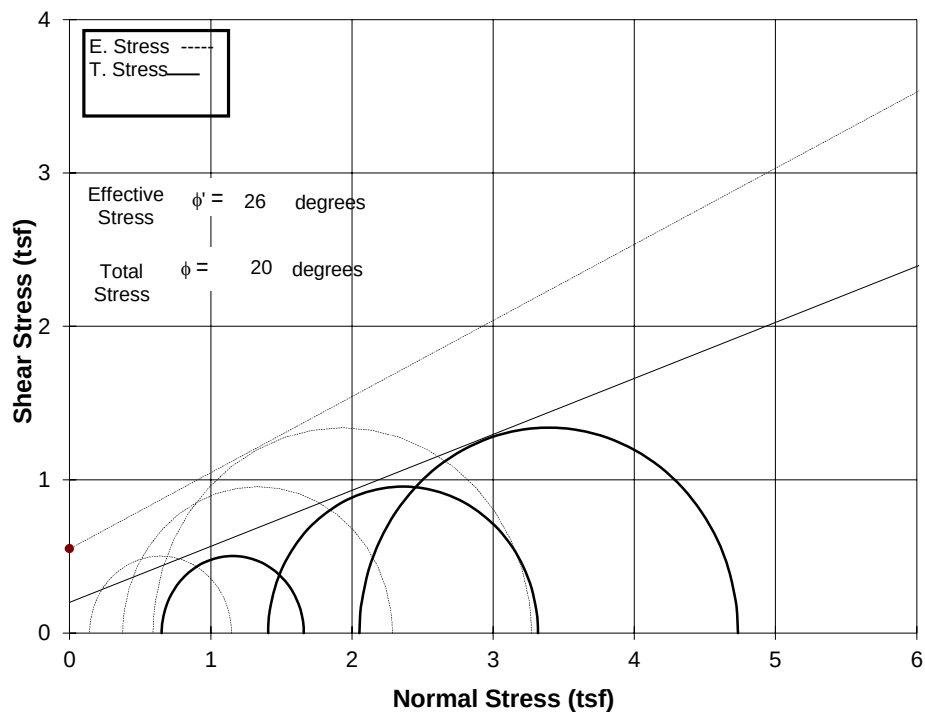
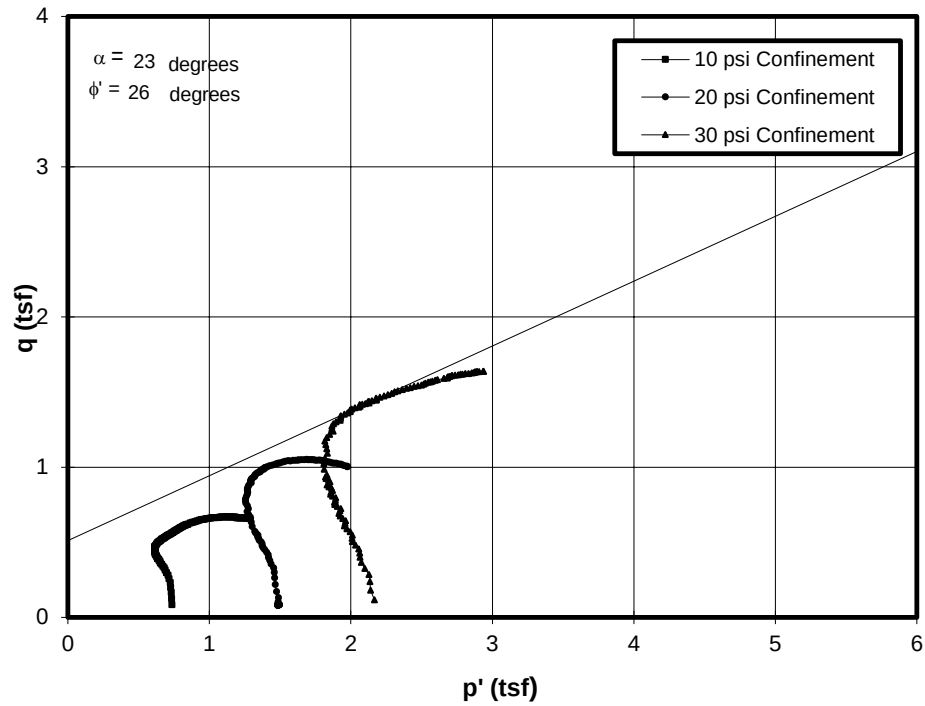
Tested By: AT	Calc'd By: EG	Check'd By: AT
Date: 7/15/2021	Date: 7/27/2021	Date: 7/27/2021



I-70 Corridor Improvements
MoDOT Project J6I0624
Wentzville, Missouri

CONSOLIDATED-UNDRAINED TRIAXIAL
COMPRESSION TEST ASTM D4767

Project Number: J032438.03



SAMPLE INFORMATION

Boring: B-20 Sample: ST4/5 Depth: 8 to 12 feet

SAMPLE DATA

Average Moisture Content (%): 21.6
 Average Dry Unit Weight (pcf): 105.1

RESULTS

Total Friction Angle (degrees): 20
 Effective Friction Angle (degrees): 26
 Effective Cohesion (tsf): 0.3

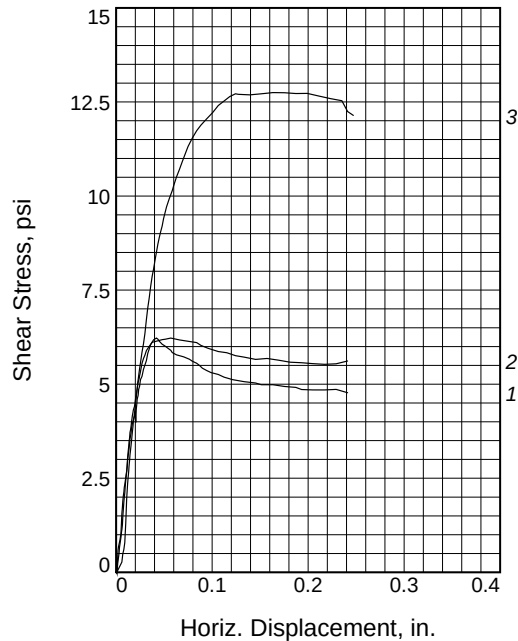
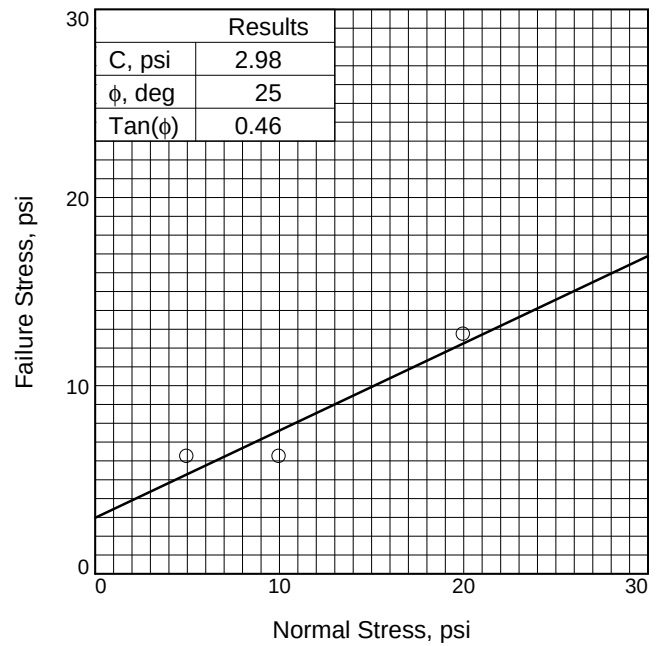
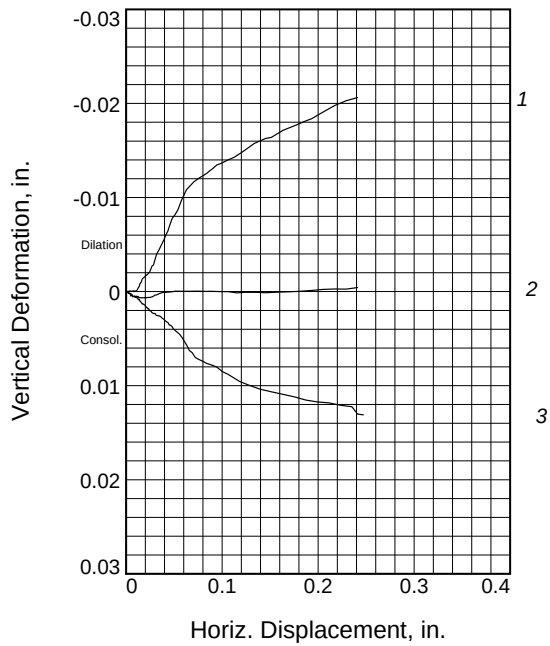
Tested By: AT	Calc'd By: EG	Check'd By: AT
Date: 7/15/2021	Date: 7/26/2021	Date: 7/26/2021



I-70 Corridor Improvements
MoDOT Project J6I0624
Wentzville, Missouri

CONSOLIDATED-UNDRAINED TRIAXIAL
COMPRESSION TEST ASTM D4767

Project Number: J032438.03



Sample No.		1	2	3
Initial	Water Content, %	18.4	18.4	18.4
	Dry Density, pcf	104.4	103.3	103.7
	Saturation, %	80.7	78.4	79.3
	Void Ratio	0.6139	0.6321	0.6249
	Diameter, in.	2.50	2.50	2.50
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	24.6	29.2	25.3
	Dry Density, pcf	107.0	107.1	108.2
	Void Ratio	0.5753	0.5745	0.5578
	Diameter, in.	2.50	2.50	2.50
	Height, in.	0.98	0.96	0.96
	Normal Stress, psi	5.00	10.00	20.00
Failure Stress, psi		6.23	6.22	12.72
Displacement, in.		0.04	0.06	0.12
Ultimate Stress, psi				
Displacement, in.				
Strain rate, %/min.		0.0040	0.0040	0.0040

Sample Type: Shelby Tube

Description: CLAY- olive-brown mottled olive-gray and brown, fat, trace rock - (CH)

LL= 66 **PL=** 15 **PI=** 51

Assumed Specific Gravity= 2.7

Remarks:

Figure _____

Client: HDR Engineering, Inc.

Project: MODOT I-70 Wentzville

Location: B-69

Sample Number: ST-1

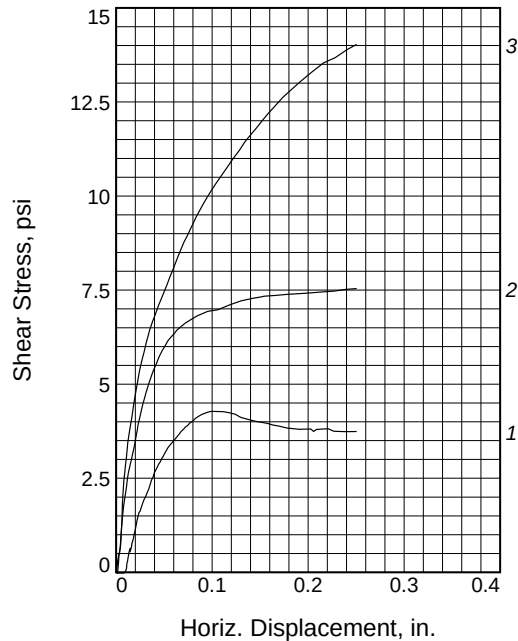
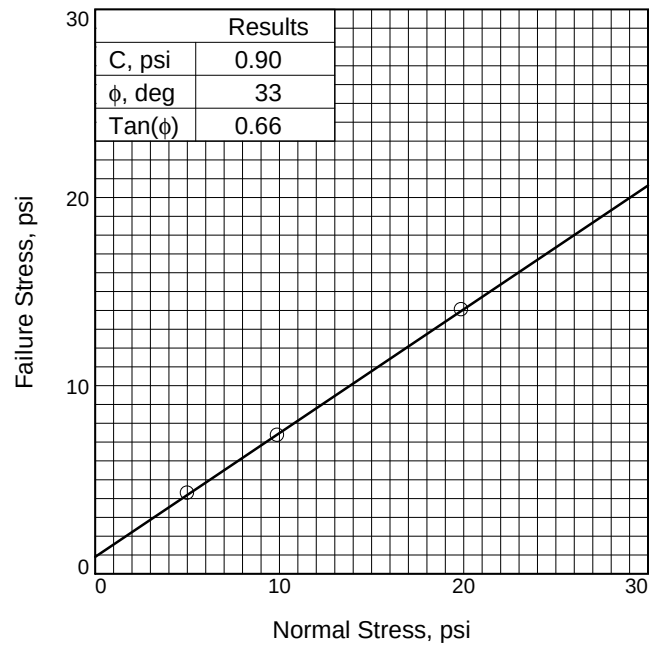
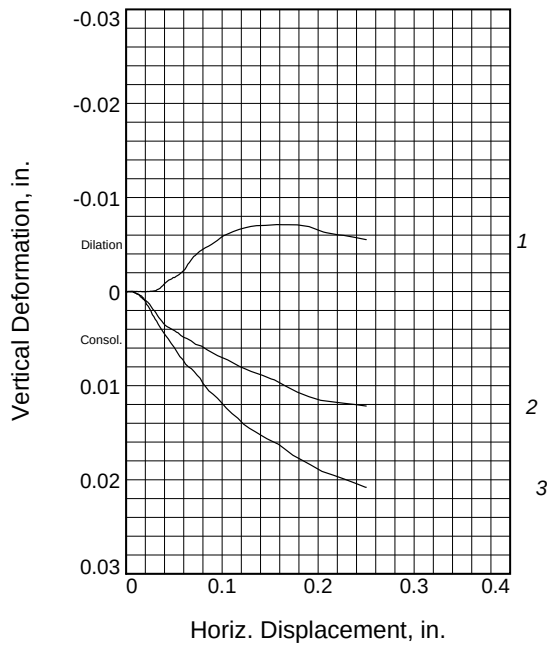
Depth: 3.0' - 5.0'

Proj. No.: J032438.03

Date Sampled: N/A

DIRECT SHEAR TEST REPORT
Geotechnology, Inc.
Overland Park, Kansas

Tested By: ADC **Checked By:** MHM



Sample No.		1	2	3
Initial	Water Content, %	24.0	24.0	24.0
	Dry Density, pcf	92.1	92.3	91.7
	Saturation, %	78.1	78.5	77.3
	Void Ratio	0.8294	0.8258	0.8386
	Diameter, in.	2.50	2.50	2.50
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	28.6	29.0	27.0
	Dry Density, pcf	95.1	96.8	99.9
	Void Ratio	0.7729	0.7422	0.6880
	Diameter, in.	2.50	2.50	2.50
	Height, in.	0.97	0.95	0.92
	Normal Stress, psi	5.03	9.92	19.90
Failure Stress, psi		4.27	7.34	14.02
Displacement, in.		0.10	0.15	0.25
Ultimate Stress, psi				
Displacement, in.				
Strain rate, %/min.		0.50	0.50	0.50

Sample Type: Shelby Tube

Description: CLAY - brown to gray brown, lean - (CL)

LL= 40 **PL=** 17 **PI=** 23

Assumed Specific Gravity= 2.7

Remarks:

Figure _____

Client: HDR Engineering, Inc.

Project: MODOT I-70 Wentzville

Location: B-94

Sample Number: ST-2

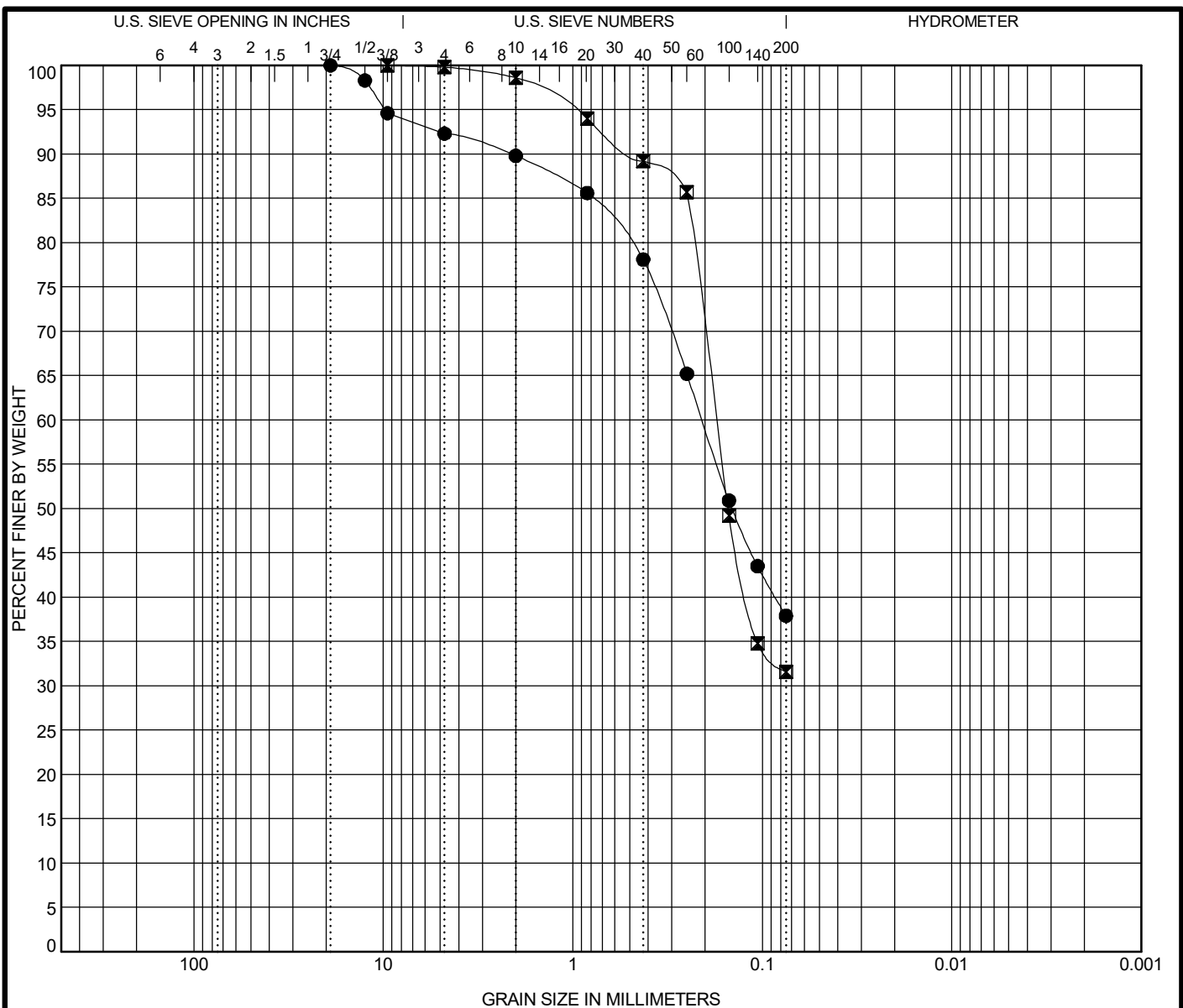
Depth: 3.0' - 5.0'

Proj. No.: J032438.03

Date Sampled: N/A

DIRECT SHEAR TEST REPORT
Geotechnology, Inc.
Overland Park, Kansas

Tested By: ADC **Checked By:** MHM



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

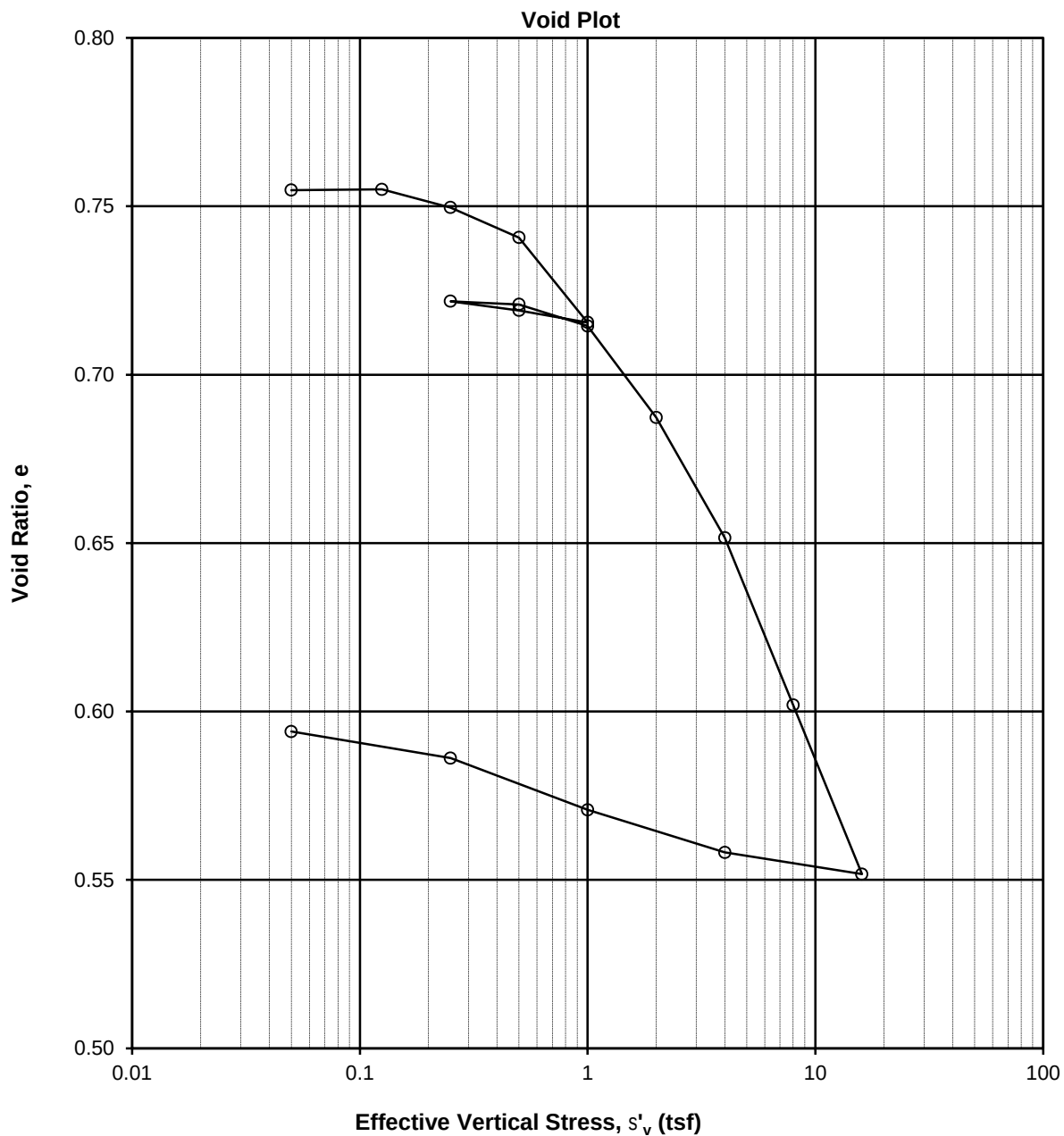
Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	B-12 8.5	Silty, clayey SAND trace gravel - SC-SM					
✕	B-23 6.0	Silty, clayey SAND - SC-SM	49	19	30		

Specimen Identification		D100	D90	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-12 8.5	19	2.1	0.2	0.1			7.7	54.4	37.9	
✕	B-23 6.0	9.5	0.5	0.2	0.2			0.2	68.2	31.6	



GRAIN SIZE DISTRIBUTION

I-70 Corridor Improvements
MoDOT Project J610624
Wentzville, Missouri
J032438.03



SAMPLE INFORMATION

Boring: B-19 Sample: ST5 Depth: 13-15 feet

SAMPLE DATA

Moisture Content (%): 26.0
Dry Unit Weight (pcf): 96.5

RESULTS

Compression Index, C_c : 0.17
Recompression Index, C_r : 0.01
Preconsolidation Pressure (tsf): 1.50
Initial Void Ratio: 0.76

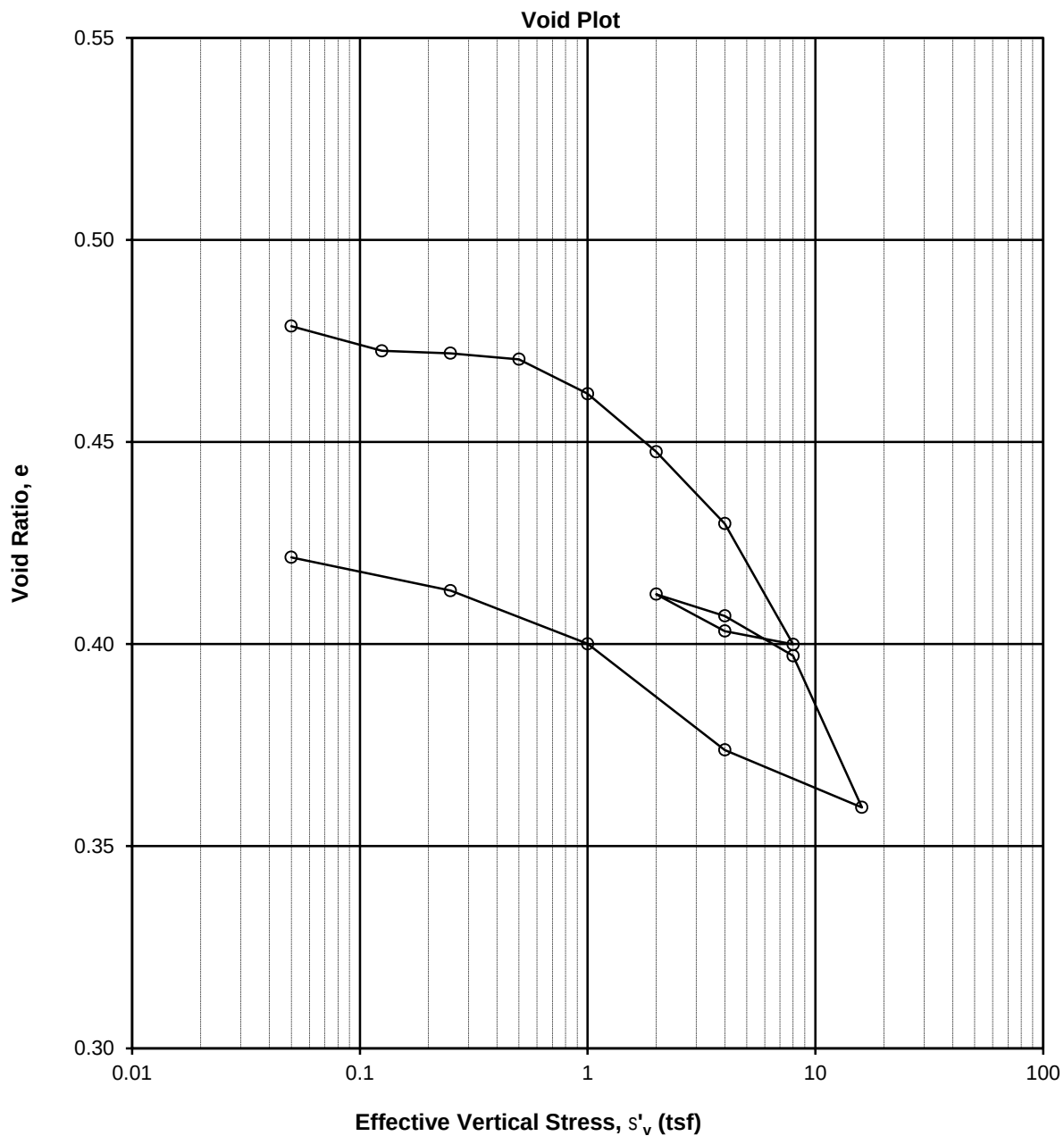
Tested By: EG	Calc'd By: EG	Check'd By: AT
Date: 7/15/2021	Date: 7/27/2021	Date: 7/27/2021



**I-70 Corridor Improvements
MoDOT Project J6I0624
Wentzville, Missouri**

**ONE-DIMENSIONAL INCREMENTAL
CONSOLIDATION TEST ASTM D2435**

Project Number: J032438.03



SAMPLE INFORMATION

Boring: B-20 Sample: ST5 Depth: 10-12 feet

SAMPLE DATA

Moisture Content (%): 16.6
Dry Unit Weight (pcf): 112.8

RESULTS

Compression Index, C_c : 0.12
Recompression Index, C_r : 0.03
Preconsolidation Pressure (tsf): 2.80
Initial Void Ratio: 0.48

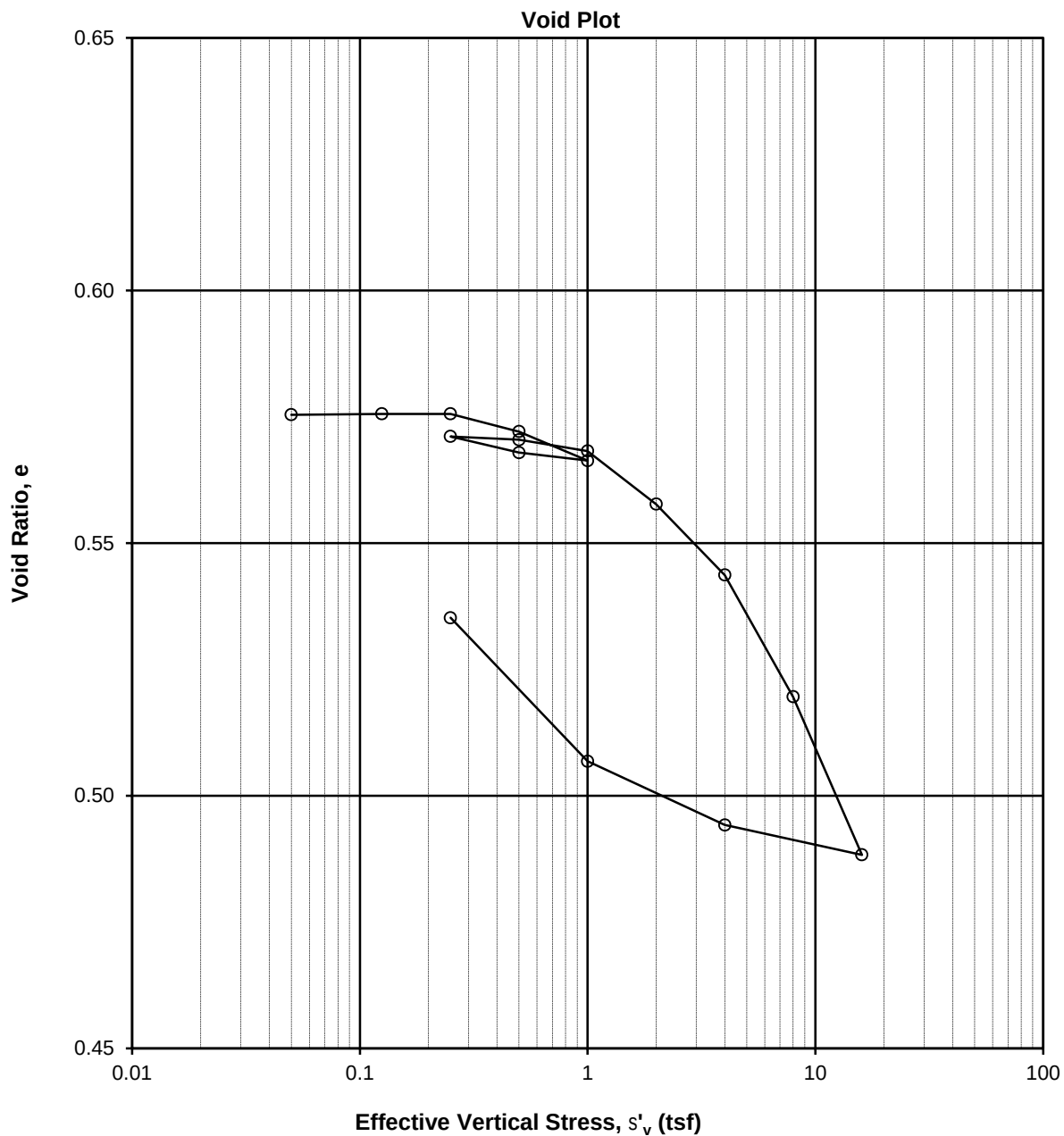
Tested By: EG	Calc'd By: EG	Check'd By: AT
Date: 7/20/2021	Date: 7/30/2021	Date: 7/30/2021



I-70 Corridor Improvements
MoDOT Project J6I0624
Wentzville, Missouri

ONE-DIMENSIONAL INCREMENTAL
CONSOLIDATION TEST ASTM D2435

Project Number: J032438.03



SAMPLE INFORMATION

Boring: B-23 Sample: ST3 Depth: 6-8 feet

SAMPLE DATA

Moisture Content (%): 16.7
Dry Unit Weight (pcf): 105.3

RESULTS

Compression Index, C_c : 0.10
Recompression Index, C_r : 0.01
Preconsolidation Pressure (tsf): 3.50
Initial Void Ratio: 0.57

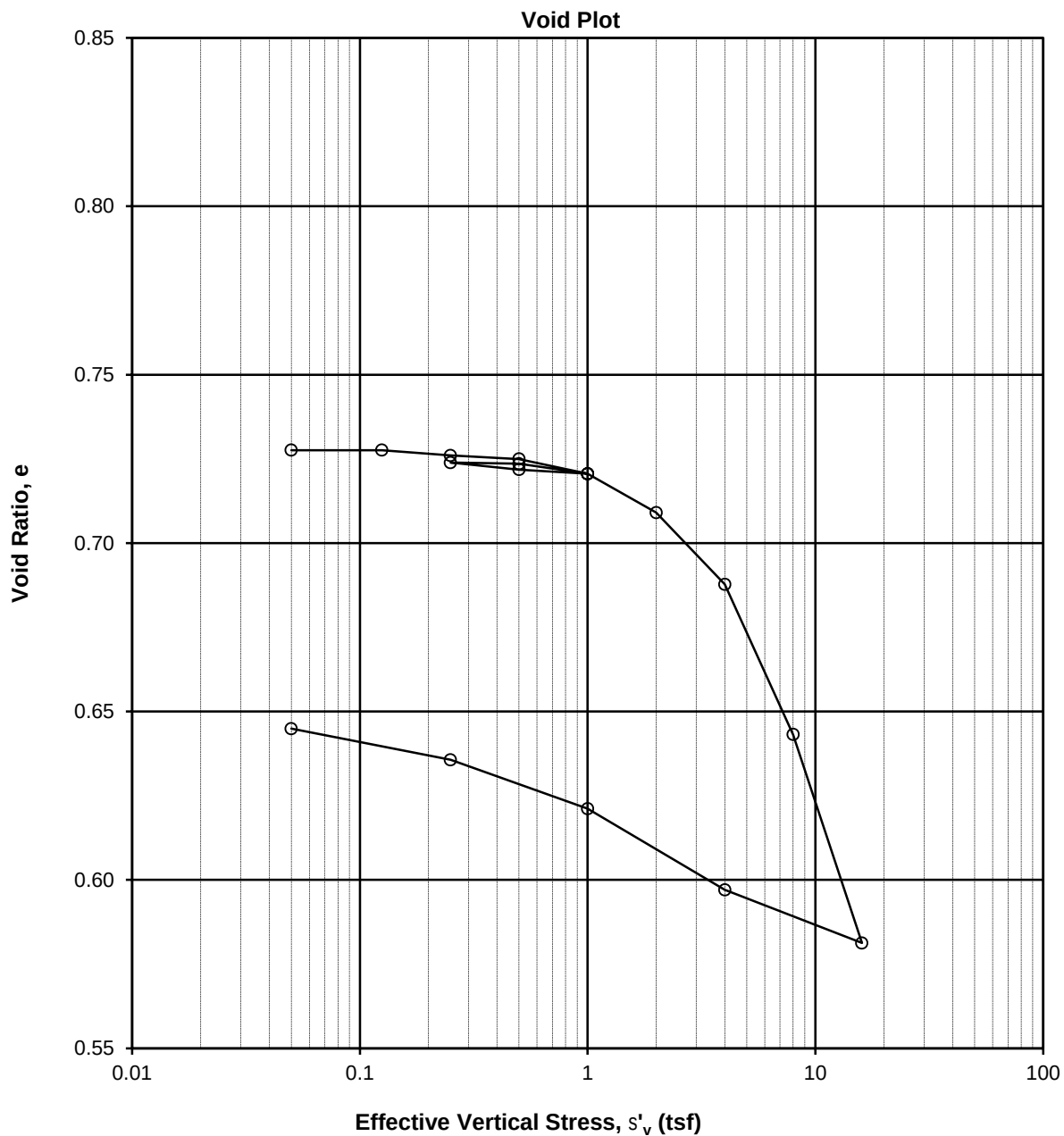
Tested By: EG	Calc'd By: EG	Check'd By: AT
Date: 7/12/2021	Date: 7/26/2021	Date: 7/26/2021



I-70 Corridor Improvements
MoDOT Project J6I0624
Wentzville, Missouri

ONE-DIMENSIONAL INCREMENTAL
CONSOLIDATION TEST ASTM D2435

Project Number: J032438.03



SAMPLE INFORMATION

Boring: B-25 Sample: ST4 Depth: 8-10 feet

SAMPLE DATA

Moisture Content (%): 22.8
Dry Unit Weight (pcf): 96.5

RESULTS

Compression Index, C_c : 0.20
Recompression Index, C_r : 0.01
Preconsolidation Pressure (tsf): 3.50
Initial Void Ratio: 0.73

Tested By: EG	Calc'd By: EG	Check'd By: AT
Date: 7/12/2021	Date: 7/26/2021	Date: 7/26/2021



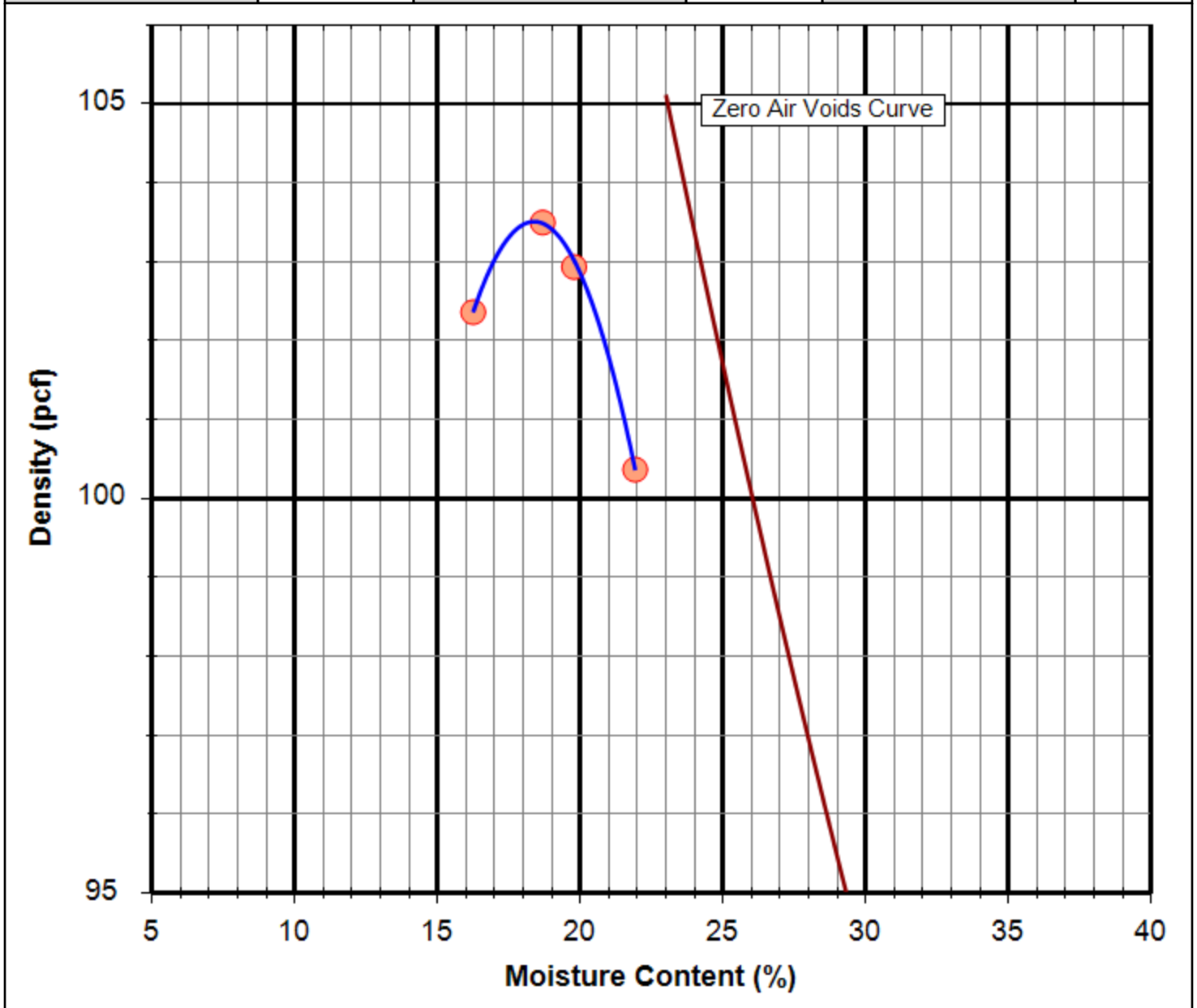
I-70 Corridor Improvements
MoDOT Project J6I0624
Wentzville, Missouri

ONE-DIMENSIONAL INCREMENTAL
CONSOLIDATION TEST ASTM D2435

Project Number: J032438.03

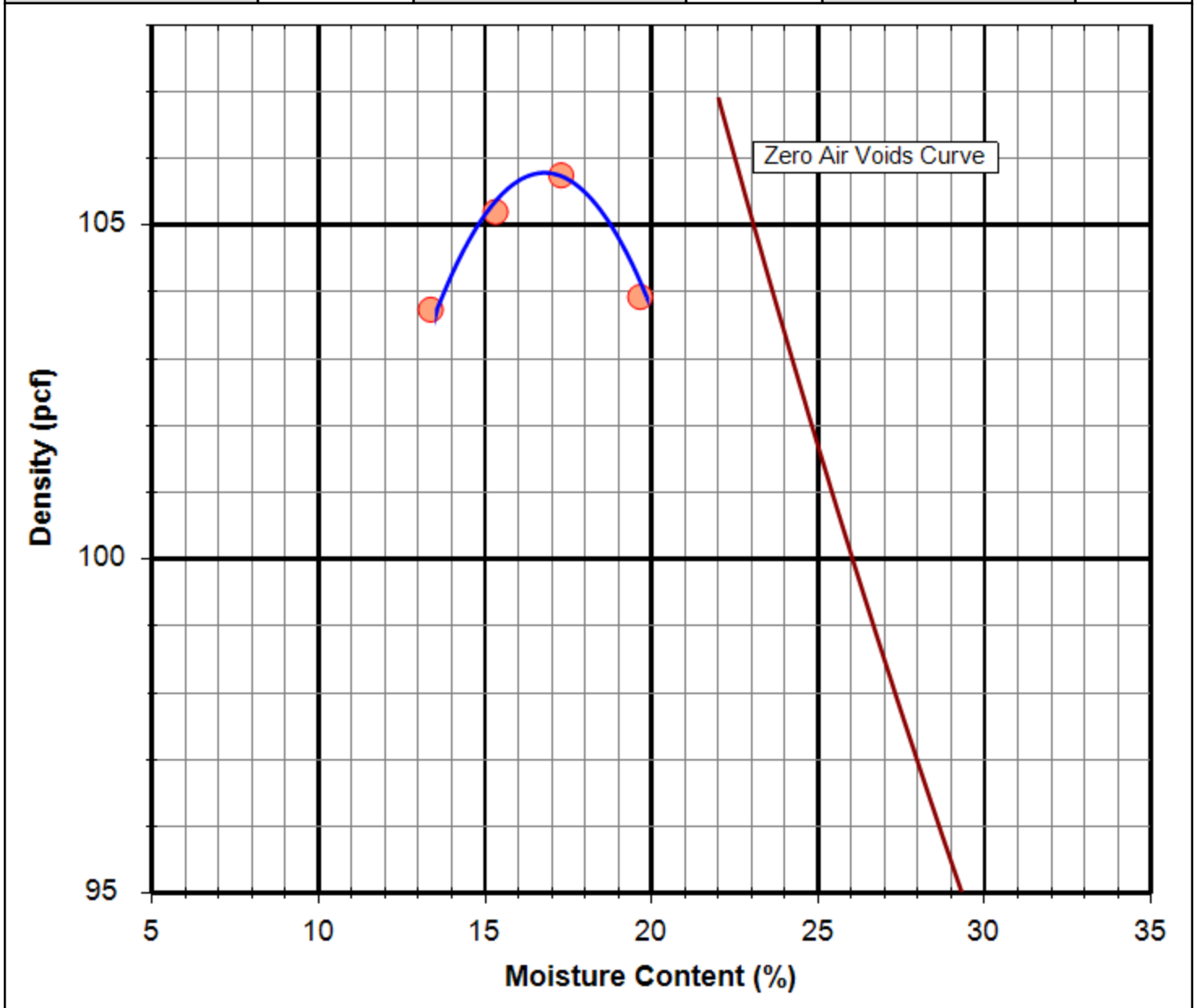
STANDARD PROCTOR MOISTURE DENSITY TEST, ASTM D698, METHOD A

Client:	HDR Engineering, Inc.					Project No.:	J032438.03		
Project:	MoDOT I-70 Wentzville, Wentzville, MO					Date:	10/7/2021		
Sample Obtained From:		B-22 Bulk				Depth (ft.):			
Sample Description:		Brown, FAT CLAY; C6775			LL	PL	PI	USCS	
					63	16	47	CH	
Maximum Dry Density (pcf):		103.5	Optimum Moisture Content:		18.4%	In Situ Moisture Content:			-



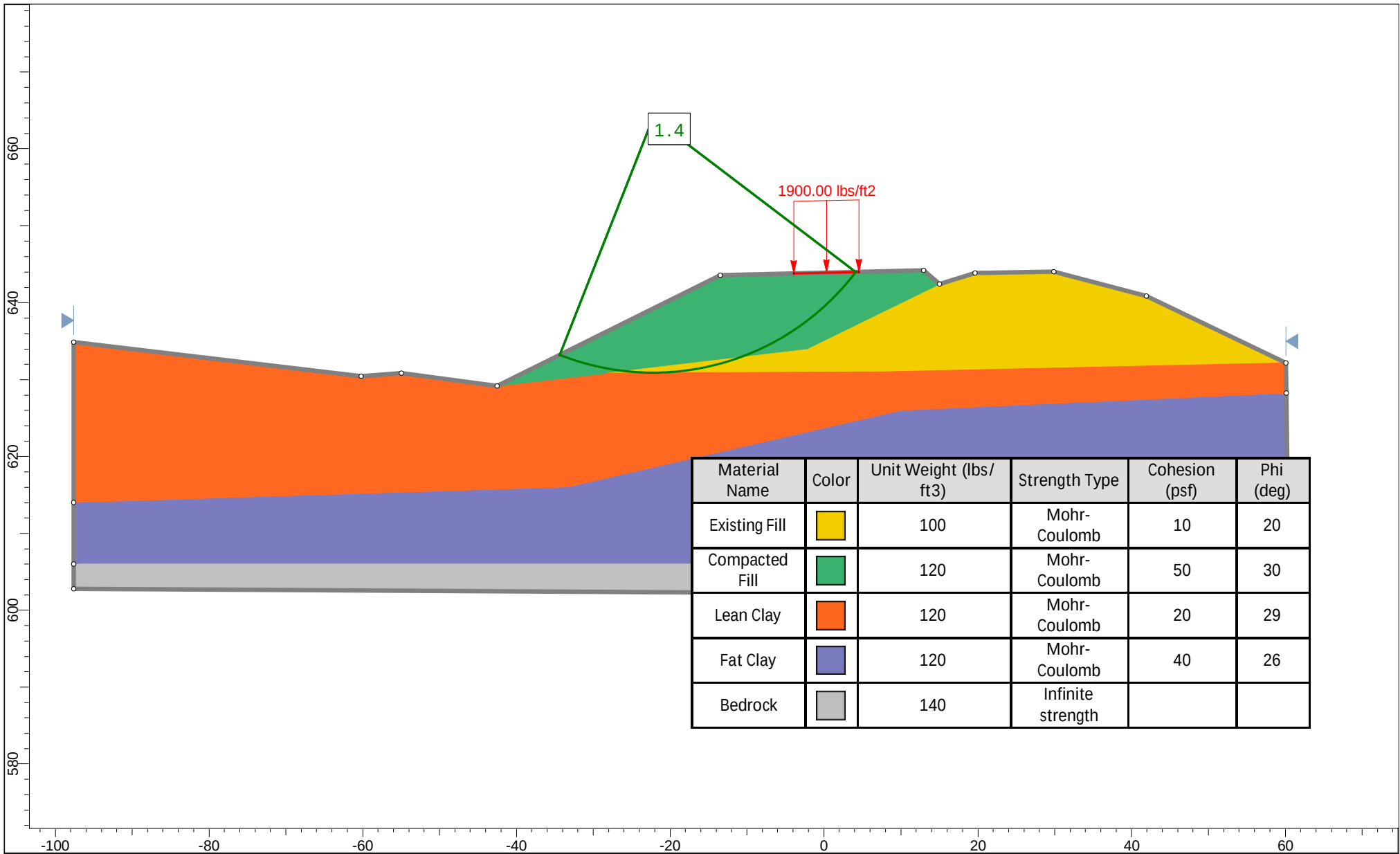
STANDARD PROCTOR MOISTURE DENSITY TEST, ASTM D698, METHOD A

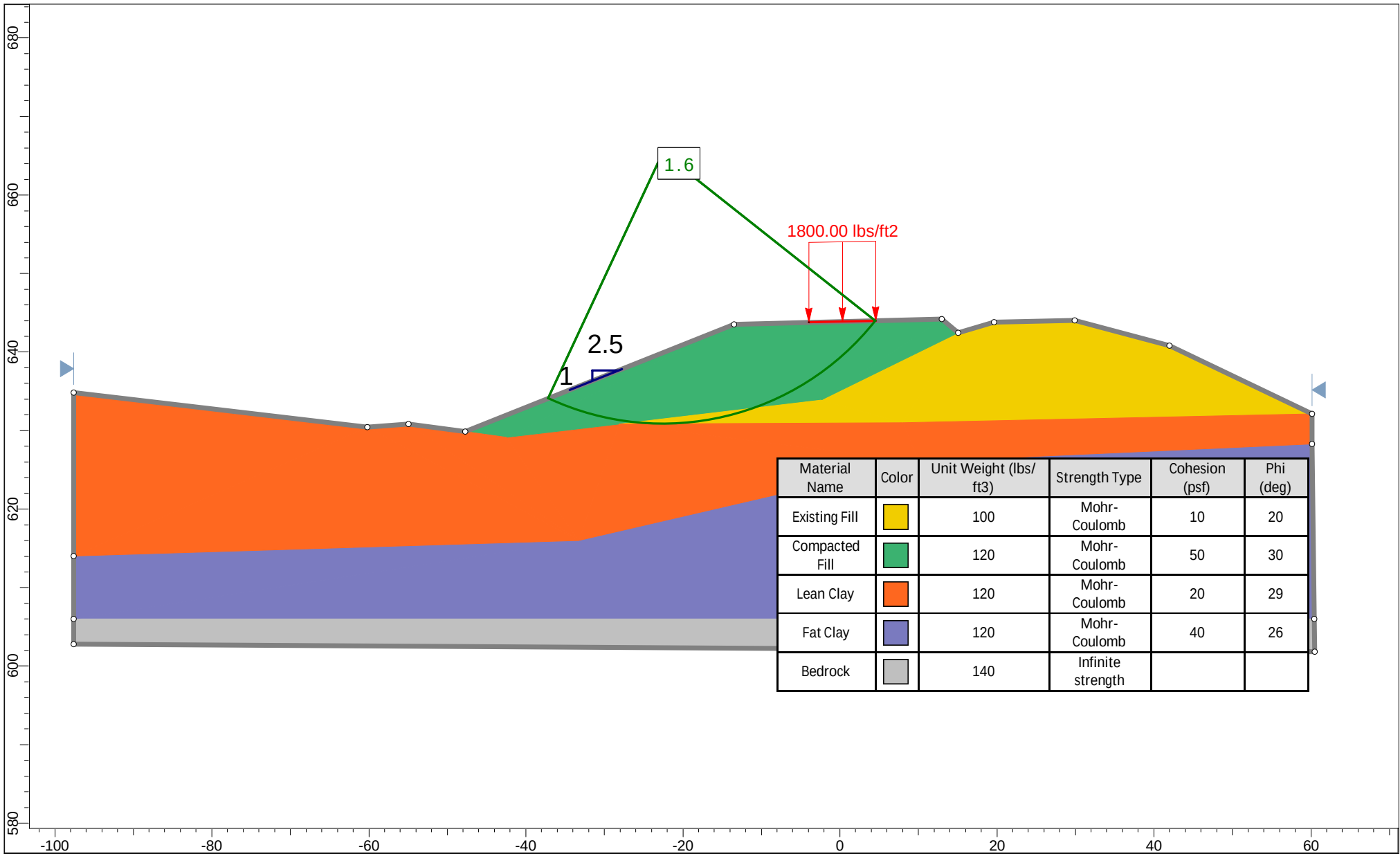
Client:	HDR Engineering, Inc.					Project No.:	J032438.03		
Project:	MoDOT I-70 Wentzville, Wentzville, MO					Date:	10/7/2021		
Sample Obtained From:		B-24				Depth (ft.):			
Sample Description:		Brown, LEAN CLAY; C6776			LL	PL	PI	USCS	
					40	17	23	CL	
Maximum Dry Density (pcf):		105.8	Optimum Moisture Content:		16.8%	In Situ Moisture Content:			-

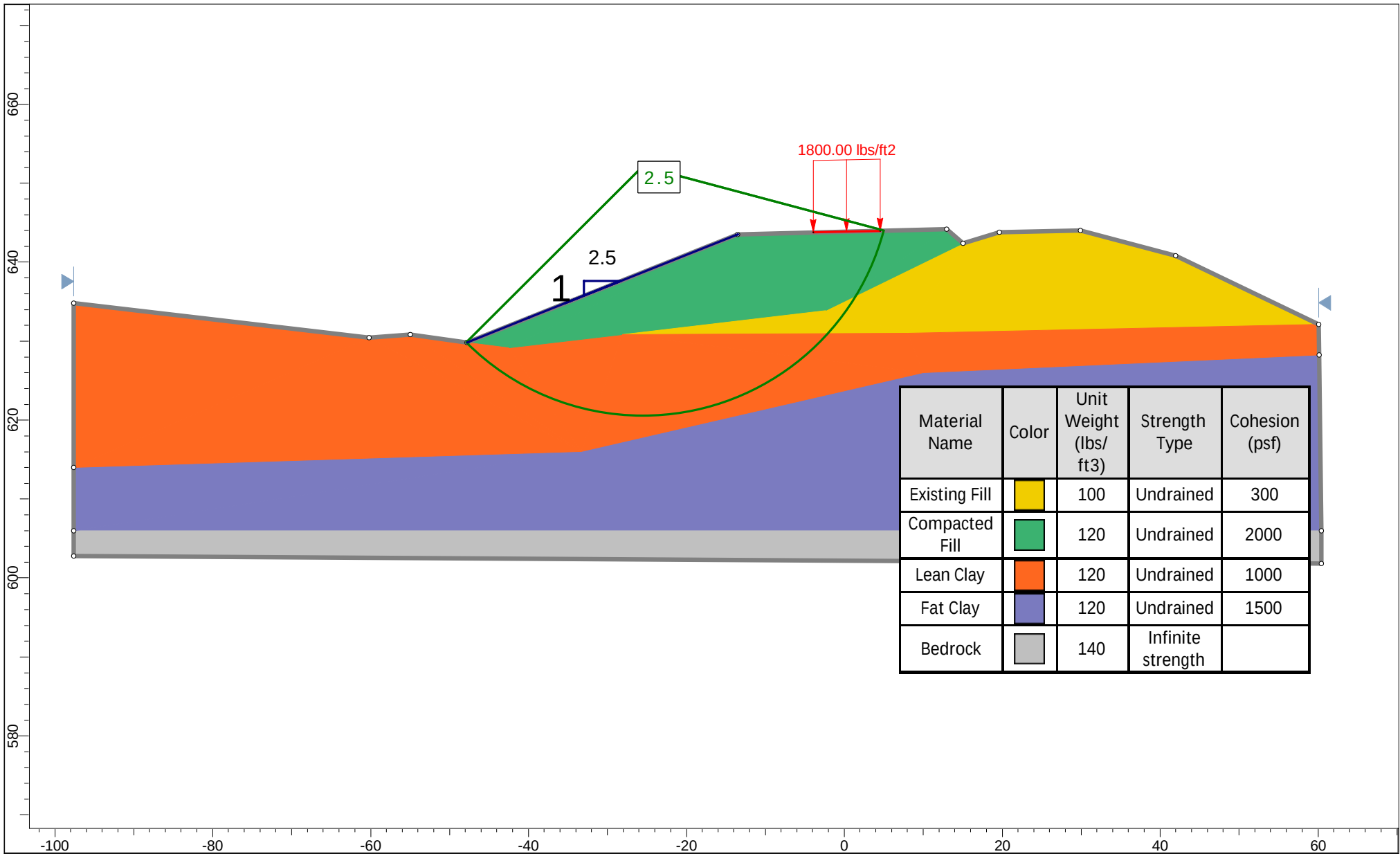


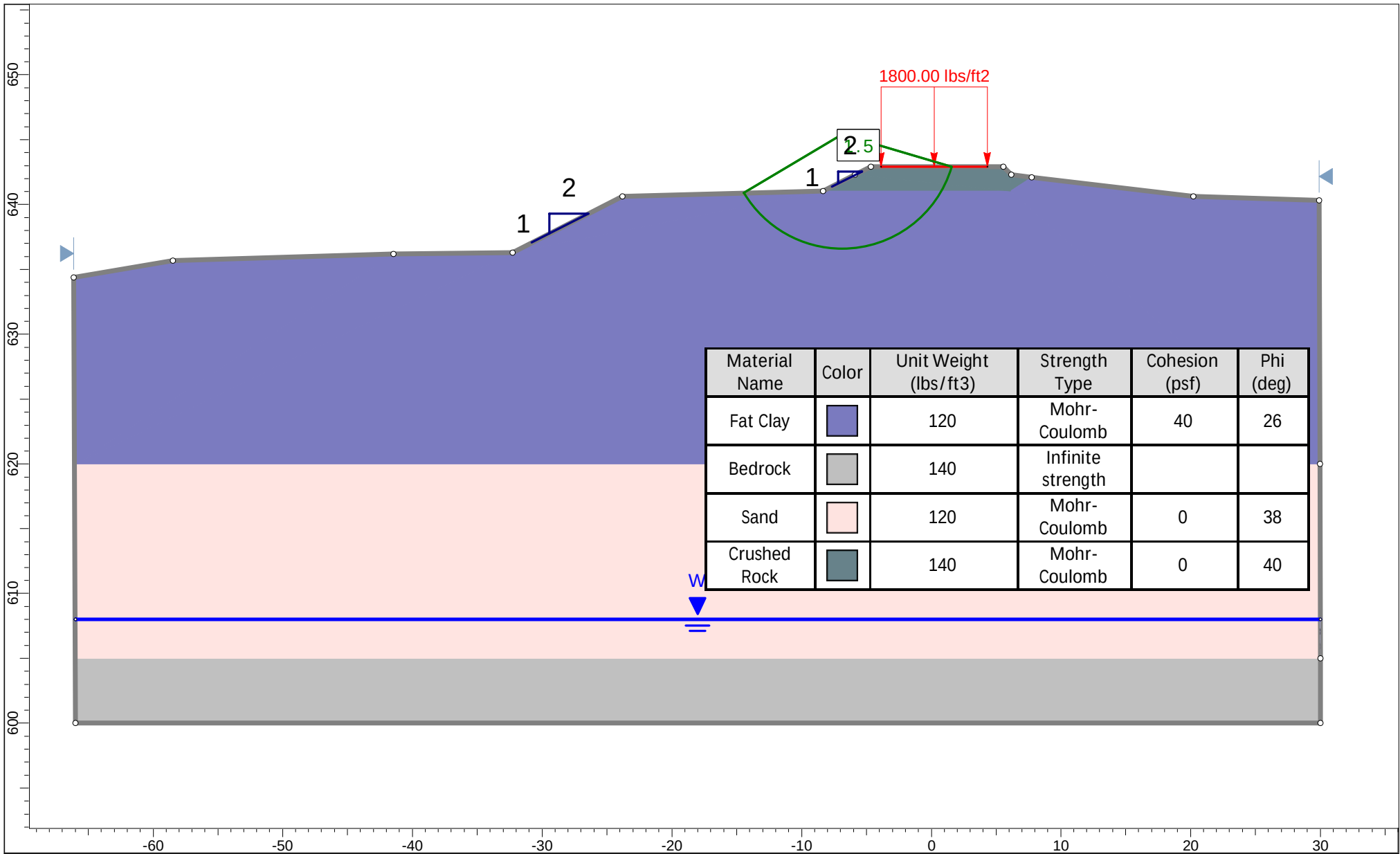


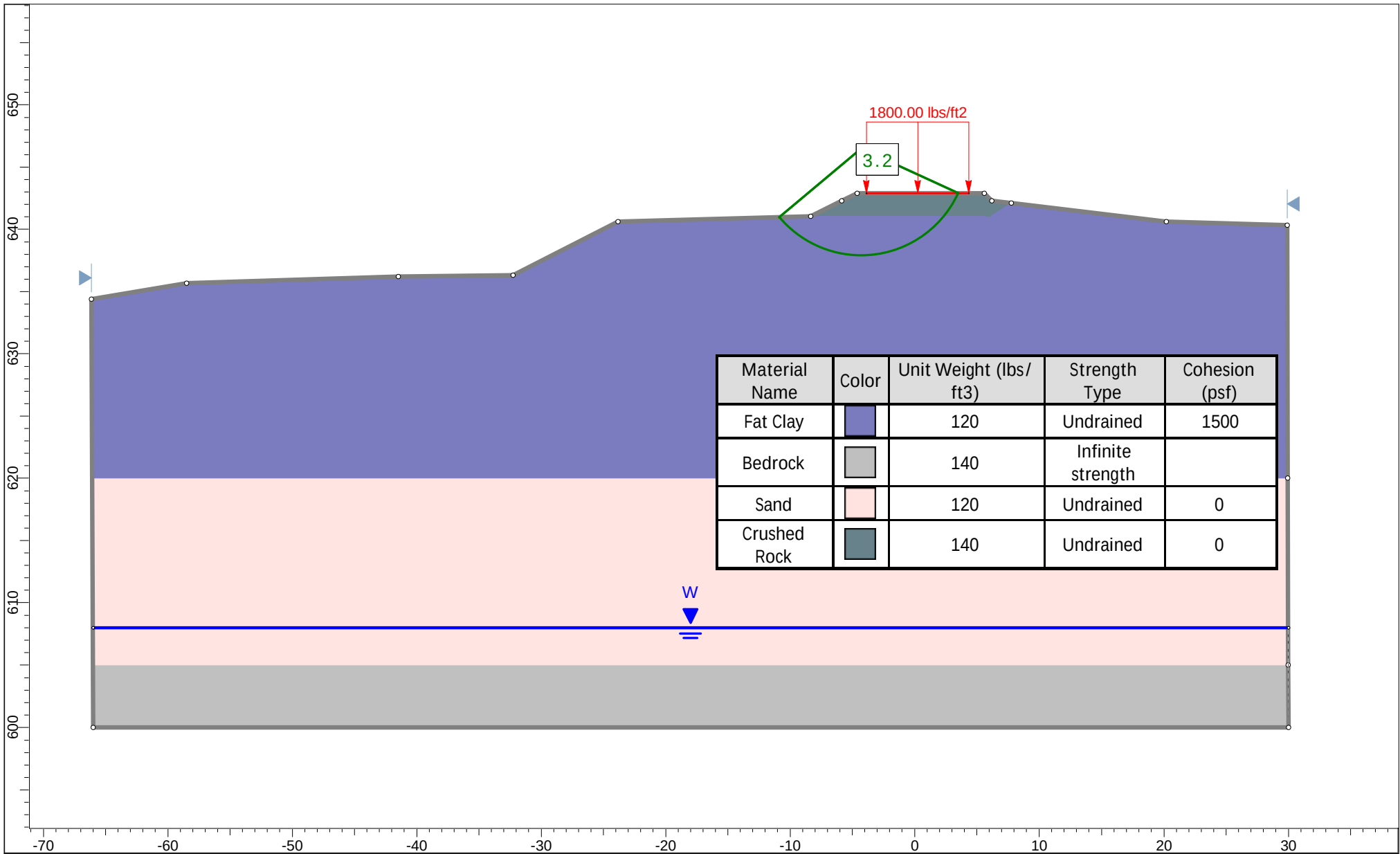
APPENDIX J – SLOPE STABILITY ANALYSIS RESULTS

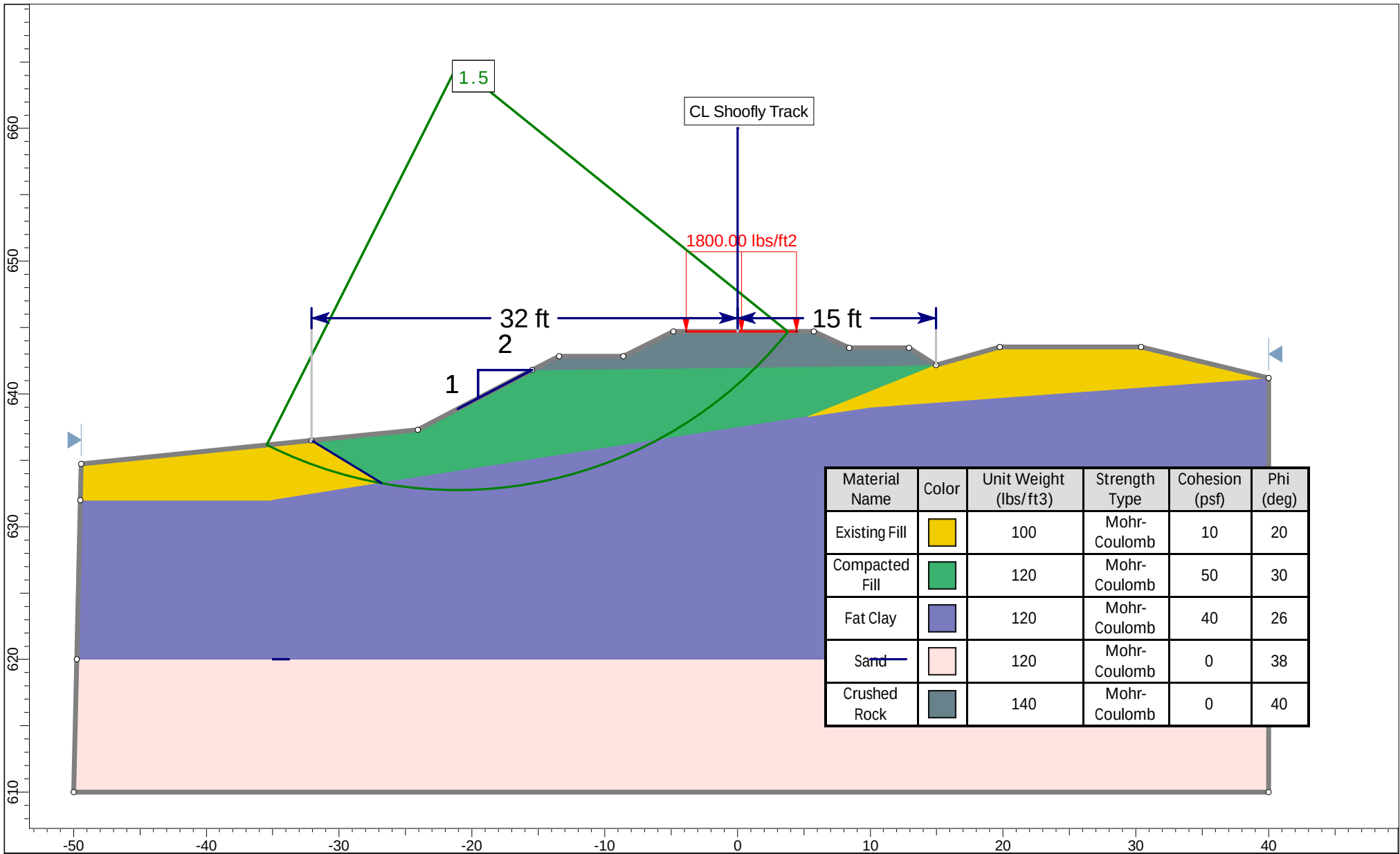


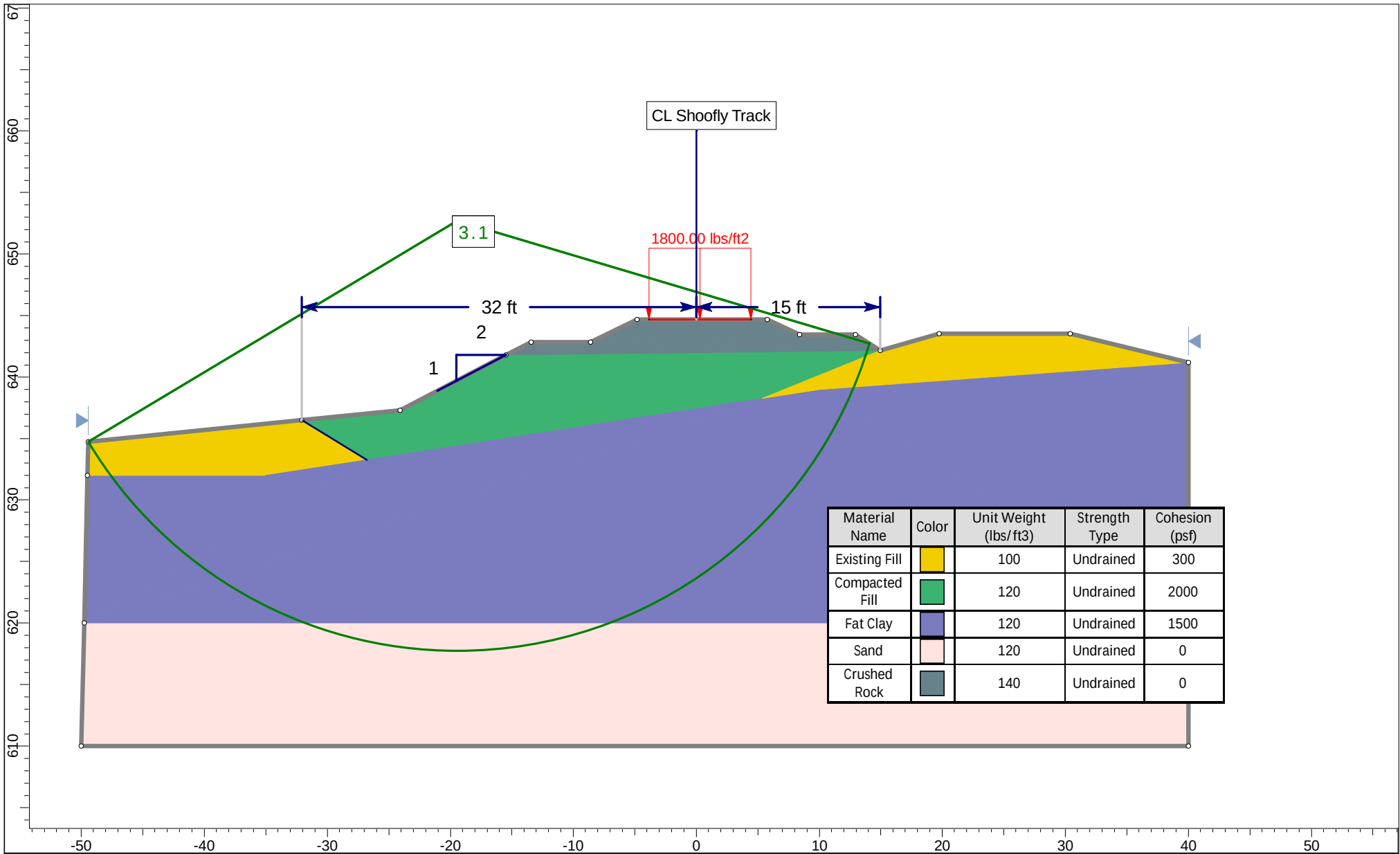






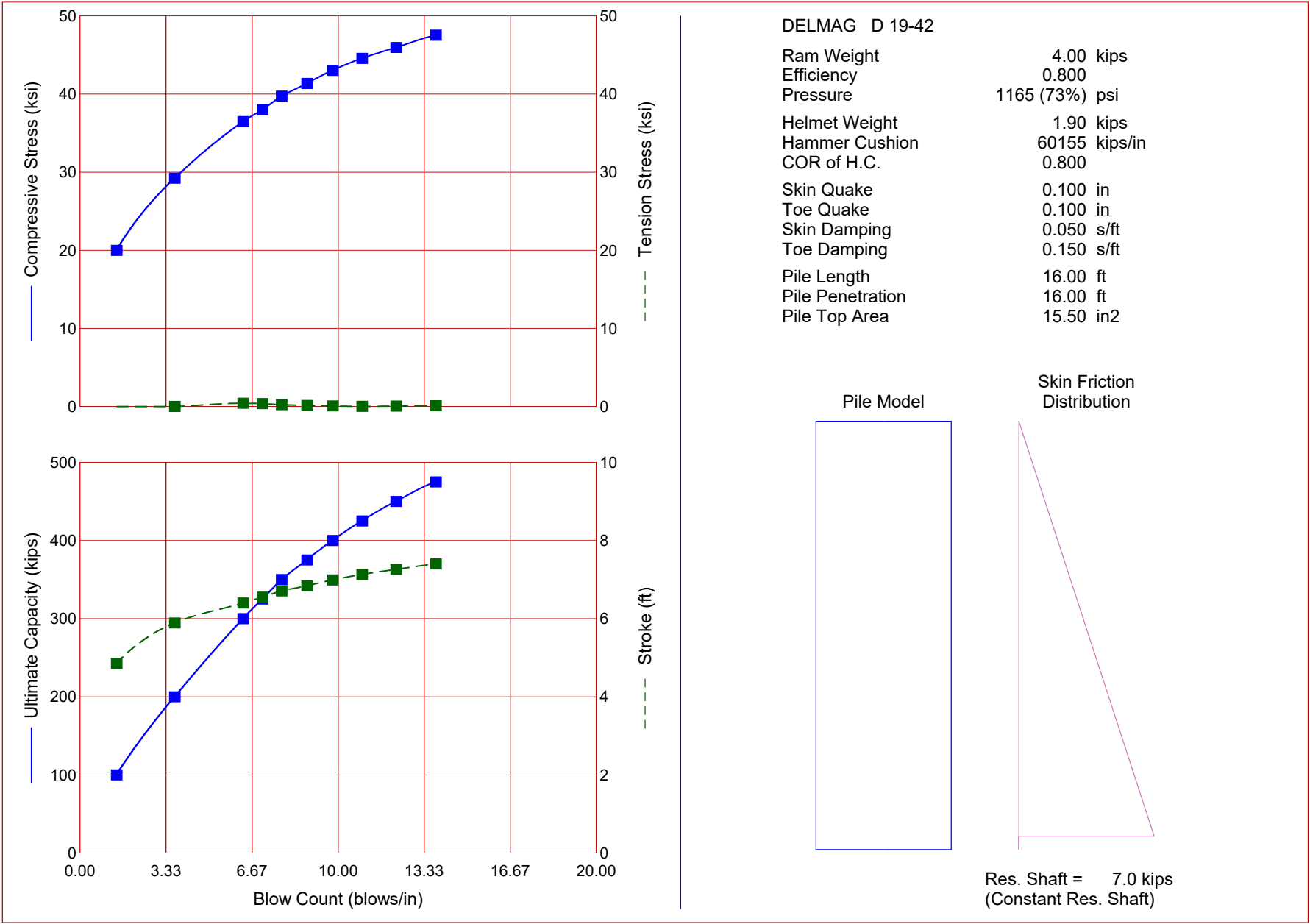








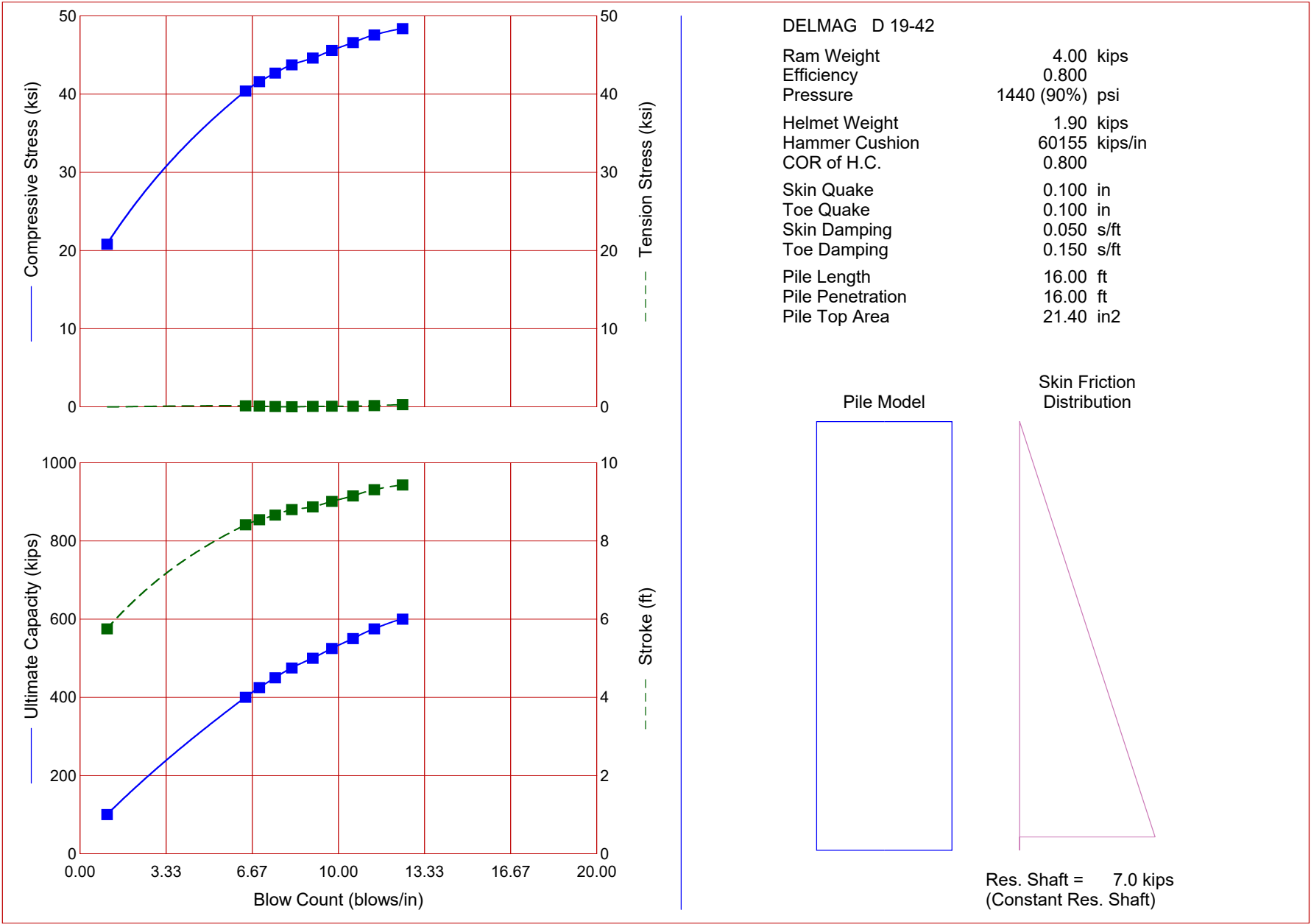
APPENDIX K – PRECONSTRUCTION WAVE EQUATION ANALYSIS RESULTS



Geotechnology, Inc.
Eastbnd I-70 over Route Z DM2 East Abut

23-Sep-2021
GRLWEAP Version 2010

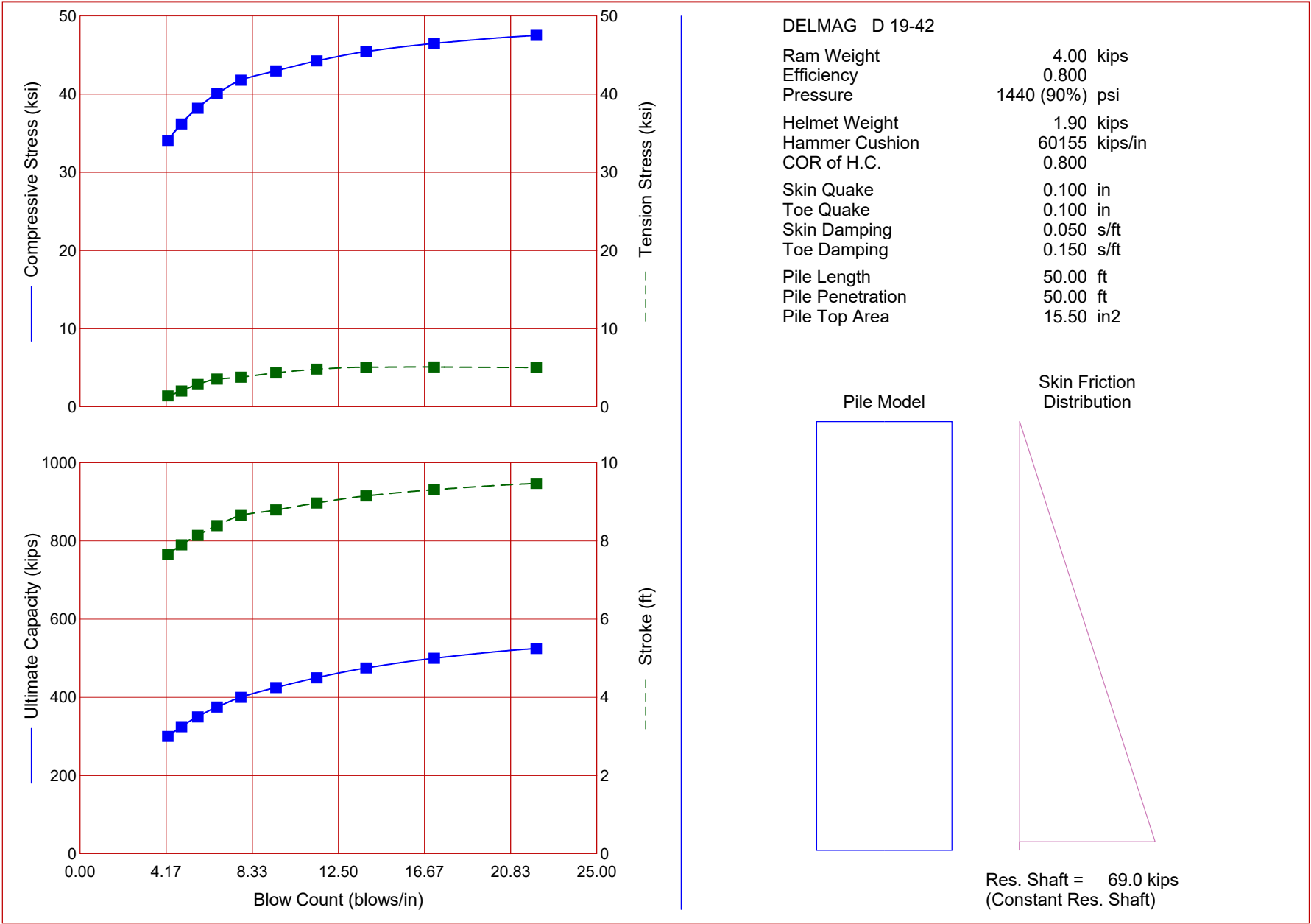
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
100.0	19.98	0.00	1.4	4.85	11.24
200.0	29.21	0.01	3.7	5.89	10.32
300.0	36.47	0.42	6.3	6.40	10.52
325.0	37.99	0.38	7.1	6.55	10.72
350.0	39.72	0.24	7.8	6.71	11.01
375.0	41.34	0.15	8.8	6.84	11.15
400.0	43.02	0.08	9.8	6.99	11.38
425.0	44.55	0.03	10.9	7.13	11.61
450.0	45.94	0.06	12.3	7.26	11.84
475.0	47.52	0.11	13.8	7.40	12.06



Geotechnology, Inc.
Eastbnd I-70 over Route Z DM2 East Abut

23-Sep-2021
GRLWEAP Version 2010

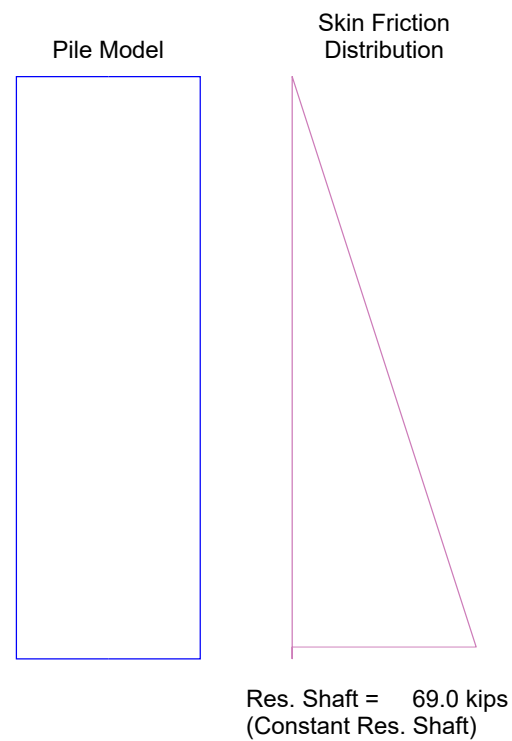
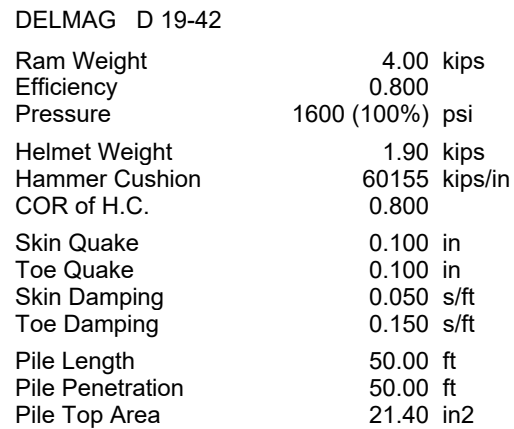
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
100.0	20.80	0.00	1.0	5.75	16.30
400.0	40.38	0.14	6.4	8.41	14.92
425.0	41.59	0.10	6.9	8.54	15.06
450.0	42.68	0.05	7.6	8.66	15.14
475.0	43.73	0.02	8.2	8.80	15.25
500.0	44.59	0.06	9.0	8.87	15.23
525.0	45.58	0.09	9.8	9.01	15.41
550.0	46.58	0.09	10.6	9.15	15.56
575.0	47.55	0.17	11.4	9.31	15.81
600.0	48.36	0.29	12.5	9.43	15.89



Geotechnology, Inc.
Eastbnd I-70 over Route Z DM2 West Abut

23-Sep-2021
GRLWEAP Version 2010

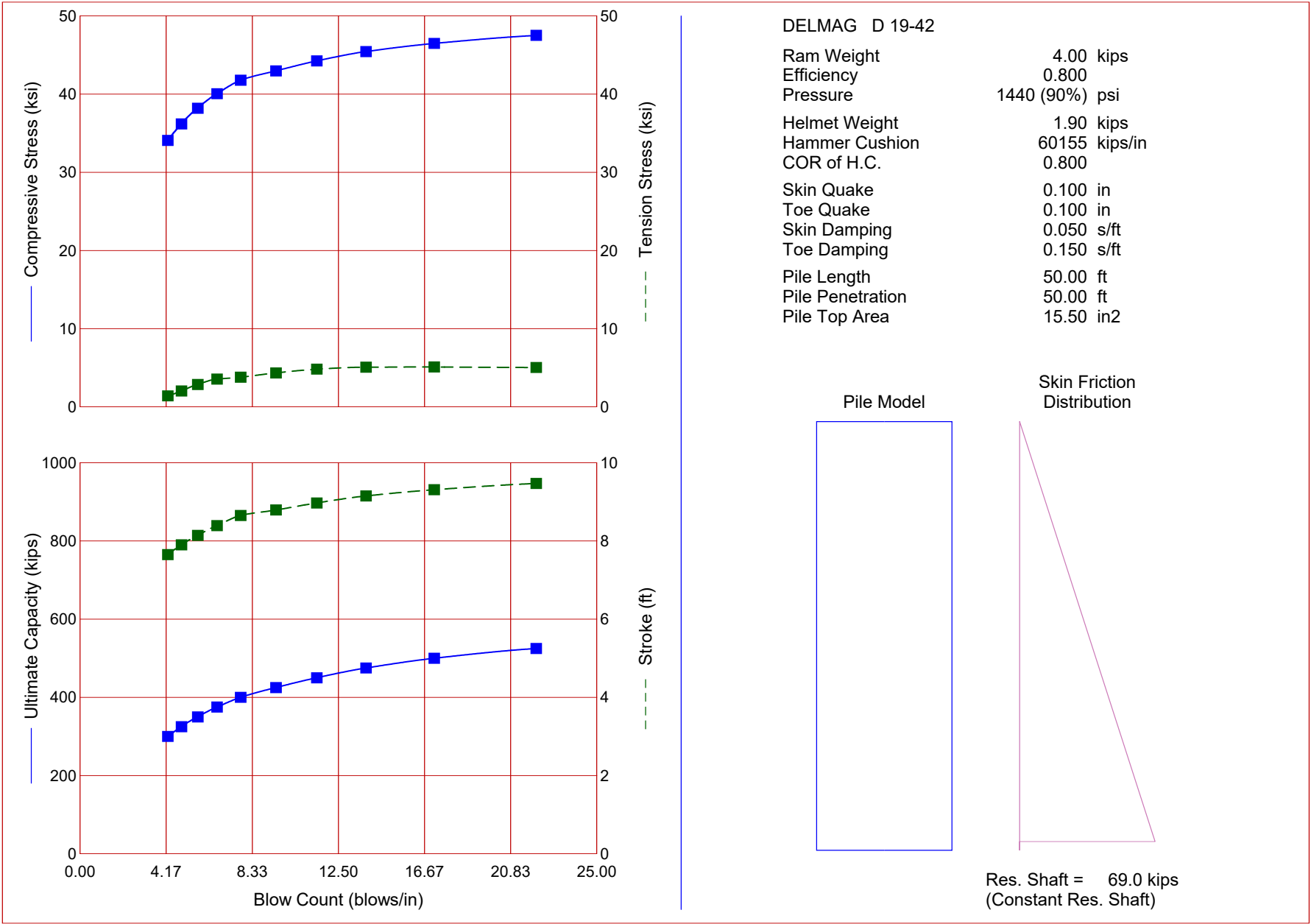
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
300.0	34.07	1.41	4.3	7.65	16.65
325.0	36.18	2.04	4.9	7.90	17.15
350.0	38.19	2.86	5.7	8.14	17.63
375.0	40.04	3.55	6.6	8.39	18.11
400.0	41.76	3.79	7.8	8.65	18.74
425.0	42.96	4.35	9.5	8.79	19.08
450.0	44.23	4.82	11.5	8.97	19.47
475.0	45.43	5.08	13.8	9.15	19.95
500.0	46.48	5.11	17.1	9.31	20.39
525.0	47.50	5.04	22.1	9.47	20.76



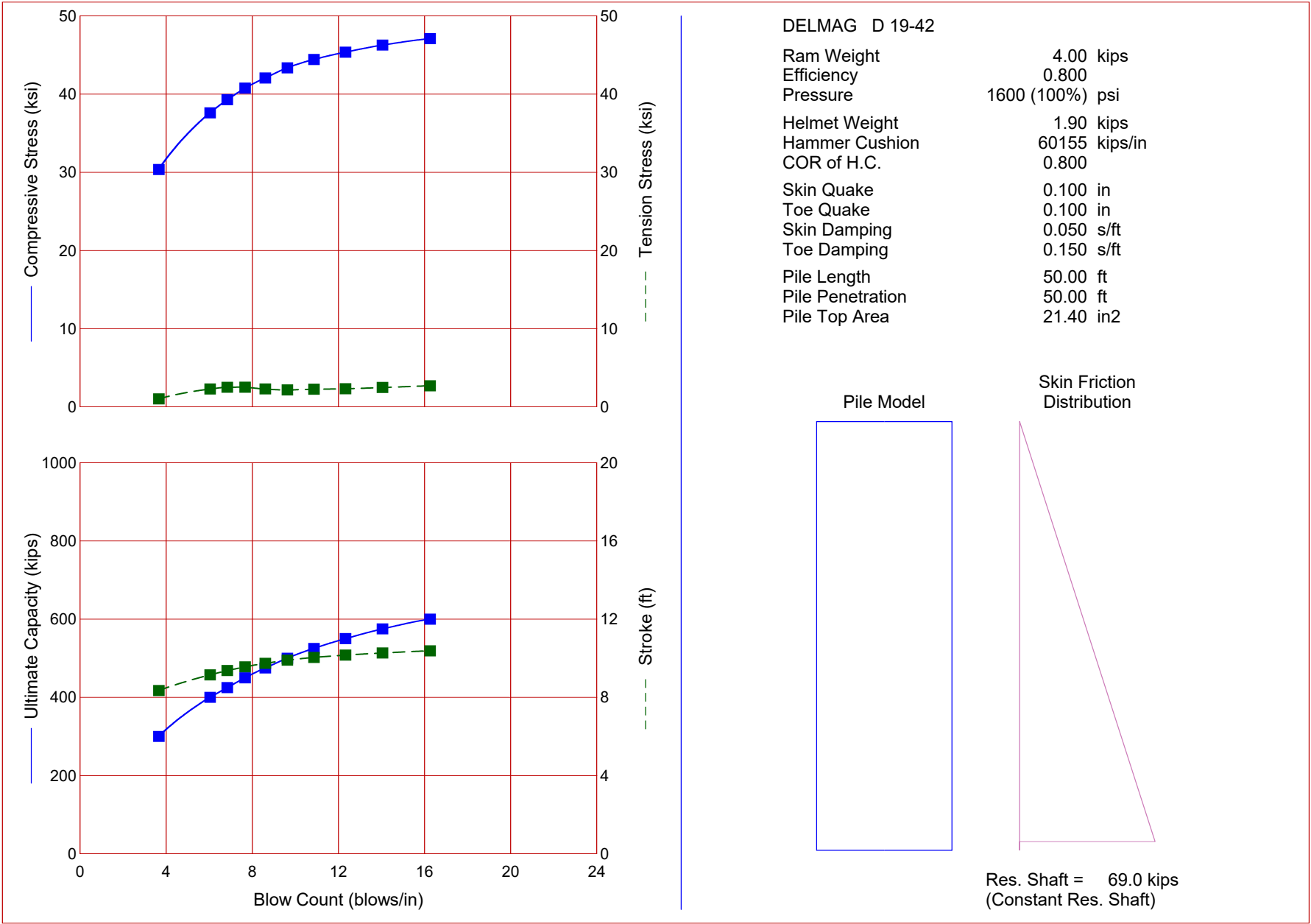
Geotechnology, Inc.
Eastbnd I-70 over Route Z DM2 West Abut

23-Sep-2021
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
300.0	30.35	1.02	3.7	8.35	18.20
400.0	37.59	2.29	6.0	9.15	19.66
425.0	39.28	2.51	6.8	9.37	20.20
450.0	40.75	2.52	7.7	9.56	20.74
475.0	42.05	2.29	8.6	9.74	21.13
500.0	43.35	2.17	9.6	9.90	21.51
525.0	44.42	2.27	10.9	10.04	21.83
550.0	45.36	2.33	12.3	10.16	22.13
575.0	46.26	2.48	14.0	10.27	22.43
600.0	47.09	2.70	16.3	10.38	22.67



Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
300.0	34.07	1.41	4.3	7.65	16.65
325.0	36.18	2.04	4.9	7.90	17.15
350.0	38.19	2.86	5.7	8.14	17.63
375.0	40.04	3.55	6.6	8.39	18.11
400.0	41.76	3.79	7.8	8.65	18.74
425.0	42.96	4.35	9.5	8.79	19.08
450.0	44.23	4.82	11.5	8.97	19.47
475.0	45.43	5.08	13.8	9.15	19.95
500.0	46.48	5.11	17.1	9.31	20.39
525.0	47.50	5.04	22.1	9.47	20.76



Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
300.0	30.35	1.02	3.7	8.35	18.20
400.0	37.59	2.29	6.0	9.15	19.66
425.0	39.28	2.51	6.8	9.37	20.20
450.0	40.75	2.52	7.7	9.56	20.74
475.0	42.05	2.29	8.6	9.74	21.13
500.0	43.35	2.17	9.6	9.90	21.51
525.0	44.42	2.27	10.9	10.04	21.83
550.0	45.36	2.33	12.3	10.16	22.13
575.0	46.26	2.48	14.0	10.27	22.43
600.0	47.09	2.70	16.3	10.38	22.67

Table: Element Forces - Frames, Part 1 of 2**Table: Element Forces - Frames, Part 1 of 2**

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
1	0.	DEAD	LinStatic	0.	-1.802	0.	0.	0.
1	1.5	DEAD	LinStatic	0.	1.110E-16	0.	0.	0.
2	0.	DEAD	LinStatic	0.	-17.64	0.	0.	0.
2	0.4	DEAD	LinStatic	0.	-13.439	0.	0.	0.
2	0.4	DEAD	LinStatic	0.	-13.439	0.	0.	0.
2	0.8	DEAD	LinStatic	0.	-9.238	0.	0.	0.
2	0.8	DEAD	LinStatic	0.	-9.238	0.	0.	0.
2	1.2	DEAD	LinStatic	0.	-5.038	0.	0.	0.
2	1.2	DEAD	LinStatic	0.	-5.038	0.	0.	0.
2	1.6	DEAD	LinStatic	0.	-0.837	0.	0.	0.
2	1.6	DEAD	LinStatic	0.	-0.837	0.	0.	0.
2	2.	DEAD	LinStatic	0.	3.363	0.	0.	0.
2	2.	DEAD	LinStatic	0.	3.363	0.	0.	0.
2	2.4	DEAD	LinStatic	0.	7.564	0.	0.	0.
2	2.4	DEAD	LinStatic	0.	7.564	0.	0.	0.
2	2.8	DEAD	LinStatic	0.	11.765	0.	0.	0.
2	2.8	DEAD	LinStatic	0.	11.765	0.	0.	0.
2	3.2	DEAD	LinStatic	0.	15.965	0.	0.	0.
2	3.2	DEAD	LinStatic	0.	15.965	0.	0.	0.
2	3.6	DEAD	LinStatic	0.	20.166	0.	0.	0.
2	3.6	DEAD	LinStatic	0.	20.166	0.	0.	0.
2	4.	DEAD	LinStatic	0.	24.366	0.	0.	0.
3	0.	DEAD	LinStatic	0.	-21.003	0.	0.	0.
3	0.4	DEAD	LinStatic	0.	-16.802	0.	0.	0.
3	0.4	DEAD	LinStatic	0.	-16.802	0.	0.	0.
3	0.8	DEAD	LinStatic	0.	-12.602	0.	0.	0.
3	0.8	DEAD	LinStatic	0.	-12.602	0.	0.	0.
3	1.2	DEAD	LinStatic	0.	-8.401	0.	0.	0.
3	1.2	DEAD	LinStatic	0.	-8.401	0.	0.	0.
3	1.6	DEAD	LinStatic	0.	-4.201	0.	0.	0.
3	1.6	DEAD	LinStatic	0.	-4.201	0.	0.	0.
3	2.	DEAD	LinStatic	0.	-1.181E-15	0.	0.	0.
3	2.	DEAD	LinStatic	0.	-1.421E-14	0.	0.	0.
3	2.4	DEAD	LinStatic	0.	4.201	0.	0.	0.
3	2.4	DEAD	LinStatic	0.	4.201	0.	0.	0.
3	2.8	DEAD	LinStatic	0.	8.401	0.	0.	0.
3	2.8	DEAD	LinStatic	0.	8.401	0.	0.	0.
3	3.2	DEAD	LinStatic	0.	12.602	0.	0.	0.
3	3.2	DEAD	LinStatic	0.	12.602	0.	0.	0.
3	3.6	DEAD	LinStatic	0.	16.802	0.	0.	0.
3	3.6	DEAD	LinStatic	0.	16.802	0.	0.	0.
3	4.	DEAD	LinStatic	0.	21.003	0.	0.	0.
4	0.	DEAD	LinStatic	0.	-24.366	0.	0.	0.
4	0.4	DEAD	LinStatic	0.	-20.166	0.	0.	0.
4	0.4	DEAD	LinStatic	0.	-20.166	0.	0.	0.
4	0.8	DEAD	LinStatic	0.	-15.965	0.	0.	0.
4	0.8	DEAD	LinStatic	0.	-15.965	0.	0.	0.
4	1.2	DEAD	LinStatic	0.	-11.765	0.	0.	0.
4	1.2	DEAD	LinStatic	0.	-11.765	0.	0.	0.
4	1.6	DEAD	LinStatic	0.	-7.564	0.	0.	0.

Table: Element Forces - Frames, Part 1 of 2

Frame	Station ft	OutputCase	CaseType	P Kip	V2 Kip	V3 Kip	T Kip-ft	M2 Kip-ft
4	1.6	DEAD	LinStatic	0.	-7.564	0.	0.	0.
4	2.	DEAD	LinStatic	0.	-3.363	0.	0.	0.
4	2.	DEAD	LinStatic	0.	-3.363	0.	0.	0.
4	2.4	DEAD	LinStatic	0.	0.837	0.	0.	0.
4	2.4	DEAD	LinStatic	0.	0.837	0.	0.	0.
4	2.8	DEAD	LinStatic	0.	5.038	0.	0.	0.
4	2.8	DEAD	LinStatic	0.	5.038	0.	0.	0.
4	3.2	DEAD	LinStatic	0.	9.238	0.	0.	0.
4	3.2	DEAD	LinStatic	0.	9.238	0.	0.	0.
4	3.6	DEAD	LinStatic	0.	13.439	0.	0.	0.
4	3.6	DEAD	LinStatic	0.	13.439	0.	0.	0.
4	4.	DEAD	LinStatic	0.	17.64	0.	0.	0.
5	0.	DEAD	LinStatic	0.	-1.802	0.	0.	0.
5	1.5	DEAD	LinStatic	0.	2.776E-15	0.	0.	0.

Table: Element Forces - Frames, Part 2 of 2

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
1	0.	DEAD	-1.3517	1-1	0.
1	1.5	DEAD	2.665E-15	1-1	1.5
2	0.	DEAD	-1.3517	2-1	0.
2	0.4	DEAD	4.864	2-1	0.4
2	0.4	DEAD	4.864	2-2	0.
2	0.8	DEAD	9.3994	2-2	0.4
2	0.8	DEAD	9.3994	2-3	0.
2	1.2	DEAD	12.2546	2-3	0.4
2	1.2	DEAD	12.2546	2-4	0.
2	1.6	DEAD	13.4296	2-4	0.4
2	1.6	DEAD	13.4296	2-5	0.
2	2.	DEAD	12.9243	2-5	0.4
2	2.	DEAD	12.9243	2-6	0.
2	2.4	DEAD	10.7388	2-6	0.4
2	2.4	DEAD	10.7388	2-7	0.
2	2.8	DEAD	6.8731	2-7	0.4
2	2.8	DEAD	6.8731	2-8	0.
2	3.2	DEAD	1.3271	2-8	0.4
2	3.2	DEAD	1.3271	2-9	0.
2	3.6	DEAD	-5.8992	2-9	0.4
2	3.6	DEAD	-5.8992	2-10	0.
2	4.	DEAD	-14.8056	2-10	0.4
3	0.	DEAD	-14.8056	3-1	0.
3	0.4	DEAD	-7.2446	3-1	0.4
3	0.4	DEAD	-7.2446	3-2	0.
3	0.8	DEAD	-1.3637	3-2	0.4
3	0.8	DEAD	-1.3637	3-3	0.
3	1.2	DEAD	2.8369	3-3	0.4
3	1.2	DEAD	2.8369	3-4	0.
3	1.6	DEAD	5.3572	3-4	0.4
3	1.6	DEAD	5.3572	3-5	0.
3	2.	DEAD	6.1974	3-5	0.4
3	2.	DEAD	6.1974	3-6	0.

Table: Element Forces - Frames, Part 2 of 2

Frame	Station ft	OutputCase	M3 Kip-ft	FrameElem	ElemStation ft
3	2.4	DEAD	5.3572	3-6	0.4
3	2.4	DEAD	5.3572	3-7	0.
3	2.8	DEAD	2.8369	3-7	0.4
3	2.8	DEAD	2.8369	3-8	0.
3	3.2	DEAD	-1.3637	3-8	0.4
3	3.2	DEAD	-1.3637	3-9	0.
3	3.6	DEAD	-7.2446	3-9	0.4
3	3.6	DEAD	-7.2446	3-10	0.
3	4.	DEAD	-14.8056	3-10	0.4
4	0.	DEAD	-14.8056	4-1	0.
4	0.4	DEAD	-5.8992	4-1	0.4
4	0.4	DEAD	-5.8992	4-2	0.
4	0.8	DEAD	1.3271	4-2	0.4
4	0.8	DEAD	1.3271	4-3	0.
4	1.2	DEAD	6.8731	4-3	0.4
4	1.2	DEAD	6.8731	4-4	0.
4	1.6	DEAD	10.7388	4-4	0.4
4	1.6	DEAD	10.7388	4-5	0.
4	2.	DEAD	12.9243	4-5	0.4
4	2.	DEAD	12.9243	4-6	0.
4	2.4	DEAD	13.4296	4-6	0.4
4	2.4	DEAD	13.4296	4-7	0.
4	2.8	DEAD	12.2546	4-7	0.4
4	2.8	DEAD	12.2546	4-8	0.
4	3.2	DEAD	9.3994	4-8	0.4
4	3.2	DEAD	9.3994	4-9	0.
4	3.6	DEAD	4.864	4-9	0.4
4	3.6	DEAD	4.864	4-10	0.
4	4.	DEAD	-1.3517	4-10	0.4
5	0.	DEAD	-1.3517	5-1	0.
5	1.5	DEAD	-1.332E-15	5-1	1.5

Table: Frame Loads - Distributed, Part 1 of 3

Table: Frame Loads - Distributed, Part 1 of 3

Frame	LoadPat	CoordSys	Type	Dir	DistType	RelDistA
2	DEAD	GLOBAL	Force	Gravity	RelDist	0.
2	E80 Reaction	GLOBAL	Force	Gravity	RelDist	0.
3	DEAD	GLOBAL	Force	Gravity	RelDist	0.
3	E80 Reaction	GLOBAL	Force	Gravity	RelDist	0.
4	DEAD	GLOBAL	Force	Gravity	RelDist	0.
4	E80 Reaction	GLOBAL	Force	Gravity	RelDist	0.

Table: Frame Loads - Distributed, Part 2 of 3

Table: Frame Loads - Distributed, Part 2 of 3

Frame	LoadPat	RelDistB	AbsDistA ft	AbsDistB ft	FOverLA Kip/ft	FOverLB Kip/ft
2	DEAD	1.	0.	4.	9.3	9.3
2	E80 Reaction	1.	0.	4.	59.88	59.88
3	DEAD	1.	0.	4.	9.3	9.3
3	E80 Reaction	1.	0.	4.	59.88	59.88

Table: Frame Loads - Distributed, Part 2 of 3

Frame	LoadPat	RelDistB	AbsDistA ft	AbsDistB ft	FOverLA Kip/ft	FOverLB Kip/ft
4	DEAD	1.	0.	4.	9.3	9.3
4	E80 Reaction	1.	0.	4.	59.88	59.88

Table: Frame Loads - Distributed, Part 3 of 3

Table: Frame Loads - Distributed, Part 3 of 3

Frame	LoadPat	GUID
2	DEAD	637ee67f-34af-467c-831e-af90fba459f0
2	E80 Reaction	ba5eabad-8ff2-4d35-8f7c-b5e6aada42dd
3	DEAD	4953a584-c896-4e7a-b449-4f731b90aecd
3	E80 Reaction	78ad6970-159b-4d2a-ad60-ddcba0ae9e5e
4	DEAD	4c00942b-35ee-4dd8-9026-a5cf544e0a52
4	E80 Reaction	6b66a324-26fc-44b4-9828-245d51dc729d

Table: Frame Section Assignments

Table: Frame Section Assignments

Frame	SectionType	AutoSelect	AnalSect	DesignSect	MatProp
1	Rectangular	N.A.	CAP	CAP	Default
2	Rectangular	N.A.	CAP	CAP	Default
3	Rectangular	N.A.	CAP	CAP	Default
4	Rectangular	N.A.	CAP	CAP	Default
5	Rectangular	N.A.	CAP	CAP	Default

Table: Frame Section Properties 01 - General, Part 1 of 7

Table: Frame Section Properties 01 - General, Part 1 of 7

SectionName	Material	Shape	t3 ft	t2 ft	tf ft	tw ft
CAP	4000Psi	Rectangular	2.67	3.		
HP14x117	A709Gr50	I/Wide Flange	1.18	1.24	0.067	0.067

Table: Frame Section Properties 01 - General, Part 2 of 7

Table: Frame Section Properties 01 - General, Part 2 of 7

SectionName	t2b ft	tfb ft	FilletRadius ft	Area ft2	TorsConst ft4	I33 ft4	I22 ft4
CAP				8.01	8.919719	4.758541	6.0075
HP14x117	1.24	0.067	0.	0.2362	0.000341	0.05791	0.021317

Table: Frame Section Properties 01 - General, Part 3 of 7

Table: Frame Section Properties 01 - General, Part 3 of 7

SectionName	I23 ft4	AS2 ft2	AS3 ft2	S33Top ft3	S33Bot ft3	S22Left ft3	S22Right ft3
CAP	0.	6.675	6.675	3.56445	3.56445	4.005	4.005
HP14x117	0.	0.0791	0.1385	0.098153	0.098153	0.034382	0.034382

Table: Frame Section Properties 01 - General, Part 4 of 7

Table: Frame Section Properties 01 - General, Part 4 of 7

SectionName	Z33 ft3	Z22 ft3	R33 ft	R22 ft	CGOffset3 ft	CGOffset2 ft	EccV2 ft
CAP	5.346675	6.0075	0.77076	0.86603	0.	0.	0.
HP14x117	0.110794	0.052683	0.49511	0.30039	0.	0.	0.

Table: Frame Section Properties 01 - General, Part 5 of 7

Table: Frame Section Properties 01 - General, Part 5 of 7

SectionName	EccV3 ft	Cw ft6	ConcCol	ConcBeam	Color	TotalWt Kip	TotalMass Kip-s2/ft
CAP	0.	0.	Yes	No	Magenta	18.023	0.56
HP14x117	0.	0.006594	No	No	Green	0.	0.

Table: Frame Section Properties 01 - General, Part 6 of 7

Table: Frame Section Properties 01 - General, Part 6 of 7

SectionName	FromFile	AMod	A2Mod	A3Mod	JMod	I2Mod	I3Mod
CAP	No	1.	1.	1.	1.	1.	1.
HP14x117	No	1.	1.	1.	1.	1.	1.

Table: Frame Section Properties 01 - General, Part 7 of 7

Table: Frame Section Properties 01 - General, Part 7 of 7

SectionName	MMod	WMod	GUID	Notes
CAP	1.	1.		Added 4/7/2025 11:21:17 AM
HP14x117	1.	1.		Added 7/6/2025 2:05:51 PM

Table: Joint Coordinates, Part 1 of 2

Table: Joint Coordinates, Part 1 of 2

Joint	CoordSys	CoordType	XorR ft	Y ft	Z ft	SpecialJt	GlobalX ft
1	GLOBAL	Cartesian	-7.5	0.	0.	No	-7.5
2	GLOBAL	Cartesian	-6.	0.	0.	No	-6.
3	GLOBAL	Cartesian	-2.	0.	0.	No	-2.
4	GLOBAL	Cartesian	2.	0.	0.	No	2.
5	GLOBAL	Cartesian	6.	0.	0.	No	6.
6	GLOBAL	Cartesian	7.5	0.	0.	No	7.5

Table: Joint Coordinates, Part 2 of 2

Table: Joint Coordinates, Part 2 of 2			
Joint	GlobalY ft	GlobalZ ft	GUID
1	0.	0.	7f72fa35-af06-4277-be19 -d6a3a1934a82
2	0.	0.	0c7acf2e-2701-4baf-bf5e -a1c7a86c47fb
3	0.	0.	75a9c4c4-a892-4123-b1 80-4c13c75f760c
4	0.	0.	bb38e22b-fe21-453a-bea 1-8ac063932f0c
5	0.	0.	809a0159-1084-471a-ae 2d-6131f207d755
6	0.	0.	bda850a7-fea9-4700-ba6 3-91b2e670c7f9

Table: Joint Displacements

Table: Joint Displacements								
Joint	OutputCase	CaseType	U1 ft	U2 ft	U3 ft	R1 Radians	R2 Radians	R3 Radians
1	DEAD	LinStatic	0.	0.	0.000012	0.	8.667E-06	0.
2	DEAD	LinStatic	0.	0.	0.	0.	8.941E-06	0.
3	DEAD	LinStatic	0.	0.	0.	0.	-6.507E-07	0.
4	DEAD	LinStatic	0.	0.	0.	0.	6.507E-07	0.
5	DEAD	LinStatic	0.	0.	0.	0.	-8.941E-06	0.
6	DEAD	LinStatic	0.	0.	0.000012	0.	-8.667E-06	0.
~1	DEAD	LinStatic	0.	0.	-7.854E-06	0.	8.634E-06	0.
~2	DEAD	LinStatic	0.	0.	-0.000014	0.	7.456E-06	0.
~3	DEAD	LinStatic	0.	0.	-0.000019	0.	5.680E-06	0.
~4	DEAD	LinStatic	0.	0.	-0.000022	0.	3.578E-06	0.
~5	DEAD	LinStatic	0.	0.	-0.000022	0.	1.422E-06	0.
~6	DEAD	LinStatic	0.	0.	-0.000021	0.	-5.166E-07	0.
~7	DEAD	LinStatic	0.	0.	-0.000018	0.	-1.965E-06	0.
~8	DEAD	LinStatic	0.	0.	-0.000013	0.	-2.652E-06	0.
~9	DEAD	LinStatic	0.	0.	-6.808E-06	0.	-2.304E-06	0.
~10	DEAD	LinStatic	0.	0.	-5.370E-06	0.	1.112E-06	0.
~11	DEAD	LinStatic	0.	0.	-0.00001	0.	1.786E-06	0.
~12	DEAD	LinStatic	0.	0.	-0.000014	0.	1.644E-06	0.
~13	DEAD	LinStatic	0.	0.	-0.000016	0.	9.582E-07	0.
~14	DEAD	LinStatic	0.	0.	-0.000017	0.	0.	0.
~15	DEAD	LinStatic	0.	0.	-0.000016	0.	-9.582E-07	0.
~16	DEAD	LinStatic	0.	0.	-0.000014	0.	-1.644E-06	0.
~17	DEAD	LinStatic	0.	0.	-0.00001	0.	-1.786E-06	0.
~18	DEAD	LinStatic	0.	0.	-5.370E-06	0.	-1.112E-06	0.
~19	DEAD	LinStatic	0.	0.	-6.808E-06	0.	2.304E-06	0.
~20	DEAD	LinStatic	0.	0.	-0.000013	0.	2.652E-06	0.
~21	DEAD	LinStatic	0.	0.	-0.000018	0.	1.965E-06	0.
~22	DEAD	LinStatic	0.	0.	-0.000021	0.	5.166E-07	0.
~23	DEAD	LinStatic	0.	0.	-0.000022	0.	-1.422E-06	0.
~24	DEAD	LinStatic	0.	0.	-0.000022	0.	-3.578E-06	0.
~25	DEAD	LinStatic	0.	0.	-0.000019	0.	-5.680E-06	0.
~26	DEAD	LinStatic	0.	0.	-0.000014	0.	-7.456E-06	0.
~27	DEAD	LinStatic	0.	0.	-7.854E-06	0.	-8.634E-06	0.

Table: Joint Reactions

Table: Joint Reactions								
Joint	OutputCase	CaseType	F1 Kip	F2 Kip	F3 Kip	M1 Kip-ft	M2 Kip-ft	M3 Kip-ft
2	DEAD	LinStatic	0.	0.	19.442	0.	0.	0.
3	DEAD	LinStatic	0.	0.	45.369	0.	0.	0.
4	DEAD	LinStatic	0.	0.	45.369	0.	0.	0.
5	DEAD	LinStatic	0.	0.	19.442	0.	0.	0.

HNTB GEOTECH MEMO

To: Jeff Smith, David Glastetter
From: Kevin Kuhl, Don Hammond
Subject: **GEOTECHNICAL ENGINEERING RECOMMENDATIONS
NORFOLK SOUTHERN RAILROAD (NSRR) SHOOFLY
IMPROVE I-70 PROGRAM
WARRENTON TO WENTZVILLE, ST. CHARLES AND WARREN COUNTIES, MO
JOB NO. J4I1486D**

Date: April 10, 2025
HNTB Job No: 71886

The purpose of this memorandum is to summarize HNTB's geotechnical recommendations for the proposed Norfolk Southern Railway Shoofly Bridge over I-70 at Mile Post S-45.25. It will be located 25 feet south of the current bridge alignment. In the RFP for this project, MoDOT provided plans for this bridge (by HDR) and geotechnical recommendations (by Geotechnology). So that the new EB I-70 pavement can be built and used for maintenance of highway traffic while the shoofly is carrying rail traffic, the JV team has elected to modify the shoofly bridge from 9 spans to 8 spans. Changes to the foundation layout and foundation type are illustrated in the attached markups to Figures 8, taken from Geotechnology's report, titled "Geotechnical Exploration, I-70 Corridor Improvements, MoDOT Project No. J6I0624, Wentzville, Missouri", dated April 6, 2022. The proposed bridge shoofly layout titled Norfolk Southern Railway Shoofly over I-70 Bridge Layout is attached.

The proposed shoofly has an additional bent as compared to the bridge layout provided in the above geotechnical report. The bridge layout provided in the geotechnical report consisted of all pile foundations. The proposed shoofly has two drilled shaft bents, Bents 6 and 7. In general, the pile tip elevation recommendations provided in the report are appropriate. Top of rock at the new bents is expected to be encountered between elevations 605' to 608'.

The field exploration completed by Geotechnology consisted of drilling eleven borings (Borings B-9 through B-21, except B-17) for the NSRR main and shoofly alignments. See attached Figure 3 from the above referenced Geotechnology report.

Drilled Shaft Foundations (Bent 6 and 7)

In general, the limestone encountered at this site has high strength and high RQD (Rock Quality Designation), though low quality rock may be present at the location of some bents for the top 2 ft of rock. For the drilled shafts, it is recommended to either drill through the highly fractured surficial rock or exclude that length from estimating socket side shear resistance. Top of rock for the drilled shafts (bents 6 & 7) is expected at elevations 607.8' and 606.9', respectively. Top of competent rock is expected at elevation 606.8' approximately for both bents.

The minimum unconfined compressive strength of the rock encountered at this site is 6.4 ksi. Assuming concrete with a minimum 28-day compressive strength of 4 ksi is to be used, the allowable rock socket stresses are controlled by the strength of the concrete. Considering a geotechnical factor of safety of 2.5 in compression and/or uplift and side shear reduction factor of 0.7 in uplift, the allowable stress on the rock socket sidewalls is estimated to be 14 ksf in compression and 9.8 ksf in tension/uplift.

The allowable unit tip resistance of the rock socket is estimated to be 926 ksf considering a geotechnical factor of safety of 2.5. If end-bearing is to be relied upon in conjunction with side shear resistance, it is recommended to verify that peak side shear and end-bearing resistances can be mobilized together through field load testing. Otherwise, it is recommended to limit the axial compression capacity of the rock socket to either total side shear capacity or total end-bearing capacity.

Table 1: Drilled Shaft Design

Shoofly Bent No.	Boring Number	Top of Rock Elevation (ft)	Top of Competent Rock Elevation (ft)	Lowest Bottom of Casing Elevation (ft) ¹
Bent 6	B-11 & B-16	607.8	606.8	605.8
Bent 7	B-12	606.9	606.9	605.9

The minimum recommended drilled shaft tip elevation should be two diameters below bottom of casing.

Pile Foundations (Bent 1, Bent 2, Bent 3, Bent 4, Bent 5, Bent 8, Bent 9)

The table below provides the top of rock elevation, top of competent rock elevation, pile refusal elevation and prebore length. See notes 1 and 2 below the table for an explanation of the last two columns.

Table 2: Pile Design

Shoofly Bent No.	Boring Number	Top of Rock Elevation (ft)	Top of Competent Rock Elevation (ft)	Anticipated Pile Refusal Elevation (ft) ¹	Prebore Below Top of Competent Rock (Tip Elevation) (ft) ²
East Abutment, End Bent 1 (Pile Bent)	B-13	606.2	605.2	603	No Prebore
Bent 2 (Pile Bent)	B-20, B-14, B-13	605.8	604.6	NA	5 ft Minimum
Bent 3 (Pile Bent)	B-14, B-10	606.5	604.6	NA	5 ft Minimum
Bent 4 (Pile Bent)	B-9, B-10	607.2	605.8	NA	5 ft Minimum
Bent 5 (Pile Bent)	B-11, B-9	607.6	606.6	NA	5 ft Minimum
Bent 8 (Pile Bent)	B-15, B-12	606.0	606.0	NA	5 ft Minimum
West Abutment, Bent 9 (Pile Bent)	B-15	605	605	603	No Prebore

Note 1: Bent 1 and Bent 9 piles should be driven to pile refusal elevation. NA indicates piles at these bents are not to be driven to rock without prebore. Note 2: Prebore depth is 5 ft minimum below top of competent rock.

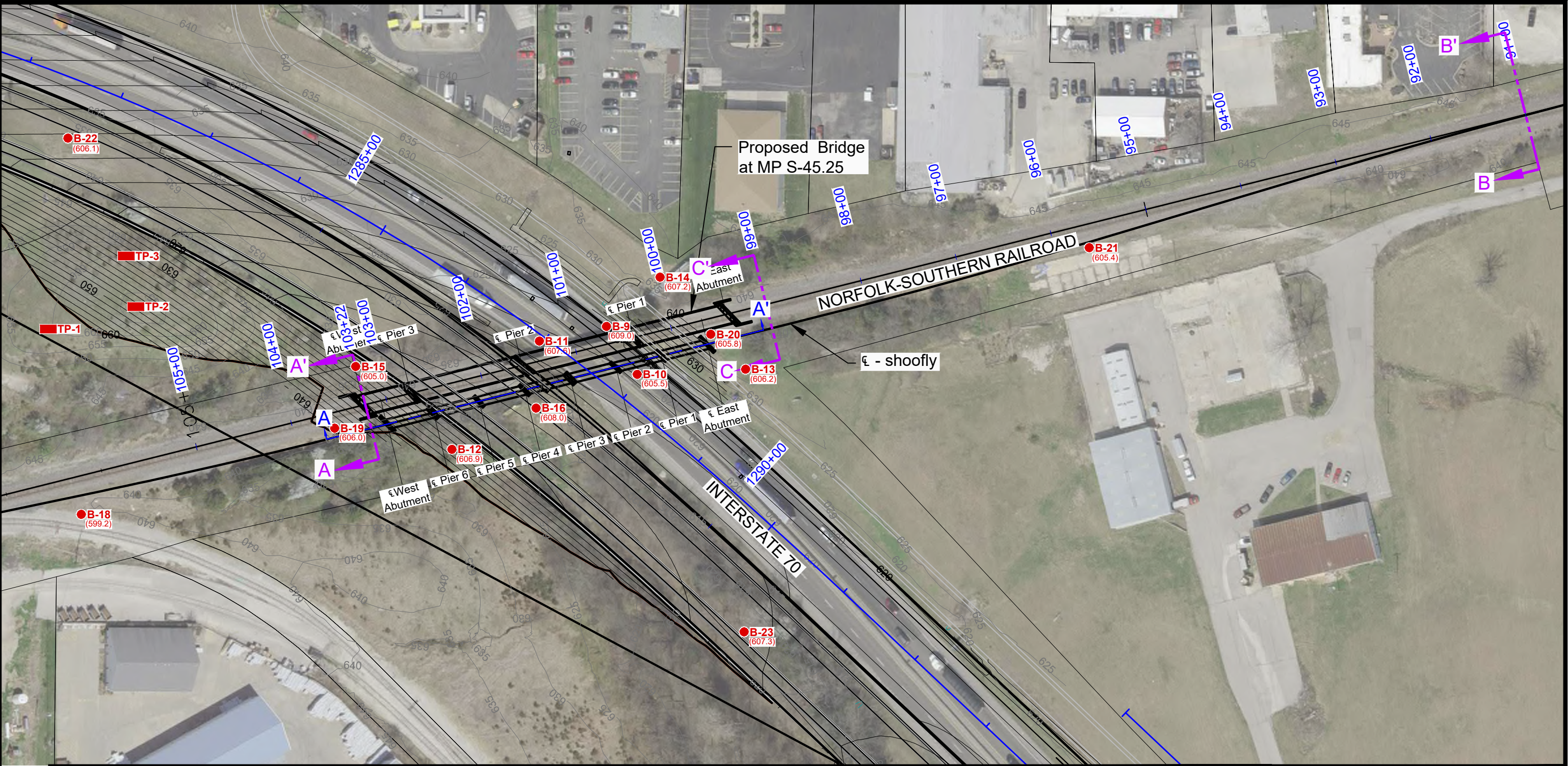
Following preboring the piles at Bent 2, Bent 3, Bent 4, Bent 5, and Bent 8, the pile should be dropped in the prebored hole. Once the pile is centered in the prebored hole, concrete with a minimum compressive strength of 4000 psi should be used to backfill the prebored hole from tip of pile to ground surface.

Don Hammond, P.E.
Geotechnical Engineer

Kevin Kuhl, P.E.
Geotechnical Engineer

Attachments: Figure 3 From Geotechnology Report
 Figure 8 Form Geotechnology Report
 Norfolk Southern Railway Shoofly over I-70 Bridge Layout

ATTACHMENTS

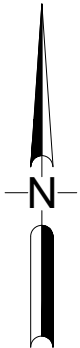


NOTES

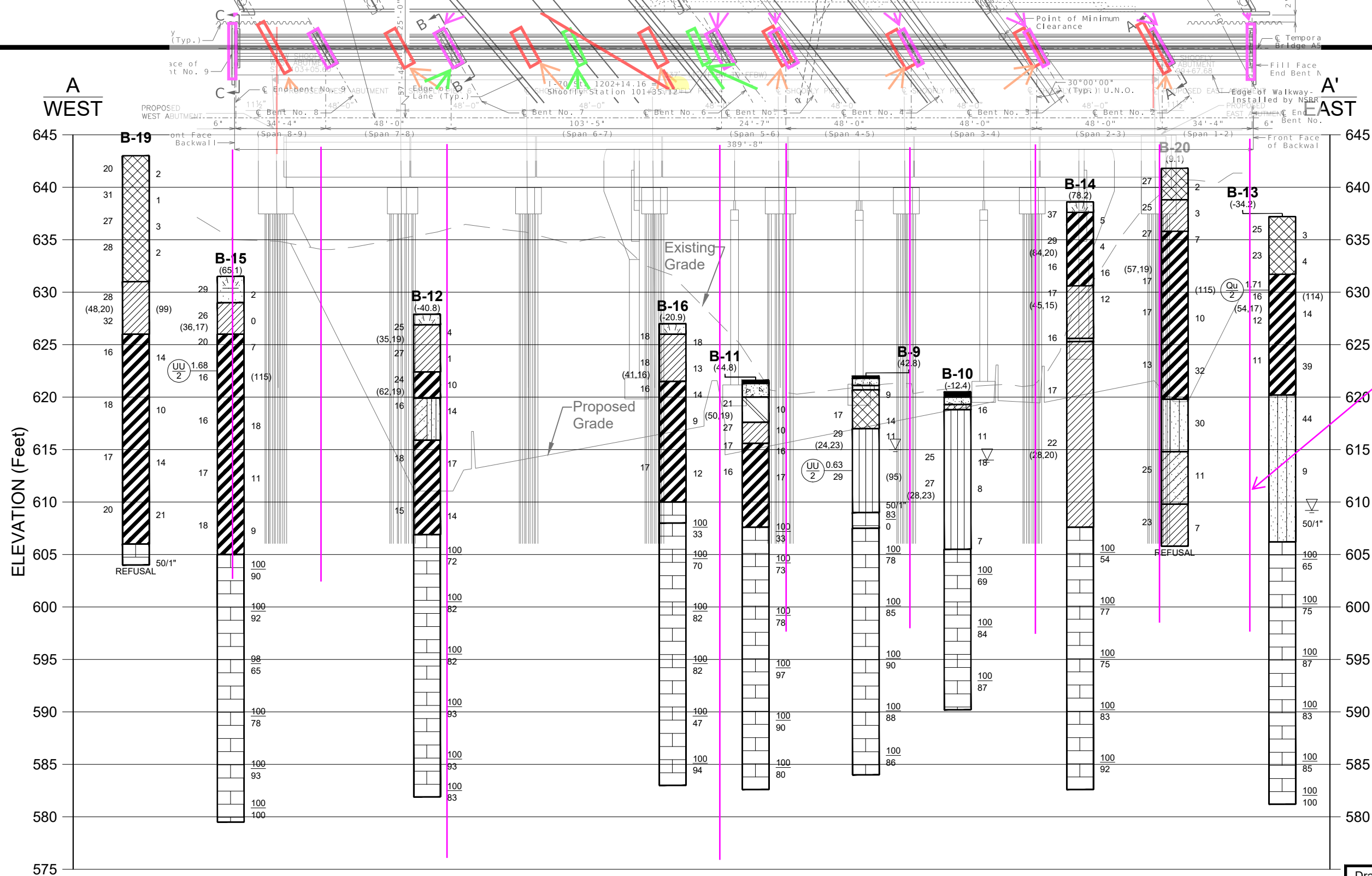
1. Plan adapted from "2015 Aerial Imagery for the St. Louis Region" supplied by East-West Gateway Council of Governments.
2. The borings and test pits were located by Geotechnology and were subsequently surveyed by the project surveyor.

LEGEND

- Test Pit Location
- Boring Location
- Approximate Auger Refusal Elevation, feet
- Slope Stability Section Location
- Generalized Subsurface Profile (See Figure 8 for Cross-Section A-A')



Drawn By: WAH	Ck'd By: SK	App'vd By: AWR
Date: 2-3-22	Date: 3-22-22	Date: 4-5-22
 I-70 Corridor Improvements MoDOT Project J6I0624 Wentzville, Missouri		
DETAIL AREA 1, BORING AND TEST PIT LOCATIONS		
Project Number J032438.03		FIGURE 3



NOTES

1. See Figure 3 for location of Generalized Subsurface Profile A-A'.
2. Data concerning subsurface conditions were obtained at boring locations only.

BENT LOCATIONS
AS OF 2/28/2025

SCALE IN FEET
Horizontal 1" = 40'
Vertical 1" = 10'

KEY TO BOREHOLE SYMBOLS

Asphalt	Concrete	Crushed Rock
Topsoil	Fill	Lean Clay
Fat Clay	Lean to Fat Clay	Silt
Silty Sand	Clayey Sand	Limestone

KEY TO TEST DATA

Natural Water Content in Percent
Liquid and Plastic Limits

21
(58,31)

Shear Strength in TSF
from Indicated Test

0.73

Unconfined Compression
Unconsolidated, Undrained
Compression

Qu
2
UU
2

Standard Penetration Test Resistance (No. of Blows of a 140-lb. Hammer Dropping 30-in.
Required to Drive a 2-in. O.D. Split Spoon One Foot or Indicated Depth - "S" Denotes Seating)

(97) Dry Unit Weight in Pounds per Cubic Foot

Groundwater Elevation Observed at Time of Drilling

100
83 Percent Core Recovery
R.Q.D.*

*R.Q.D. Denotes Modified Core Recovery Percentage in Which Only Pieces
of Sound Core Over 4 Inches Long are Counted as Recovery

Drawn By: WAH	Ck'd By: SK	App'vd By: AWR
Date: 2-9-22	Date: 3-22-22	Date: 4-5-22

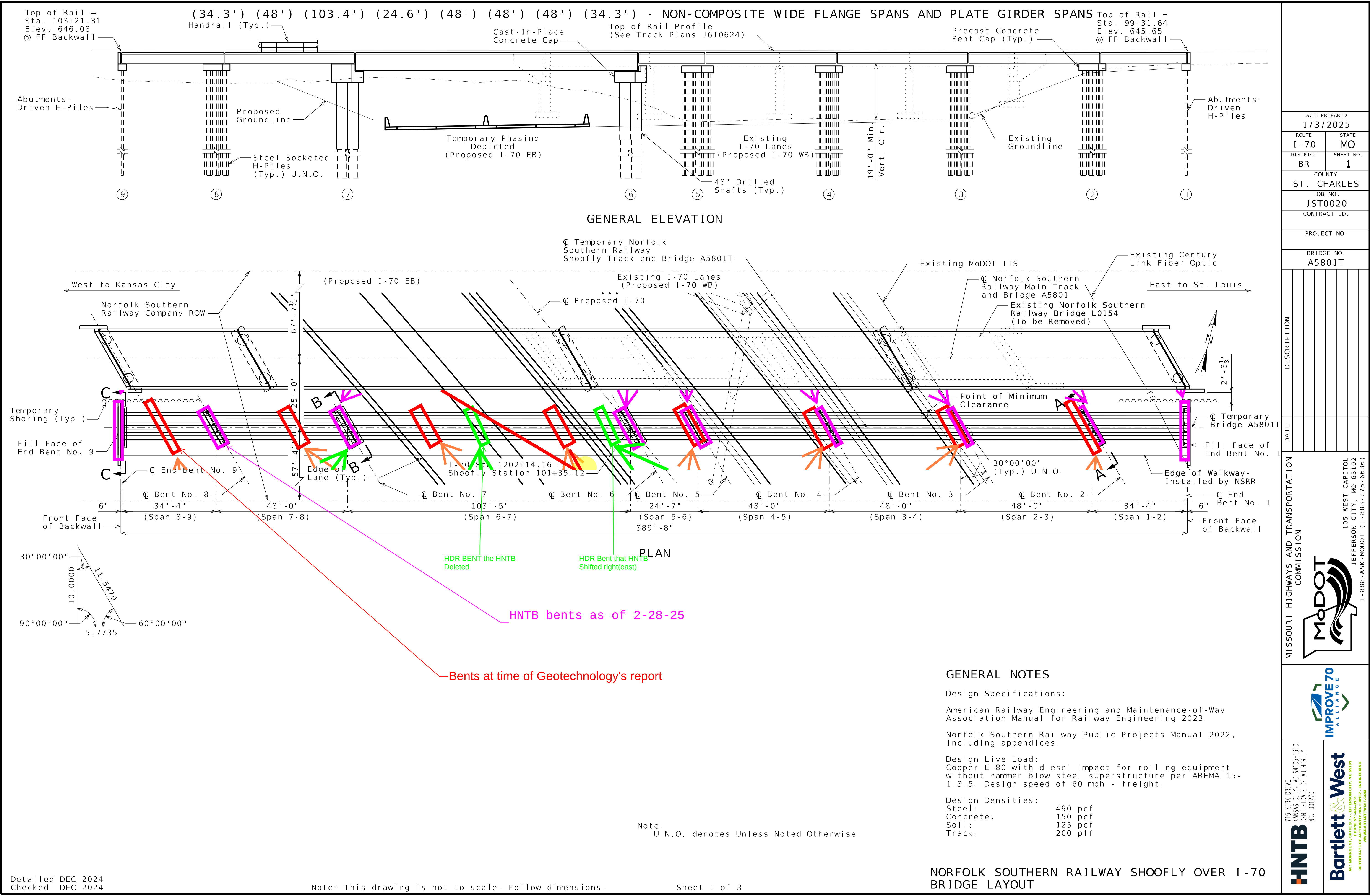


I-70 Corridor Improvements
MoDOT Project J6I0624
Wentzville, Missouri

GENERALIZED SUBSURFACE PROFILE ALONG NSRR BRIDGE

Project Number
J032438.03

FIGURE 8



Detailed DEC 2024
Checked DEC 2024

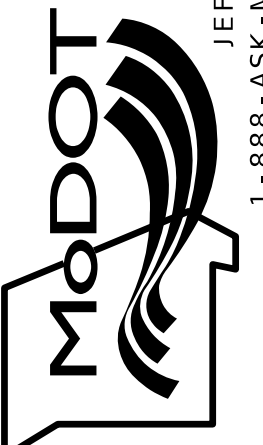
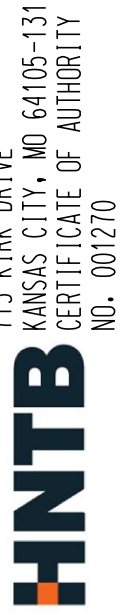
Note: This drawing is not to scale. Follow dimensions.

Sheet 1 of 3

NORFOLK SOUTHERN RAILWAY SHOOFLY OVER I-70 BRIDGE LAYOUT

GENERAL NOTES

Design Specifications:
American Railway Engineering and Maintenance-of-Way Association Manual for Railway Engineering 2023.
Norfolk Southern Railway Public Projects Manual 2022, including appendices.
Design Live Load:
Cooper E-80 with diesel impact for rolling equipment without hammer blow steel superstructure per AREMA 15-1.3.5. Design speed of 60 mph - freight.
Design Densities:
Steel: 490 pcf
Concrete: 150 pcf
Soil: 125 pcf
Track: 200 plf

DATE PREPARED 1/3/2025	
ROUTE I-70	STATE MO
DISTRICT BR	SHEET NO. 1
COUNTY ST. CHARLES	
JOB NO. JST0020	
CONTRACT ID.	
PROJECT NO.	
BRIDGE NO. A5801T	
DESCRIPTION	DATE
MISSOURI HIGHWAYS AND TRANSPORTATION COMMISSION	
	
	
 715 KIRK DRIVE KANSAS CITY, MO 64105-1310 PHONE 874-3331 FAX 874-3331 WWW.HNTB.COM	
 601 INDORE ST., SUITE 201 - JEFFERSON CITY, MO 65101 PHONE 874-3331 FAX 874-3331 WWW.BARTLETTWEST.COM	

BEARING DESIGN

HNTB	Document number: QF 06
Calculation Cover Sheet	Page 1 of __

Project: NSRR Shoofly over I-70	Job No: 71886	Design Criteria Document: Below
Client: NSRR / MODOT	Discipline: Bridge	Calculation No:

Name or Description of Calculation: Bearing design

Note: Unique QF 06 to be created for each revision of a calculation.

Calc. Rev. No.	Description of Change (i.e., Original Issue or description of changes since last revision)	Confirmation required with other deliverables (Y/N)	List Deliverables for which confirmation is required (NA if none) Add additional rows as necessary	Confirmation Verified by Originator of Calc for each deliverable listed (Y/N)

Calculation Objective: Size bearings for two different span configurations – 48’ and 103’. The 48’ design will work for all the shorter spans.
--

Calculation Methodology/List of Assumptions: AREMA 2024 chapter 15 with some detail items from BNSF standards

References/Inputs: AREMA 2024, BNSF Standard Drawings 2024
--

Attachments: (List each attachment following the subject calculation)
--

Conclusions: For 48’ and shorter spans – 2”x12”x20” Steel reinforced elastomeric For 103’ span – 5 1/4”x14”x20” Steel reinforced elastomeric

Document Check:	Name:	Initials:	Date:
Originator:	Todd Kelley	TSK	7/14/2025
Checker:	Temple Overman	TIO	7/16/2025
Backchecker:	Todd Kelley	TSK	7/17/2025
Updater:	Todd Kelley	TSK	7/17/2025
Verifier:	Temple Overman	TIO	7/20/2025

BEARING DESIGN (103' SPAN)

NSRR Shoofly- Bearing Design - Span 6 - 103'

References:
AREMA Manual for Railway Engineering, 2024

Material Properties

Structural Steel Yield Stress	$F_y := 50 \text{ ksi}$	(AREMA Table 15-1-1)
Modulus of Elasticity	$E_s := 29000 \text{ ksi}$	

Bridge Geometry

Out-to-Out Beam Length	$L := 103 \text{ ft} + 1 \text{ in}$
------------------------	--------------------------------------

Girder Dimensions

Bottom Flange Thickness	$t_{bf} := 2.5 \text{ in}$
Bottom Flange Width	$b_{bf} := 16 \text{ in}$

Bearing Design Parameters

Thickness of Sole Plate	$t_{sp} := 2 \text{ in}$	Minimum thickness is 3/4" - 2" to match BNSF std	(AREMA 15-5.3.5)
Thickness of Masonry Plate	$t_{mp} := 0 \text{ in}$		
Thickness of Masonry Plate Bearing Pad	$t_{mp, bp} := 0 \text{ in}$	70 Durometer	
Width of Bearing Pad (perpendicular to longitudinal axis)	$w_{brg} := 20 \text{ in}$		
Length of Bearing Pad (parallel to longitudinal axis)	$l_{brg} := 14 \text{ in}$		
Area of Bearing Pad	$A := l_{brg} \cdot w_{brg} = 280 \text{ in}^2$		
Exterior Elastomeric Layer	$t_e := 0.375 \text{ in}$		
Interior Elastomeric Layer	$t_i := 0.5 \text{ in}$		
Number of Interior Layers	$N_{in, l} := 4$		
Elastomeric Thickness	$t_{brg} := (N_{in, l} \cdot t_i) + (2 \cdot t_e) = 2.75 \text{ in}$	70 Durometer	
Min. Shear Modulus, Neoprene	$G_{min} := 165 \text{ psi}$	70 dur (AREMA Table 15-5-7)	
Max. Shear Modulus, Neoprene	$G_{max} := 245 \text{ psi}$	70 dur (AREMA Table 15-5-7)	

Loads

(From Main span cap design sheet)

Dead Load reaction

$$R_D := \frac{145 \text{ kip}}{4} = 36.25 \text{ kip} \quad \text{per girder}$$

Shear Live Load + Impact
(IM + RE) + EC + CF

$$R_{L.I} := \frac{(305 \cdot 2 \text{ kip}) \cdot (1 + .35)}{4} = 205.875 \text{ kip} \quad \text{per girder}$$

Total Reaction

$$R_{total} := R_D + R_{L.I} = 242.125 \text{ kip} \quad \text{per girder}$$

Shear Deformation

(AREMA 15-5.1.2c)

Using 80 degree Fahrenheit temperature differential for design.

Joint space shall be capable of accommodating full longitudinal movement plus a construction tolerance of 1/2" per 100 ft span - 15.5.1.3.c

Maximum Shear Deformation Limit

$$\delta_{all} := \frac{t_{brg}}{2} = 1.375 \text{ in}$$

(AREMA 15-5.6.3.7b)

Temperature Differential

$$\Delta T := 90 \text{ } ^\circ F$$

Deformation - Temp. Zone 2 -
15.5.1.2c

$$\delta_{temp} := \frac{1.25 \text{ in}}{100 \text{ ft}} \cdot L = 1.289 \text{ in}$$

Coefficient of Expansion - Steel

$$\alpha := 0.0000065 \frac{\text{ft}}{^\circ F}$$

Shear Deformation

$$\delta_{steel} := \alpha \cdot \Delta T \cdot L = 0.724 \text{ in}$$

Determination of Controlling
Deformation

$$\delta_{control} := \max(\delta_{steel}, \delta_{temp}) = 1.289 \text{ in}$$

Shear force induced by shear
deformation

$$F_s := \frac{\left(\frac{G_{max} + G_{min}}{2} \right) \cdot \delta_{control} \cdot A}{t_{brg}} = 26.895 \text{ kip}$$

Deformation is along the skew (30 degrees)
therefore deformation checks are for both
axis of the pad

Deformation - longitudinal

$$\delta_x := \delta_{control} \cdot \sin(60^\circ) = 1.116 \text{ in}$$

Deformation - transverse

$$\delta_y := \delta_{control} \cdot \cos(60^\circ) = 0.644 \text{ in}$$

Capacity over Demand Ratio

$$C.D. := \frac{\delta_{all}}{\max(\delta_x, \delta_y)} = 1.23$$

$$\text{if } (\delta_{all} > \max(\delta_x, \delta_y), \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

Compressive Stress

(AREMA 15-5.6.3.4)

Modifying Factor

$$k_{brg} := 1.0$$

(AREMA 15-5.6.3.3)

Shape Factor

$$S_{brg} := \frac{l_{brg} \cdot w_{brg}}{2 \cdot t_i \cdot (l_{brg} + w_{brg})} = 8.235$$

(AREMA 15-5.6.3.3)

Allowable Compressive Stress

$$\sigma_{all,brg} := \min \left(1000 \text{ psi}, \frac{G_{min} \cdot S_{brg}}{k_{brg}} \right) = 1000 \text{ psi}$$

Max. Compressive Stress

$$\sigma_{brg} := \frac{R_{total}}{A} = 864.7 \text{ psi}$$

Capacity over Demand Ratio

$$C.D. := \frac{\sigma_{all,brg}}{\sigma_{brg}} = 1.16$$

$$\text{if } (\sigma_{all,brg} > \sigma_{brg}, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

Compressive Deflection

(AREMA 15-5.6.3.5)

Allowable Deflection

$$\Delta_{all} := \min (0.07 \cdot t_{brg}, 0.125 \text{ in}) = 0.125 \text{ in}$$

S/K

$$\frac{S_{brg}}{k_{brg}} = 8.235 \text{ Used to find compressive strain}$$

Compressive Strain Factor

$$e_c := 3.0\%$$

(Fig. 15-5-1, Graph A)

Instantaneous Deflection

$$d_c := e_c \cdot t_{brg} = 0.083 \text{ in}$$

$$\text{if } (\Delta_{all} > d_c, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

Steel Reinforcement Check

(AREMA 15-5.6.3.9)

Minimum Allow. Reinf. Thickness

$$t_{min,r} := 0.092 \cdot (t_i) = 0.046 \text{ in}$$

Thickness of Steel Plate

$$t_{plate} := 0.1046 \text{ in} \quad 12 \text{ Gage}$$

$$\text{if } (t_{plate} > t_{min,r}, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

Number of reinforcement layers

$$N_p := N_{in,l} + 1 = 5$$

total steel thickness

$$t_r := t_{plate} \cdot N_p = 0.523 \text{ in}$$

Bearing Rotation Check

(AREMA 15-5.6.3.6)

Dead plus live (w/impact) moment
- Per girder
Girder moment of inertia

$$M_{max} := 5419 \text{ kip} \cdot \text{ft}$$

$$I_{girder} := 154363 \text{ in}^4$$

Rotation

$$\theta_{girder} := \frac{M_{max} \cdot L}{3 \cdot E_s \cdot I_{girder}} = 0.006$$

Allowable Relative Rotation

$$rot_{all} := 2 \cdot d_c = 0.165 \text{ in}$$

Relative Rotation

$$rot := l_{brg} \cdot \theta_{girder} = 0.084 \text{ in}$$

$$\text{if } (rot < rot_{all}, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

Stability Check

(AREMA 15-5.6.3.8)

Thickness check

$$t_{max} := \min \left(\frac{l_{brg}}{3}, \frac{w_{brg}}{3} \right) = 4.667 \text{ in}$$

$$\text{if } (t_{max} \geq t_{brg}, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

Stiffener Check

(AREMA 15-5.6.3.11)

Flange Width

$$b_{bf} = 1.333 \text{ ft}$$

Flange Thickness + Coverplate

$$t_{f.s} := t_{bf} + t_{sp} = 4.5 \text{ in}$$

Compressive Stress

$$f_a := \frac{R_{total}}{A} = 864.732 \text{ psi}$$

$$\text{if } \left(\frac{b_{bf}}{2 \cdot t_{f.s}} \leq \left(\frac{F_y}{3.4 \cdot f_a} \right)^{0.5}, \text{"okay"}, \text{"need add'l stiffeners"} \right) = \text{"okay"}$$

Girder flanges are stiff enough to not damage bearing, no additional stiffeners needed.

Bearing Total Thickness

$$t_{bg.tot} := t_{sp} + t_{mp} + t_{mp.bp} + t_{brg} + t_r = 5.273 \text{ in}$$

BEARING DESIGN (48' SPAN)

NSRR Shoofly- Bearing Design - 48' Span

References:
AREMA Manual for Railway Engineering, 2024

Material Properties

Structural Steel Yield Stress	$F_y := 50 \text{ ksi}$	(AREMA Table 15-1-1)
Modulus of Elasticity	$E_s := 29000 \text{ ksi}$	

Bridge Geometry

Out-to-Out Beam Length	$L := 48 \text{ ft} + 2.25 \text{ in}$
------------------------	--

Girder Dimensions

Bottom Flange Thickness	$t_{bf} := 1.25 \text{ in}$
Bottom Flange Width	$b_{bf} := 15.8 \text{ in}$

Bearing Design Parameters

Thickness of Sole Plate	$t_{sp} := 2 \text{ in}$	Minimum thickness is 3/4" - 2" to match BNSF std	(AREMA 15-5.3.5)
Thickness of Masonry Plate	$t_{mp} := 0 \text{ in}$		
Thickness of Masonry Plate Bearing Pad	$t_{mp, bp} := 0 \text{ in}$	70 Durometer	
Width of Bearing Pad (perpendicular to longitudinal axis)	$w_{brg} := 20 \text{ in}$		
Length of Bearing Pad (parallel to longitudinal axis)	$l_{brg} := 12 \text{ in}$		
Area of Bearing Pad	$A := l_{brg} \cdot w_{brg} = 240 \text{ in}^2$		
Exterior Elastomeric Layer	$t_e := 0.375 \text{ in}$		
Interior Elastomeric Layer	$t_i := 0.5 \text{ in}$		
Number of Interior Layers	$N_{in, l} := 2$		
Elastomeric Thickness	$t_{brg} := (N_{in, l} \cdot t_i) + (2 \cdot t_e) = 1.75 \text{ in}$	70 Durometer	
Min. Shear Modulus, Neoprene	$G_{min} := 165 \text{ psi}$		70 dur (AREMA Table 15-5-4)
Max. Shear Modulus, Neoprene	$G_{max} := 245 \text{ psi}$		70 dur (AREMA Table 15-5-4)

Loads

(From Main span cap design sheet)

Dead Load reaction

$$R_D := \frac{48 \text{ kip}}{4} = 12 \text{ kip} \quad \text{per girder}$$

Shear Live Load + Impact
(IM + RE) + EC + CF

$$R_{L.I} := \frac{167 \cdot 1.47 \cdot 2 \text{ kip}}{4} = 122.745 \text{ kip} \quad \text{per girder}$$

Total Reaction

$$R_{total} := R_D + R_{L.I} = 134.745 \text{ kip} \quad \text{per girder}$$

Shear Deformation

(AREMA 15-5.1.2c)

Using 80 degree Fahrenheit temperature differential for design.

Joint space shall be capable of accommodating full longitudinal movement plus a construction tolerance of 1/2" per 100 ft span - 15.5.1.3.c

Maximum Shear Deformation Limit

$$\delta_{all} := \frac{t_{brg}}{2} = 0.875 \text{ in}$$

(AREMA 15-5.6.3.7b)

Temperature Differential

$$\Delta T := 90 \text{ }^{\circ}\text{F}$$

Deformation - Temp. Zone 2 -
15.5.1.2c

$$\delta_{temp} := \frac{1.25 \text{ in}}{100 \text{ ft}} \cdot L = 0.602 \text{ in}$$

Coefficient of Expansion - Steel

$$\alpha := 0.0000065 \frac{\text{ft}}{^{\circ}\text{F}}$$

Shear Deformation

$$\delta_{steel} := \alpha \cdot \Delta T \cdot L = 0.338 \text{ in}$$

Determination of Controlling
Deformation

$$\delta_{control} := \max(\delta_{steel}, \delta_{temp}) = 0.602 \text{ in}$$

Shear force induced by shear
deformation

$$F_s := \frac{\left(\frac{G_{max} + G_{min}}{2} \right) \cdot \delta_{control} \cdot A}{t_{brg}} = 16.934 \text{ kip}$$

Deformation is along the skew (30 degrees)
therefore deformation checks are for both
axis of the pad

Deformation - longitudinal

$$\delta_x := \delta_{control} \cdot \sin(60^{\circ}) = 0.522 \text{ in}$$

Deformation - transverse

$$\delta_y := \delta_{control} \cdot \cos(60^{\circ}) = 0.301 \text{ in}$$

Capacity over Demand Ratio

$$C.D. := \frac{\delta_{all}}{\max(\delta_x, \delta_y)} = 1.68$$

$$\text{if } (\delta_{all} > \max(\delta_x, \delta_y), \text{ "OK", "NG"}) = \text{ "OK"}$$

Compressive Stress

(AREMA 15-5.6.3.4)

Modifying Factor

$$k_{brg} := 1.0$$

(AREMA 15-5.6.3.3)

Shape Factor

$$S_{brg} := \frac{l_{brg} \cdot w_{brg}}{2 \cdot t_i \cdot (l_{brg} + w_{brg})} = 7.5$$

(AREMA 15-5.6.3.3)

Allowable Compressive Stress

$$\sigma_{all,brg} := \min \left(1000 \text{ psi}, \frac{G_{min} \cdot S_{brg}}{k_{brg}} \right) = 1000 \text{ psi}$$

Max. Compressive Stress

$$\sigma_{brg} := \frac{R_{total}}{A} = 561.4 \text{ psi}$$

Capacity over Demand Ratio

$$C.D. := \frac{\sigma_{all,brg}}{\sigma_{brg}} = 1.78$$

$$\text{if } (\sigma_{all,brg} > \sigma_{brg}, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

Compressive Deflection

(AREMA 15-5.6.3.5)

Allowable Deflection

$$\Delta_{all} := \min (0.07 \cdot t_{brg}, 0.125 \text{ in}) = 0.123 \text{ in}$$

S/K

$$\frac{S_{brg}}{k_{brg}} = 7.5 \quad \text{Used to find compressive strain}$$

Compressive Strain Factor

$$e_c := 2.5\%$$

(Fig. 15-5-1, Graph A)

Instantaneous Deflection

$$d_c := e_c \cdot t_{brg} = 0.044 \text{ in}$$

$$\text{if } (\Delta_{all} > d_c, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

Steel Reinforcement Check

(AREMA 15-5.6.3.9)

Minimum Allow. Reinf. Thickness

$$t_{min,r} := 0.092 \cdot (t_i) = 0.046 \text{ in}$$

Thickness of Steel Plate

$$t_{plate} := 0.1046 \text{ in} \quad 12 \text{ Gage}$$

$$\text{if } (t_{plate} > t_{min,r}, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

Number of reinforcement layers

$$N_p := N_{in,l} + 1 = 3$$

total steel thickness

$$t_r := t_{plate} \cdot N_p = 0.314 \text{ in}$$

Bearing Rotation Check

(AREMA 15-5.6.3.6)

Dead plus live (w/impact) moment
- Per girder
Girder moment of inertia

$$M_{max} := 1424 \text{ kip} \cdot \text{ft}$$

$$I_{girder} := 20667 \text{ in}^4$$

Rotation

$$\theta_{girder} := \frac{M_{max} \cdot L}{3 \cdot E_s \cdot I_{girder}} = 0.005$$

Allowable Relative Rotation

$$rot_{all} := 2 \cdot d_c = 0.088 \text{ in}$$

Relative Rotation

$$rot := l_{brg} \cdot \theta_{girder} = 0.066 \text{ in}$$

$$\text{if } (rot < rot_{all}, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

Stability Check

(AREMA 15-5.6.3.8)

Thickness check

$$t_{max} := \min \left(\frac{l_{brg}}{3}, \frac{w_{brg}}{3} \right) = 4 \text{ in}$$

$$\text{if } (t_{max} \geq t_{brg}, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

Stiffener Check

(AREMA 15-5.6.3.11)

Flange Width

$$b_{bf} = 1.317 \text{ ft}$$

Flange Thickness + Coverplate

$$t_{f.s} := t_{bf} + t_{sp} = 3.25 \text{ in}$$

Compressive Stress

$$f_a := \frac{R_{total}}{A} = 561.438 \text{ psi}$$

$$\text{if } \left(\frac{b_{bf}}{2 \cdot t_{f.s}} \leq \left(\frac{F_y}{3.4 \cdot f_a} \right)^{0.5}, \text{"okay"}, \text{"need add'l stiffeners"} \right) = \text{"okay"}$$

Girder flanges are stiff enough to not damage bearing, no additional stiffeners needed.

Bearing Total Thickness

$$t_{bg,tot} := t_{sp} + t_{mp} + t_{mp.bp} + t_{brg} + t_r = 4.064 \text{ in}$$

Anchor Bolt Design

Bearing anchor bolts - 5 per sole plate

References:

AREMA Manual for Railway Engineering, 2024

ACI Building Code Requirements for Structural Concrete 318-14

Material Properties

Concrete Strength

$$f'_c := 4500 \text{ psi}$$

Modification Factor

$$\lambda_a := 1$$

(ACI Table 19.2.4.2)

Bolt Properties

Yield Strength

$$F_y := 105 \text{ ksi}$$

Bolt Diameter

$$d_a := 2.25 \text{ in}$$

Number of Threads/Inch

$$n_t := 5$$

Bolt Effective Shear Cross
Sectional Area

$$A_{se,V} := \frac{\pi}{4} \left(d_a - \frac{0.9743 \text{ in}}{n_t} \right)^2 = 3.317 \text{ in}^2$$

(ACI R17.5.1.2)

Number of Bolts

$$n := 5$$

Anchor Bolt Embed.

$$h_{ef} := 1 \text{ ft}$$

Anchor Bolt Spacing-
avg

$$S_I := 2.67 \text{ ft}$$

Loading

Wind on Loaded Structure	$V_{WS} := 30 \text{ psf} \cdot 1.5 \cdot 83 \text{ in} \cdot \frac{103.08 \text{ ft}}{2} = 16.042 \text{ kip}$
Wind on Live Load	$V_{WL} := 300 \text{ plf} \cdot \frac{103.08 \text{ ft}}{2} = 15.462 \text{ kip}$
Longitudinal wind Force	$V_{WLONG} := 0.25 \cdot V_{WS} = 4.01 \text{ kip}$
Longitudinal Force (est. 90% load to fixed bearings)	$V_{LF} := 0.9 \cdot 25 \text{ kip} \cdot \sqrt{103.08} = 228.439 \text{ kip}$
Resultant Force	$V_{tot} := \sqrt{(V_{WS} + V_{WL})^2 + (V_{WLONG} + V_{LF})^2} = 234.574 \text{ kip}$

Steel Strength of Anchor in Shear

Bolt Tensile Strength	$f_u := 125 \text{ ksi}$	(AREMA Table 15-5-13)
Bolt Shear allowable Strength	$v_{allow} := f_u \cdot 0.2 = 25 \text{ ksi}$	15.5.2.1
Bolt Area	$A_{bolt} := \frac{d_a^2 \cdot \pi}{4} = 3.976 \text{ in}^2$	
Bolt Stress	$v_{bolt} := \frac{V_{tot} \cdot \frac{1}{n}}{A_{bolt}} = 11.799 \text{ ksi}$	

if $(v_{allow} > v_{bolt}, \text{"OK"}, \text{"not ok"}) = \text{"OK"}$

Concrete Breakout Strength of Anchor in Shear

Sufficient fully developed reinforcement surround anchor bolt locations in the form of main top reinforcement, skin reinforcement, and stirrups. Therefore shear breakout is ok by inspection.

Steel Strength of Anchor in Bending

Bending Moment arm = bearing height	$Arm := 3.27 \text{ in}$
Moment in single anchor	$M_{anchor} := \frac{V_{tot}}{n \cdot 2} \cdot Arm = 76.706 \text{ kip} \cdot \text{in}$
Anchor Plastic section	$Z := \frac{d_a^3}{6} = 1.898 \text{ in}^3$
Bending Stress	$f_b := \frac{M_{anchor}}{Z} = 40.405 \text{ ksi}$
Allowable bending stress	$F_b := 0.38 \cdot f_u = 47.5 \text{ ksi}$

if $(F_b > f_b, \text{"OK"}, \text{"not ok"}) = \text{"OK"}$

$$CD := \frac{F_b}{f_b} = 1.176$$

SUPERSTRUCTURE DESIGN

HNTB	Prepared by: M. Ellis (M. Briggs)	Approved by: D. Evans	Document number: QF 06
Calculation Cover Sheet	Revision Number: 0 (KCO_2)	Revision Date: 01/22/16 (05/12/2017)	Page 1 of ____ (includes attachments)

Project: NSRR Shoofly over I-70	Job No: 71886	Design Criteria Document: (See Below)
Client: NSRR / MoDOT	Discipline: Bridge	Calculation No:

Name or Description of Calculation: NSRR Shoofly Bridge Girder Design				
Calc. Rev. No.	Originator	Checker	Senior Technical Reviewer (if required)	Confirmation Required (Y/N)

Calculation Objective: Size girders for NSRR Shoofly Bridge -Verify girder sizing from previous design are adequate for 48'-0" and 34'-4" spans -Design girders for 103'-5" Span and 24'-7" span
--

Calculation Methodology/List of Assumptions: Follow AREMA MRE 2023 ASD steel design specifications
--

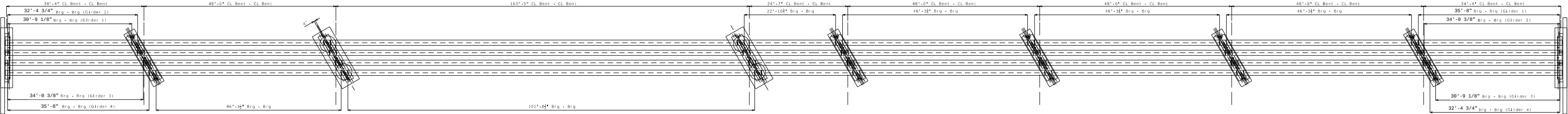
References/Inputs: AREMA MRE 2023

Attachments: (List each attachment following the subject calculation)
--

Conclusions: For 48'-0", 34'-4", and 24'-7" spans use a W44x230 rolled shape For 103'-5" Span use a build-up member with 16"x2.5" flanges and a 78"x.625" Web See calculations for more detail
--

Document Check:	Name	Initials	Date
Originator:	Ryan Rogowski / Ryan Rogowski	RCR / RCR	12-18-2024 / 9-12-2025
Checker:	Todd Kelley / Sean Cooney	TSK / STC	12-27-2024 / 9-12-2025
Backchecker:	Ryan Rogowski /	RCR /	1-7-2024 /
Updater:	Ryan Rogowski /	RCR /	1-7-2024 /
Verifier:	Todd Kelley /	TSK /	2-19-2025 /

Applies to all pages unless noted otherwise (), attachments excluded.



Span 8
Girder Section:
W44x230

Span 7
Girder Section:
W44x230

Span 6
Girder Section:
Top Flange = 16" x 2 1/2"
Web = 78" x 5/8"
Btm Flange = 16" x 2 1/2"

Span 5
Girder Section:
W44x230

Span 4
Girder Section:
W44x230

Span 3
Girder Section:
W44x230

Span 2
Girder Section:
W44x230

Span 1
Girder Section:
W44x230

SUPERSTRUCTURE DESIGN (103' SPAN)

103'-5" DPG Design
Super Structure**Design Criteria****Design Codes:**AREMA MRE 2023
NSRR Public Improvement Projects Manual**Geometry**Span configuration :
103'-5" CL Bent to CL Bent
101'-8 1/2" brg. to brg.

Horizontal curvature = N/A

Skew = 30°00'00"

4 girders @ 2'-10" centers (1'-5" overhangs)

Open Deck Structure-Timber tie deck include a cantilevered walkway on south
side of superstructure**Vertical Loads****DL_{Track & Fasteners}**

Assumed weight of 200 plf as per AREMA 15.1.3.2b

DL_{Timber Tie Deck}Assumed 10" x 10" cross section at 60pcf per AREMA 15.1.3.2a
The timber tie packed deck over the roadway will consist of a series
of three ties, assume decking consists of 1 - 16ft tie paired with
2 - 11.33 ft ties. Assume the grouping is spaced at 3'-6".**DL_{Walkway}**Assumed to have 2 - 6" x4" x1/2" brackets on either side of the
walkway grating, use 18psf for walkway grating loading, and
assume 3'-9" tall 3" x3" x 3/8" angles spaced at 3'-6" for rail post.
See attached detail for more information.**DL_{Girder Self-weight}**

Assumed weight of steel as 490 pcf as per AREMA 15.1.3.2a

DL_{ALL}Included summation Track & Fastener load, Timber Tie Deck load,
Walkway load, and Girder Self-weight Load.**LL = COOPER E80 or Alternate Live Load, whichever Controls**For Open Deck structure assume LL is distributed equally to all
girders as per AREMA 15.1.3.4.1**Impact**

IM = Direct Vertical +Rocking applied as per AREMA (15.1.3.5)

Fatigue

F = 35% of the IM loading applied per AREMA (15.1.3.13.d)

Lateral Loads**Wind**Wind loading for steel diaphragm design follows AREMA (15.1.3.7)
for wind loading on loaded bridges.Wind loading for steel diaphragm design follows AREMA (15.1.3.8)
for wind loading on unloaded bridges.**Longitudinal Loads**No longitudinal forces were accounted for in this design. Longitudinal
force will be transferred to the substructure through the bearing
anchor bolts.

HNTB The HNTB Companies Engineers Architects Planners	Made	RCR	Date	12/10/2024	Job Number	71886
	Checked		Date			
	Backchk'd		Date		Sheet No.	2
For	NSRR Shoofly Bridge					

103'-5" DPG Design Load Input

1. General:

Span Length (Out to Out) = 103.4 ft
Span Length (Ctr to Ctr Bearings) = 101.7 ft

Ballasted or Open Deck = O (B = ballast, O = open)

No. of Girders = 4

Unbraced Length (Compression Flange), l_y = 120.0 in

Ctr to Ctr Girder Spacing = 34.0 in

Ballast Deck
Curb and Deck Material Type = (S = steel, C = conc.)
Width of Concrete/Steel Deck = ft
Thickness of Concrete/Steel Deck = in
Distance Between Ballast Curbs = ft
Max. Ballast Depth (Includes Tie) = in
Min. Ballast Depth (Includes Tie) = in

Open Deck

Tie Depth = 10.0 in
Tie Width = 10.0 in
Tie Area = 0.69 ft²

2. Material Properties:

Steel		
Fy =	50	ksi
Es =	29,000	ksi

AREMA Unit Weights for Dead Load Stresses	
Type	Kips per Cubic Foot
Track Rails and Fastenings	0.20
Steel	0.49
Timber	0.06

3. Girder and Deck Dimensions:

Girder	Width (in)	Thickness (in)
Top Flange	16.0	2.50
Web	0.625	78.0
Bottom Flange	16.0	2.50

Deck Type	Effective Width (in)	Thickness (in)
Steel Ballast Pan	0.0	0.00
or		
Concrete Interior	0	0
Concrete Exterior	0	0

4. Dead Load

	Tie Length (ft)	Tie Spacing (ft)	Tie Loading (kip/ft)
Long Tie :	16	3.5	0.19
Short Tie (1):	11	3.5	0.13
Short Tie (2):	11	3.5	0.13
Sum loading =			0.46 kip/ft
Misc. Detail Factor =			10 %
Total loading =			0.51 kip/ft

Bridge Component	Load (All Girders)
Track Rails and Tie	0.71 kip/ft
Walkway	0.16 kip/ft
Plate Girders and Details	1.93 kip/ft

Walkway Bracket : 0.03 kip/ft
2 - 6"x 4"x 1/2" Angles
Walkway Grating : 0.11 kip/ft
18 psf for a 6' wide walkway
Walkway Handrail : 0.01 kip/ft
3'-9" tall 3"x 3"x 3/8" Angle spa @ 3'-6"
Sum loading = 0.15 kip/ft
Misc. Detail Factor = 10 %
Total loading = 0.16 kip/ft

Steel Area (Per Girder), A_s = 128.75 in²
Misc. Detail Factor = 10 %



The HNTB Companies
Engineers Architects Planners

Made **RCR**

Date **12/10/2024**

Job Number **71886**

Checked

Date

For **NSRR Shoofly Bridge**

Backchk'd

Date

Sheet No. **3**

103'-5" DPG Design

Load Input

5. Live Load

Note: Loads are per track

Live Load Type	AREMA Maximum	
	End Shear (kips)	Moment (kip-ft)
Cooper E-80	610	13,276
Alternate	370	9,072
Maximum LL	610	13,276

NOTE:

Following AREMA 15.1.3.4.1, it is assumed that the COOPER E80 and alternative loads will be equally distributed to all girders.

6. Impact

(AREMA 15.1.3.5)

Maximum Axle Load = 80.0 kips
Maximum Axle Moment = 100 k*ft
-Assuming a 5ft track width

Girder Line Location (ft)	I_x	Rocking
4.25	18.06	11%
1.42	2.01	4%
1.42	2.01	4%
4.25	18.06	11%
$\Sigma I_x =$		40.14

Rocking effect, R.E. = 10.6%
Impact, I = 24.4% (w/ out hammer blow)
Total Impact = 35.0%

Impact (Fatigue) = 12.2% (Mean impact load percentage = 35% per AREMA 15.1.3.13.d)

7. Load Summary

Load Summary (Per Girder)						
Load Type	Single Girder Maximums					
	End Shear (kips)	Moment (kip-ft)				
-DEAD LOADING						
Track Rails and Tie	9	228				
Walkway	2	53				
Plate Girders and Details	25	623				
Total Dead Load	36	904				
-LIVE LOADING						
Maximum LL w/Impact	206	4,479				
Maximum LL w/Impact (Fatigue)	171	3,725				
-TOTAL LOADING						
Dead + Live Loading	242	5,383				
Dead + Fatigue Live Loading	207	4,629				

NOTE: Assume all Dead and Live Loading is shared equally between all 4 girders

 The HNTB Companies	Made RCR	Date 12/10/2024	Job Number 71886
	Checked	Date	
For NSRR Shoofly Bridge	Backchk'd	Date	Sheet No. 4

[103'-5" DPG Design](#)
[Girder Section Properties](#)

Section Properties:
 Corrosion Loss = 0 in.

*Taken about the base of the bottom flange

Gross Section Properties								
Location	Width (in)	Thickness (in)	Area (in ²)	y* (in)	Ay (in ²)	Ay^2 (in ³)	Io (in ⁴)	Ixx (in ⁴)
Top Flange	16.0	2.50	40.0	81.8	3,270	267,323	21	267,343
Web	0.625	78.0	48.8	41.5	2,023	83,960	24,716	108,676
Btm Flange	16.0	2.50	40.0	1.3	50	63	21	83
		83.00	128.8	41.5	5,343			376,103

I gross= 154,363 in⁴
S top = 3,720 in³
S bot = 3,720 in³

I_y comp flange = 854 in⁴
A comp flange = 64.4 in²
r_y comp flange = 3.64 in

For	HNTB The HNTB Companies NSRR Shoofly Bridge	Made	RCR	Date	12/10/2024	Job Number 71886
		Checked		Date		
		Backchk'd		Date		
						Sheet No. 5

103'-5" DPG Design Allowable Stresses

Allowable Stresses

(AREMA 15.1.4)

Bending:

(Steel) Tension in Extreme Fiber, $F_T = 0.55F_y$

$$F_{T \text{ Allowable}} = 27.5 \text{ ksi}$$

$$\text{(Steel) Compression in Extreme Fiber, } F_C = 0.55F_y - \frac{0.55(F_y)^2}{6.3\pi^2 E} \left(\frac{L}{r_y} \right)^2 = 26.7 \text{ ksi}$$

Larger of :

$$\frac{0.131\pi E}{\left(\frac{Ld\sqrt{1+\mu}}{A_f} \right)} = 42.0 \text{ ksi}$$

Not to exceed : $0.55F_y$

$$F_{C \text{ Allowable}} = 27.5 \text{ ksi}$$

Shear:

Shear in Web, $F_V = 0.35F_y$

$$F_{V \text{ Allowable}} = 17.5 \text{ ksi}$$

Fatigue

(AREMA 15.1.3.13)

Stress Cycles, N = Greater Than 2 Million

Threshold is 100ft since we are at 101ft say "Greater Than 2 Million" for conservative design

Allowable Stress Range, $S_r = 16.0 \text{ ksi}$

Category B AREMA Table 15-1-8, Detail 3.1

S_{Rfat} from Category B AREMA Table 15-1-9

Deflection

(AREMA 15.1.2.5)

$$\text{Allowable Deflection, } \Delta = \frac{L}{640} \quad \text{AREMA 15.1.2.5 b}$$

$$\Delta_{(Allow)} = 1.91 \text{ in}$$

Girder Proportions

(AREMA 15.1.7)

$$\text{Ratio (Unbraced Length/Rad. of Gyration)} = 5.55 \sqrt{\frac{E}{F_y}} \quad \text{AREMA 15.1.7.1b}$$

$$\text{Max Ratio } (l_y/r_y) = 133.7$$

$$\text{Min. Thickness of Plate Girder Web, } t_{web} = 0.18 \sqrt{\frac{F_y}{E}} \times D_{web} \quad \text{or} \quad \frac{t_f}{6}$$

(without longitudinal stiffeners)

$$\text{min } t_{web} = 0.58 \text{ in} \quad \text{AREMA 15.1.7.3a}$$

(AREMA 15.1.2.4)

$$\text{Min Ctr to Ctr Distance Between Exterior Girders} = \frac{L}{15}$$

$$\text{min distance} = 6.8 \text{ ft} \quad \text{AREMA 15.1.2.4a}$$

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103'-5" DPG Design
Girder Proportioning

AREMA 15.1.7.1.b - Flange Buckling

Unbraced Length (Compression Flange), l_y = 120 in
Rad.of Gyration (Compression Flange+Portion of Web), r_y = 3.64 in
Ratio (l_y/r_y) = 32.9
Max Ratio (l_y/r_y) = 133.7
Status: OK

AREMA 15.1.7.3.a - Web Buckling

Web Thickness, t_{web} = 0.625 in
min t_{web} = 0.58 in
Status: OK

AREMA 15.1.7.3.c - Web Buckling

Web Thickness, t_{web} = 0.625 in.
Flange Thickness/6 = 0.42 in.
Status: OK

AREMA 15.1.2.4 - Girder Spacing

Ctr to Ctr Distance Between Exterior Girders = 8.5 ft
Min Required Distance = 6.8 ft
Status: OK

AREMA 15.1.5.5 - Accessibility of Parts

Distance Between Girder Flanges = 18.0 in
Min Required Distance = 18.0 in
Status: OK

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Section Properties:

Non-Composite Steel Girder Section Properties - Summary				
Location	y (in)	I _{gross} (in ⁴)	I _{net} (in ⁴)	S (in ³)
Top Steel	41.5	154,363	----	3,720
Btm Steel	41.5	----	131,208	3,162

*Conservatively I_{net} is assume 85% of gross section

Flexural Stress:

Non-Composite Flexural Stresses (Unshored)					
Location	DL all (ksi)	LL + IM (ksi)	Total Stress (ksi)	Allowable Stress	Status
Top of Steel	2.92	14.45	17.37	27.5	OK
Btm of Steel	3.43	17.00	20.43	27.5	OK

D/C
0.63
0.74

Shear Stress:

Shear Stress				
V _{max} (kips)	A _{web} (in ²)	v (ksi)	Allowable Stress	Status
242	48.75	4.96	17.5	OK

D/C
0.28

Fatigue:

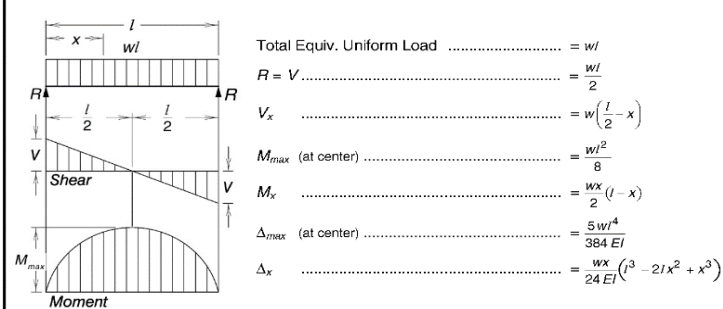
Fatigue Stress Range			
Location	E80 LL+I (ksi)	Allowable S _r	Status
Btm of Steel	14.1	16.0	OK

D/C
0.88

Deflection:

Deflection (E80 LL+I)				
Location	Equiv. Uniform Load, w (kip/ft)	Deflection (in)	Allowable Deflection	Status
Midspan	3.5	1.86	1.91	OK

D/C
0.98

103'-5" DPG Design
Girder Camber - Maximum
1. SIMPLE BEAM — UNIFORMLY DISTRIBUTED LOAD

 Span Length= **101.71** ft
 1220.50 in

 E= **29000** ksi
 I Steel= **154363** in⁴
Typical Girder

 DL GDR= 0.48 klf
 DL ADT'L= 0.22 klf
 DL ALL= 0.70 klf

NOTE: Detail all girders for the same camber so that girders will line up and diaphragms can be bolted up.

Span Check Points										
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0.00	10.17	20.34	30.51	40.68	50.85	61.03	71.20	81.37	91.54	101.71
0.00	122.05	244.10	366.15	488.20	610.25	732.30	854.35	976.40	1098.45	1220.50

		Girder Moments (k*ft)										
		0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
DL GDR		0	224	399	523	598	623	598	523	399	224	0
DL ADT'L		0	101	180	236	270	281	270	236	180	101	0

		Girder Deflections (in)										
		0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
DL GDR	0	0.08	0.15	0.21	0.25	0.26	0.25	0.21	0.15	0.08	0	
DL ADT'L	0	0.04	0.07	0.10	0.11	0.12	0.11	0.10	0.07	0.04	0	
Total Camber	0	0.12	0.22	0.31	0.36	0.38	0.36	0.31	0.22	0.12	0	

		Girder Deflections (in)										
		0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
DL GDR		0	1/16	2/16	3/16	4/16	4/16	4/16	3/16	2/16	1/16	0
DL ADT'L		0	1/16	1/16	2/16	2/16	2/16	2/16	2/16	1/16	1/16	0
Total Camber		0	2/16	3/16	5/16	6/16	6/16	6/16	5/16	3/16	2/16	0

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103'-5" DPG Design Flange to Web Weld

Weld Capacity:

Weld type = **F** (F = fillet, CJP = full pen.)

CJP Weld:

Effective throat = 0.625 in
Ten/comp. capacity = 0.0 kip/in
Shear capacity = 0.0 kip/in

Fillet Weld:

Leg size = **0.3125** in
Electrode = **E70** (E60, E70 or E80)
Allowable weld stress = 19.0 ksi
Allowable base metal stress = 17.5 ksi
Weld capacity = 8.4 kip/in (assumes weld on both sides of web)

AREMA - Allowable Stress on Welds			
Groove Welds			
Tension/Compression		27.5	ksi
Shear		17.5	ksi
Fillet Welds			
E60	(60ksi tensile strength)	16.5	ksi
E70	(70ksi tensile strength)	19.0	ksi
E80	(80ksi tensile strength)	22.0	ksi

Note: not to exceed 0.35F_y, shear stress on base metal

Top Flange to Web Connection:

(AREMA 15.1.7.4)

$$\text{Horiz. shear flow, } \tau = \frac{VQ_f}{I} = 2.52 \text{ kip/in}$$

$$\begin{aligned} \text{Shear force, } V &= 242 \text{ kip} \\ A' &= 40.0 \text{ in}^2 \\ y' &= 40.25 \text{ in} \\ Q_f &= 1610.0 \text{ in}^3 \\ I &= 154,363 \text{ in}^4 \end{aligned}$$

$$\text{Vert. wheel load shear, } w = \frac{1.8W}{S_w} = 1.25 \text{ kip/in}$$

$$\begin{aligned} \text{Wheel load} &= 25.0 \text{ kip/girder} \\ \text{Load distribution, } S_w &= 3.0 \text{ ft} \end{aligned}$$

$$\text{Resultant force} = \sqrt{(t^2 + w^2)} = 2.82 \text{ kip/in}$$

Status: Weld OK

$$D/C = 0.34$$

Fatigue at Bottom Flange to Web Weld:

Stress cycles, N = Greater Than 2 Million

(AREMA Table 15-1-9)

Threshold is 100ft since we are at 101ft say "Greater Than 2 Million" for conservative design

Allowable stress range, S_{Rfat} = 10.0 ksi (Category C)

(AREMA 15-1-7-4(b-2))

Allowable capacity = 4.41875 kip/in

Fatigue stress on weld = 2.16 kip/in

$$\begin{aligned} V_{\text{fatigue}} &= 207.3 \text{ kips} \\ A' &= 40.0 \text{ in}^2 \\ y' &= 40.25 \text{ in} \\ Q_f &= 1610.0 \text{ in}^3 \\ I_{\text{net}} &= 154,363 \text{ in}^4 \end{aligned}$$

Status: Fatigue OK

$$D/C = 0.49$$

Note: For open deck and non-composite spans with PJP or fillet welds. Fatigue strength is controlled by weld toe cracking (fatigue category C).

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103'-5" DPG Design Bearing Stiffeners

Input Parameters:

Btm. flange width, b_f = 16.00 in
 Web depth, D = 78.00 in
 Web thickness, t_w = 0.625 in
 Stiffener yield stress, F_y = 50 ksi
 Mod. of elasticity, E = 29,000 ksi

Design Reactions:

Dead load, DL = 36 kips
 Live Load + Impact = 205.8 kips
 Total Reaction = 242 kips

Trial Plate Size:

Stiffener width, b_{stiff} = 7.000 in
 Stiffener thickness, t_{stiff} = 0.750 in

O.K. - Less than maximum PL Width

(AREMA 15.1.6.2)

O.K. - Exceeds minimum PL Thickness

(AREMA 15.1.5.4a)

Check Bearing Condition:

Bearing area = 8.25 in² (Assuming 2 - 1.5" clips) (AREMA 15.1.7.7d)
 Allowable bearing stress = 41.50 ksi (AREMA 15.1.4.1)
 Actual bearing stress = 29.33 ksi **O.K. - Less than allowable stress** D/C 0.71

Check Column Condition:

Compression in Concentrically loaded columns

Effective Web Width = 15.625 in (AREMA 15.1.7.7c)
 use $25 \cdot t_w$ for stiffeners away from end of web
 Column area = 20.27 in² (AREMA 15.1.7.7c)
 Column mom. of inertia, I_{column} = 195.65 in⁴
 Radius of gyration, r = 3.11 in
 Effective Stiffener Length = 58.5 in (AREMA 15.1.7.7c)
 kl/r = 18.83 (AREMA 15.1.7.7c)
 Allowable comp. stress, F_a = 26.88 ksi (AREMA 15.1.4.1)
 Actual comp. stress, f_a = 11.94 ksi **O.K. - Less than allowable stress** D/C 0.44

Web to Stiffener Weld:

Fillet weld size = 0.3125 in
 Electrode = E70 (E60, E70, E80)
 Allowable stress = 17.50 ksi (AREMA 1.4.2)
 Weld capacity = 3.87 kip/in
 Actual weld force = 0.81 kip/in **O.K. - Less than allowable** D/C 0.21

Summary:

Use	2 Plates	0.750 inch x	7 inch
Use	Grade	50	
Use	0.3125	in. double sided fillet welds	

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103'-5" DPG Design

Intermediate Stiffeners

AREMA 15.1.7.8 (2014)

Properties:

$d_{a, actual} =$	6.00	ft	(actual spacing)
DPG $b_f =$	16	in	
DPG $t_f =$	2.50	in	
DPG $d_w =$	78	in	
DPG $t_w =$	0.625	in	
Stiffener $t_{int} =$	0.75	in	
Stiffener $b_{int} =$	7	in	
E=	29000	ksi	
Fy=	50	ksi	
L=	102.17	ft	

Transverse Stiffeners Required and Stiffener Spacing

$$2.12 \sqrt{\frac{E}{F_y}} t_w = 31.91 \text{ in}$$

Int. Stiffeners Needed

$$d \leq 1.95 t \sqrt{\frac{E}{f_s}} = 93.16 \text{ in}$$

Web Buckling

fs= 4.96 ksi Max Shear Stress

$d_{a, max} = 96 \text{ in}$

D= web btwn flngs = 78 in

$d_{a, actual} = 72.0 \text{ in}$ **Spacing OK**

Moment of Inertia Required

AREMA 15.1.7.8a

$$I = 2.5 d_a t^3 \left(\frac{D^2}{d^2} - 0.7 \right)$$

$d_{a, actual} = 72.0 \text{ in}$

max. spacing, d= 93.2 in

D= 78.0 in

D/d= 0.8 **Check N/A**

I= 6.0 in⁴

Iactual= 195.5 in⁴

Moment of Intertia OK

Outstanding Leg Proportions

AREMA 15.1.7.8b

$$2" + \frac{h}{30} \leq b_{out} \leq 16 t_a$$

$16 t_a = 12.00 \text{ in}$ **Width OK**

$2" + h/30 = 4.77 \text{ in}$ **Width OK**

Longitudinal Stiffeners Required

AREMA 15.1.7.8f

$$4.18 \sqrt{\frac{E}{f_{comp}}} t_w = 98.423 \text{ in}$$

fcomp= 20.43 ksi (see DPG design)

$$D = 78.000 \text{ in}$$

No Longitudinal Stiffeners Required

Welded Connection to Web

Top Clip=	1.5	in
Bottom Clip=	1.5	in
Min=	3.75	in (AREMA 15-1.10.4.b)
Lweld=	72.8	in
Weld size=	0.3125	in

Check Fatigue Stress at End of Int. Stiffener Weld

N= 2,000,000 cycles

Mfat= 3,725 k-ft (AREMA Tbl 15-1-7)

Inet= 154,363 in⁴ (Use Gross Section)

y= 32.5 in

Weld end 9" from bottom of Bottom Flange

SRfat= 13.0 ksi Category C'

f_{fat}= 9.41 ksi

Fatigue Stress at Weld OK

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103'-5" DPG Design

End Diaphragm Design

Objective: Design the steel diaphragms for NSRR Shoofly bridge over I-70

Transverse Loads for Diaphragm Design

Vertical Projection of Span:

Girder= 83.000 in
H= 83.000 in 6.917 ft
Girder Spacing= 2.833 ft
Diaphragm spacing= 10.000 ft
Spacing <18ft - OK AREMA 15.1.11.4e

Wind on Train (WL) - AREMA 15.1.3.7a

w= 0.3 k/ft
V_{wl}= 3.000 k/diaphragm

Wind on Loaded Bridge (WS) - AREMA 15.1.3.7b

W_{Loaded Bridge}= 0.31 k/ft
V_{ws}= 3.11 k/diaphragm

Wind on Unloaded Bridge (WS) - AREMA 15.1.3.8

W_{Unloaded Bridge}= 0.52 k/ft
V_{ws}= 5.19 k/diaphragm

Lateral Equipment Force - AREMA 15.1.3.9

V_{le}= 25.000 k/diaphragm

Compression Flange Force - AREMA 15.1.11.6

F_{cf}= 17.37 ksi
A_{cf}= 40 in²
P_{cf}= 695 k
% of force= 2.500 %
V_{cf}= 17.4 k/diaphragm

Diaphragm Properties

Size: W30x90
A= 26.300 in²
d= 29.5 in
t_w= 0.47 in
t_{stiff}= 0.75 in
I_x= 3610.00 in⁴
I_y= 115.00 in⁴
Number= 2 shapes
x Spa. = 34.00 in
y Spa. = 0.00 in
L= 25.38 in (Dist. Between Bolt Group C.G.)
k= 0.75
E= 29000 ksi
F_y= 50 ksi
I_{xtotal}= 7220.00 in⁴ I_{ytotal}= 230.00 in⁴
A_{total}= 52.60 in²
r_x= 11.72 in
r_y= 2.09 in
kl/r_x= 1.62
kl/r_y= 9.10

Compressive Strength - AREMA 15.1.4 and 15.1.6.2

Outstanding Elements in Compression

Beam b_f= 4.965 in (outstanding flange minus web)
Beam t_f= 0.610 in

Limit b_f= $0.50t_f\sqrt{\frac{E}{F_y}}$ 7.35 in

Flange width OK

Allowable Stress - AREMA Table 15-1-11

$\frac{0.629}{\sqrt{\frac{F_y}{E}}} = 15.148$ $\frac{5.034}{\sqrt{\frac{F_y}{E}}} = 121.235$

F_{a compr}= 27.5 ksi

Check of Individual Diaphragm:

Combinations Checked: AREMA REF
1 - WS (Loaded) + WL + Equipment Tbl 15-1-10 (3rd row)
2 - WS (unloaded) Tbl 15-1-10 (5th row)
3 - 2.5% of Compression Flange Force 15.1.11.6

Controlling Comb. : 1 - WS (Loaded) + WL + Equipment

Total force= 15.56 kips D/C
f_a= 0.59 ksi 0.02

Diaphragm OK

Use 2 - W30x90

Check Connection to Angles - AREMA 15.1.5.9 and 15.1.11.4c

Design connection for lesser of design allowable stress or 1.5 x maximum computed stress.
Connection shall be design for no less that 1/2 shear capacity of the diaphragm.

f_a= 0.9 ksi

F_{a compr}= 27.5 ksi

1.5x Max Computed Stress Controls

Design for: 46.7 k

Shear Capacity of Diaphragm (Table 1-15-11):

f_a=0.35F_y= 17.5 ksi

1/2 Shear Cap. = 121.32 k

1/2 Shear Capacity Controls

Design conn. For = 121.32 k/connection

Bolt Shear - Table 15-1-11

d_b= 0.875 in

A325 bolts F_v= 21.5 ksi (slip critical Class B)

No. of bolts= 14

Shear planes= 1

R_n= 181 k

Connection OK

-Use 2 rows of 7 bolts

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103'-5" DPG Design End Diaphragm Design

Check Connection to Angles - AREMA 15.1.5.9 and 15.1.11.4
(continued)

Bolt Bearing - 15.1.4.1 and 15.1.5.3

$$\begin{aligned}
 L &= 1.50 \text{ in} \\
 F_u &= 65 \text{ ksi} \\
 L F_u / 2d &= 56 \text{ ksi} \\
 1.2 F_u &= 78 \text{ ksi} \\
 A_{\text{bolt bearing}} &= 0.41 \text{ in}^2 \text{ (Bearing Area)} & \text{D/C} \\
 R_n &= 320.8 \text{ k} & 0.38 \\
 & \text{Connection OK}
 \end{aligned}$$

Edge Distance Requirement - AREMA 15.1.9.3

$$\begin{aligned}
 \text{Min: } 1.5d_b &= 1.31 \text{ in} \\
 2d_b * f_p / F_u &= 0.57 \text{ in} \\
 \text{Max: } 1.5 + 4t &= 3.38 \text{ in} \\
 \text{Vert. Edge Dist. Prov.} &= 2.75 \text{ in} \\
 \text{Horiz. Edge Dist. Prov.} &= 1.50 \text{ in} & \text{Connection OK}
 \end{aligned}$$

Minimum Bolt Spacing Requirements - AREMA 15.1.9.2

$$\begin{aligned}
 3d_b &= 2.625 \text{ in} \\
 2d_b * f_p / F_u + d/2 &= 1.00 \text{ in} \\
 \text{Vert. Spacing Prov.} &= 3.000 \text{ in} \\
 \text{Horiz. Spacing Prov.} &= 3.000 \text{ in} & \text{Connection OK}
 \end{aligned}$$

Bolt Connection Geometry Check

$$\begin{aligned}
 \text{Connection Length} &= 23.500 \text{ in} \\
 \text{Av. Conn. Length} &= 29.500 \text{ in} & \text{Connection OK}
 \end{aligned}$$

Available connection length equal to depth of Diaphragm member
Top and bottom flanges to be coped

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103'-5" DPG Design

Intermediate Diaphragm Design

Objective: Design the steel diaphragms for NSRR Shoofly bridge over I-70

Transverse Loads for Diaphragm Design

Vertical Projection of Span:

Girder= 83.000 in
H= 83.000 in 6.917 ft
Girder Spacing= 2.833 ft
Diaphragm spacing= 10.000 ft
Spacing <18ft - OK AREMA 15.1.11.4e

Wind on Train (WL) - AREMA 15.1.3.7a

w= 0.3 k/ft
V_{wl}= 3.000 k/diaphragm

Wind on Loaded Bridge (WS) - AREMA 15.1.3.7b

W_{Loaded Bridge}= 0.31 k/ft
V_{ws}= 3.11 k/diaphragm

Wind on Unloaded Bridge (WS) - AREMA 15.1.3.8

W_{Unloaded Bridge}= 0.52 k/ft
V_{ws}= 5.19 k/diaphragm

Lateral Equipment Force - AREMA 15.1.3.9

V_{le}= 25.000 k/diaphragm

Compression Flange Force - AREMA 15.1.11.6

F_{cf}= 17.37 ksi
A_{cf}= 40 in²
P_{cf}= 695 k
% of force= 2.500 %
V_{cf}= 17.4 k/diaphragm

Diaphragm Properties

Size: W30x90
A= 26.300 in²
d= 29.5 in
t_w= 0.47 in
t_{stiff}= 0.75 in
I_x= 3610.00 in⁴
I_y= 115.00 in⁴
Number= 2 shapes
x Spa. = 34.00 in
y Spa. = 0.00 in
L= 25.38 in (Dist. Between Bolt Group C.G.)
k= 0.75
E= 29000 ksi
F_y= 50 ksi
I_{xtotal}= 7220.00 in⁴ I_{ytotal}= 230.00 in⁴
A_{total}= 52.60 in²
r_x= 11.72 in
r_y= 2.09 in
kl/r_x= 1.62
kl/r_y= 9.10

Compressive Strength - AREMA 15.1.4 and 15.1.6.2

Outstanding Elements in Compression

Beam b_f= 4.965 in (outstanding flange minus web)
Beam t_f= 0.610 in

Limit b_f= $0.50t_f\sqrt{\frac{E}{F_y}}$ 7.35 in

Flange width OK

Allowable Stress - AREMA Table 15-1-11

$\frac{0.629}{\sqrt{\frac{F_y}{E}}} = 15.148$ $\frac{5.034}{\sqrt{\frac{F_y}{E}}} = 121.235$

F_{a compr}= 27.5 ksi

Check of Individual Diaphragm:

Combinations Checked: AREMA REF
1 - WS (Loaded) + WL + Equipment Tbl 15-1-10 (3rd row)
2 - WS (unloaded) Tbl 15-1-10 (5th row)
3 - 2.5% of Compression Flange Force 15.1.11.6

Controlling Comb. : 1 - WS (Loaded) + WL + Equipment

Total force= 15.56 kips D/C
f_a= 0.59 ksi 0.02

Diaphragm OK

Use 2 - W30x90

Check Connection to Angles - AREMA 15.1.5.9 and 15.1.11.4c

Design connection for lesser of design allowable stress or 1.5 x maximum computed stress.
Connection shall be design for no less that 1/2 shear capacity of the diaphragm.

f_a= 0.9 ksi

F_{a compr}= 27.5 ksi

1.5x Max Computed Stress Controls

Design for: 46.7 k

Shear Capacity of Diaphragm (Table 1-15-11):

f_a=0.35F_y= 17.5 ksi

1/2 Shear Cap. = 121.32 k

1/2 Shear Capacity Controls

Design conn. For = 121.319 k/connection

Bolt Shear - Table 15-1-11

d_b= 0.875 in

A325 bolts F_v= 21.5 ksi (slip critical Class B)

No. of bolts= 14

Shear planes= 1

R_n= 181 k

D/C

0.67

Connection OK

-Use 2 rows of 7 bolts

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103'-5" DPG Design

Intermediate Diaphragm Design

Check Connection to Angles - AREMA 15.1.5.9 and 15.1.11.4
(continued)

Bolt Bearing - 15.1.4.1 and 15.1.5.3

$$\begin{aligned}
L &= 1.50 \text{ in} \\
F_u &= 65 \text{ ksi} \\
LF_u/2d &= 56 \text{ ksi} \\
1.2F_u &= 78 \text{ ksi} \\
A_{\text{bolt bearing}} &= 0.41 \text{ in}^2 \text{ (Bearing Area)} & \text{D/C} \\
R_n &= 320.8 \text{ k} & 0.38 \\
& \text{Connection OK}
\end{aligned}$$

Edge Distance Requirement - AREMA 15.1.9.3

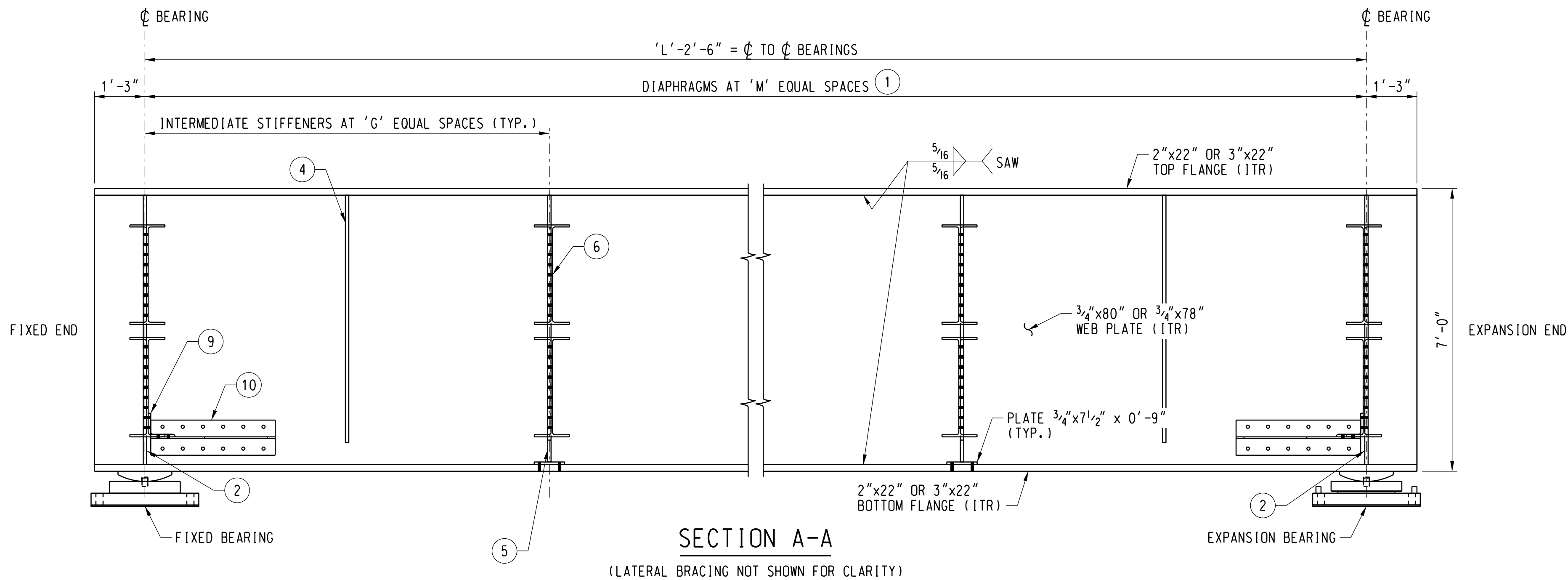
$$\begin{aligned}
\text{Min: } 1.5d_b &= 1.31 \text{ in} \\
2d_b * f_p / F_u &= 0.57 \text{ in} \\
\text{Max: } 1.5 + 4t &= 3.38 \text{ in} \\
\text{Vert. Edge Dist. Prov.} &= 2.75 \text{ in} \\
\text{Horiz. Edge Dist. Prov.} &= 1.50 \text{ in} & \text{Connection OK}
\end{aligned}$$

Minimum Bolt Spacing Requirements - AREMA 15.1.9.2

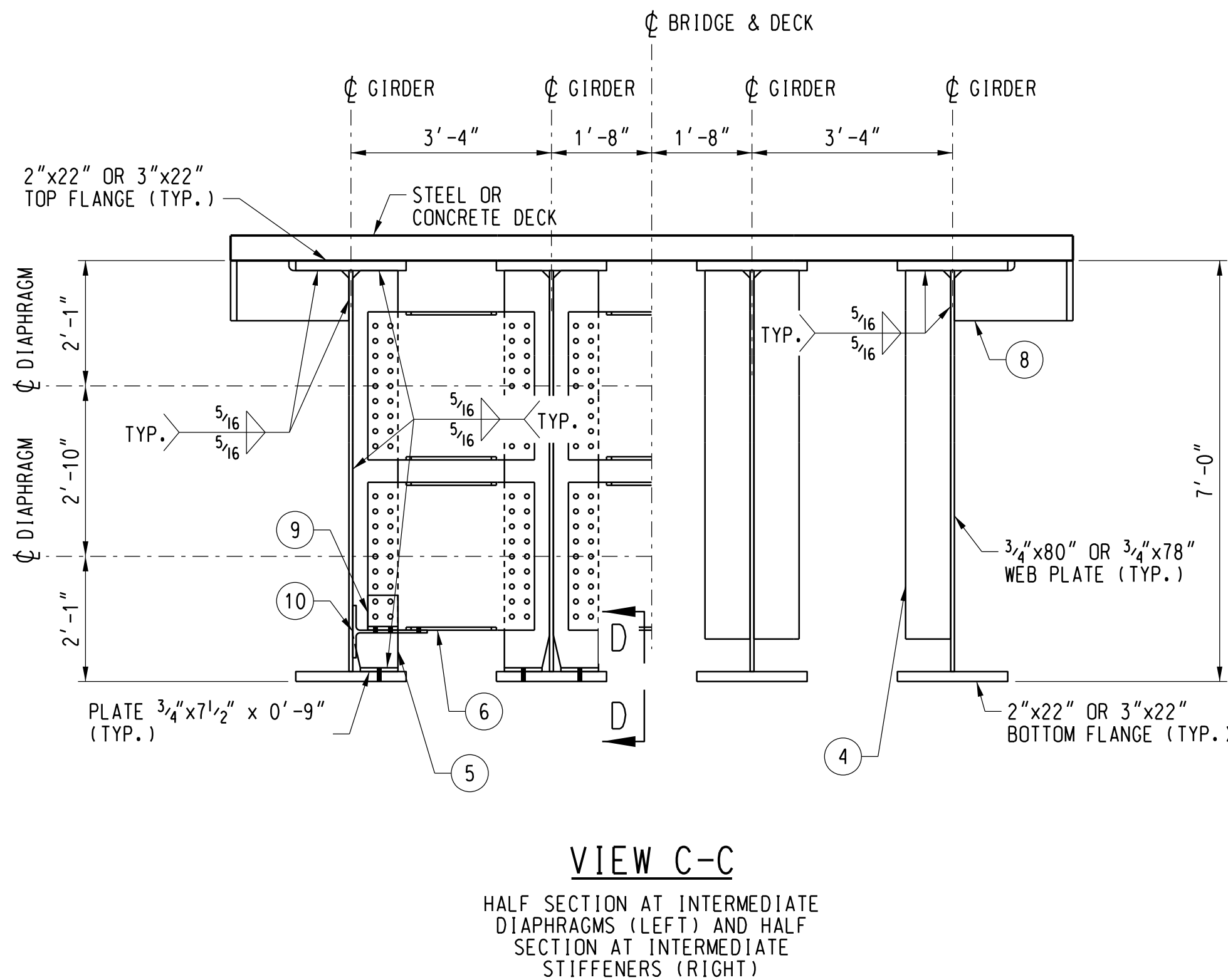
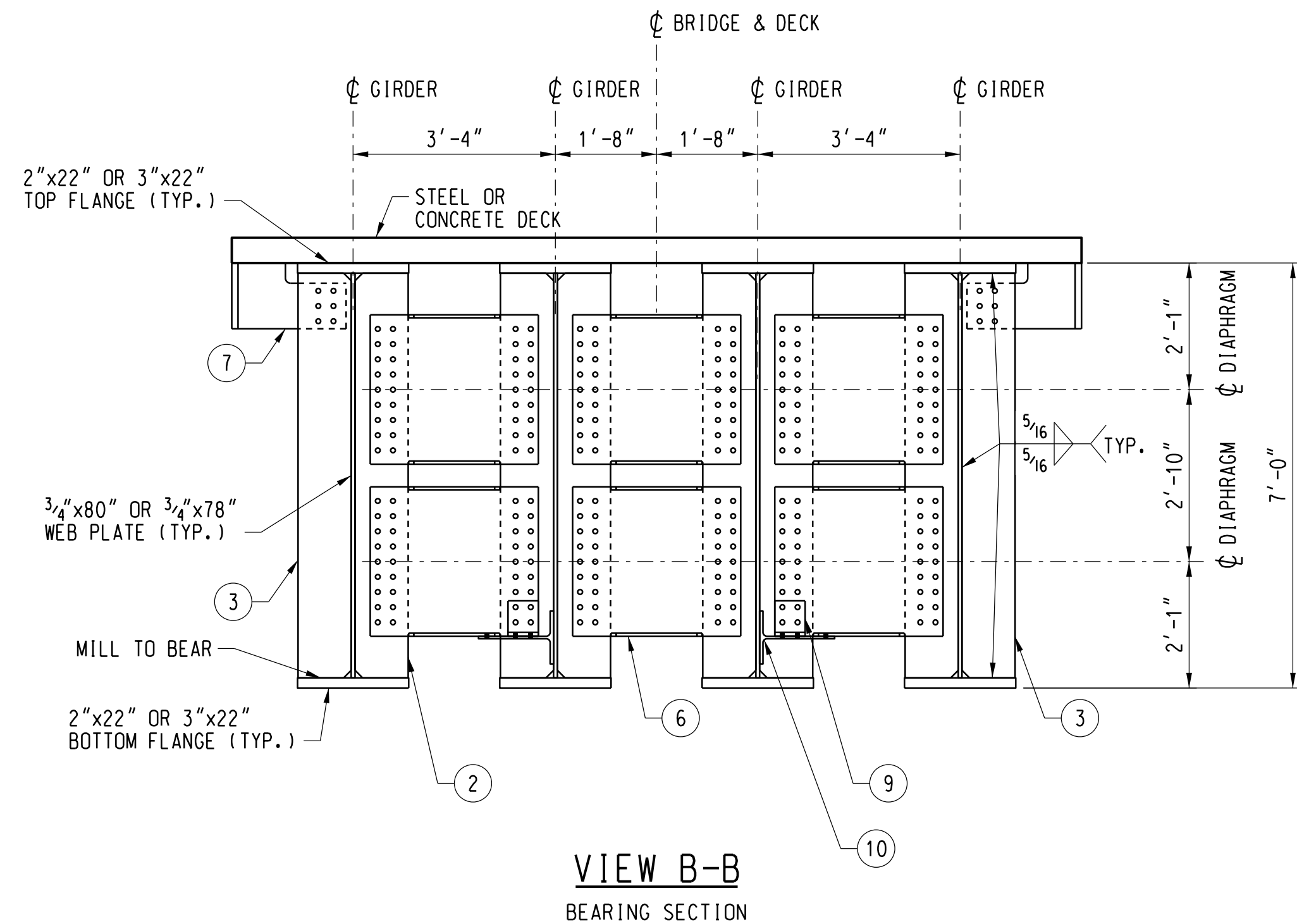
$$\begin{aligned}
3d_b &= 2.625 \text{ in} \\
2d_b * f_p / F_u + d/2 &= 1.00 \text{ in} \\
\text{Vert. Spacing Prov.} &= 3.000 \text{ in} \\
\text{Horiz. Spacing Prov.} &= 3.000 \text{ in} & \text{Connection OK}
\end{aligned}$$

Bolt Connection Geometry Check

$$\begin{aligned}
\text{Connection Length} &= 23.500 \text{ in} \\
\text{Av. Conn. Length} &= 29.500 & \text{Connection OK} \\
& \text{Available connection length equal to depth of Diaphragm member} \\
& \text{Top and bottom flanges to be coped}
\end{aligned}$$



For reference for diaphragm design only,
girder sizing shown here not to be used



- ① SEE PLAN NO. 0000-1229-02 FOR DIAPHRAGM AND INTERMEDIATE STIFFENER SPACING
- ② STIFFENER PLATE SF07 (ITR)
- ③ STIFFENER PLATE SF08 (ITR)
- ④ STIFFENER PLATE SF09 (TYP.)(ITR)
- ⑤ STIFFENER PLATE SF11 (TYP.)(ITR)
- ⑥ DIAPHRAGM DP5 (TYP.)
- ⑦ CSB1 (TYP.)(STEEL DECKS ONLY)
- ⑧ CSB3 FOR LIGHT DPG & CSB4 FOR MEDIUM DPG (TYP.)(STEEL DECKS ONLY)
- ⑨ LATERAL CONNECTION LC1 (TYP.)
- ⑩ LATERAL CONNECTION LC2 (TYP.)

NOTES:

1. SEE PLAN NO. 0000-1235-01 FOR LOCATION OF SECTION A-A, B-B AND C-C.
2. SEE PLAN NO. 0000-1250-01 FOR CONCRETE DECK DETAILS.
SEE PLAN NO. 0000-1252-01 FOR STEEL DECK DETAILS.
3. SEE PLAN NO. 0000-1240-01 AND 0000-1240-02 FOR LATERAL BRACING DETAILS AND SECTION D-D.
4. SEE PLAN NO. 0000-1910-13 AND 0000-1910-14 FOR BEARING DETAILS.
5. SEE PLAN NO. 0000-1910-09 FOR DIAPHRAGM DETAILS.
SEE PLAN NO. 0000-1910-10 FOR STIFFENER PLATE DETAILS.
SEE PLAN NO. 0000-1253-02 FOR CURB SUPPORT BRACKET DETAILS.

LIGHT DPG SPANS 84" DPG WITH 2"x22" FLANGE	MAXIMUM SPAN LENGTH	
	84" LIGHT DPG	113'-0"
	EST. LIFTING WEIGHT	
	TYPE	WEIGHT (PLF)
	1 GIRDER	505
	DESIGN LOADS	
	LOAD CASE	84" GIRDER LOADS/ (LBS./FT OF TRACK)
MEDIUM DPG SPANS 84" DPG WITH 3"x22" FLANGE	TRACK, FASTENERS, ETC.	200
	BALLAST	3,850
	CURB, WALK & HANDRAIL (STEEL/CONCRETE)	215/680
	DECK (STEEL/CONCRETE)	360/1,795
	GIRDERS	2,705

MEDIUM DPG SPANS 84" DPG WITH 3"x22" FLANGE	MAXIMUM SPAN LENGTH	
	84" MEDIUM DPG	125'-0"
	EST. LIFTING WEIGHT	
	TYPE	WEIGHT (PLF)
	1 GIRDER	650
	DESIGN LOADS	
	LOAD CASE	84" GIRDER LOADS/ (LBS./FT OF TRACK)
MEDIUM DPG SPANS 84" DPG WITH 3"x22" FLANGE	TRACK, FASTENERS, ETC.	200
	BALLAST	3,850
	CURB, WALK & HANDRAIL (STEEL/CONCRETE)	215/680
	DECK (STEEL/CONCRETE)	360/1,795
	GIRDERS	3,305

STANDARD PLAN

DATE ISSUED OCTOBER 13, 2022



BRIDGE ENGINEERING KANSAS CITY, KS

APPROVED: *Nadine Guarino*

ASST. DIRECTOR STRUCTURES DESIGN

SUPERSTRUCTURE
DECK PLATE GIRDER

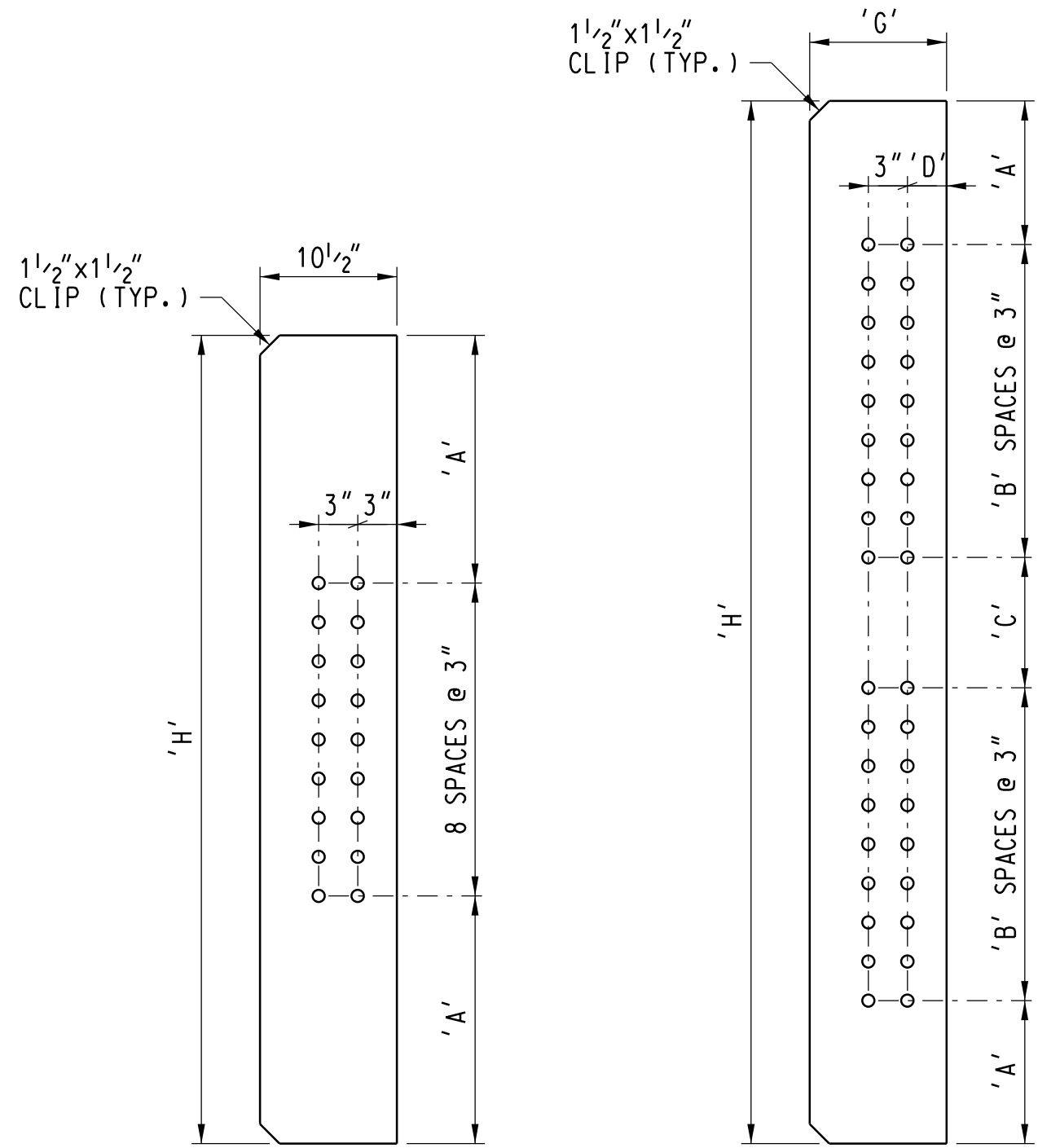
84" FRAMING PLAN -
LIGHT & MEDIUM PLATE GIRDERS

PLAN NO: 0000-1231-01

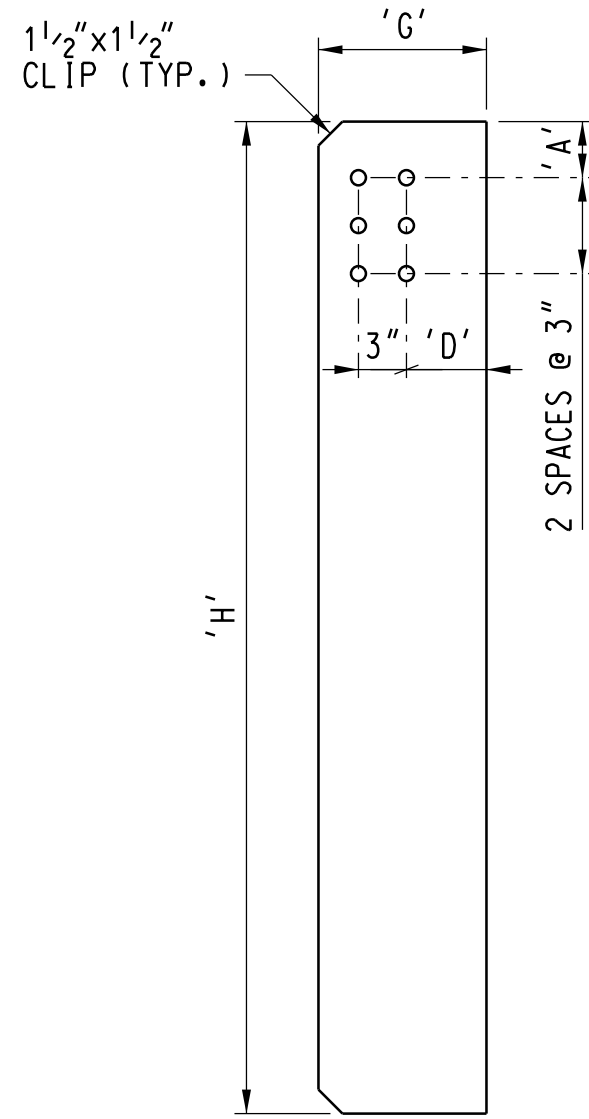
SHEET: 1 OF 1

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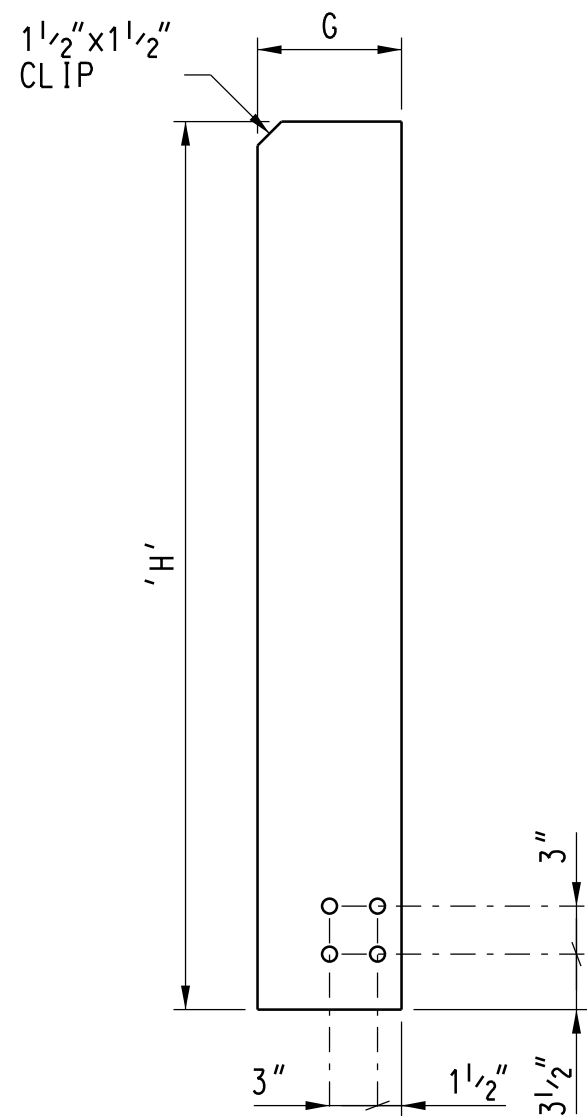
Date Printed: 10/13/2022 Time Printed: 11:22:56 AM



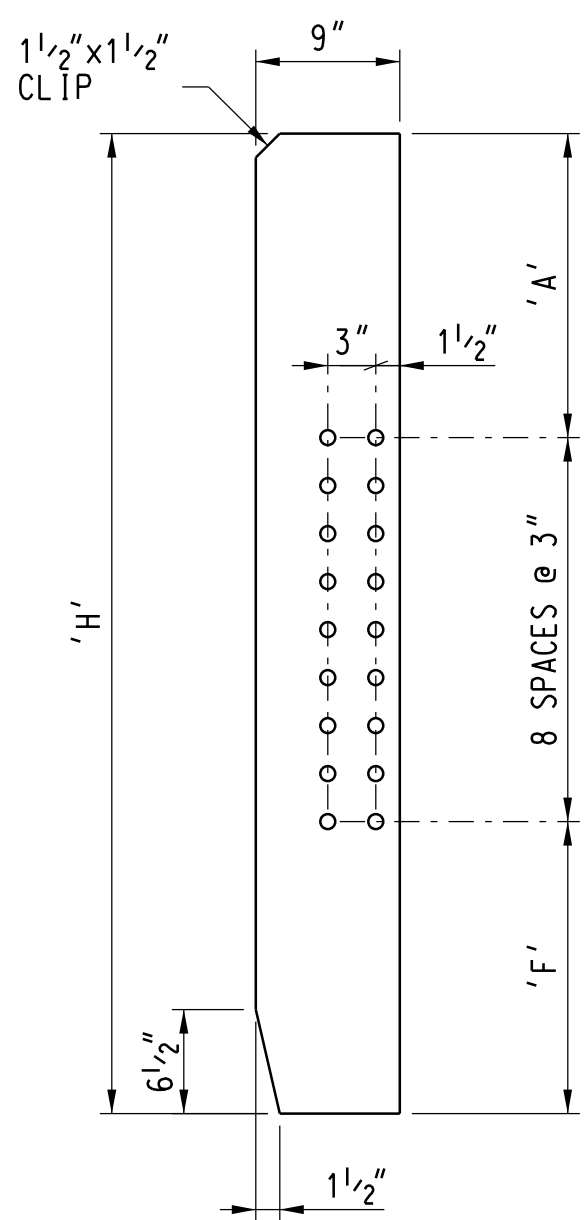
STIFFENER - SF06
PLATE 'J' x 10 1/2 x 'H'



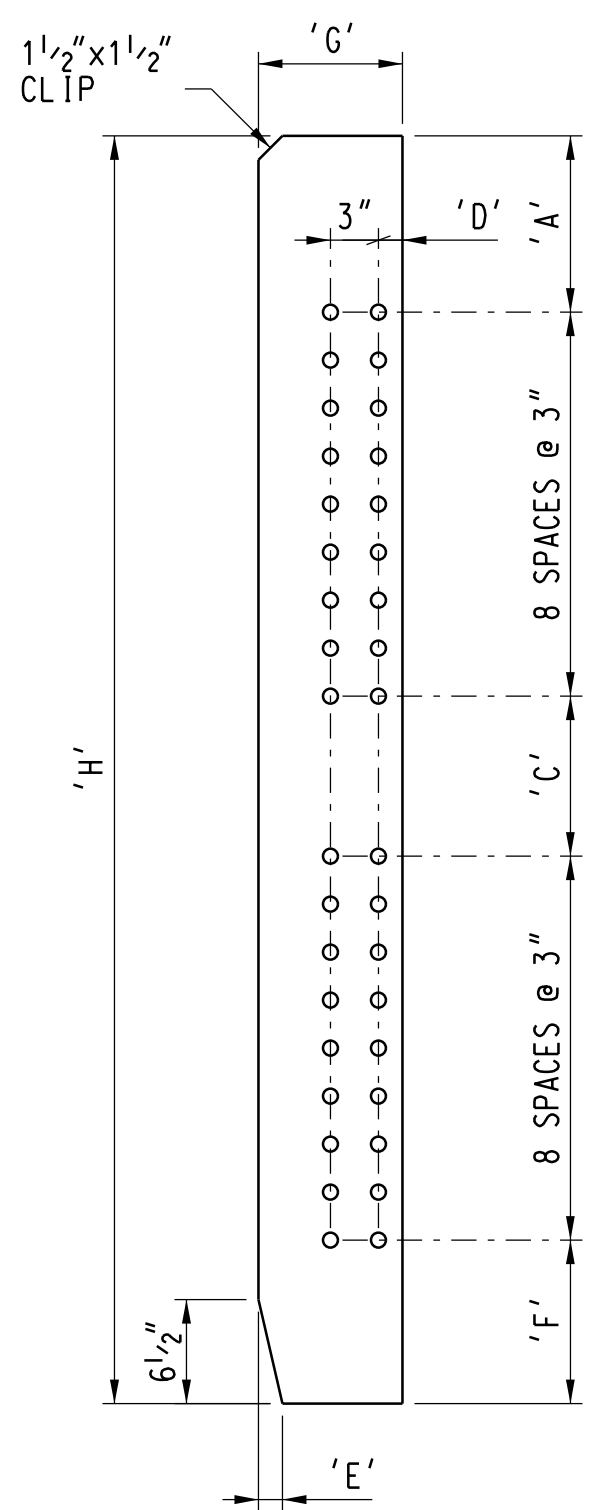
STIFFENER - SF07
PLATE 'J' x 'G' x 'H'



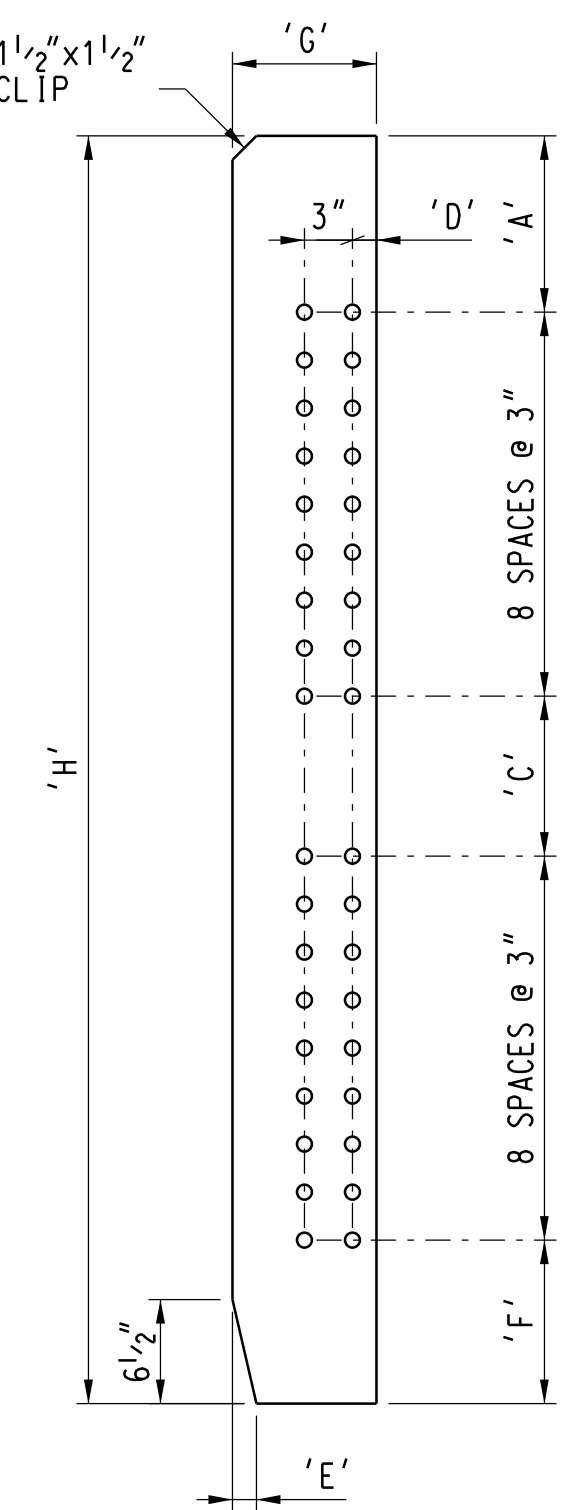
STIFFENER - SF08
PLATE 'J' x 'G' x 'H'
BOLT HOLES ARE NOT
REQUIRED ON CONCRETE DECK



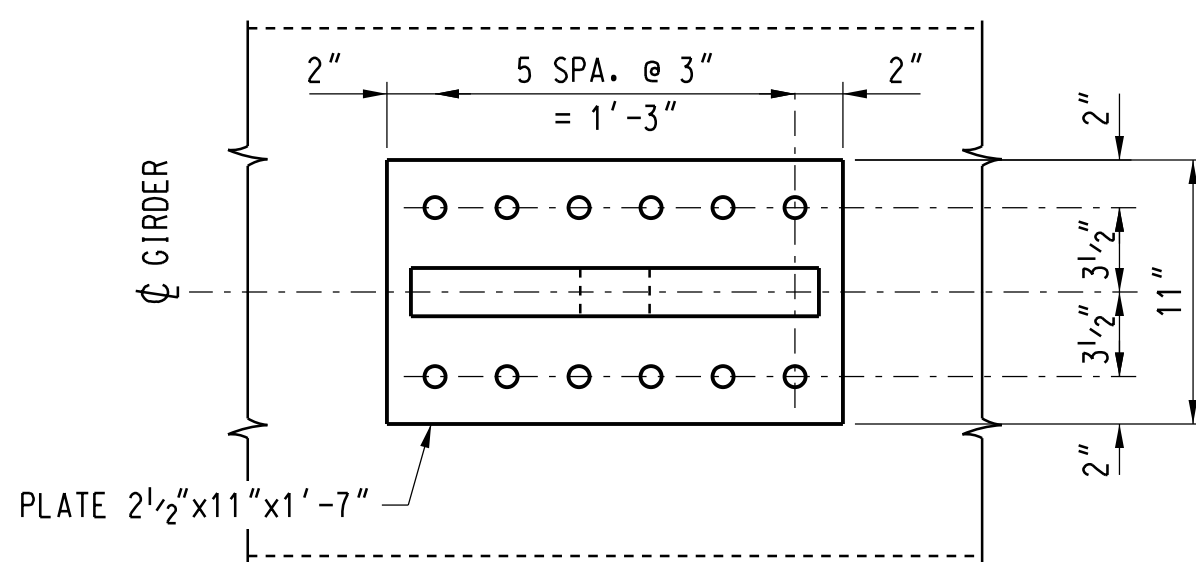
STIFFENER - SF09
PLATE 'J' x 'G' x 'H'
HOLES ONLY REQUIRED AT LATERAL
BRACING CONNECTION FOR
HEAVY DPG



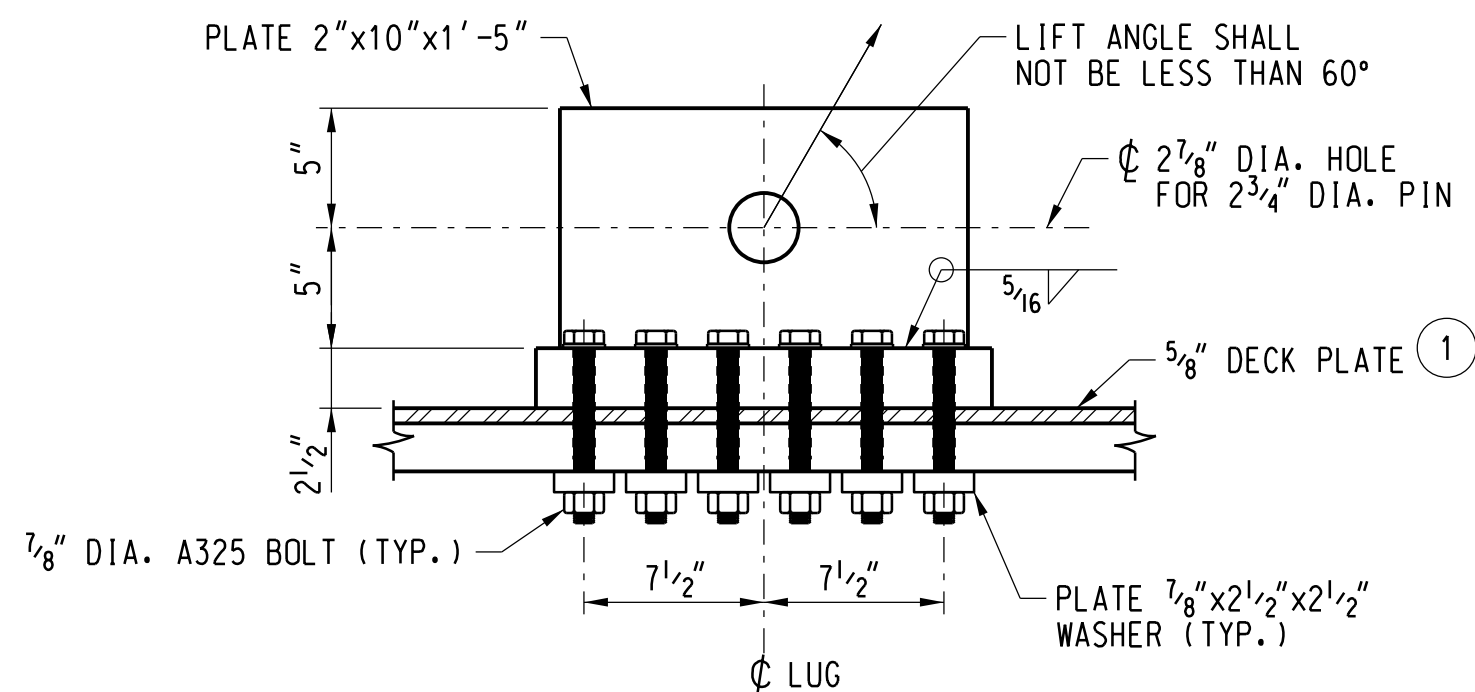
STIFFENER - SF10
PLATE 'J' x 9 x 'H'



STIFFENER - SF11
PLATE 'J' x 'G' x 'H'



PLAN



ELEVATION

LIFTING LUG DETAIL

NO SCALE
ASTM A709, GR. 50
NOTE: REQUIRED CAPACITY = MIN. 35.0 TONS

For reference on diaphragm design

SFXX-XXXX
ABBREVIATION
TYPE
GIRDER DEPTH
GIRDER TYPE

STIFFENER PLATES			
ABBREVIATION	TYPE	GIRDER TYPE	GIRDER DEPTH
SF	(00) (01) (02) (03) (04) (05) (06) (07) (08) (09) (10) (11)	(B) BEAM (L) LIGHT (M) MEDIUM (H) HEAVY	(024) - 2'-0" (030) - 2'-6" (042) - 3'-6" (048) - 4'-0" (066) - 5'-6" (084) - 7'-0" (102) - 8'-6" (120) - 10'-0" (138) - 11'-6"

① STEEL DECK ONLY.

NOTES:

- LIFTING LUGS TO BE LOCATED OUTSIDE THE MIDDLE 20' OF NON-SPLICED GIRDERS AND LONGER SPLICED GIRDER SECTIONS AND THE MIDDLE 15' OF THE SHORTER SPLICED SECTIONS. LUGS SHALL NOT BE PLACED WITHIN 5' ON EITHER SIDE OF MIDSPAN FOR ANY GIRDER.
- CONTRACTOR OR FABRICATOR MAY USE ALTERNATE LIFTING LUG. CALCULATIONS AND DRAWINGS FOR ALTERNATE LIFTING LUG SHALL BE SUBMITTED TO BNSF PRIOR TO FABRICATION OF STEEL SPANS.
- FABRICATOR TO FURNISH 7/8" DIA. A325 BOLTS FOR FILLING HOLES IN GIRDERS ONCE LIFTING LUGS ARE REMOVED.

WELDED PLATE GIRDER STIFFENER DIMENSIONS

STIFFENER MARK NO.	'A'	'B'	'C'	'D'	'E'	'F'	'G'	'H'	'J'
SF06-L066	1'-7"	-	-	-	-	-	-	5'-2"	1"
SF06-M066	1'-6"	-	-	-	-	-	-	5'-0"	1"
SF07-L084	11"	8	10"	3"	-	-	10 1/2"	6'-8"	1"
SF07-M084	10"	8	10"	3"	-	-	10 1/2"	6'-6"	1"
SF07-L102	11"	8	2'-4"	3"	-	-	10 1/2"	8'-2"	1"
SF07-M102	10"	8	2'-4"	3"	-	-	10 1/2"	8'-0"	1"
SF07-L120	11"	8	3'-10"	3 1/8"	-	-	10 1/2"	9'-8"	1"
SF07-M120	10"	8	3'-10"	3 1/8"	-	-	10 1/2"	9'-6"	1"
SF07-H102	10"	8	2'-4"	3 1/2"	-	-	1'-1"	8'-0"	1 1/4"
SF07-H120	10"	8	3'-10"	3 5/8"	-	-	1'-1"	9'-6"	1 1/4"
SF07-L138	11"	10	4'-4"	3 1/8"	-	-	10 1/2"	11'-2"	1"
SF07-H102	10"	8	2'-4"	3 1/2"	-	-	1'-1"	8'-0"	1 1/4"
SF07-M138	10"	10	4'-4"	3 5/8"	-	-	1'-1"	11'-0"	1 1/4"
SF08-L066	3 1/2"	-	-	4"	-	-	10 1/2"	5'-2"	1"
SF08-M066	2 1/2"	-	-	4"	-	-	10 1/2"	5'-0"	1"
SF08-L084	3 1/2"	-	-	4"	-	-	10 1/2"	6'-8"	1"
SF08-M084	2 1/2"	-	-	4"	-	-	10 1/2"	6'-6"	1"
SF08-L102	3 1/2"	-	-	4"	-	-	10 1/2"	8'-2"	1"
SF08-M102	2 1/2"	-	-	4"	-	-	10 1/2"	8'-0"	1"
SF08-L120	3 1/2"	-	-	4 1/8"	-	-	10 1/2"	9'-8"	1"
SF08-M120	2 1/2"	-	-	4 1/8"	-	-	10 1/2"	9'-6"	1"
SF08-L138	3 1/2"	-	-	4 1/8"	-	-	10 1/2"	11'-2"	1"
SF08-M138	2 1/2"	-	-	4 1/8"	-	-	10 1/2"	11'-0"	1"
SF08-H102	-	-	-	-	-	-	1'-1"	8'-0"	1 1/4"
SF08-H120	-	-	-	-	-	-	1'-1"	9'-6"	1 1/4"
SF08-H138	-	-	-	-	-	-	1'-1"	11'-0"	1 1/4"
SF09-L066	-	-	-	-	-	-	9"	4'-7 1/2"	1"
SF09-M066	-	-	-	-	-	-	9"	4'-5 1/2"	1"
SF09-L084	-	-	-	-	-	-	9"	6'-1 1/2"	1"
SF09-M084	-	-	-	-	-	-	9"	5'-11 1/2"	1"
SF09-L102	-	-	-	-	-	-	9"	7'-7 1/2"	1"
SF09-M102	-	-	-	-	-	-	9"	7'-5 1/2"	1"
SF09-L120	-	-	-	-	-	-	9"	9'-1 1/2"	1"
SF09-M120	-	-	-	-	-	-	9"	8'-11 1/2"	1"
SF09-L138	-	-	-	-	-	-	9"	10'-7 1/2"	1"
SF09-M138	-	-	-	-	-	-	9"	10'-5 1/2"	1"
SF09-H102	-	-	-	-	-	-	11"	7'-5 1/2"	1 1/4"
SF09-H120	-	-	-	-	-	-	11"	8'-11 1/2"	1 1/4"
SF09-H138	-	-	-	-	-	-	11"	10'-5 1/2"	1 1/4"
SF10-L066	1'-7"	-	-	-	-	1'-6 1/4"	-	5'-1 1/4"	1"
SF10-M066	1'-6"	-	-	-	-	1'-5 1/4"	-	4'-11 1/4"	1"
SF11-L084	11"	-	10"	1 1/2"	1 1/2"	10 1/4"	9"	6'-7 1/4"	1"
SF11-M084	10"	-	10"	1 1/2"	1 1/2"	9 1/4"	9"	6'-5 1/4"	1"
SF11-L102	11"	-	2'-4"	1 1/2"	1 1/2"	10 1/4"	9"	8'-1 1/4"	1"
SF11-M102	10"	-	2'-4"	1 1/2"	1 1/2"	9 1/4"	9"	7'-11 1/4"	1"
SF11-L120	11"	-	3'-10"	1 5/8"	1 1/2"	10 1/4"	9"	9'-7 1/4"	1"
SF11-M120	10"	-	3'-10"	1 5/8"	1 1/2"	9 1/4"	9"	9'-5 1/4"	1"
SF11-L138	11"	-	5'-4"	1 5/8"	1 1/2"	10 1/4"	9"	11'-1 1/4"	1"
SF11-M138	10"	-	5'-4"	1 5/8"	1 1/2"	9 1/4"	9"	10'-11 1/4"	1"
SF11-H102	10"	-	2'-4"	1 1/2"	2"	9 1/4"	11"	7'-11 1/4"	1 1/4"
SF11-H120	10"	-	3'-10"	1 5/8"	2"	9 1/4"	11"	9'-5 1/4"	1 1/4"
SF11-H138	10"	-	5'-4"	1 5/8"	2"	9 1/4"	11"	10'-11 1/4"	1 1/4"

STANDARD PLAN

DATE ISSUED OCTOBER 13, 2022

BNSF
RAILWAY

BRIDGE ENGINEERING KANSAS CITY, KS

APPROVED: *Nadine Guarino*

ASST. DIRECTOR STRUCTURES DESIGN

COMPONENT DETAILS
LATERAL BRACING

STEEL DETAILS -
LATERAL BRACES AND CONNECTION PLATES

PLAN NO: 0000-1910-02

SHEET: 2 OF 2

SUPERSTRUCTURE DESIGN (48' SPAN)

48 ft DPG Design
Super Structure**Design Criteria****Design Codes:**AREMA MRE 2023
NSRR Public Improvement Projects Manual**Geometry**Span configuration :
48'-0" CL Bent to CL Bent
46'-3 1/2" brg. to brg.

Horizontal curvature = N/A

Skew = 30°00'00"

4 girders @ 2'-10" centers (1'-5" overhangs)

Open Deck Structure-Timber tie deck include a cantilevered walkway on south
side of superstructure**Vertical Loads****DL_{Track & Fasteners}**

Assumed weight of 200 plf as per AREMA 15.1.3.2b

DL_{Timber Tie Deck}Assumed 10" x 10" cross section at 60pcf per AREMA 15.1.3.2a
The timber tie packed deck over the roadway will consist of a series
of three ties, assume decking consists of 1 - 16ft tie paired with
2 - 11.33 ft ties. Assume the grouping is spaced at 3'-6".**DL_{Walkway}**Assumed to have 2 - 6" x4" x1/2" brackets on either side of the
walkway grating, use 18psf for walkway grating loading, and
assume 3'-9" tall 3" x3" x 3/8" angles spaced at 3'-6" for rail post.
See attached detail for more information.**DL_{Girder Self-weight}**

Assumed weight of steel as 490 pcf as per AREMA 15.1.3.2a

DL_{ALL}Included summation Track & Fastener load, Timber Tie Deck load,
Walkway load, and Girder Self-weight Load.**LL = COOPER E80 or Alternate Live Load, whichever Controls**For Open Deck structure assume LL is distributed equally to all
girders as per AREMA 15.1.3.4.1**Impact**

IM = Direct Vertical +Rocking applied as per AREMA (15.1.3.5)

Fatigue

F = 35% of the IM loading applied per AREMA (15.1.3.13.d)

Lateral Loads**Wind**Wind loading for steel diaphragm design follows AREMA (15.1.3.7)
for wind loading on loaded bridges.Wind loading for steel diaphragm design follows AREMA (15.1.3.8)
for wind loading on unloaded bridges.**Longitudinal Loads**No longitudinal forces were accounted for in this design. Longitudinal
force will be transferred to the substructure through the bearing
anchor bolts.

HNTB The HNTB Companies Engineers Architects Planners	Made	RCR	Date	12/10/2024	Job Number	71886	
	Checked		Date				
	For	NSRR Shoofly Bridge	Backchk'd		Date		Sheet No.

48 ft DPG Design
Load Input

1. General:

Span Length (Out to Out) = 48.0 ft
 Span Length (Ctr to Ctr Bearings) = 46.3 ft

 No. of Girders = 4

 Unbraced Length (Compression Flange), l_y = 72.0 in

 Ctr to Ctr Girder Spacing = 34.0 in

Ballasted or Open Deck = O (B =ballast, O = open)

Ballast Deck
 Curb and Deck Material Type= (S = steel, C = conc.)
 Width of Concrete/Steel Deck = ft
 Thickness of Concrete/Steel Deck = in
 Distance Between Ballast Curbs = ft
 Max. Ballast Depth (Includes Tie) = in
 Min. Ballast Depth (Includes Tie) = in

Open Deck
 Tie Depth = 10.0 in
 Tie Width = 10.0 in
 Tie Area = 0.69 ft²

2. Material Properties:

Steel		
Fy =	50	ksi
Es =	29,000	ksi

AREMA Unit Weights for Dead Load Stresses	
Type	Kips per Cubic Foot
Track Rails and Fastenings	0.20
Steel	0.49
Timber	0.06

3. Girder and Deck Dimensions:

Girder	Width (in)	Thickness (in)
Top Flange	15.800	1.220
Web	0.710	40.460
Bottom Flange	15.800	1.220

NOTE : Use W44 x 230

4. Dead Load

	Tie Length (ft)	Tie Spacing (ft)	Tie Loading (kip/ft)
Long Tie :	16	3.5	0.19
Short Tie (1):	11	3.5	0.13
Short Tie (2):	11	3.5	0.13

Sum loading = 0.46 kip/ft
 Misc. Detail Factor = 10 %
 Total loading = 0.51 kip/ft

Walkway Bracket : 0.03 kip/ft
 2 - 6"x 4"x 1/2" Angles
 Walkway Grating : 0.11 kip/ft
 18 psf for a 6' wide walkway
 Walkway Handrail : 0.01 kip/ft
 3'-9" tall 3"x 3"x 3/8" Angle spa @ 3'-6"
 Sum loading = 0.15 kip/ft
 Misc. Detail Factor = 10 %
 Total loading = 0.16 kip/ft

Steel Area (Per Girder), A_s = 67.2786 in²
 Misc. Detail Factor = 10 %

Bridge Component	Load (All Girders)
Track Rails and Tie	0.71 kip/ft
Walkway	0.16 kip/ft
Plate Girders and Details	1.01 kip/ft

For	HNTB The HNTB Companies Engineers Architects Planners NSRR Shoofly Bridge	Made	RCR	Date	12/10/2024	Job Number	71886
		Checked		Date			
		Backchk'd		Date		Sheet No.	3

48 ft DPG Design

Load Input

5. Live Load

Note: Loads are per track

Live Load Type	AREMA Maximum	
	End Shear (kips)	Moment (kip-ft)
Cooper E-80	334	3,350
Alternate	332	3,544
Maximum LL	334	3,544

NOTE:

Following AREMA 15.1.3.4.1, it is assumed that the COOPER E80 and alternative loads will be equally distributed to all girders.

6. Impact

(AREMA 15.1.3.5)

Maximum Axle Load = 80.0 kips
Maximum Axle Moment = 100 k*ft
-Assuming a 5ft track width

Girder Line Location (ft)	I_x	Rocking
4.3	18.06	11%
1.4	2.01	4%
1.4	2.01	4%
4.3	18.06	11%

$\Sigma I_x = 40.14$

Rocking effect, R.E. = 10.6%
Impact, I = 36.0% (w/ out hammer blow)
Total Impact = 46.6%

Impact (Fatigue) = 16.3% (Mean impact load percentage = 35% per AREMA 15.1.3.13.d)

7. Load Summary

Load Summary (Per Girder)						
Load Type	Single Girder Maximums					
	End Shear (kips)	Moment (kip-ft)				
-DEAD LOADING						
Track Rails and Tie	4	47				
Walkway	1	11				
Plate Girders and Details	6	67				
Total Dead Load	11	126				
-LIVE LOADING						
Maximum LL w/Impact	122	1,299				
Maximum LL w/Impact (Fatigue)	97	1,030				
-TOTAL LOADING						
Dead + Live Loading	134	1,424				
Dead + Fatigue Live Loading	108	1,156				

NOTE: Assume all Dead and Live Loading is shared equally between all 4 girders

 The HNTB Companies	Made RCR	Date 12/10/2024	Job Number 71886
	Checked	Date	
For NSRR Shoofly Bridge	Backchk'd	Date	Sheet No. 4

48 ft DPG Design
 Girder Section Properties

Section Properties:
 Corrosion Loss = 0 in.

*Taken about the base of the bottom flange

Gross Section Properties								
Location	Width (in)	Thickness (in)	Area (in ²)	y* (in)	Ay (in ²)	Ay ² (in ³)	Io (in ⁴)	Ixx (in ⁴)
Top Flange	15.8	1.22	19.3	42.3	815	34,474	2	34,476
Web	0.710	40.5	28.7	21.5	616	13,217	3,919	17,136
Btm Flange	15.8	1.22	19.3	0.6	12	7	2	10
		42.90	67.3	21.5	1,443			51,622

I gross=

20,667

in⁴

S top =

963

in³

S bot =

963

in³

I_y comp flange =

402

in⁴

A comp flange =

33.6

in²

r_y comp flange =

3.46

in

For	HNTB The HNTB Companies NSRR Shoofly Bridge	Made	RCR	Date	12/10/2024	Job Number 71886
		Checked		Date		
		Backchk'd		Date		
						Sheet No. 5

48 ft DPG Design Allowable Stresses

Allowable Stresses

(AREMA 15.1.4)

Bending:

(Steel) Tension in Extreme Fiber, $F_T = 0.55F_y$

$$F_{T \text{ Allowable}} = 27.5 \text{ ksi}$$

$$(Steel) \text{ Compression in Extreme Fiber, } F_C = 0.55F_y - \frac{0.55(F_y)^2}{6.3\pi^2 E} \left(\frac{L}{r_y} \right)^2 = 27.2 \text{ ksi}$$

Larger of :

$$\frac{0.131\pi E}{\left(\frac{Ld\sqrt{1+\mu}}{A_f} \right)} = 65.3 \text{ ksi}$$

Not to exceed : $0.55F_y$

$$F_{C \text{ Allowable}} = 27.5 \text{ ksi}$$

Shear:

Shear in Web, $F_V = 0.35F_y$

$$F_{V \text{ Allowable}} = 17.5 \text{ ksi}$$

Fatigue

(AREMA 15.1.3.13)

Stress Cycles, N = Greater Than 2 Million

$$\text{Allowable Stress Range, } S_r = 16.0 \text{ ksi}$$

Category B AREMA Table 15-1-8, Detail 1.2

S_{Rfat} from Category B AREMA Table 15-1-9

Deflection

(AREMA 15.1.2.5)

$$\text{Allowable Deflection, } \Delta = \frac{L}{640} \quad \text{AREMA 15.1.2.5 b}$$

$$\Delta_{(Allow)} = 0.87 \text{ in}$$

Girder Proportions

(AREMA 15.1.7)

$$\text{Ratio (Unbraced Length/Rad. of Gyration)} = 5.55 \sqrt{\frac{E}{F_y}} \quad \text{AREMA 15.1.7.1b}$$

$$\text{Max Ratio } (l_y/r_y) = 133.7$$

$$\text{Min. Thickness of Plate Girder Web, } t_{web} = 0.18 \sqrt{\frac{F_y}{E}} \times D_{web} \quad \text{or} \quad \frac{t_f}{6}$$

(without longitudinal stiffeners)

$$\text{min } t_{web} = 0.30 \text{ in} \quad \text{AREMA 15.1.7.3a}$$

(AREMA 15.1.2.4)

$$\text{Min Ctr to Ctr Distance Between Exterior Girders} = \frac{L}{15}$$

$$\text{min distance} = 3.1 \text{ ft} \quad \text{AREMA 15.1.2.4a}$$

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48 ft DPG Design
Girder Proportioning

AREMA 15.1.7.1.b - Flange Buckling

Unbraced Length (Compression Flange), l_y = 72 in
Rad.of Gyration (Compression Flange+Portion of Web), r_y = 3.46 in
Ratio (l_y/r_y) = 20.8
Max Ratio (l_y/r_y) = 133.7
Status: OK

AREMA 15.1.7.3.a - Web Buckling

Web Thickness, t_{web} = 0.71 in
min t_{web} = 0.30 in
Status: OK

AREMA 15.1.7.3.c - Web Buckling

Web Thickness, t_{web} = 0.71 in.
Flange Thickness/6 = 0.20 in.
Status: OK

AREMA 15.1.2.4 - Girder Spacing

Ctr to Ctr Distance Between Exterior Girders = 8.5 ft
Min Required Distance = 3.1 ft
Status: OK

AREMA 15.1.5.5 - Accessibility of Parts

Distance Between Girder Flanges = 18.2 in
Min Required Distance = 18.0 in
Status: OK

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48 ft DPG Design

Section Properties:

Non-Composite Steel Girder Section Properties - Summary				
Location	y (in)	I _{gross} (in ⁴)	I _{net} (in ⁴)	S (in ³)
Top Steel	21.5	20,667	----	963
Btm Steel	21.5	----	17,567	819

*I_{net} conservatively I_{net} is assume 85% of gross section

Flexural Stress:

Non-Composite Flexural Stresses (Unshored)					
Location	DL all (ksi)	LL + IM (ksi)	Total Stress (ksi)	Allowable Stress	Status
Top of Steel	1.57	16.17	17.74	27.5	OK
Btm of Steel	1.84	19.03	20.87	27.5	OK

D/C
0.65
0.76

Shear Stress:

Shear Stress				
V _{max} (kips)	A _{web} (in ²)	v (ksi)	Allowable Stress	Status
134	28.73	4.65	17.5	OK

D/C
0.27

Fatigue:

Fatigue Stress Range			
Location	E80 LL+I (ksi)	Allowable S _r	Status
Btm of Steel	15.1	16.0	OK

D/C
0.94

Deflection:

Deflection (E80 LL+I)				
Location	Equiv. Uniform Load, w (kip/ft)	Deflection (in)	Allowable Deflection	Status
Midspan	4.8	0.84	0.87	OK

D/C
0.96

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48 ft DPG Design Bearing Stiffeners

Input Parameters:

Btm. flange width, b_f = 15.80 in
 Web depth, D = 40.46 in
 Web thickness, t_w = 0.710 in
 Stiffener yield stress, F_y = 50 ksi
 Mod. of elasticity, E = 29,000 ksi

Design Reactions:

Dead load, DL = 11 kips
 Live Load + Impact = 122.4 kips
 Total Reaction = 134 kips

Trial Plate Size:

Stiffener width, b_{stiff} = 7.000 in
 Stiffener thickness, t_{stiff} = 0.750 in

O.K. - Less than maximum PL Width

(AREMA 15.1.6.2)

O.K. - Exceeds minimum PL Thickness

(AREMA 15.1.5.4a)

Check Bearing Condition:

Bearing area = 8.25 in² (Assuming 2 - 1.5" clips)
 Allowable bearing stress = 41.50 ksi (AREMA 15.1.4.1)
 Actual bearing stress = 16.20 ksi

O.K. - Less than allowable stress

D/C
0.39

Check Column Condition:

Compression in Concentrically loaded columns

Effective Web Width = 17.75 in (AREMA 15.1.7.7c)
 use $25 \cdot t_w$ for stiffeners away from end of web
 Column area = 23.10 in² (AREMA 15.1.7.7c)
 Column mom. of inertia, I_{column} = 199.17 in⁴
 Radius of gyration, r = 2.94 in
 Effective Stiffener Length = 30.3 in (AREMA 15.1.7.7c)
 kl/r = 10.33 (AREMA 15.1.7.7c)
 Allowable comp. stress, F_a = 27.50 ksi (AREMA 15.1.4.1)
 Actual comp. stress, f_a = 5.78 ksi

O.K. - Less than allowable stress

D/C
0.21

Web to Stiffener Weld:

Fillet weld size = 0.3125 in
 Electrode = E70
 Allowable stress = 19.00 ksi
 Weld capacity = 4.20 kip/in
 Actual weld force = 0.89 kip/in

(E60, E70, E80)
(AREMA 1.4.2)

O.K. - Less than allowable

D/C
0.21

Summary:

Use **2 Plates** 0.750 inch x 7 inch
 Use **Grade 50**
 Use **0.3125** in. double sided fillet welds

SUPERSTRUCTURE DESIGN (34' SPAN)

34ft 4in DPG Design
Super Structure**Design Criteria****Design Codes:**

AREMA MRE 2023

NSRR Public Improvement Projects Manual

Geometry

Span configuration :

34'-4" CL End Bent to CL Bent

Varying Girder Lengths

Girder length for west end span shown, east end span similar

Girder Line 1 : 30'-9 1/8" brg. to brg.

Girder Line 2 : 32'-4 3/4" brg. to brg.

Girder Line 3 : 34'-0 3/8" brg. to brg.

Girder Line 4 : 35'-8" brg. to brg.

Horizontal curvature = N/A

End Bent Skew = N/A

Intermediate Bent Skew = 30°00'00"

4 girders @ 2'-10" centers (1'-5" overhangs)

Open Deck Structure

-Timber tie deck include a cantilevered walkway on south side of superstructure

Vertical Loads**DL_{Track & Fasteners}**

Assumed weight of 200 plf as per AREMA 15.1.3.2b

DL_{Timber Tie Deck}

Assumed 10" x 10" cross section at 60pcf per AREMA 15.1.3.2a

The timber tie packed deck over the roadway will consist of a series of three ties, assume decking consists of 1 - 16ft tie paired with 2 - 11.33 ft ties. Assume the grouping is spaced at 3'-6".

DL_{Walkway}

Assumed to have 2 - 6" x4" x1/2" brackets on either side of the walkway grating, use 18psf for walkway grating loading, and assume 3'-9" tall 3" x3" x 3/8" angles spaced at 3'-6" for rail post. See attached detail for more information.

DL_{Girder Self-weight}

Assumed weight of steel as 490 pcf as per AREMA 15.1.3.2a

DL_{ALL}

Included summation Track & Fastener load, Timber Tie Deck load, Walkway load, and Girder Self-weight Load.

LL = COOPER E80 or Alternate Live Load, whichever Controls

For Open Deck structure assume LL is distributed equally to all girders as per AREMA 15.1.3.4.1

Impact

IM = Direct Vertical +Rocking applied as per AREMA (15.1.3.5)

Fatigue

F = 35% of the IM loading applied per AREMA (15.1.3.13.d)

Lateral Loads**Wind**

Wind loading for steel diaphragm design follows AREMA (15.1.3.7) for wind loading on loaded bridges.

Wind loading for steel diaphragm design follows AREMA (15.1.3.8) for wind loading on unloaded bridges.

Longitudinal Loads

No longitudinal forces were accounted for in this design. Longitudinal force will be transferred to the substructure through the bearing anchor bolts.

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34ft 4in DPG Design Load Input

1. General:

Span Length (Out to Out) = 36.9 ft
Span Length (Ctr to Ctr Bearings) = 35.7 ft
No. of Girders = 4
Unbraced Length (Compression Flange), l_y = 72.0 in
Ctr to Ctr Girder Spacing = 34.0 in

Ballasted or Open Deck = O (B = ballast, O = open)

Ballast Deck

Curb and Deck Material Type = (S = steel, C = conc.)
Width of Concrete/Steel Deck = ft
Thickness of Concrete/Steel Deck = in
Distance Between Ballast Curbs = ft
Max. Ballast Depth (Includes Tie) = in
Min. Ballast Depth (Includes Tie) = in

Open Deck

Tie Depth = 10.0 in
Tie Width = 10.0 in
Tie Area = 0.69 ft²

2. Material Properties:

Steel		
Fy =	50	ksi
Es =	29,000	ksi

AREMA Unit Weights for Dead Load Stresses	
Type	Kips per Cubic Foot
Track Rails and Fastenings	0.20
Steel	0.49
Timber	0.06

3. Girder and Deck Dimensions:

Girder	Width (in)	Thickness (in)
Top Flange	15.800	1.220
Web	0.710	40.460
Bottom Flange	15.800	1.220

NOTE : Use W44 x 230

4. Dead Load

	Tie Length (ft)	Tie Spacing (ft)	Tie Loading (kip/ft)
Long Tie :	16	3.5	0.19
Short Tie (1):	11	3.5	0.13
Short Tie (2):	11	3.5	0.13
Sum loading =			0.46 kip/ft
Misc. Detail Factor =			10 %
Total loading =			0.51 kip/ft

Bridge Component	Load (All Girders)
Track Rails and Tie	0.71 kip/ft
Walkway	0.16 kip/ft
Plate Girders and Details	1.01 kip/ft

Walkway Bracket : 0.03 kip/ft
2 - 6"x 4"x 1/2" Angles
Walkway Grating : 0.11 kip/ft
18 psf for a 6' wide walkway
Walkway Handrail : 0.01 kip/ft
3'-9" tall 3"x 3"x 3/8" Angle spa @ 3'-6"
Sum loading = 0.15 kip/ft
Misc. Detail Factor = 10 %
Total loading = 0.16 kip/ft

Steel Area (Per Girder), A_s = 67.2786 in²
Misc. Detail Factor = 10 %

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34ft 4in DPG Design

Load Input

5. Live Load

Note: Loads are per track

Live Load Type	AREMA Maximum	
	End Shear (kips)	Moment (kip-ft)
Cooper E-80	280	2,126
Alternate	310	2,464
Maximum LL	310	2,464

NOTE:

Following AREMA 15.1.3.4.1, it is assumed that the COOPER E80 and alternative loads will be equally distributed to all girders.

6. Impact

(AREMA 15.1.3.5)

Maximum Axle Load = 80.0 kips
Maximum Axle Moment = 100 k*ft
-Assuming a 5ft track width

Girder Line Location (ft)	I_x	Rocking
4.3	18.06	11%
1.4	2.01	4%
1.4	2.01	4%
4.3	18.06	11%

$\Sigma I_x = 40.14$

Rocking effect, R.E. = 10.6%
Impact, I = 37.6% (w/ out hammer blow)
Total Impact = 48.2%

Impact (Fatigue) = 16.9% (Mean impact load percentage = 35% per AREMA 15.1.3.13.d)

7. Load Summary

Load Summary (Per Girder)						
Load Type	Single Girder Maximums					
	End Shear (kips)	Moment (kip-ft)				
-DEAD LOADING						
Track Rails and Tie	3	28				
Walkway	1	6				
Plate Girders and Details	5	40				
Total Dead Load	9	75				
-LIVE LOADING						
Maximum LL w/Impact	115	913				
Maximum LL w/Impact (Fatigue)	91	720				
-TOTAL LOADING						
Dead + Live Loading	124	988				
Dead + Fatigue Live Loading	99	795				

NOTE: Assume all Dead and Live Loading is shared equally between all 4 girders

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[34ft 4in DPG Design](#)
[Girder Section Properties](#)

Section Properties:
 Corrosion Loss = 0 in.

*Taken about the base of the bottom flange

Gross Section Properties								
Location	Width (in)	Thickness (in)	Area (in ²)	y* (in)	Ay (in ²)	Ay^2 (in ³)	Io (in ⁴)	Ixx (in ⁴)
Top Flange	15.8	1.22	19.3	42.3	815	34,474	2	34,476
Web	0.710	40.5	28.7	21.5	616	13,217	3,919	17,136
Btm Flange	15.8	1.22	19.3	0.6	12	7	2	10
		42.90	67.3	21.5	1,443			51,622

I gross=

20,667

in⁴

S top =

963

in³

S bot =

963

in³

I_y comp flange =

402

in⁴

A comp flange =

33.6

in²

r_y comp flange =

3.46

in

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34ft 4in DPG Design Allowable Stresses

Allowable Stresses

(AREMA 15.1.4)

Bending:

(Steel) Tension in Extreme Fiber, $F_T = 0.55F_y$

$$F_{T \text{ Allowable}} = 27.5 \text{ ksi}$$

$$(Steel) \text{ Compression in Extreme Fiber, } F_C = 0.55F_y - \frac{0.55(F_y)^2}{6.3\pi^2 E} \left(\frac{L}{r_y} \right)^2 = 27.2 \text{ ksi}$$

Larger of :

$$\frac{0.131\pi E}{\left(\frac{Ld\sqrt{1+\mu}}{A_f} \right)} = 65.3 \text{ ksi}$$

Not to exceed : $0.55F_y$

$$F_{C \text{ Allowable}} = 27.5 \text{ ksi}$$

Shear:

Shear in Web, $F_V = 0.35F_y$

$$F_{V \text{ Allowable}} = 17.5 \text{ ksi}$$

Fatigue

(AREMA 15.1.3.13)

Stress Cycles, N = Greater Than 2 Million

$$\text{Allowable Stress Range, } S_r = 16.0 \text{ ksi}$$

Category B AREMA Table 15-1-8, Detail 1.2

S_{Rfat} from Category B AREMA Table 15-1-9

Deflection

(AREMA 15.1.2.5)

$$\text{Allowable Deflection, } \Delta = \frac{L}{640} \quad \text{AREMA 15.1.2.5 b}$$

$$\Delta_{(Allow)} = 0.67 \text{ in}$$

Girder Proportions

(AREMA 15.1.7)

$$\text{Ratio (Unbraced Length/Rad. of Gyration)} = 5.55 \sqrt{\frac{E}{F_y}} \quad \text{AREMA 15.1.7.1b}$$

$$\text{Max Ratio } (l_y/r_y) = 133.7$$

$$\text{Min. Thickness of Plate Girder Web, } t_{web} = 0.18 \sqrt{\frac{F_y}{E}} \times D_{web} \quad \text{or} \quad \frac{t_f}{6}$$

(without longitudinal stiffeners)

$$\text{min } t_{web} = 0.30 \text{ in} \quad \text{AREMA 15.1.7.3a}$$

(AREMA 15.1.2.4)

$$\text{Min Ctr to Ctr Distance Between Exterior Girders} = \frac{L}{15}$$

$$\text{min distance} = 2.4 \text{ ft} \quad \text{AREMA 15.1.2.4a}$$

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34ft 4in DPG Design
Girder Proportioning

AREMA 15.1.7.1.b - Flange Buckling

Unbraced Length (Compression Flange), l_y = 72 in
Rad.of Gyration (Compression Flange+Portion of Web), r_y = 3.46 in
Ratio (l_y/r_y) = 20.8
Max Ratio (l_y/r_y) = 133.7
Status: OK

AREMA 15.1.7.3.a - Web Buckling

Web Thickness, t_{web} = 0.71 in
min t_{web} = 0.30 in
Status: OK

AREMA 15.1.7.3.c - Web Buckling

Web Thickness, t_{web} = 0.71 in.
Flange Thickness/6 = 0.20 in.
Status: OK

AREMA 15.1.2.4 - Girder Spacing

Ctr to Ctr Distance Between Exterior Girders = 8.5 ft
Min Required Distance = 2.4 ft
Status: OK

AREMA 15.1.5.5 - Accessibility of Parts

Distance Between Girder Flanges = 18.2 in
Min Required Distance = 18.0 in
Status: OK

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34ft 4in DPG Design

Section Properties:

Non-Composite Steel Girder Section Properties - Summary				
Location	y (in)	I _{gross} (in ⁴)	I _{net} (in ⁴)	S (in ³)
Top Steel	21.5	20,667	----	963
Btm Steel	21.5	----	17,567	819

*I_{net} conservatively I_{net} is assume 85% of gross section

Flexural Stress:

Non-Composite Flexural Stresses (Unshored)					
Location	DL all (ksi)	LL + IM (ksi)	Total Stress (ksi)	Allowable Stress	Status
Top of Steel	0.93	11.37	12.30	27.5	OK
Btm of Steel	1.09	13.38	14.47	27.5	OK

D/C
0.45
0.53

Shear Stress:

Shear Stress				
V _{max} (kips)	A _{web} (in ²)	v (ksi)	Allowable Stress	Status
124	28.73	4.30	17.5	OK

D/C
0.25

Fatigue:

Fatigue Stress Range			
Location	E80 LL+I (ksi)	Allowable S _r	Status
Btm of Steel	10.5	16.0	OK

D/C
0.66

Deflection:

Deflection (E80 LL+I)				
Location	Equiv. Uniform Load, w (kip/ft)	Deflection (in)	Allowable Deflection	Status
Midspan	5.7	0.35	0.67	OK

D/C
0.52

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34ft 4in DPG Design Bearing Stiffeners

Input Parameters:

Btm. flange width, b_f = 15.80 in
 Web depth, D = 40.46 in
 Web thickness, t_w = 0.710 in
 Stiffener yield stress, F_y = 50 ksi
 Mod. of elasticity, E = 29,000 ksi

Design Reactions:

Dead load, DL = 9 kips
 Live Load + Impact = 114.9 kips
 Total Reaction = 124 kips

Trial Plate Size:

Stiffener width, b_{stiff} = 7.000 in
 Stiffener thickness, t_{stiff} = 0.750 in

O.K. - Less than maximum PL Width

(AREMA 15.1.6.2)

O.K. - Exceeds minimum PL Thickness

(AREMA 15.1.5.4a)

Check Bearing Condition:

Bearing area = 8.25 in² (Assuming 2 - 1.5" clips)
 Allowable bearing stress = 41.50 ksi (AREMA 15.1.4.1)
 Actual bearing stress = 14.97 ksi

O.K. - Less than allowable stress

D/C
0.36

Check Column Condition:

Compression in Concentrically loaded columns

Effective Web Width = 17.75 in (AREMA 15.1.7.7c)
 use $25 \cdot t_w$ for stiffeners away from end of web
 Column area = 23.10 in² (AREMA 15.1.7.7c)

Column mom. of inertia, I_{column} = 199.17 in⁴

Radius of gyration, r = 2.94 in

Effective Stiffener Length = 30.3 in (AREMA 15.1.7.7c)

kl/r = 10.33 (AREMA 15.1.7.7c)

Allowable comp. stress, F_a = 27.50 ksi (AREMA 15.1.4.1)

Actual comp. stress, f_a = 5.35 ksi

O.K. - Less than allowable stress

D/C
0.19

Web to Stiffener Weld:

Fillet weld size = 0.3125 in
 Electrode = E70 (E60, E70, E80)
 Allowable stress = 19.00 ksi (AREMA 1.4.2)
 Weld capacity = 4.20 kip/in
 Actual weld force = 0.82 kip/in

O.K. - Less than allowable

D/C
0.20

Summary:

Use	2 Plates	0.750 inch x	7 inch
Use	Grade	50	
Use	0.3125	in. double sided fillet welds	

SUPERSTRUCTURE DESIGN (24' SPAN)

24ft 7in DPG Design
Super Structure**Design Criteria****Design Codes:**AREMA MRE 2023
NSRR Public Improvement Projects Manual**Geometry**Span configuration :
24'-7" CL Bent to CL Bent
22'-10 1/4" brg. to brg.

Horizontal curvature = N/A

Skew = 30°00'00"

4 girders @ 2'-10" centers (1'-5" overhangs)

Open Deck Structure-Timber tie deck include a cantilevered walkway on south
side of superstructure**Vertical Loads****DL_{Track & Fasteners}**

Assumed weight of 200 plf as per AREMA 15.1.3.2b

DL_{Timber Tie Deck}Assumed 10" x 10" cross section at 60pcf per AREMA 15.1.3.2a
The timber tie packed deck over the roadway will consist of a series
of three ties, assume decking consists of 1 - 16ft tie paired with
2 - 11.33 ft ties. Assume the grouping is spaced at 3'-6".**DL_{Walkway}**Assumed to have 2 - 6" x4" x1/2" brackets on either side of the
walkway grating, use 18psf for walkway grating loading, and
assume 3'-9" tall 3" x3" x 3/8" angles spaced at 3'-6" for rail post.
See attached detail for more information.**DL_{Girder Self-weight}**

Assumed weight of steel as 490 pcf as per AREMA 15.1.3.2a

DL_{ALL}Included summation Track & Fastener load, Timber Tie Deck load,
Walkway load, and Girder Self-weight Load.**LL = COOPER E80 or Alternate Live Load, whichever Controls**For Open Deck structure assume LL is distributed equally to all
girders as per AREMA 15.1.3.4.1**Impact**

IM = Direct Vertical +Rocking applied as per AREMA (15.1.3.5)

Fatigue

F = 35% of the IM loading applied per AREMA (15.1.3.13.d)

Lateral Loads**Wind**Wind loading for steel diaphragm design follows AREMA (15.1.3.7)
for wind loading on loaded bridges.Wind loading for steel diaphragm design follows AREMA (15.1.3.8)
for wind loading on unloaded bridges.**Longitudinal Loads**No longitudinal forces were accounted for in this design. Longitudinal
force will be transferred to the substructure through the bearing
anchor bolts.

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24ft 7in DPG Design
Load Input

1. General:

Span Length (Out to Out) = 24.6 ft
 Span Length (Ctr to Ctr Bearings) = 22.9 ft

 No. of Girders = 4

 Unbraced Length (Compression Flange), l_y = 72.0 in

 Ctr to Ctr Girder Spacing = 34.0 in

Ballasted or Open Deck = O (B =ballast, O = open)

Ballast Deck
 Curb and Deck Material Type= (S = steel, C = conc.)
 Width of Concrete/Steel Deck = ft
 Thickness of Concrete/Steel Deck = in
 Distance Between Ballast Curbs = ft
 Max. Ballast Depth (Includes Tie) = in
 Min. Ballast Depth (Includes Tie) = in

Open Deck
 Tie Depth = 10.0 in
 Tie Width = 10.0 in
 Tie Area = 0.69 ft²

2. Material Properties:

Steel			AREMA Unit Weights for Dead Load Stresses	
Fy =	50	ksi	Type	Kips per Cubic Foot
Es =	29,000	ksi	Track Rails and Fastenings	0.20
			Steel	0.49
			Timber	0.06

3. Girder and Deck Dimensions:

Girder	Width (in)	Thickness (in)
Top Flange	15.800	1.220
Web	0.710	40.460
Bottom Flange	15.800	1.220

NOTE : Use W44 x 230

4. Dead Load

	Tie Length (ft)	Tie Spacing (ft)	Tie Loading (kip/ft)
Long Tie :	16	3.5	0.19
Short Tie (1):	11	3.5	0.13
Short Tie (2):	11	3.5	0.13

Sum loading = 0.46 kip/ft
 Misc. Detail Factor = 10 %
 Total loading = 0.51 kip/ft

Walkway Bracket : 0.03 kip/ft
 2 - 6"x 4"x 1/2" Angles
 Walkway Grating : 0.11 kip/ft
 18 psf for a 6' wide walkway
 Walkway Handrail : 0.01 kip/ft
 3'-9" tall 3"x 3"x 3/8" Angle spa @ 3'-6"
 Sum loading = 0.15 kip/ft
 Misc. Detail Factor = 10 %
 Total loading = 0.16 kip/ft

Steel Area (Per Girder), A_s = 67.2786 in²
 Misc. Detail Factor = 10 %

Bridge Component	Load (All Girders)
Track Rails and Tie	0.71 kip/ft
Walkway	0.16 kip/ft
Plate Girders and Details	1.01 kip/ft

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24ft 7in DPG Design

Load Input

5. Live Load

Note: Loads are per track

Live Load Type	AREMA Maximum	
	End Shear (kips)	Moment (kip-ft)
Cooper E-80	216	1,050
Alternate	260	1,222
Maximum LL	260	1,222

NOTE:

Following AREMA 15.1.3.4.1, it is assumed that the COOPER E80 and alternative loads will be equally distributed to all girders.

6. Impact

(AREMA 15.1.3.5)

Maximum Axle Load = 80.0 kips
Maximum Axle Moment = 100 k*ft
-Assuming a 5ft track width

Girder Line Location (ft)	I_x	Rocking
4.3	18.06	11%
1.4	2.01	4%
1.4	2.01	4%
4.3	18.06	11%

$\Sigma I_x = 40.14$

Rocking effect, R.E. = 10.6%
Impact, I = 39.0% (w/ out hammer blow)
Total Impact = 49.6%

Impact (Fatigue) = 17.4% (Mean impact load percentage = 35% per AREMA 15.1.3.13.d)

7. Load Summary

Load Summary (Per Girder)						
Load Type	Single Girder Maximums					
	End Shear (kips)	Moment (kip-ft)				
-DEAD LOADING						
Track Rails and Tie	2	12				
Walkway	1	3				
Plate Girders and Details	3	16				
Total Dead Load	6	31				
-LIVE LOADING						
Maximum LL w/Impact	97	457				
Maximum LL w/Impact (Fatigue)	76	359				
-TOTAL LOADING						
Dead + Live Loading	103	488				
Dead + Fatigue Live Loading	82	389				

NOTE: Assume all Dead and Live Loading is shared equally between all 4 girders

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24ft 7in DPG Design
 Girder Section Properties

Section Properties:
 Corrosion Loss = 0 in.

*Taken about the base of the bottom flange

Gross Section Properties								
Location	Width (in)	Thickness (in)	Area (in ²)	y* (in)	Ay (in ²)	Ay^2 (in ³)	Io (in ⁴)	Ixx (in ⁴)
Top Flange	15.8	1.22	19.3	42.3	815	34,474	2	34,476
Web	0.710	40.5	28.7	21.5	616	13,217	3,919	17,136
Btm Flange	15.8	1.22	19.3	0.6	12	7	2	10
		42.90	67.3	21.5	1,443			51,622

I gross=

20,667

in⁴

S top =

963

in³

S bot =

963

in³

I_y comp flange =

402

in⁴

A comp flange =

33.6

in²

r_y comp flange =

3.46

in

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24ft 7in DPG Design Allowable Stresses

Allowable Stresses

(AREMA 15.1.4)

Bending:

(Steel) Tension in Extreme Fiber, $F_T = 0.55F_y$

$$F_{T \text{ Allowable}} = 27.5 \text{ ksi}$$

$$(Steel) \text{ Compression in Extreme Fiber, } F_C = 0.55F_y - \frac{0.55(F_y)^2}{6.3\pi^2 E} \left(\frac{L}{r_y} \right)^2 = 27.2 \text{ ksi}$$

Larger of :

$$\frac{0.131\pi E}{\left(\frac{Ld\sqrt{1+\mu}}{A_f} \right)} = 65.3 \text{ ksi}$$

Not to exceed : $0.55F_y$

$$F_{C \text{ Allowable}} = 27.5 \text{ ksi}$$

Shear:

Shear in Web, $F_V = 0.35F_y$

$$F_{V \text{ Allowable}} = 17.5 \text{ ksi}$$

Fatigue

(AREMA 15.1.3.13)

Stress Cycles, N = Greater Than 2 Million

$$\text{Allowable Stress Range, } S_r = 16.0 \text{ ksi}$$

Category B AREMA Table 15-1-8, Detail 1.2

S_{Rfat} from Category B AREMA Table 15-1-9

Deflection

(AREMA 15.1.2.5)

$$\text{Allowable Deflection, } \Delta = \frac{L}{640} \quad \text{AREMA 15.1.2.5 b}$$

$$\Delta_{(Allow)} = 0.43 \text{ in}$$

Girder Proportions

(AREMA 15.1.7)

$$\text{Ratio (Unbraced Length/Rad. of Gyration)} = 5.55 \sqrt{\frac{E}{F_y}} \quad \text{AREMA 15.1.7.1b}$$

$$\text{Max Ratio } (l_y/r_y) = 133.7$$

$$\text{Min. Thickness of Plate Girder Web, } t_{web} = 0.18 \sqrt{\frac{F_y}{E}} \times D_{web} \quad \text{or} \quad \frac{t_f}{6}$$

(without longitudinal stiffeners)

$$\text{min } t_{web} = 0.30 \text{ in} \quad \text{AREMA 15.1.7.3a}$$

(AREMA 15.1.2.4)

$$\text{Min Ctr to Ctr Distance Between Exterior Girders} = \frac{L}{15}$$

$$\text{min distance} = 1.5 \text{ ft} \quad \text{AREMA 15.1.2.4a}$$

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24ft 7in DPG Design
Girder Proportioning

AREMA 15.1.7.1.b - Flange Buckling

Unbraced Length (Compression Flange), l_y = 72 in
Rad.of Gyration (Compression Flange+Portion of Web), r_y = 3.46 in
Ratio (l_y/r_y) = 20.8
Max Ratio (l_y/r_y) = 133.7
Status: OK

AREMA 15.1.7.3.a - Web Buckling

Web Thickness, t_{web} = 0.71 in
min t_{web} = 0.30 in
Status: OK

AREMA 15.1.7.3.c - Web Buckling

Web Thickness, t_{web} = 0.71 in.
Flange Thickness/6 = 0.20 in.
Status: OK

AREMA 15.1.2.4 - Girder Spacing

Ctr to Ctr Distance Between Exterior Girders = 8.5 ft
Min Required Distance = 1.5 ft
Status: OK

AREMA 15.1.5.5 - Accessibility of Parts

Distance Between Girder Flanges = 18.2 in
Min Required Distance = 18.0 in
Status: OK

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24ft 7in DPG Design

Section Properties:

Non-Composite Steel Girder Section Properties - Summary				
Location	y (in)	I _{gross} (in ⁴)	I _{net} (in ⁴)	S (in ³)
Top Steel	21.5	20,667	----	963
Btm Steel	21.5	----	17,567	819

*I_{net} conservatively I_{net} is assume 85% of gross section

Flexural Stress:

Non-Composite Flexural Stresses (Unshored)					
Location	DL all (ksi)	LL + IM (ksi)	Total Stress (ksi)	Allowable Stress	Status
Top of Steel	0.38	5.69	6.07	27.5	OK
Btm of Steel	0.45	6.70	7.15	27.5	OK

D/C
0.22
0.26

Shear Stress:

Shear Stress				
V _{max} (kips)	A _{web} (in ²)	v (ksi)	Allowable Stress	Status
103	28.73	3.59	17.5	OK

D/C
0.20

Fatigue:

Fatigue Stress Range			
Location	E80 LL+I (ksi)	Allowable S _r	Status
Btm of Steel	5.3	16.0	OK

D/C
0.33

Deflection:

Deflection (E80 LL+I)				
Location	Equiv. Uniform Load, w (kip/ft)	Deflection (in)	Allowable Deflection	Status
Midspan	7.0	0.07	0.43	OK

D/C
0.17

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24ft 7in DPG Design Bearing Stiffeners

Input Parameters:

Btm. flange width, b_f = 15.80 in
 Web depth, D = 40.46 in
 Web thickness, t_w = 0.710 in
 Stiffener yield stress, F_y = 50 ksi
 Mod. of elasticity, E = 29,000 ksi

Design Reactions:

Dead load, DL = 6 kips
 Live Load + Impact = 97.2 kips
 Total Reaction = 103 kips

Trial Plate Size:

Stiffener width, b_{stiff} = 7.000 in
 Stiffener thickness, t_{stiff} = 0.750 in

O.K. - Less than maximum PL Width

(AREMA 15.1.6.2)

O.K. - Exceeds minimum PL Thickness

(AREMA 15.1.5.4a)

Check Bearing Condition:

Bearing area = 8.25 in² (Assuming 2 - 1.5" clips)
 Allowable bearing stress = 41.50 ksi (AREMA 15.1.4.1)
 Actual bearing stress = 12.49 ksi

O.K. - Less than allowable stress

D/C
0.30

Check Column Condition:

Compression in Concentrically loaded columns

Effective Web Width = 17.75 in (AREMA 15.1.7.7c)
 use $25 \cdot t_w$ for stiffeners away from end of web
 Column area = 23.10 in² (AREMA 15.1.7.7c)
 Column mom. of inertia, I_{column} = 199.17 in⁴
 Radius of gyration, r = 2.94 in
 Effective Stiffener Length = 30.3 in (AREMA 15.1.7.7c)
 kl/r = 10.33 (AREMA 15.1.7.7c)
 Allowable comp. stress, F_a = 27.50 ksi (AREMA 15.1.4.1)
 Actual comp. stress, f_a = 4.46 ksi

O.K. - Less than allowable stress

D/C
0.16

Web to Stiffener Weld:

Fillet weld size = 0.3125 in
 Electrode = E70
 Allowable stress = 19.00 ksi
 Weld capacity = 4.20 kip/in
 Actual weld force = 0.69 kip/in

(E60, E70, E80)
(AREMA 1.4.2)

O.K. - Less than allowable

D/C
0.16

Summary:

Use	2 Plates	0.750 inch x	7 inch
Use	Grade	50	
Use	0.3125	in. double sided fillet welds	

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Span 1, 2, 3, 4, 5, 7, & 8

End Diaphragm Design

Objective: Design the steel diaphragms for NSRR Shoofly bridge over I-70

Transverse Loads for Diaphragm Design

Vertical Projection of Span:

Girder= 42.900 in
H= 42.900 in 3.575 ft
Girder Spacing= 2.833 ft
Diaphragm spacing= 3.000 ft
Spacing <18ft - OK AREMA 15.1.11.4e

Wind on Train (WL) - AREMA 15.1.3.7a

w= 0.3 k/ft
V_{wl}= 0.900 k/diaphragm

Wind on Loaded Bridge (WL) - AREMA 15.1.3.8

W_{Loaded Bridge}= 0.20 k/ft
V_{ws}= 0.60 k/diaphragm

Wind on Unloaded Bridge (WS) - AREMA 15.1.3.8

W_{Unloaded Bridge}= 0.27 k/ft
V_{ws}= 0.80 k/diaphragm

Lateral Equipment Force - AREMA 15.1.3.9

V_{le}= 25.000 k/diaphragm

Compression Flange Force - AREMA 15.1.11.6

F_{cf}= 17.74 ksi
A_{cf}= 19.276 in²
P_{cf}= 342 k
% of force= 2.500 %
V_{cf}= 8.5 k/diaphragm

Diaphragm Properties

Size: W30x90
A= 26.300 in²
d= 29.5 in
t_w= 0.47 in
t_{stiff}= 0.75 in *Bearing Stiffener
t_{w(girder)}= 0.71 in *W44x230
I_x= 3610.00 in⁴
I_y= 115.00 in⁴
Number= 1 shapes
L= 28.0 in (Dist. Between Bolt Group C.G.)
k= 0.75
E= 29000 ksi
F_y= 50 ksi
I_{xtotal}= 3610.00 in⁴
I_{ytotal}= 115.00 in⁴
A_{total}= 26.30 in²
r_x= 11.72 in
r_y= 2.09 in
kl/r_x= 1.79
kl/r_y= 10.04

Compressive Strength - AREMA 15.1.4 and 15.1.6.2

Outstanding Elements in Compression

Beam b_f= 4.965 in (outstanding flange minus web)
Beam t_f= 0.610 in

Limit b_f= $0.50t_f\sqrt{\frac{E}{F_y}}$ = 7.35 in

Flange width OK

Allowable Stress - AREMA Table 15-1-11

$\frac{0.629}{\sqrt{\frac{F_y}{E}}} = 15.148$ $\frac{5.034}{\sqrt{\frac{F_y}{E}}} = 121.235$

F_{a compr}= 27.5 ksi

Check of Diaphragm:

Combinations Checked: AREMA REF
1 - WS (Loaded) + WL + Equipment Tbl 15-1-10 (3rd row)
2 - WS (unloaded) Tbl 15-1-10 (5th row)
3 - 2.5% of Compression Flange Force 15.1.11.6

Controlling Comb. : 1 - WS (Loaded) + WL + Equipment

Total force= 26.50 kips D/C
f_a= 1.01 ksi 0.04

Diaphragm OK

Use 1 - W30x90

Check Connection to Angles - AREMA 15.1.5.9 and 15.1.11.4c

Design connection for lesser of design allowable stress or 1.5 x maximum computed stress.
Connection shall be design for no less that 1/2 shear capacity of the diaphragm.

f_a= 1.5 ksi
F_{a compr}= 27.5 ksi
1.5x Max Computed Stress Controls
Design for: 39.8 k

Shear Capacity of Diaphragm (Table 1-15-11):

f_a=0.35F_y= 17.5 ksi
1/2 Shear Cap. = 121.32 k
1/2 Shear Capacity Controls
Design conn. For = 121.319 k/connection

Diaphragms are connected to beams at bearing by a single L5x5x1/2 member and the bearing stiffener.

t_{angle}= 0.5 in

For design assume diaphragm loads are transferred to the beam equally both the stiffener and the angle

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Span 1, 2, 3, 4, 5, 7, & 8 End Diaphragm Design

Check Connection to Angles - AREMA 15.1.5.9 and 15.1.11.4
(continued)

Bolt Shear (Diaphragm to Stiffener/Angle) - Table 15-1-11

$d_b =$	0.875	in	
A325 bolts $F_u =$	21.5	ksi (slip critical Class B)	
No. of bolts =	7		
Shear planes =	2		
$R_n =$	181	k	D/C
$R_u =$	121.32	k	0.67

1x Design Load from diaphragm to stiffener & angle through 1 line of bolts

Connection OK

-Use 1 rows of 7 bolts

Bolt Shear (Angle to Beam) - Table 15-1-11

$d_b =$	0.875	in	
A325 bolts $F_u =$	21.5	ksi (slip critical Class B)	
No. of bolts =	7	*total bolts from 2 angle pairs	
Shear planes =	1		
$R_n =$	90	k	D/C
$R_u =$	60.66	k	0.67

1/2x Design Load from diaphragm to beam through 1 line of bolts in angle

Connection OK

-For the angle use 1 rows of 7 bolts

Bolt Bearing (Diaphragm to Stiffener/Angle) - 15.1.4.1 and 15.1.5.3

$L =$	1.50	in	
$F_u =$	65	ksi	
$LF_u/2d =$	56	ksi	
$1.2F_u =$	78	ksi	
$A_{\text{bolt bearing}} =$	0.41	in ² (Min. Bearing Area)	
$R_n =$	160.4	k	D/C
$R_u =$	121.32	k	0.76

1x Design Load bearing diaphragm, stiffener, or angle

Connection OK

Bolt Bearing (Angle to Beam) - 15.1.4.1 and 15.1.5.3

$L =$	1.50	in	
$F_u =$	65	ksi	
$LF_u/2d =$	56	ksi	
$1.2F_u =$	78	ksi	
$A_{\text{bolt bearing}} =$	0.44	in ² (Min. Bearing Area)	
$R_n =$	170.6	k	D/C
$R_u =$	60.66	k	0.36

1/2x Design Load bearing on angle or beam web

Connection OK

Edge Distance Requirement - AREMA 15.1.9.3

Min:	$1.5d_b =$	1.31	in
	$2d_b * f_p / F_u =$	0.00	in
Max:	$1.5 + 4t =$	3.38	in

Vert. Edge Dist. Prov. = 1.50 in

Horiz. Edge Dist. Prov. = 2.00 in

Connection OK

Minimum Bolt Spacing Requirements - AREMA 15.1.9.2

$3d_b =$	2.625	in
$2d_b * f_p / F_u + d/2 =$	0.44	in

Vert. Spacing Prov. = 3.750 in

Horiz. Spacing Prov. = - in

Connection OK

Maximum Bolt Spacing Requirements - AREMA 15.1.5.13

Min of : $4 + 4t$ or $7" =$ 7 in

Vert. Spacing Prov. = 3.750 in

Connection OK

Block Shear in Angles - 15.1.4.1 and 15.1.5.3

$F_y =$	50	ksi
$F_u =$	65	ksi
$L_{gv} =$	22.5	in
$L_{nv} =$	17.25	in
$L_{nt} =$	1.56	in
$t_{leg} =$	0.5	in
$A_{gv} =$	11.25	in ²
$A_{nv} =$	8.625	in ²
$A_{nt} =$	0.7813	in ²
$U_{bs} =$	1	

$R_{n1} =$ 193.58 k

$R_{n2} =$ 194.14 k

$R_n =$ 193.6 k

$R_u =$ 60.66 k

D/C

0.31

1x Design Load from diaphragm split by 2 angles

Connection OK

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Span 1, 2, 3, 4, 5, 7, & 8

Intermediate Diaphragm Design

Objective: Design the steel diaphragms for NSRR Shoofly bridge over I-70

Transverse Loads for Diaphragm Design

Vertical Projection of Span:

Girder= 42.900 in
H= 42.900 in 3.575 ft
Girder Spacing= 2.833 ft
Diaphragm spacing= 3.000 ft
Spacing <18ft - OK AREMA 15.1.11.4e

Wind on Train (WL) - AREMA 15.1.3.7a

w= 0.3 k/ft
V_{wl}= 0.900 k/diaphragm

Wind on Loaded Bridge (WL) - AREMA 15.1.3.8

w_{Loaded Bridge}= 0.20 k/ft
V_{ws}= 0.60 k/diaphragm

Wind on Unloaded Bridge (WS) - AREMA 15.1.3.8

w_{Unloaded Bridge}= 0.27 k/ft
V_{ws}= 0.80 k/diaphragm

Lateral Equipment Force - AREMA 15.1.3.9

V_{le}= 20.000 k/diaphragm

Compression Flange Force - AREMA 15.1.11.6

F_{cf}= 17.74 ksi
A_{cf}= 19.276 in²
P_{cf}= 342 k
% of force= 2.500 %
V_{cf}= 8.5 k/diaphragm

Diaphragm Properties

Size: W30x90
A= 26.300 in²
d= 29.5 in
t_w= 0.47 in
t_{stiff}= 0.5 in *L5x5x1/2
t_{w(girder)}= 0.71 in *W44x230
I_x= 3610.00 in⁴
I_y= 115.00 in⁴
Number= 1 shapes
L= 28 in (Dist. Between Bolt Group C.G.)
k= 0.75
E= 29000 ksi
F_y= 50 ksi
I_{xtotal}= 3610.00 in⁴
I_{ytotal}= 115.00 in⁴
A_{total}= 26.30 in²
r_x= 11.72 in
r_y= 2.09 in
kl/r_x= 1.79
kl/r_y= 10.04

Compressive Strength - AREMA 15.1.4 and 15.1.6.2

Outstanding Elements in Compression

Beam b_f= 4.965 in (outstanding flange minus web)
Beam t_f= 0.610 in

Limit b_f= $0.50t_f\sqrt{\frac{E}{F_y}}$ = 7.35 in

Flange width OK

Allowable Stress - AREMA Table 15-1-11

$\frac{0.629}{\sqrt{\frac{F_y}{E}}} = 15.148$ $\frac{5.034}{\sqrt{\frac{F_y}{E}}} = 121.235$

F_{a compr}= 27.5 ksi

Check of Diaphragm:

Combinations Checked: AREMA REF
1 - WS (Loaded) + WL + Equipment Tbl 15-1-10 (3rd row)
2 - WS (unloaded) Tbl 15-1-10 (5th row)
3 - 2.5% of Compression Flange Force 15.1.11.6

Controlling Comb. : 1 - WS (Loaded) + WL + Equipment

Total force= 21.50 kips D/C
f_a= 0.82 ksi 0.03

Diaphragm OK

Use 1 - W30x90

Check Connection to Angles - AREMA 15.1.5.9 and 15.1.11.4c

Design connection for lesser of design allowable stress or 1.5 x maximum computed stress.
Connection shall be design for no less than 1/2 shear capacity of the diaphragm.

f_a= 1.2 ksi

F_{a compr}= 27.5 ksi

1.5x Max Computed Stress Controls

Design for: 32.3 k

Shear Capacity of Diaphragm (Table 1-15-11):

f_a=0.35F_y= 17.5 ksi

1/2 Shear Cap. = 121.32 k

1/2 Shear Capacity Controls

Design conn. For = 121.32 k/connection

Diaphragms are connected to beams through a pair of L5x5x1/2 angles.

At interior girders diaphragms will be framing in on either side of the beam at the same locations. For design assume each diaphragm connection is loaded with the design load calculated above and that all loads are transferred equally between angle connections.

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Span 1, 2, 3, 4, 5, 7, & 8

Intermediate Diaphragm Design

Check Connection to Angles - AREMA 15.1.5.9 and 15.1.11.4

(continued)

Bolt Shear (Diaphragm to Angles) - Table 15-1-11

$d_b =$	0.875	in		
A325 bolts $F_v =$	21.5	ksi (slip critical Class B)		
No. of bolts =	7			
Shear planes =	2			
$R_n =$	181	k	D/C	
$R_u =$	121.32	k	0.67	

1x Design Load from diaphragm to 2 angles through 1 line of bolts

Connection OK

-Use 1 rows of 7 bolts

Bolt Shear (Angles to Beam) - Table 15-1-11

$d_b =$	0.875	in		
A325 bolts $F_v =$	21.5	ksi (slip critical Class B)		
No. of bolts =	14	*total bolts from 2 angle pairs		
Shear planes =	2			
$R_n =$	362	k	D/C	
$R_u =$	242.64	k	0.67	

2x Design Load from diaphragms to 2-pair of angle each with 1 line of bolts

Connection OK

-For each angle use 1 rows of 7 bolts

Bolt Bearing (Diaphragm to Angles) - 15.1.4.1 and 15.1.5.3

$L =$	1.50	in		
$F_u =$	65	ksi		
$LF_u/2d =$	56	ksi		
$1.2F_u =$	78	ksi		
$A_{bolt\ bearing} =$	0.41	in ² (Min. Bearing Area)		
$R_n =$	160.4	k	D/C	
$R_u =$	121.32	k	0.76	

1x Design Load bearing on diaphragm or one of 2 angles

Connection OK

Bolt Bearing (Angles to Beam) - 15.1.4.1 and 15.1.5.3

$L =$	1.50	in		
$F_u =$	65	ksi		
$LF_u/2d =$	56	ksi		
$1.2F_u =$	78	ksi		
$A_{bolt\ bearing} =$	0.44	in ² (Min. Bearing Area)		
$R_n =$	170.6	k	D/C	
$R_u =$	121.32	k	0.71	

2x Design Load split by 2 pairs of angles bearing on beam web or angle

Connection OK

Edge Distance Requirement - AREMA 15.1.9.3

Min:	$1.5d_b =$	1.31	in
	$2d_b * f_p / F_u =$	1.13	in
Max:	$1.5 + 4t =$	3.38	in

Vert. Edge Dist. Prov. = 1.50 in

Horiz. Edge Dist. Prov. = 2.00 in

Connection OK

Minimum Bolt Spacing Requirements - AREMA 15.1.9.2

$3d_b =$	2.625	in
$2d_b * f_p / F_u + d/2 =$	1.57	in

Vert. Spacing Prov. = 3.750 in

Horiz. Spacing Prov. = - in

Connection OK

Maximum Bolt Spacing Requirements - AREMA 15.1.5.13

Min of : $4 + 4t$ or 7" = 7 in

Vert. Spacing Prov. = 3.750 in

Connection OK

Block Shear in Angles - 15.1.4.1 and 15.1.5.3

$F_y =$	50	ksi
$F_u =$	65	ksi
$L_{gv} =$	22.5	in
$L_{nv} =$	17.25	in
$L_{nt} =$	1.56	in
$t_{leg} =$	0.5	in
$A_{gv} =$	11.25	in ²
$A_{nv} =$	8.625	in ²
$A_{nt} =$	0.78125	in ²
$U_{bs} =$	1	

$R_{n1} =$ 193.58 k

$R_{n2} =$ 194.14 k

$R_n =$ 193.6 k

$R_u =$ 60.66 k

D/C

0.31

1x Design Load from diaphragm split by 2 angles

Connection OK

TOP & BOTTOM LATERAL BRACING DESIGN

HNTB	Prepared by: M. Ellis (M. Briggs)	Approved by: D. Evans	Document number: QF 06
Calculation Cover Sheet	Revision Number: 0 (KCO_2)	Revision Date: 01/22/16 (05/12/2017)	Page 1 of _____ (includes attachments)

Project: NSRR Shoofly over I-70	Job No: 71886	Design Criteria Document: (See Below)
Client: NSRR / MoDOT	Discipline: Bridge	Calculation No:

Name or Description of Calculation: NSRR Shoofly Bridge Lateral Bracing Design				
Calc. Rev. No.	Originator	Checker	Senior Technical Reviewer (if required)	Confirmation Required (Y/N)

Calculation Objective:
Design upper and lower lateral bracing system for Span 6
Design upper lateral bracing system for Span 1-5, 7, &8

Calculation Methodology/List of Assumptions:
Follow AREMA MRE 2023 ASD steel design specifications

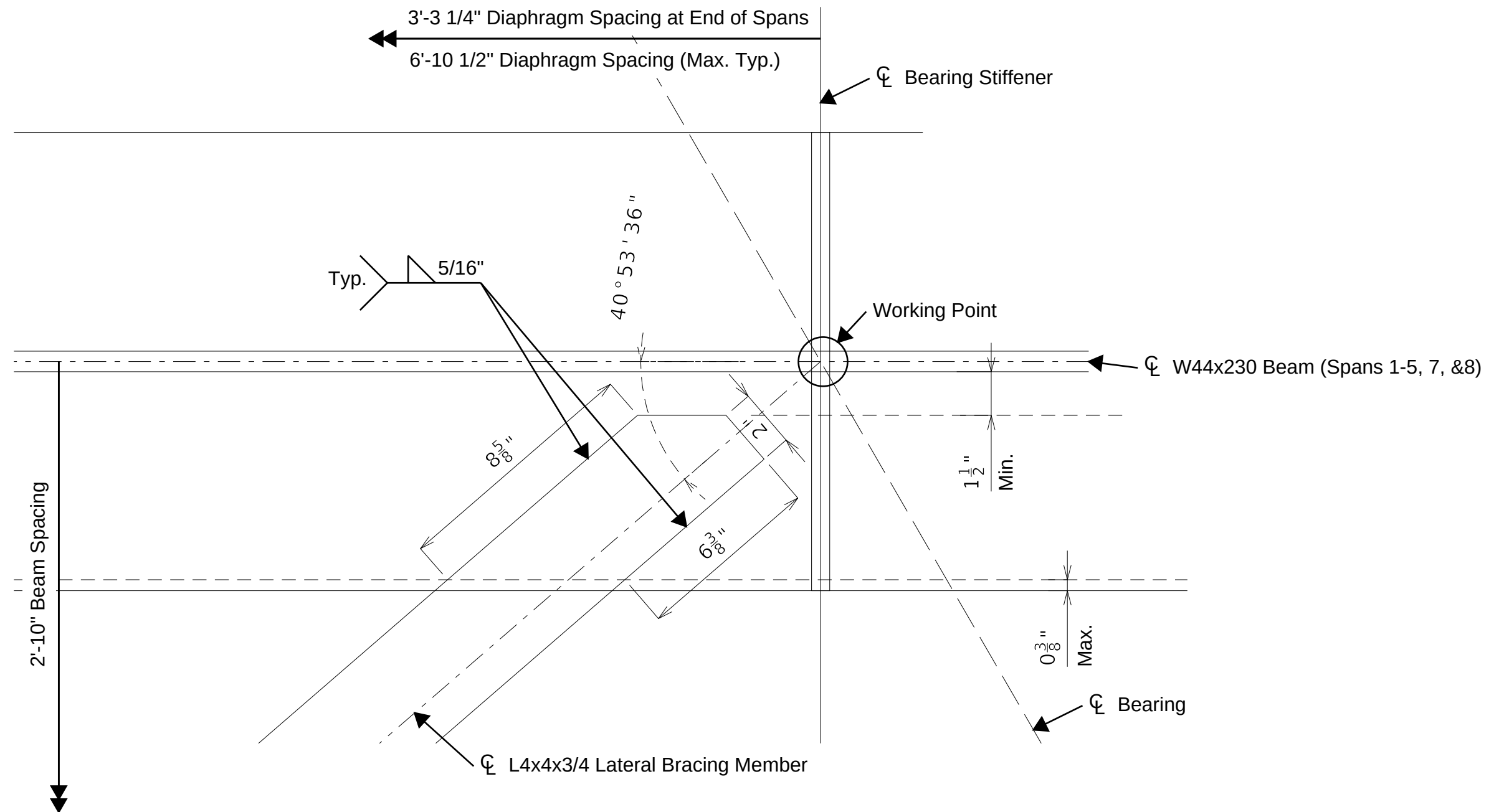
References/Inputs:
AREMA MRE 2023

Attachments: (List each attachment following the subject calculation)

Conclusions:
Use WT5x30 for top and bottom lateral bracing members in Span 6, use 12 bolts to connect to gusset plate
Use a 1/2" gusset plate connected to the girder web with 12 bolts on either side of stiffener
Use L4x4x3/4 for top lateral bracing on Spans 1-5, 7, &8
Use 5/16" fillet weld with min weld length of 10 1/4", weld to the top flange

Document Check:	Name	Initials	Date
Originator:	Ryan Rogowski	RCR	7/17/2025
Checker:			
Backchecker:			
Updater:			
Verifier:			

Applies to all pages unless noted otherwise (), attachments excluded.



Lateral Bracing Connection For Spans 1-5, 7, & 8

Note : Lateral bracing bay at end spans is shown above to illustrate minimum available weld lengths, typical bays are similar but the shallower bracing angles produce more favorable connection lengths.

LATERAL BRACING DESIGN (103' SPAN)

HNTB The HNTB Companies Engineers Architects Planners	Made RCR	Date 7/16/2025	Job Number 71886
	Checked	Date	
For NSRR Shoofly Bridge	Backchk'd	Date	Sheet No. 1

Lateral Bracing Design for 103'-5" Span Diagonal Chord Design

Lateral Bracing Design

Design bracing for tension and compression using maximum axial loading from wind loading on loaded and unloaded bridge, the lateral equipment force and Compression flange force.

Bridge Geometry and Girder Section

Girder Spacing= 2.833 ft
Bracing Spacing= 4.844 ft

Girder	Width (in)	Thickness (in)
Top Flange	16.0	2.50
Web	0.625	78.0
Bottom Flange	16.0	2.50

Girder Depth : 83.00

y bar = 41.5 in
I gross = 154363 in⁴

Lateral Bracing Geometry

Bracing Angle = 30.33 degrees
0.53 rad
measures CCW from girder web

Member Length = 5.61 ft
Conservatively use full length as Unbraced Length
Tributary Width = 9.69 ft

Wind on Train (WL) - AREMA 15.1.3.7a

w = 0.3 k/ft
V_{wl} = 2.91 k
Axial Force = 5.76 k

Wind on Loaded Bridge (WS) - AREMA 15.1.3.7b

W_{Loaded Bridge} = 0.31 k/ft
V_{ws} = 3.02 k
Axial Force = 5.97 k

Wind on Unloaded Bridge (WS) - AREMA 15.1.3.8

W_{Unloaded Bridge} = 0.52 k/ft
V_{ws} = 5.03 k
Axial Force = 9.95 k

Compression Flange Force - AREMA 15.1.11.6

Moment Demand = 5419 k*ft
Moment Demand from Total Live and Dead Loading on Individual Girder

F_{cf} = 17.48 ksi
A_{cf} = 40 in²
P_{cf} = 699 k
% of force = 2.500 %
V_{cf} = 17.5 k
Axial Force = 34.63 k

Lateral Equipment Force - AREMA 15.1.3.9

Heavy Axle = 100 k
V_{le} = 25 k
1/4 of the weight of the heaviest axle
Axial Force = 49.51 k

Load Combinaitions

- 1) WL (on LL & Bridge) + N (Equipment)
- 2) Flange Compression Force
- 3) Wind on Unloaded Bridge

Controlling Compression Force

Tension Compr.
V = 61.24 61.24
Tension Comb. : Wind on Loaded Bridge w/Eq. Force
Compr. Comb. : Wind on Loaded Bridge w/Eq. Force k

Calc'd USE
Axial Comp. Load = 30.62 31.00 k
Axial Tens. Load = 30.62 31.00 k

Conservatively divided by 2, assume half load goes to one upper lateral brace members and half goes to one lower lateral brace member

Lateral Bracing Member

Use: WT5X30
Fy = 50.00 ksi tw = 0.42 in
Fu = 65.00 ksi tf = 0.68 in
E = 29000.00 ksi bf = 10.10 in
A = 8.84 in² d = 5.11 in
Ix = 12.90 in⁴ y = 0.88 in
Iy = 58.10 in⁴ L = 5.61 ft
rx = 1.21 in k = 0.75
ry = 2.57 in

Slenderness Ratio

AREMA 15.1.5.1
kL/rx = 41.74
kL/ry = 19.65
Limit = 120 OK

Outstanding Members in Comp.

AREMA 15.1.6.2

Check width of 1/2 tee flange.
 $bf \leq 0.50t \sqrt{\frac{E}{F_y}}$
bf/2 = 4.840 in
bf <= 8.188 in
OK
 $d \leq 0.56t \sqrt{\frac{E}{F_y}}$
d = 4.430 in
d <= 5.664 in
OK

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Lateral Bracing Design for 103'-5" Span Diagonal Chord Design

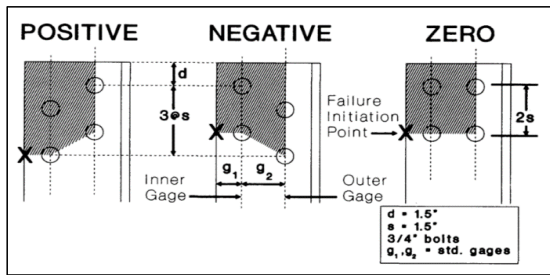
Bolt Pattern

Bolt Diameter = 0.875 in

No. Bolt Columns: 2 per Flange
Column Spacing = 1.75 in

No. Bolt Rows: 3 per Flange
Row Spacing = 2.00 in

Bolt Stagger: Negative
Member End to Bolt Dist. = 1.50 in
Member Edge to Bolt Dist. = 1.50 in



Connection Design - Bolt Group Strength AREMA Table 15-1-11a

A325 Bolts $F_v = 21.50$ ksi (Class B)
Shear Planes = 1
Total No. of Bolts = 12

$R_n = 155$ k D/C
0.20

Connection Design - Bearing on Bracing Member AREMA T15-1-11

$l_c = 1.50$ in
 $t = 0.68$ in

Bearing Strength = 55.714286 ksi
= 33.15 k

Force per Bolt = 2.58 k D/C
0.08

Connection Design - Block Shear in Bracing Member AREMA 15.1.5.9e

$A_{gv} = 15.64$ in²
 $A_{nv} = 12.665$ in²
 $A_{nt} = 5.7$ in²

$U_{bs} = 1$
 $R_{n1} = 430.73$ k
 $R_{n2} = 418.36$ k

$R_n = 418.36$ k D/C
0.07

Net Section AREMA 15.1.6.5

No. Bolts in X-Section: 2.00 bolts

$A_{net} = 7.65$ in² $I_{y_{net}} = 43.10$ in⁴
 $y_{net} = 0.97$ in $r_{x_{net}} = 1.27$ in
 $I_{x_{net}} = 12.43$ in⁴ $r_{y_{net}} = 2.37$ in

$L = 6.00$ in Length of conn.
 $U = 0.85$ $U = 1 - x/L$
 $A_e = 6.52$ in² (Effective)

Allowable Stresses AREMA Table 15-1-11

Tension - Gross Section

$F_a = 0.55 * F_y = 27.50$ ksi D/C
Demand $F_u = 3.51$ ksi 0.13

Tension - Net Section

$F_a = 0.47 * F_u = 30.55$ ksi D/C
Demand $F_u = 4.75$ ksi 0.16

Compression - Gross Section

$0.629 / \sqrt{F_y/E} = 15.148$
 $5.034 / \sqrt{F_y/E} = 121.235$
kl/r between upper and lower bound, use Eq.2

Eq.1 $F_a = 0.55 * F_y = -$ ksi

Eq.2 $F_a = 0.60 * F_y - \left(17,500 \frac{F_y}{E} \right)^{\frac{3}{2}} * \frac{kl}{r} = 29.78$ ksi

Eq.3 $F_a = 0.47 * F_u = -$ ksi

Controlling $F_a = 29.78$ ksi D/C
Demand $F_u = 3.51$ ksi 0.12

Compression - Extreme Fibers

The larger of Eq.1 and Eq.2 but not to exceed Eq.3

Eq.1 $0.55 F_y - \frac{0.55 F_y^2}{6.3 \pi^2 E} * \left(\frac{L}{r_y} \right)^2 = 26.98$ ksi

Eq.2 $\frac{0.131 \pi E}{ld \sqrt{1 + \mu/A_f}} = 195.40$ ksi

Eq.3 $0.55 * F_y = 27.50$ ksi

Controlling $F_a = 27.50$ ksi D/C
Demand $F_u = 3.51$ ksi 0.13

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Lateral Bracing Design for 103'-5" Span Diagonal Chord Design

Wind Load on Loaded Structure

Use 125% allowables - 15.1.3.14.3

Axial Stress:

AREMA 15.1.3.14.1

Axial Tens. Load = 31.0 k

$f_{a\text{tension}} = 4.8$ ksi

Used effective section for tension.

$F_{a\text{tension}} = 30.55$ ksi

Axial Comp. Load = 31.00 k

$f_{a\text{compr}} = 3.51$ ksi

$F_{a\text{compr}} = 29.78$ ksi

Bending Stress:

$M_{\text{chord}} = 27.40$ k-in

Moment due to force application
on top of flange. Use effective section.

$f_{b\text{tension}} = 9.13$ ksi (bottom)

$f_{b\text{compr}} = 1.88$ ksi (top)

$F_{b\text{tension}} = 30.55$ ksi (bottom)

$F_{b\text{compr}} = 27.50$ ksi (top)

Combined Stresses:

Bottom of Web (Tension):

$f_a / F_a = 0.16 > 0.15$

$f_a / 1.25F_a = 0.124$

$\frac{f_{b1}}{1.25F_{b1}} = 0.239$

$\frac{f_{b1}}{1.25F_{b1} \left[1 - \frac{f_a}{0.514\pi^2 E} \left(\frac{KL}{r_x} \right)^2 \right]} = 0.253$

Interaction includes 25% increase in allowable stress.

Total Interaction = 0.378 OK

Top Flange (Compression):

$f_a / F_a = 0.12 \leq 0.15$

$f_a / 1.25F_a = 0.094$

$\frac{f_{b1}}{1.25F_{b1}} = 0.055$

$\frac{f_{b1}}{1.25F_{b1} \left[1 - \frac{f_a}{0.514\pi^2 E} \left(\frac{KL}{r_x} \right)^2 \right]} = 0.057$

Interaction includes 25% increase in allowable stress.

Total Interaction = 0.149 OK

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Lateral Bracing Design for 103'-5" Span Gusset Member Design Lateral bracing will be connected to girders through connection to a gusset plate. The gusset plate will be welded to a base plate and bolted to the girder web. <u>Lateral Bracing Geometry</u> Bracing Angle = 30.33 degrees 0.53 rad measures CCW from girder web <u>Lateral Bracing Loading</u> <table> <tr> <td></td> <td>Tens.</td> <td>Compr.</td> <td></td> </tr> <tr> <td>Axial Force =</td> <td>31.00</td> <td>31.00</td> <td>k</td> </tr> <tr> <td>F_x =</td> <td>26.76</td> <td>26.76</td> <td>k (Along Girder)</td> </tr> <tr> <td>F_y =</td> <td>15.65</td> <td>15.65</td> <td>k (Perp. To Girder)</td> </tr> </table> <u>Gusset Plate Thickness</u> <table> <tr> <td>tw=</td> <td>0.50</td> <td>in</td> </tr> <tr> <td>Fy=</td> <td>50.00</td> <td>ksi</td> </tr> <tr> <td>Fu=</td> <td>65.00</td> <td>ksi</td> </tr> <tr> <td>E=</td> <td>29000.00</td> <td>ksi</td> </tr> </table> <u>Bolt Pattern - Lateral Bracing to Gusset Plate</u> Bolt Diameter = 0.875 in No. Bolt Columns: 2 per Flange Column Spacing = 1.75 in No. Bolt Rows: 3 per Flange Row Spacing = 2.00 in Stagger Bolts : Negative Member End to Bolt Dist. = 1.50 in Member Edge to Bolt Dist. = 1.50 in <u>Sealing of Plates</u> AREMA 15.1.5.13 $s \leq 4 + 4t \leq 7in$ <table> <tr> <td>tf=</td> <td>0.50</td> <td>in</td> </tr> <tr> <td>smax=</td> <td>6.000</td> <td>in</td> </tr> </table> Gage Limit = 3.5 in Seal Gage O.K. Pitch Limit = 4.69 in Seal Pitch O.K. <u>Gusset Plate Design - Bolt Group Strength</u> <table> <tr> <td>A325 Bolts Fv =</td> <td>21.50</td> <td>ksi (Class B)</td> </tr> <tr> <td>Shear Planes =</td> <td>1</td> <td></td> </tr> <tr> <td>Total No. of Bolts =</td> <td>12</td> <td></td> </tr> </table> <table> <tr> <td>R_n =</td> <td>155</td> <td>k</td> <td>D/C</td> </tr> <tr> <td></td> <td></td> <td></td> <td>0.20</td> </tr> </table>		Tens.	Compr.		Axial Force =	31.00	31.00	k	F _x =	26.76	26.76	k (Along Girder)	F _y =	15.65	15.65	k (Perp. To Girder)	tw=	0.50	in	Fy=	50.00	ksi	Fu=	65.00	ksi	E=	29000.00	ksi	tf=	0.50	in	smax=	6.000	in	A325 Bolts Fv =	21.50	ksi (Class B)	Shear Planes =	1		Total No. of Bolts =	12		R _n =	155	k	D/C				0.20	<u>Gusset Plate Design - Bearing on Gusset Plate</u> <table> <tr> <td>l_c =</td> <td>1.50</td> <td>in</td> </tr> <tr> <td>t =</td> <td>0.50</td> <td>in</td> </tr> <tr> <td>Bearing Strength =</td> <td>55.71</td> <td>ksi</td> </tr> <tr> <td>Bearing Strength =</td> <td>24.375</td> <td>k</td> </tr> </table> <table> <tr> <td>Force per Bolt =</td> <td>2.58</td> <td>k</td> <td>D/C</td> </tr> <tr> <td></td> <td></td> <td></td> <td>0.11</td> </tr> </table> <u>Gusset Plate Design - Block Shear in Gusset Plate</u> <table> <tr> <td>Gross Shear Length, L_{gv} =</td> <td>11.00</td> <td>in</td> </tr> <tr> <td>Gross Shear Area, A_{gv} =</td> <td>5.50</td> <td>in²</td> </tr> <tr> <td>Net Shear Length, L_{nv} =</td> <td>6.63</td> <td>in</td> </tr> <tr> <td>Net Shear Area, A_{nv} =</td> <td>3.31</td> <td>in²</td> </tr> <tr> <td>Net Tensile Length, L_{nt} =</td> <td>8.32</td> <td>in</td> </tr> <tr> <td>Net Tensile Area, A_{nt} =</td> <td>4.16</td> <td>in²</td> </tr> </table> <table> <tr> <td>U_{bs} =</td> <td>1</td> <td></td> </tr> <tr> <td>R_{n1} =</td> <td>399.43</td> <td>k</td> </tr> <tr> <td>R_{n2} =</td> <td>372.88</td> <td>k</td> </tr> <tr> <td>R_n =</td> <td>372.88</td> <td>k</td> <td>D/C</td> </tr> <tr> <td></td> <td></td> <td></td> <td>0.08</td> </tr> </table> <u>Allowable Stress</u> <u>Tension - Gross Section</u> F _a = 0.55 * Fy = 27.50 ksi <u>Tension - Net Section</u> F _a = 0.47 * Fu = 30.55 ksi <u>Shear - Webs</u> F _a = 0.47 * Fu = 17.5 ksi <u>Gusset Plate Design - Tension on Whitmore Section</u> <table> <tr> <td>Whitmore Length, L =</td> <td>13.00</td> <td>in</td> </tr> <tr> <td colspan="3">Measured in Microstation</td> </tr> <tr> <td>Gross Area, A_g =</td> <td>6.50</td> <td>in²</td> </tr> <tr> <td>Net Area, A_n =</td> <td>5.63</td> <td>in²</td> </tr> </table> <table> <tr> <td>Stress on Gross Section, f_a =</td> <td>4.77</td> <td>ksi</td> <td>D/C</td> </tr> <tr> <td>Stress on Net Section, f_a =</td> <td>5.51</td> <td>ksi</td> <td>0.17</td> </tr> <tr> <td></td> <td></td> <td></td> <td>0.18</td> </tr> </table>	l _c =	1.50	in	t =	0.50	in	Bearing Strength =	55.71	ksi	Bearing Strength =	24.375	k	Force per Bolt =	2.58	k	D/C				0.11	Gross Shear Length, L _{gv} =	11.00	in	Gross Shear Area, A _{gv} =	5.50	in ²	Net Shear Length, L _{nv} =	6.63	in	Net Shear Area, A _{nv} =	3.31	in ²	Net Tensile Length, L _{nt} =	8.32	in	Net Tensile Area, A _{nt} =	4.16	in ²	U _{bs} =	1		R _{n1} =	399.43	k	R _{n2} =	372.88	k	R _n =	372.88	k	D/C				0.08	Whitmore Length, L =	13.00	in	Measured in Microstation			Gross Area, A _g =	6.50	in ²	Net Area, A _n =	5.63	in ²	Stress on Gross Section, f _a =	4.77	ksi	D/C	Stress on Net Section, f _a =	5.51	ksi	0.17				0.18
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Lateral Bracing Design for 103'-5" Span Gusset Member Design

Gusset Plate Design - Gusset Web Buckling (Axial Load)

$$\begin{aligned}
 K &= 0.5 \\
 L_{mid} &= 10.50 \text{ in} \\
 &\text{Unbraced length from last row of fasteners in the} \\
 &\text{Lateral bracing member to the flange of the gusset member} \\
 &\text{Measured in Microstation} \\
 \text{Effective Column Width} &= 7.10 \text{ in} \\
 &\text{Conservatively assume width equal to bolt connection} \\
 A_{gross} &= 3.55 \text{ in}^2 \\
 I &= 0.07 \text{ in}^4 \\
 r &= 0.14 \text{ in} \\
 KL/r &= 36.37 \\
 \text{OK - } KL/r &< 100 \\
 \text{Slenderness Limit 1} &= 15.15 \\
 \text{Slenderness Limit 2} &= 121.23
 \end{aligned}$$

$$\begin{aligned}
 \text{Allowable } F_c &= 23.97 \text{ ksi} \\
 f_c &= 8.73 \text{ ksi} \\
 \text{Gusset Buckling OK}
 \end{aligned}$$

Gusset Plate Design - Gusset Web Buckling (Along Girder)

Purpose of this check is to determine the need for additional stiffening of the free edge of gusset plates that do not connect to the diaphragms at their center

$$\begin{aligned}
 K &= 0.5 \\
 L_{mid} &= 24.00 \text{ in} \\
 &\text{Unbraced length from point at workline and intersection last bolt} \\
 &\text{to the matching point on opposite bracing member.} \\
 &\text{Measure in Microstation} \\
 \text{Effective Column Width} &= 9.00 \text{ in} \\
 &\text{1'-6" Gusset Width minus 9" cope} \\
 A_{gross} &= 4.50 \text{ in}^2 \\
 I &= 0.09 \text{ in}^4 \\
 r &= 0.14 \text{ in} \\
 KL/r &= 83.14 \\
 \text{OK - } KL/r &< 100 \\
 \text{Slenderness Limit 1} &= 15.15 \\
 \text{Slenderness Limit 2} &= 121.23 \\
 \text{Allowable } F_c &= 16.22 \text{ ksi} \\
 f_c &= 5.95 \text{ ksi} \\
 \text{Gusset Buckling OK} \\
 \text{No Stiffening Angle Required - 15.1.5.4} \\
 \text{Add L3x3x1/2 to edges}
 \end{aligned}$$

Gusset Plate Design - Gusset Plate to Web Connection Plate

The following is for one half / one side of the full gusset plate.
Design bolt connection and weld to resist force from one lateral bracing member

$$\begin{aligned}
 \text{Bolt Diameter} &= 0.875 \text{ in} \\
 \text{No. Bolt Rows} &= 2 \text{ per Conn. PL} \\
 \text{No. Bolts} &= 6 \text{ per Bolt Row} \\
 \text{Bolt Spacing} &= 4.00 \text{ in} \\
 \text{End Member Edge Dist.} &= 1.50 \text{ in} \\
 \text{Total No. Bolts Per Conn. PL} &= 12 \\
 \text{Total Conn. PL Length} &= 23 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 \text{A325 Bolts } F_v &= 21.50 \text{ ksi (Class B)} \\
 \text{Shear Planes} &= 1
 \end{aligned}$$

$$R_n = 155 \text{ k} \quad \text{D/C} \quad 0.17$$

Gusset Plate Design - Bearing on Web Connection Plate

$$\begin{aligned}
 l_c &= 1.50 \text{ in} \\
 t &= 0.50 \text{ in} \\
 \text{Bearing Strength} &= 55.71 \text{ ksi} \\
 \text{Bearing Strength} &= 24.38 \text{ k}
 \end{aligned}$$

$$\text{Force per Bolt} = 1.30 \text{ k} \quad \text{D/C} \quad 0.05$$

Gusset Plate Design - Gusset Plate Shear

$$\begin{aligned}
 \text{Shear Plane Length} &= 23.000 \text{ in}^2 \\
 \text{Shear Area, } A_v &= 11.50 \text{ in}^2
 \end{aligned}$$

$$\text{Stress on Shear Section, } f_a = 2.33 \quad \text{D/C} \quad 0.13$$

Gusset Plate Design - Gusset Plate Weld to Connection Plate

$$\begin{aligned}
 L_{weld, \text{Total}} &= 46.00 \text{ in} \\
 &\text{Weld Both Sides} \\
 \text{Type} &= E70 \quad (\text{E60, E70, E80}) \\
 \text{Weld size} &= 0.3125 \text{ in} \\
 \text{Allowable stress} &= 17.50 \text{ ksi} \quad (\text{AREMA 1.4.2}) \\
 R_n &= 7.73 \text{ k/in} \\
 &\text{Allowable for weld to both sides} \\
 \text{Actual } p &= 0.58 \text{ k/in}
 \end{aligned}$$

O.K. - Less than allowable stress

HNTB For NSRR Shoofly Bridge	The HNTB Companies Engineers Architects Planners	Made	RCR	Date	7/16/2025	Job Number	71886
		Checked		Date			
		Backchk'd		Date		Sheet No.	6

Lateral Bracing Design for 103'-5" Span

Gusset Member Design

Gusset Plate Design - Gusset Plate Connection to Diaphragm

Where applicable the gusset plate will be bolted to the diaphragm to brace the gusset plate.

Purpose of this check is to determine the required bolt connection to resist the lateral loading from the diaphragms

Diaphragm Load = 16 k
 See 103'-5" Span Girder Design for more details

Bolt Diameter = 0.875 in
 Total No. Bolts : 4

A325 Bolts Fv = 21.50 ksi (Class B)
 Shear Planes = 1

$R_n = 52$ k D/C
0.31

Gusset Plate Design - Bolt Bearing on Diaphragm Flange

$l_c = 1.50$ in
 $t_f = 0.61$ in

Thickness of W30x90 flange

Use $t = 0.50$ in

Min. Thickness of Gusset Plate and Diaphragm Flange

Bearing Strength = 55.71 ksi
 Bearing Strength = 24.38 k

Force per Bolt = 4.00 k D/C
0.16

LATERAL BRACING DESIGN (48' SPAN)

HNTB The HNTB Companies Engineers Architects Planners	Made	RCR	Date	7/16/2025	Job Number	71886
	Checked		Date			
For	NSRR Shoofly Bridge	Backchk'd	Date		Sheet No.	7

Lateral Bracing Design for 48'-0" Span Diagonal Chord Design

Lateral Bracing Design

Design bracing for tension and compression using maximum axial loading from wind loading on loaded and unloaded bridge, the lateral equipment force and compression flange force.

Design uses the bracing bays with largest tributary area (Span 2,3,4, &7) at 6'-10 1/2" for load formulation, and the steepest bearing angle for the consideration of the available weld lengths.

Bridge Geometry and Girder Section

Girder Spacing= 2.833 ft
Bracing Spacing= 6.875 ft

Girder Depth = 49.20 in
y bar = 24.6 in
I gross = 20800 in⁴

Lateral Bracing Geometry

Bracing Angle = 22.40 degrees
0.39 rad
measures CCW from girder web

Member Length = 7.44 ft
Conservatively use full length as Unbraced Length
Tributary Width = 13.75 ft

Wind on Train (WL) - AREMA 15.1.3.7a

w= 0.3 k/ft
V_{wl}= 4.13 k
Axial Force = 10.83 k

Wind on Loaded Bridge (WS) - AREMA 15.1.3.7b

W_{Loaded Bridge}= 0.20 k/ft
V_{ws}= 2.75 k
Axial Force = 7.22 k

Wind on Unloaded Bridge (WS) - AREMA 15.1.3.8

W_{Unloaded Bridge}= 0.31 k/ft
V_{ws}= 4.23 k
Axial Force = 11.10 k

Compression Flange Force - AREMA 15.1.11.6

Moment Demand = 1424 k*ft
Moment Demand from Total Live and
Dead Loading on Individual Girder

F_{cl}= 20.21 ksi
A_{cl}= 40 in²
P_{cl}= 808 k
% of force= 2.500 %
V_{cl}= 20.2 k
Axial Force = 53.04 k

Lateral Equipment Force - AREMA 15.1.3.9

Heavy Axle = 100 k
V_{le}= 25 k
1/4 of the weight of the heaviest axle
Axial Force = 65.61 k

Load Combinations

- 1) WL (on LL & Bridge) + N (Equipment)
- 2) Flange Compression Force
- 3) Wind on Unloaded Bridge

Controlling Compression Force

Tension Compr.
V= 83.65 83.65 k
Tension Comb. : Wind on Loaded Bridge w/Eq. Force
Compr. Comb. : Wind on Loaded Bridge w/Eq. Force

Calc'd USE
Axial Comp. Load = 41.83 42.00 k
Axial Tens. Load = 41.83 42.00 k

Load divided by 2, assume load goes equally
into both upper lateral bracing members

Lateral Bracing Member

Use: L4X4X3/4

Fy= 50.00 ksi tw= 0.50 in
Fu= 65.00 ksi tf= 0.50 in
E= 29000.00 ksi bf= 4.00 in
A= 5.44 in² d= 4.00 in
Ix= 7.62 in⁴ y= 1.27 in
Iy= 7.62 in⁴ L= 7.44 ft
rx= 1.18 in k= 0.75
ry= 1.18 in

Slenderness Ratio

AREMA 15.1.5.1
kL/rx= 56.71
kL/ry= 56.71
Limit= 120 OK

Outstanding Members in Comp.

AREMA 15.1.6.2
 $bf \leq 0.50t \sqrt{\frac{E}{F_y}}$
bf= 1.750 in
bf<= 6.021 in
OK
AISC Table B4.1a (3)
 $bf \leq 0.45t \sqrt{\frac{E}{F_y}}$
bf= 4.000 in
bf<= 5.419 in
OK, Member is Non-Slender

For	HNTB The HNTB Companies Engineers Architects Planners	Made	RCR	Date	7/16/2025	Job Number	71886
		Checked		Date			
		Backchk'd		Date		Sheet No.	8

Lateral Bracing Design for 48'-0" Span Diagonal Chord Design

Weld to Flange

The differing angles of lateral bracing members in Spans 1-5, 7, & 8 due to difference in diaphragm spacing causes varying available weld lengths. The Following calc stands to show the absolute minimum weld length required to resist the applied loading.

$$*L_{weld_Total} = 10.25 \text{ in}$$

***Min length Required to meet Weld Strength Demand**

Type:	E70	(E60, E70, E80)
Weld size=	0.3125	in
Allowable stress=	19.00	ksi (AREMA 1.4.2)
Rn=	4.20	k/in (Allowable
Actual p=	4.10	k/in per weld, per in)

O.K. - Less than allowable stress

Flexural Capacity

$$M_y = 300.00 \text{ k*in} \quad \text{AISC Sect. F10}$$

Yield Strength

$$M_n = 450.00 \text{ k*in}$$

Lateral - Torsional Buckling Strength

$$C_b = 1.5$$

$$r_z = 0.776$$

$$M_{cr} = 212.79215$$

$$M_y / M_{cr} = 1.4098265$$

$$M_n = 159.24 \text{ k*in}$$

Local Leg Buckling

$$bf \leq 0.54t \sqrt{\frac{E}{F_y}} \quad \text{AISC Table B4.1a (12)}$$

$$bf/2 = 4.000 \text{ in}$$

$$bf \leq 6.502 \text{ in}$$

OK - Member is Compact, Does Not Apply

$$M_n / \Omega = 95.35 \text{ k*in}$$

$$M_u = 53.34 \text{ k*in}$$

D/C

0.56

Net Section

AREMA 15.1.6.5

$$x = 1.27 \text{ in}$$

$$L = 6.00 \text{ in}$$

$$U = 0.79$$

$$A_e = 4.29 \text{ in}^2$$

Length of conn.
U=1-x/L

Allowable Stresses

Tension - Gross Section

$$F_a = 0.55 * F_y = 27.50 \text{ ksi} \quad \text{D/C}$$

$$\text{Demand } F_u = 7.72 \text{ ksi} \quad \text{0.28}$$

Tension - Net Section

$$F_a = 0.47 * F_u = 30.55 \text{ ksi} \quad \text{D/C}$$

$$\text{Demand } F_u = 9.79 \text{ ksi} \quad \text{0.32}$$

Compression - Gross Section

$$0.629 / \sqrt{F_y/E} = 15.148$$

$$5.034 / \sqrt{F_y/E} = 121.235$$

kl/r between upper and lower bound, use Eq.2

Eq.1

$$F_a = 0.55 * F_y = - \text{ksi}$$

Eq.2

$$F_a = 0.60 * F_y - \left(17,500 \frac{F_y}{E} \right)^{\frac{3}{2}} * \frac{kl}{r} = 29.70 \text{ ksi}$$

Eq.3

$$F_a = 0.47 * F_u = - \text{ksi}$$

$$\text{Controlling } F_a = 29.70 \text{ ksi} \quad \text{D/C}$$

$$\text{Demand } F_u = 7.72 \text{ ksi} \quad \text{0.26}$$

MINIMUM CLEARANCE CALCULATIONS

Project: NSRR Shoofly over I-70		Job No: 71886		Design Criteria Document: Below	
Client: MODOT		Discipline: Bridge		Calculation No:	
Name or Description of Calculation: Minimum Clearance Calculation					
Note: Unique QF 06 to be created for each revision of a calculation.					
Calc. Rev. No.	Description of Change (i.e., Original Issue or description of changes since last revision)	Confirmation required with other deliverables (Y/N)	List Deliverables for which confirmation is required (NA if none) Add additional rows as necessary	Confirmation Verified by Originator of Calc for each deliverable listed (Y/N)	
Calculation Objective: Minimum Clearance Check for NS Shoofly over I-70					
Calculation Methodology/List of Assumptions: Station and elevation information provided by Roadway					
References/Inputs:					
Attachments: (List each attachment following the subject calculation)					
Conclusions: Minimum Clearance exceeds the 17'6" required					
Document Check:	Name:	Initials:		Date:	
Originator:	Todd Kelley	TSK		7/17/2025	
Checker:					
Backchecker:					
Updater:					
Verifier:					

NSRR Shoofly Clearance Calculations

- Based on the Shoofly profile provided within the 30% submission

Minimum Clearance to Existing I-70

Controlling Sta I-70	$Sta_{exI70} := 120277.85 \text{ ft}$
Existing I-70 Elevation	$Elev_{exI70} := 621.30 \text{ ft}$
Shoofly Sta	$Sta_{shexI70} := 10021.73 \text{ ft}$
Front face backwall elevation T/R	$Elev_{FFBW} := 645.65 \text{ ft}$
Front face backwall Sta	$Sta_{FFBW} := 9931.64 \text{ ft}$
Shoofly Bridge Grade	$slope := 0.0011$
Shoofly T/R elevation at controlling sta	$Elev_{shexI70} := (Sta_{shexI70} - Sta_{FFBW}) \cdot slope + Elev_{FFBW} = 645.749 \text{ ft}$
Superstructure Depth Assume 10" tie and 8" rail	$Depth_{Beamsuper} := 3 \text{ ft} + 6.875 \text{ in} + 10 \text{ in} + 8 \text{ in} = 5.073 \text{ ft}$
Clearance	$Clr_{exI70} := Elev_{shexI70} - Elev_{exI70} - Depth_{Beamsuper} = 19.376 \text{ ft}$

Minimum Clearance to Proposed I-70

Controlling Sta I-70	$Sta_{I70} := 120206.99 \text{ ft}$
Existing I-70 Elevation	$Elev_{I70} := 614.93 \text{ ft}$
Shoofly Sta	$Sta_{shI70} := 10140.37 \text{ ft}$
Front face backwall elevation T/R	$Elev_{FFBW} := 645.65 \text{ ft}$
Front face backwall Sta	$Sta_{FFBW} := 9931.64 \text{ ft}$
Shoofly Bridge Grade	$slope := 0.0011$
Shoofly T/R elevation at controlling sta	$Elev_{shI70} := (Sta_{shI70} - Sta_{FFBW}) \cdot slope + Elev_{FFBW} = 645.88 \text{ ft}$
Superstructure Depth Assume 10" tie and 8" rail	$Depth_{DPGsuper} := 6 \text{ ft} + 11 \text{ in} + 10 \text{ in} + 8 \text{ in} = 8.417 \text{ ft}$
Clearance	$Clr_{I70} := Elev_{shI70} - Elev_{I70} - Depth_{DPGsuper} = 22.533 \text{ ft}$

Station and elevation information provided by Roadway

Todd Kelley

From: Richard Pool
Sent: Tuesday, July 1, 2025 1:40 PM
To: Cindy McCann; Todd Kelley; Joseph Bartus
Cc: Ben Lewis; Kyle Johnson; Kate Dorman; TJ Newman; Yvette Abdelmalek; Nathan Wainwright
Subject: RE: NSRR Over I-70

All,

I've revised the minimum clearance roadway information to the "low Steel" offset from the Shoofly CL of 5.0':

Location 1:

Shoofly Sta 101+40.37
Offset 5.00' Rt
I70 Sta 1202+06.99
Offset 1.00'Rt
I70 Proposed Elv 614.93'

Location 2:

Shoofly Sta 100+21.73
Offset 5.00' Rt
I70 Sta 1202+77.85
Offset -93.01'
I70 Existing Elv 621.30'

Thanks!

GEOMETRY CALCULATIONS

HNTB	Document number: QF 06
Calculation Cover Sheet	Page 1 of __

Project: NSRR Shoofly over I-70	Job No: 71886	Design Criteria Document: See below
Client: NSRR/MoDOT	Discipline: Bridge	Calculation No:

Name or Description of Calculation: Geometry Calculations/Elevations for NSRR Temporary Shoofly Bridge No. A5801T over I-70 near Wentzville, MO

Note: Unique QF 06 to be created for each revision of a calculation.

Calc. Rev. No.	Description of Change (i.e., Original Issue or description of changes since last revision)	Confirmation required with other deliverables (Y/N)	List Deliverables for which confirmation is required (NA if none) Add additional rows as necessary	Confirmation Verified by Originator of Calc for each deliverable listed (Y/N)

Calculation Objective:
Determine elevations for Abutments and Piers for NSRR Bridge A5801T over I-70.

Calculation Methodology/List of Assumptions:
Shoofly geometry based on Alignment and Profile issued with the RFP developed by HDR and delivered to the project team by MoDOT.

References/Inputs:

AREMA MRE 2024

Attachments: (List each attachment following the subject calculation)

Conclusions:
See table of elevations for T/R, Top of Tie, Top of Cap, Pile cutoff elevation, Top of Rock and Pile Tip Elevation

Document Check:	Name:	Signature:	Date:
Originator:	Ryan Rogowski	RCR	8/27/2025
Checker:			
Backchecker:			
Updater:			
Verifier:			

PVT STA	PVT ELEV	slope	DPG t/t to seat	Beam t/t to seat	abut cap depth	bent cap depth	pier depth
9920	645.64	0.0011	8.1875	4.739583333	2	3	5

Table of Elevations									
Substructure	dist	Station	T/R	Elevations					Rock Socket
				A	B	C	D - rock	E	
Bent 1 (east abutment)	0	9927.01	645.65	644.98	640.24	638.24	605.50	-	-
Bent 2	34.33	9961.34	645.69	645.02	640.28	637.28	604.60	594.60	10
Bent 3	48	10009.34	645.74	645.07	640.33	637.33	604.60	594.60	10
Bent 4	48	10057.34	645.79	645.12	640.38	637.38	605.80	595.80	10
Bent 5	48	10105.34	645.84	645.17	640.43	637.43	606.60	596.60	10
Bent 6	24.58	10129.92	645.87	645.20	637.01	632.01	607.80	587.80	20
Bent 7	103.42	10233.34	645.98	645.31	637.13	632.13	606.90	586.90	20
Bent 8	48	10281.34	646.04	645.37	640.63	637.63	606.00	596.00	10
Bent 9 (west abutment)	34.33	10315.67	646.08	645.41	640.67	638.67	605.00	-	-