HDR

Load Rating Challenges in Idaho

Parking Garages under Public Roads
and
The Wallace Viaduct

Scott Wood, P.E. & Will Johnson, P.E.

BOISE

BOI ZEE

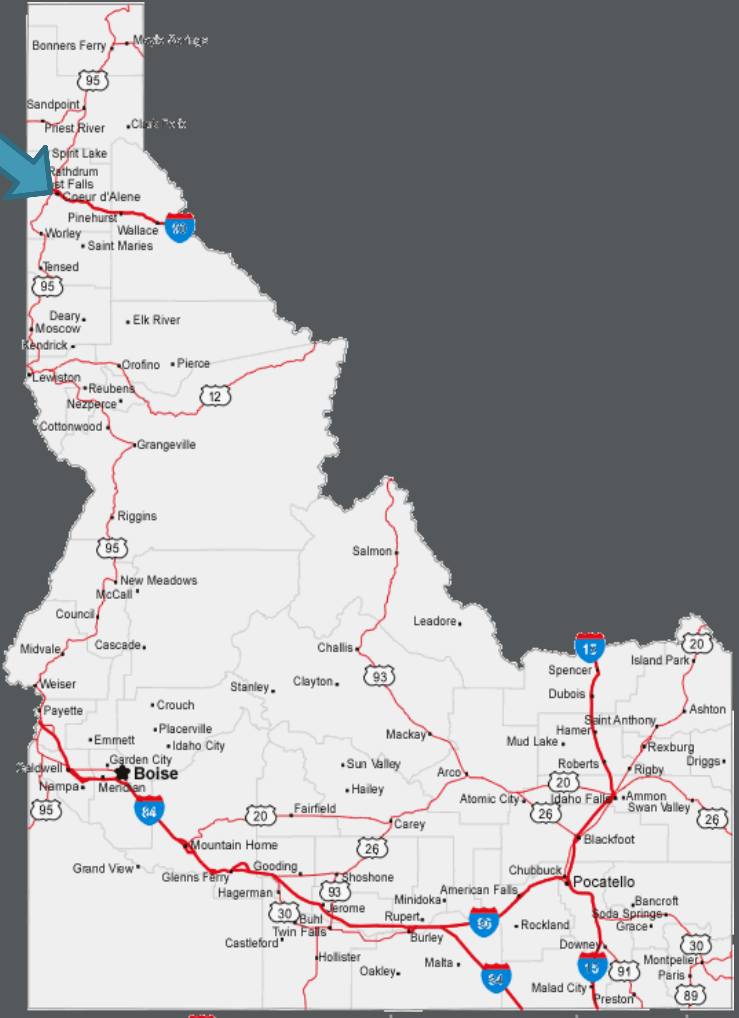
BOI SEE

WHEN YOU DON'T EVEN KNOW IT'S THERE

HDR

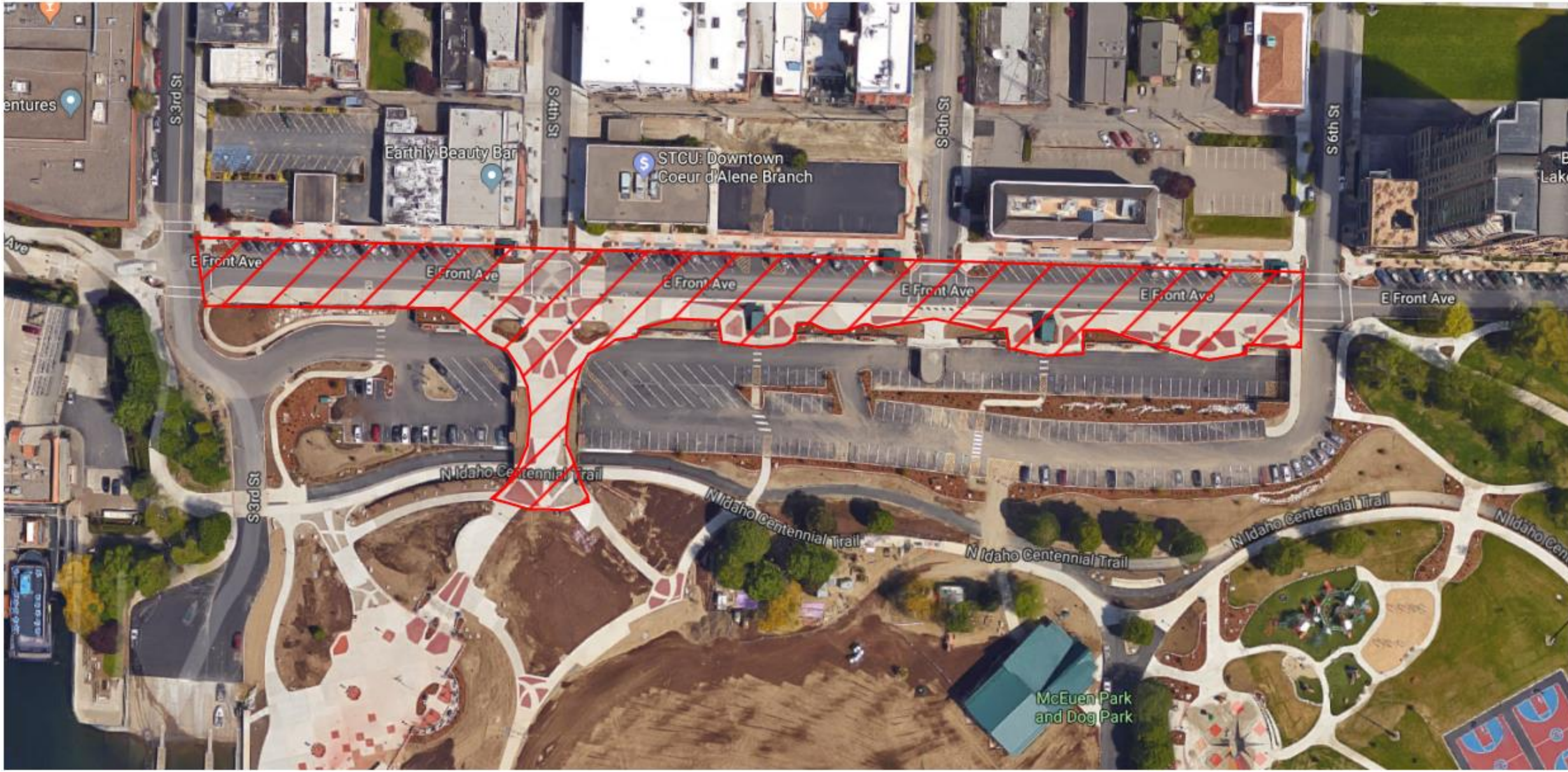
McEuen Park Garage in Coeur d’Alene, Idaho

- Owner: City of Coeur d’Alene
- Opened in 2014
- 20-acre, $20 million project
- Companies/names withheld



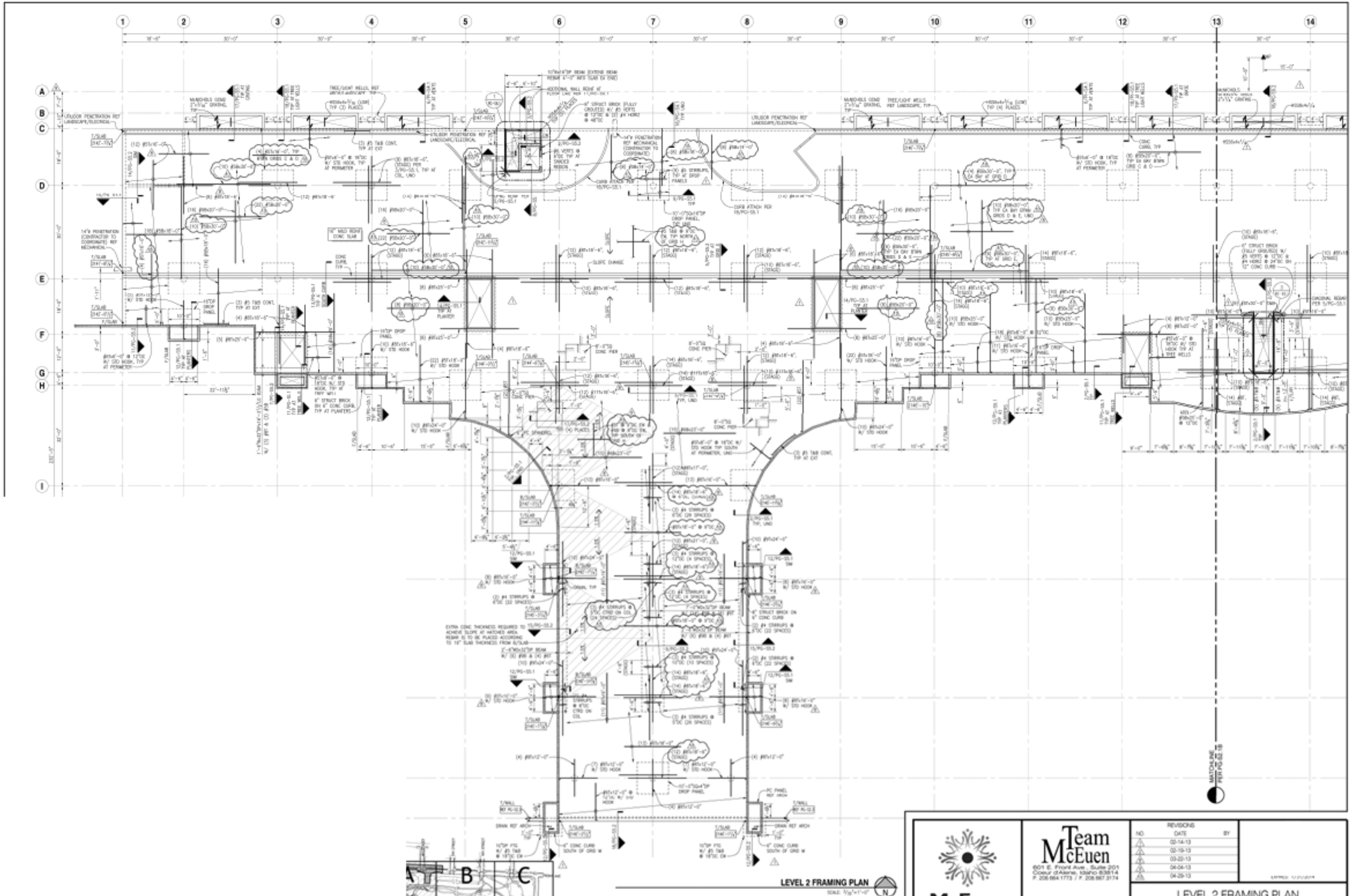

S 3rd St
S 4th St
ont Ave
S 5th St


S 5th St
N Idaho Centennial Trail
Google Earth



S 3rd St
Earthly Beauty Bar
S 4th St
STCU: Downtown Coeur d'Alene Branch
S 5th St
S 6th St
E Front Ave
N Idaho Centennial Trail
McEuen Park and Dog Park


401
Street View
stcu
E Front Ave
Jeep
Coeur d'Alene
E Front Ave
McEuen Park
and Dog Park
Google



LEVEL 2 FRAMING PLAN

KEY MAP

McEuen PARK
IMPROVEMENTS
City of Coeur d'Alene
Coeur d'Alene, Idaho 83814

Team McEuen
601 E. Front Ave., Suite 201
Coeur d'Alene, Idaho 83814
P. 208.664.1773 / F. 208.667.3174

REVISIONS NO.	DATE	BY
1	02-14-13	
2	02-19-13	
3	03-22-13	
4	04-04-13	
5	04-29-13	

LEVEL 2 FRAMING PLAN
AREA A

2013 McEuen Construction Project

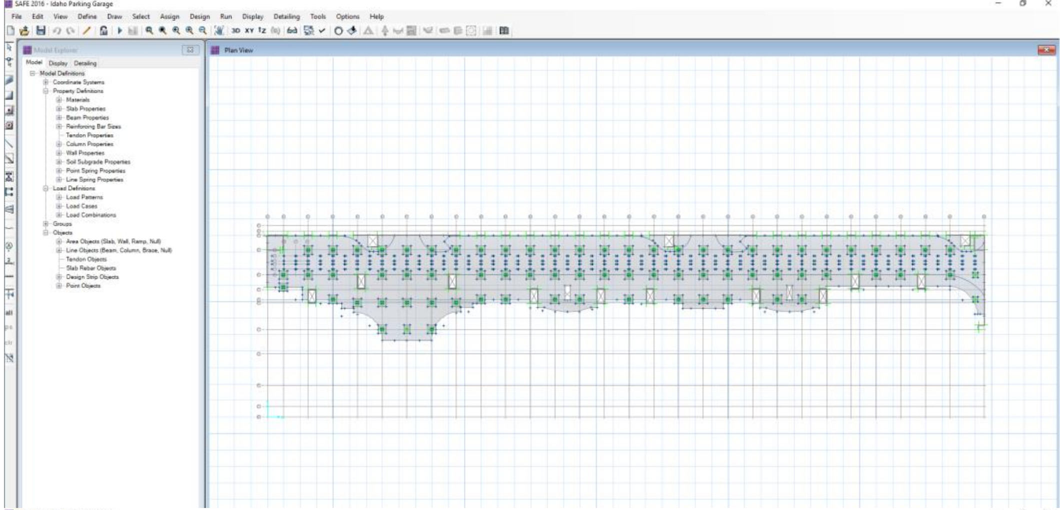
DESIGNED BY: KEA
DRAWN BY: BSD
DWG NAME: 11041-0052PG-S2-2.dwg

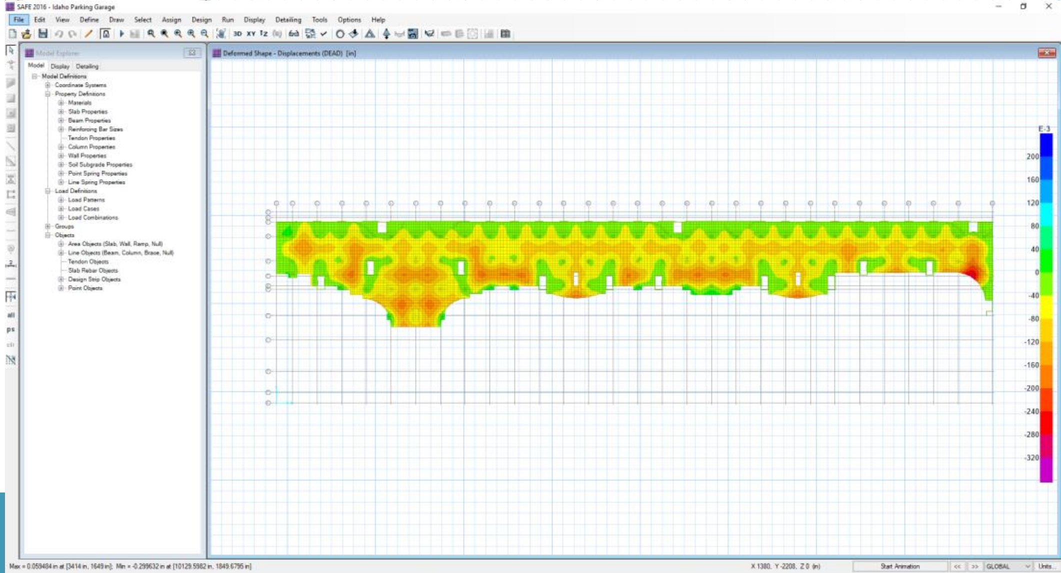
PG-S2.2A
SUBMITTAL DATE: 01-31-13

Bridge Key 37000, Drawing No. 17510

RATING PROGRAM

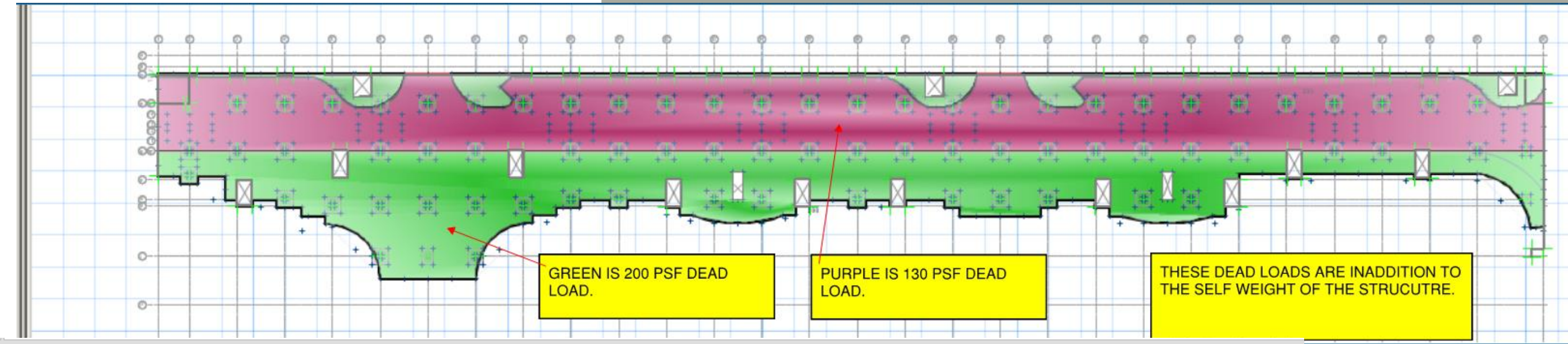
CSI SAFE





RATING PROGRAM

CSI SAFE

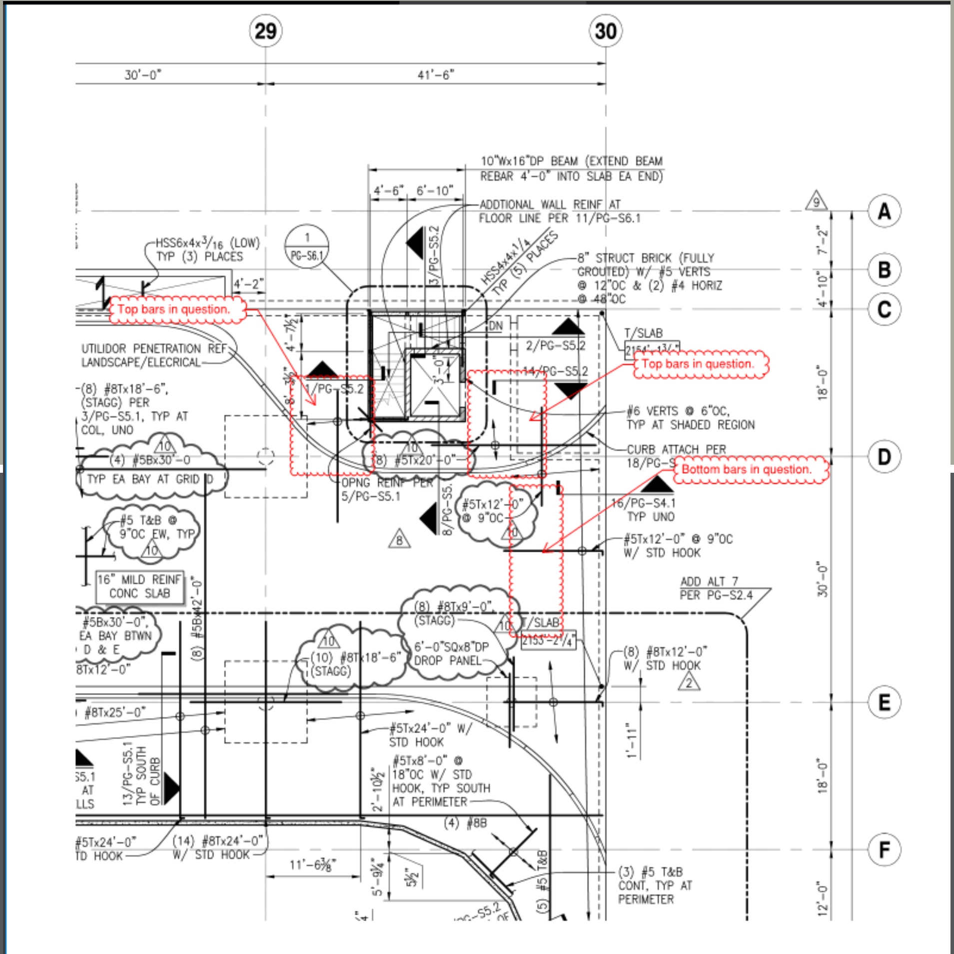


	A	B	C	D	E	F	G	H	I	J	K	L	M
1	1.3 Dead Load TABLE: Concrete Slab Design 01 – Flexural And Shear Data												
2	Strip			Station	ConcWidt	TopComb	TopMomen	electTopMo	pacityTopM	TopAre	TopAMir	BotComb	BotMomen
3	Text			in	in	Text	kip-ft	kip-ft	kip-ft	in2	in2	Text	kip-ft
4	SA9		NA	0	80.3572	1.3DL	-7.897			0	0	1.3DL	3.7532
5	SA9		NA	48	96	1.3DL	-461.133			3.4193	6.912	1.3DL	17.5691
6	SA9		NA	60	96	1.3DL	-480.1118			3.5084	5.5296	1.3DL	8.3152
7	SA9		NA	72	96	1.3DL	-537.8615			3.9275	6.912	1.3DL	7.4327
8	SA9		NA	120	120	1.3DL	-112.4617			0.8171	0	1.3DL	201.3432
9	SA9		NA	163	120		0			0	0	1.3DL	187.6527
10	SA9		NA	206	120		0			0	0	1.3DL	234.2035
11	SA9		NA	249	120		0			0	0	1.3DL	206.9493
12	SA9		NA	292	120	1.3DL	-12.4023			0.1886	0	1.3DL	109.5221
13	SA9		NA	335	120	1.3DL	-122.2248			1.8689	3.456	1.3DL	6.5765
14	SA9		NA	378	120	1.3DL	-474.9768			7.4007	3.456	1.3LL	0
15	SA9		NA	420	120	1.3DL	-1369.5963			10.101	6.912	1.3LL	0
16	SA9		NA	462	120	1.3DL	-474.94			7.4001	3.456	1.3LL	0
17	SA9		NA	505	120	1.3DL	-122.482			1.8728	3.456	1.3DL	6.8025
18	SA9		NA	548	120	1.3DL	-12.603			0.1916	0	1.3DL	110.2276
19	SA9		NA	591	120		0			0	0	1.3DL	208.8003
20	SA9		NA	634	120		0			0	0	1.3DL	236.1759
21	SA9		NA	677	120		0			0	0	1.3DL	189.3271
22	SA9		NA	720	120	1.3DL	-113.0759			0.8216	0	1.3DL	200.3584
23	SA9		NA	768	96	1.3DL	-527.2339			3.8495	6.912	1.3DL	14.1262
24	SA9		NA	780	96	1.3DL	-451.0392			3.2946	5.5296	1.3DL	11.9824
25	SA9		NA	792	96	1.3DL	-514.8424			3.8335	6.912	1.3DL	14.2945
26	SA9		NA	840	120	1.3DL	-201.5715			1.4894	6.912	1.3DL	49.9469
27	SB1			0	24.5	1.3DL	-0.9998			0	0	1.3DL	6.2559
28	SB1			45	24.5	1.3DL	-0.8644			0	0	1.3DL	11.7872
29	SB1			90	24.5	1.3DL	-9.8962			0.1589	0.7056	1.3DL	9.43
30	SB1			135	24.5	1.3DL	-20.2778			0.3305	0.7056	1.3DL	5.615
31	SB1	F2.5	S/NA	180	24.5	1.3DL	-40.1388			0.6457	0	1.3DL	63.0544
32	SB1			225	240	1.3DL	-17.2916			0.2771	0	1.3DL	47.1023
33	SB1			270	240	1.3DL	-51.0699			0.8191	6.912	1.3DL	17.1914
34	SB1			315	240	1.3DL	-105.508			1.6949	6.912	1.3LL	0
35	SB1	E2.5	S	360	240	1.3DL	-121.919			1.9594	6.912	1.3LL	0
36	SB1			405	240	1.3DL	-82.6956			1.3276	6.912	1.3DL	6.1849
37	SB1			450	240	1.3DL	-35.4112			0.5677	0	1.3DL	116.1393
38	SB1			495	240		0			0	0	1.3DL	247.1845
39	SB1			540	240		0			0	0	1.3DL	315.2516
40	SB1			585	240		0			0	0	1.3DL	302.7695
41	SB1			630	240	1.3DL	-13.3885			0.2145	0	1.3DL	203.3413
42	SB1			675	240	1.3DL	-43.589			0.699	0	1.3DL	76.5191
43	SB1	D2.5	S	720	240	1.3DL	-80.9915			1.3001	6.912	1.3DL	14.9001
44	SB1			760.8	240	1.3DL	-72.6852			1.1665	6.912	1.3DL	10.9877
45	SB1			801.6	240	1.3DL	-30.8079			0.5119	0	1.3DL	56.3034
46	SB1			842.4	240	1.3DL	-6.2442			0	0	1.3DL	95.8217
47	SB1			883.2	240	1.3DL	-4.2856			0	0	1.3DL	93.4382
48	SB1			924	240	1.3DL	-15.9818			0.4361	0	1.3DL	77.4529

	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	A
1														Case 1F							
2	SelectBotMon	apacityBotMo	BotAre	BotAMir	xialForc	VCombo	VForce	VArea	Status	GlobalX	GlobalY	Layer		SelectTopMo	electBotMo	1.3LL		2.17LL			SelectT
3	kip-ft	kip-ft	in2	in2	kip	Text	kip	in2/ft	Text	in	in	Text		kip-ft	kip-ft	Top	Bot	Top	Bot		kip
4			0	4.6286	-0.00948	1.3DL	3.839	0	OK	1614	1277	A				N/A	N/A	N/A	N/A	Controlling Value	
5			0	0	-5.752	1.3DL	28.901	0	OK	1662	1277	A				N/A	N/A	N/A	N/A	for 1.3LL:	
6			0	0	1.477	1.3DL	44.309	0	OK	1674	1277	A				N/A	N/A	N/A	N/A	0.45864	
7			0	0	5.381	1.3DL	117.69	0	OK	1686	1277	A				N/A	N/A	N/A	N/A	Controlling Value	
8			1.4644	6.912	6.745	1.3DL	109.38	0	OK	1734	1277	A				N/A	N/A	N/A	N/A	for 2.17LL:	
9			2.8791	3.456	6.32	1.3DL	22.271	0	OK	1777	1277	A				N/A	N/A	N/A	N/A	0.27476	
10			3.6021	3.456	5.867	1.3DL	1.315	0	OK	1820	1277	A				N/A	N/A	N/A	N/A		
11			3.1784	3.456	5.499	1.3DL	24.186	0	OK	1863	1277	A				N/A	N/A	N/A	N/A		
12			1.6735	3.456	5.28	1.3DL	49.503	0	OK	1906	1277	A				N/A	N/A	N/A	N/A		
13			0.1	0	5.035	1.3DL	82.932	0	OK	1949	1277	A				N/A	N/A	N/A	N/A		
14			0	0	0	1.3DL	167.65	0	OK	1992	1277	A				N/A	N/A	N/A	N/A		
15			0	0	0	1.3DL	223.71	0	OK	2034	1277	A				N/A	N/A	N/A	N/A		
16			0	0	0	1.3DL	167.78	0	OK	2076	1277	A				N/A	N/A	N/A	N/A		
17			0.1034	0	5.002	1.3DL	83.066	0	OK	2119	1277	A				N/A	N/A	N/A	N/A		
18			1.6844	3.456	5.2	1.3DL	49.66	0	OK	2162	1277	A				N/A	N/A	N/A	N/A		
19			3.2071	3.456	5.369	1.3DL	24.404	0	OK	2205	1277	A				N/A	N/A	N/A	N/A		
20			3.6329	3.456	5.683	1.3DL	1.619	0	OK	2248	1277	A				N/A	N/A	N/A	N/A		
21			2.9051	3.456	6.103	1.3DL	21.786	0	OK	2291	1277	A				N/A	N/A	N/A	N/A		
22			1.4572	6.912	6.506	1.3DL	107.59	0	OK	2334	1277	A				N/A	N/A	N/A	N/A		
23			0	0	4.669	1.3DL	116	0	OK	2382	1277	A				N/A	N/A	N/A	N/A		
24			0	0	0.991	1.3DL	42.743	0	OK	2394	1277	A				N/A	N/A	N/A	N/A		
25			0	0	-7.849	1.3DL	62.333	0	OK	2406	1277	A				N/A	N/A	N/A	N/A		
26			0.386	0	-2.421	1.3DL	6.807	0	OK	2454	1277	A				N/A	N/A	N/A	N/A		
27			0.1004	0.7056	0.112	1.3DL	0.077	0	OK	414	1709	B				N/A	N/A	N/A	N/A		
28			0.1894	0.7056	0.619	1.3DL	0.546	0	OK	414	1754	B				N/A	N/A	N/A	N/A		
29			0.1514	0.7056	1.094	1.3DL	0.947	0	OK	414	1799	B				N/A	N/A	N/A	N/A		
30			0.094	0	-0.37	1.3DL	0.325	0	OK	414	1844	B				N/A	N/A	N/A	N/A		
31	63.0544		1.0138	6.912	-0.198	1.3DL	3.55	0	OK	414	1889	B				N/A	N/A	N/A	N/A		
32			0.7554	6.912	0.34	1.3DL	6.917	0	OK	414	1934	B				N/A	N/A	N/A	N/A		
33			0.2755	0	3.399	1.3DL	30.399	0	OK	414	1979	B				N/A	N/A	N/A	N/A		
34			0	0	0	1.3DL	19.59	0	OK	414	2024	B				N/A	N/A	N/A	N/A		
35			0	0	0	1.3DL	13.746	0	OK	414	2069	B				N/A	N/A	N/A	N/A		
36			0	0	6.506	1.3DL	34.415	0	OK	414	2114	B				N/A	N/A	N/A	N/A		
37			1.8662	6.912	7.79	1.3DL	55.028	0	OK	414	2159	B				N/A	N/A	N/A	N/A		
38			3.987	6.912	8.529	1.3DL	34.472	0	OK	414	2204	B				N/A	N/A	N/A	N/A		
39	315.2516		5.0949	6.912	8.295	1.3DL	7.865	0	OK	414	2249	B				N/A	N/A	N/A	N/A		
40			4.8914	6.912	7.139	1.3DL	19.097	0	OK	414	2294	B				N/A	N/A	N/A	N/A		
41			3.2757	6.912	4.987	1.3DL	41.018	0	OK	414	2339	B				N/A	N/A	N/A	N/A		
42			1.2282	6.912	2.622	1.3DL	33.249	0	OK	414	2384	B				N/A	N/A	N/A	N/A		
43			0.2387	0	1.101	1.3DL	19.277	0	OK	414	2429	B				N/A	N/A	N/A	N/A		
44			0.176	0	0.722	1.3DL	6.134	0	OK	414	2469.8	B				N/A	N/A	N/A	N/A		
45			0.9211	6.912	-1.683	1.3DL	14.176	0	OK	414	2510.6	B				N/A	N/A	N/A	N/A		
46	95.8217		1.5461	6.912	-0.684	1.3DL	6.606	0	OK	414	2551.4	B				N/A	N/A	N/A	N/A		
47			1.5005	6.912	1.558	1.3DL	7.165	0	OK	414	2592.2	B				N/A	N/A	N/A	N/A		
48			1.4228	6.912	-16.869	1.3DL	33.123	0	OK	414	2633	B				N/A	N/A	N/A	N/A		

RATING ISSUES

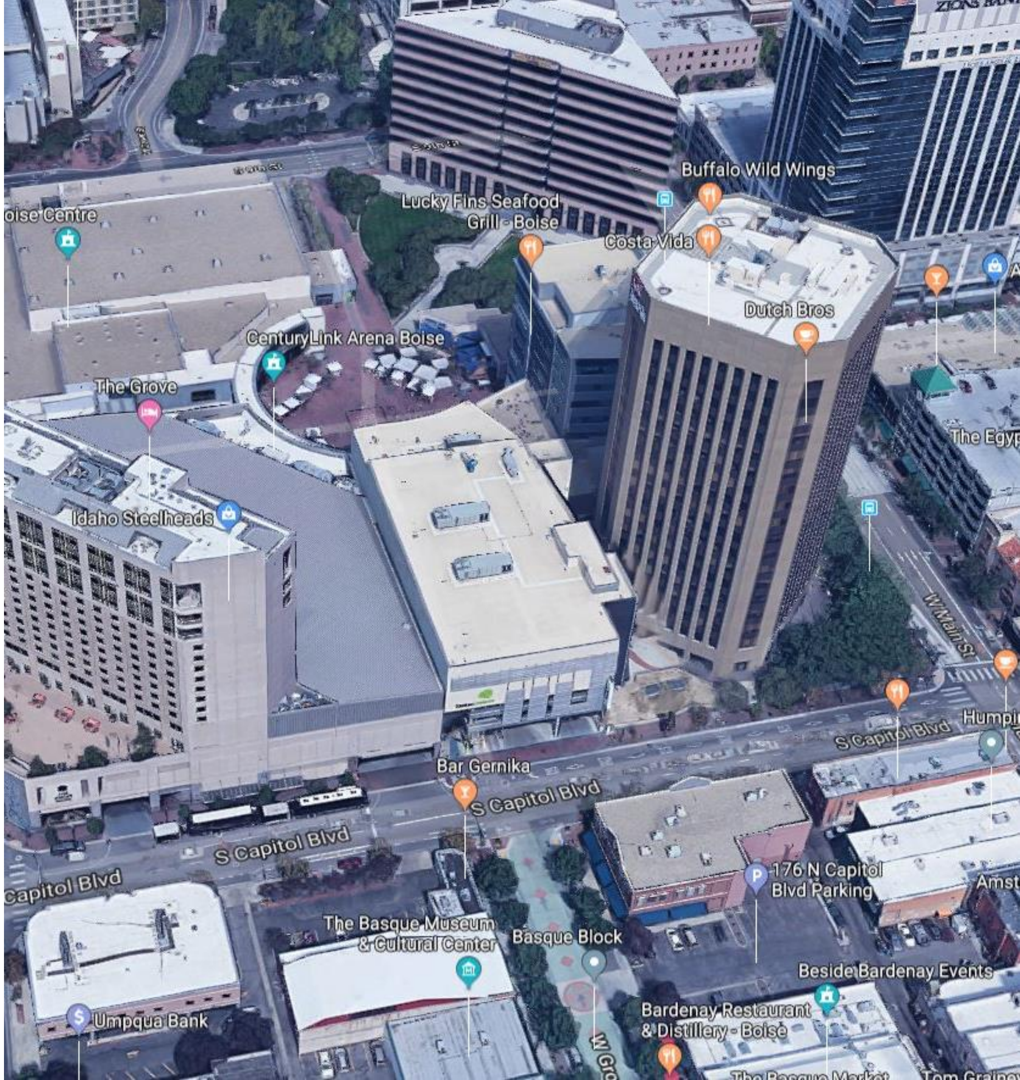
- Two-Way Slab
- DRAWINGS (Architectural, Structural & Civil)
- CSI SAFE
- Live Loading
- Pre/Post Processing
- Design Error?



Problem Areas Screenshot

Main Street in Boise, Idaho

- Owner: ??????????
- Valley Regional Transit / Ada County HD/ Private Developer
- Opened in 2016



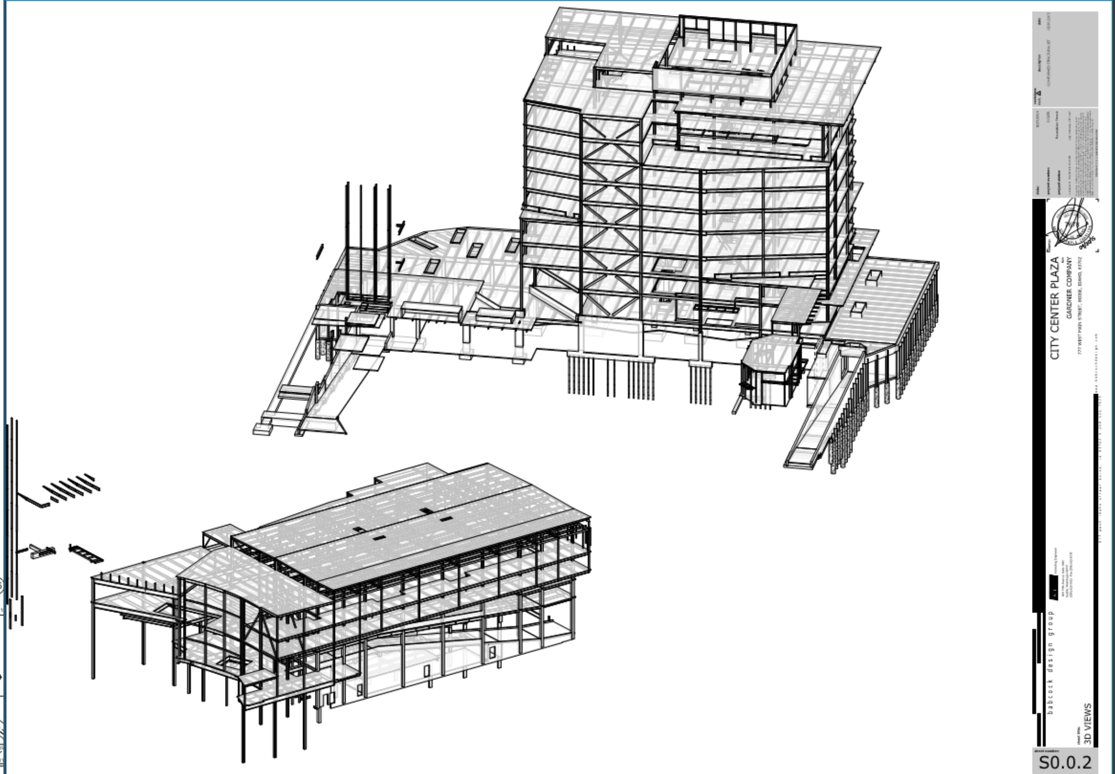

Street Station


DO NOT ENTER

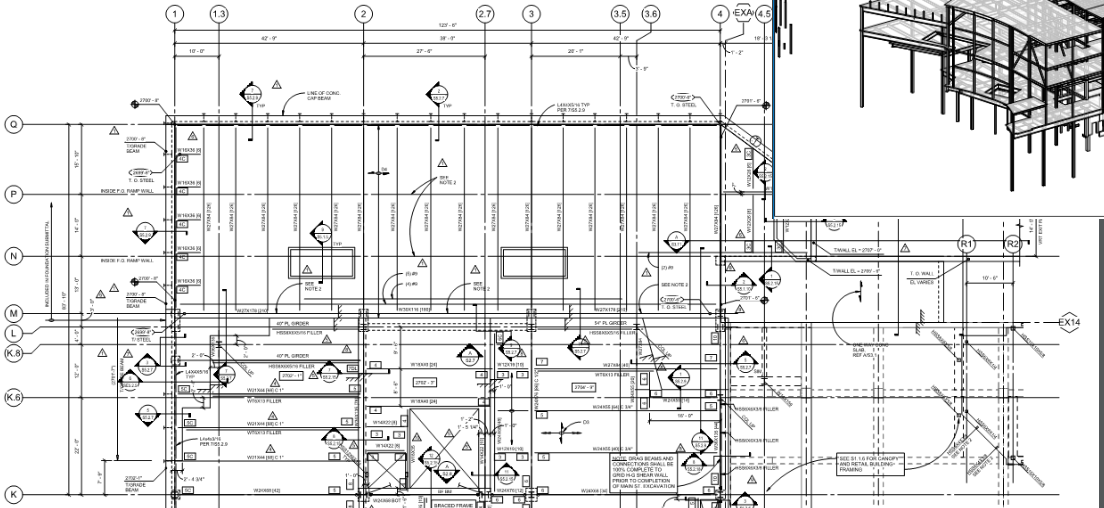

100 N 100 S
8th St
ONE WAY
BOISE STATE UNIVERSITY
BUSES CARPOOL ONLY
©2017 Google

DESIGN PLANS

- Many, many sheet
- Many, many Details
- Architectural, Structural, & Civil

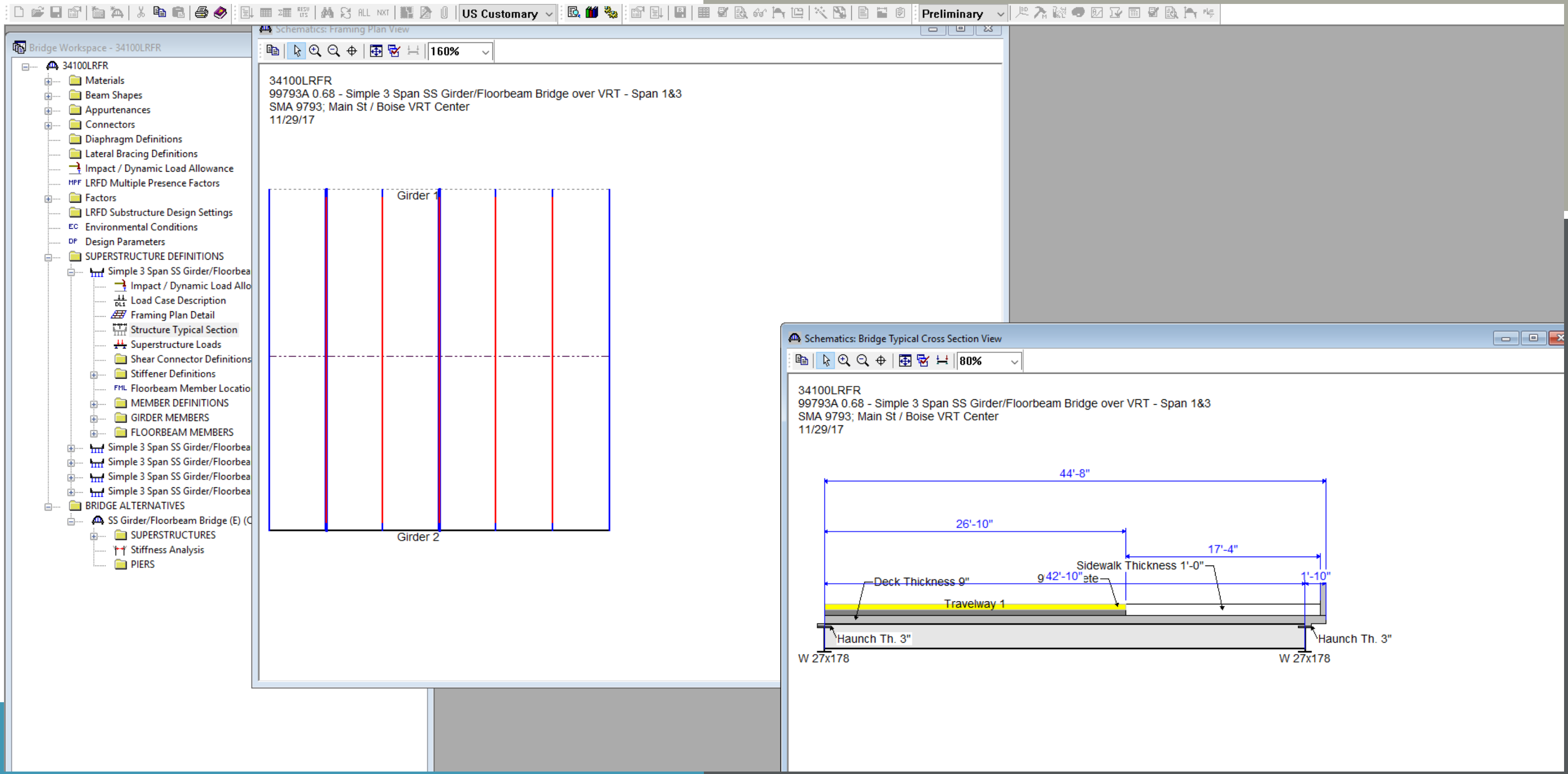


Bridge Key 34100, Drawing # 17586, Sheet 3 of 62



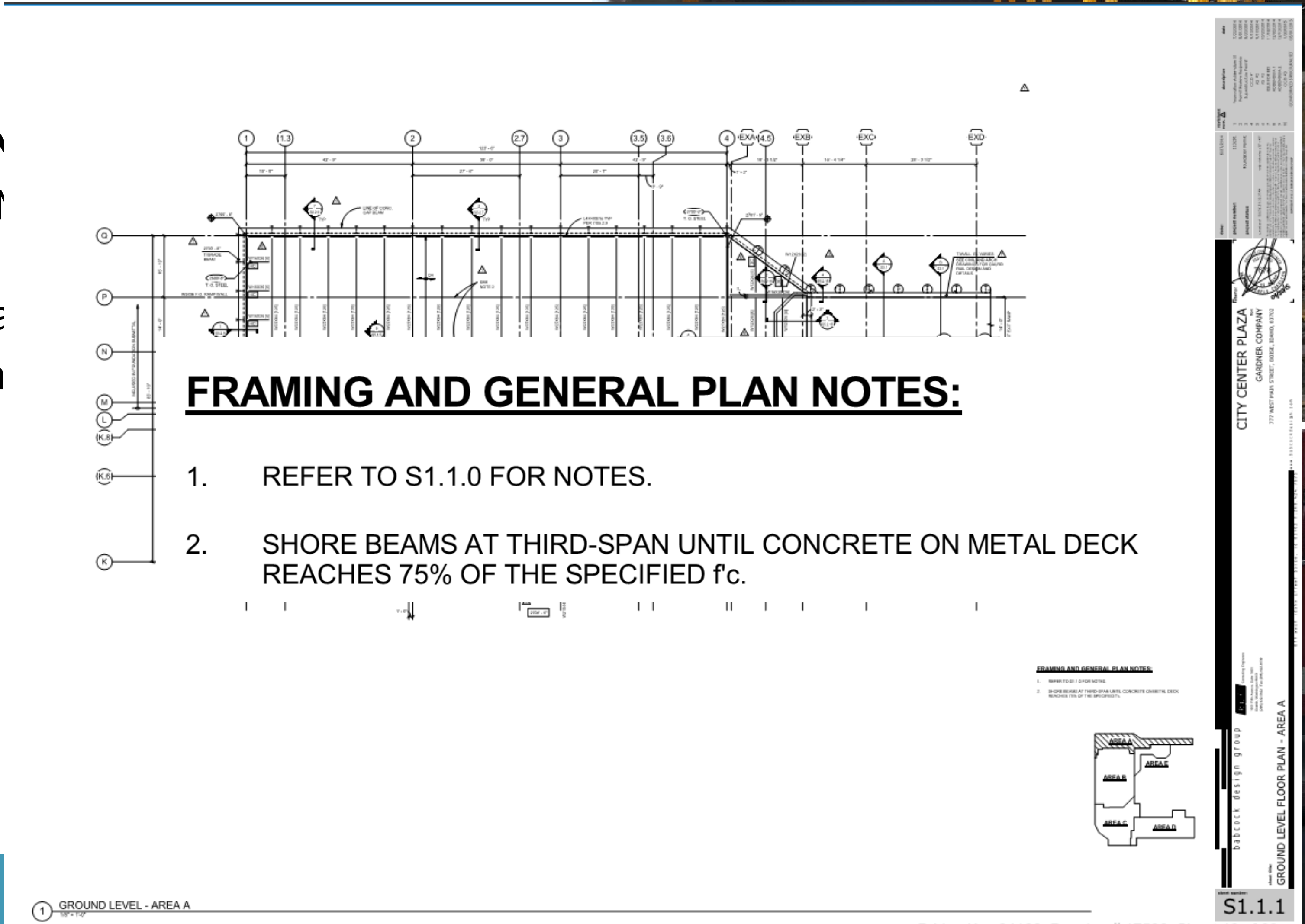
BrR RATING

- Floor Beam / Stringer



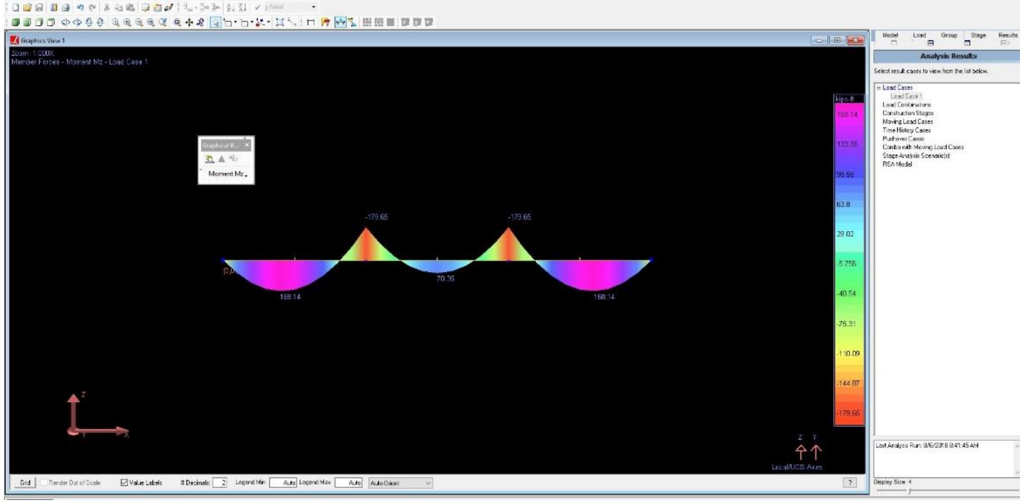
RATIN

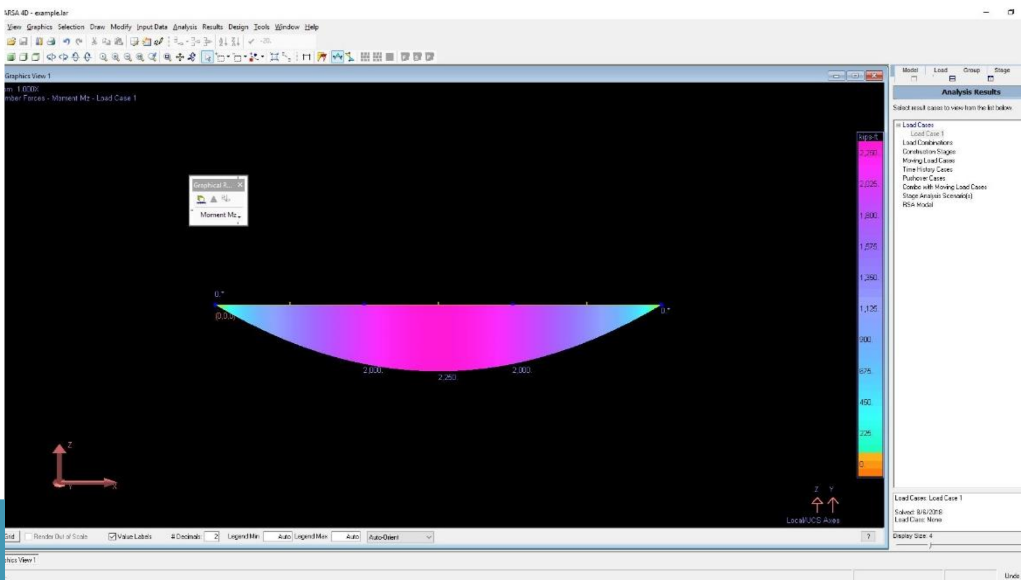
- DRAWIN Civil)
- Live Loa
- Prelimin



TEMP. SHORING

- LARSA
- Equivalent DL to match Moment





WALLACE VIADUCT

Load rating a curved PT multicell box bridge in BrR

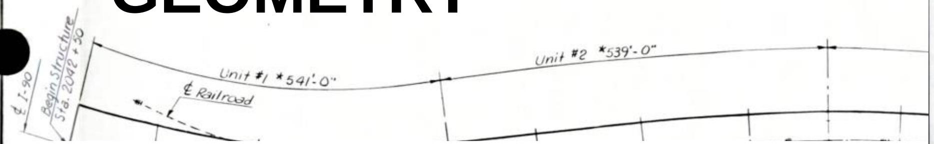
Outline:

- Location/Geometry
- BrR Information
- Geometry Challenges
- Post-Tension Limitations
- Live Load Distribution Factors
- Solid Sections
- Pier Input

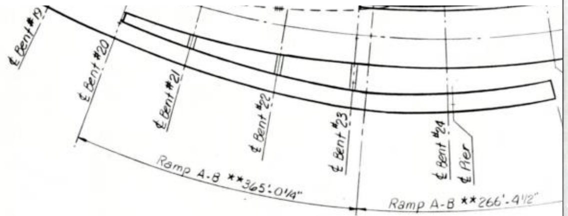
LOCATION

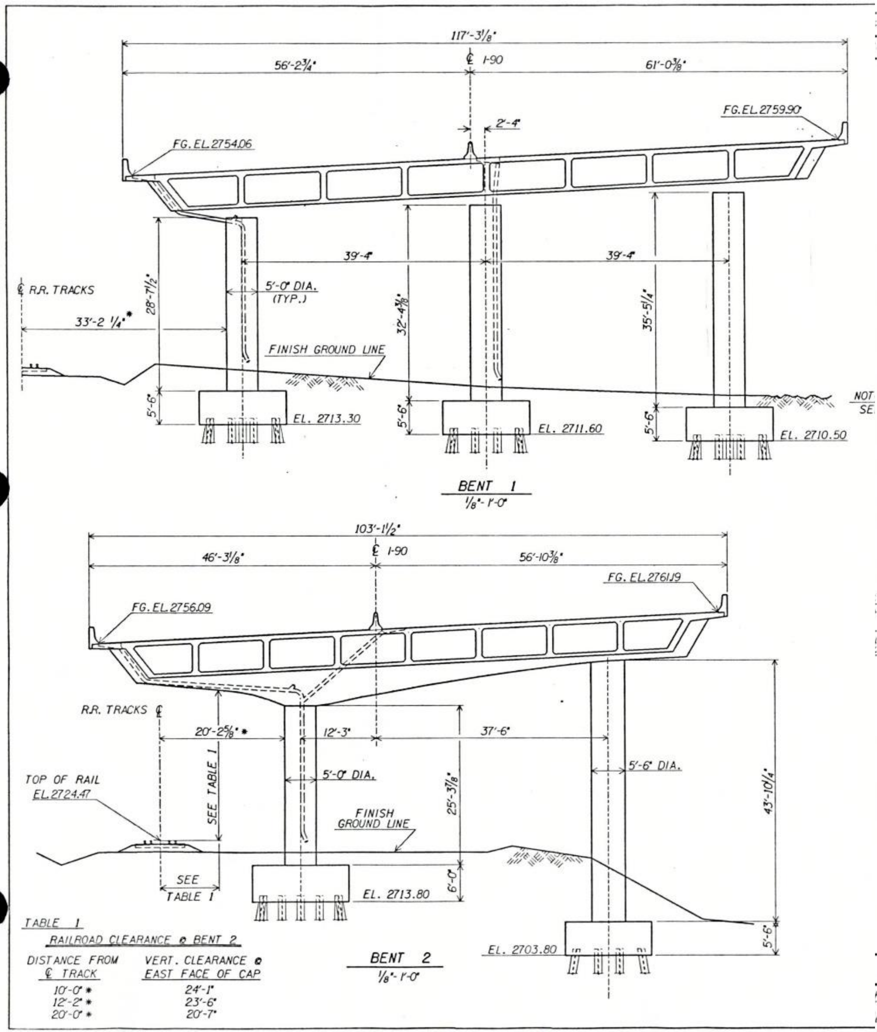
- Carries I-90 through the town of Wallace
- Located between Spokane and Missoula
- Constructed in 1991
- Railroad under most of the structure converted to Trail of the Coeur d’ Alenes

GEOMETRY



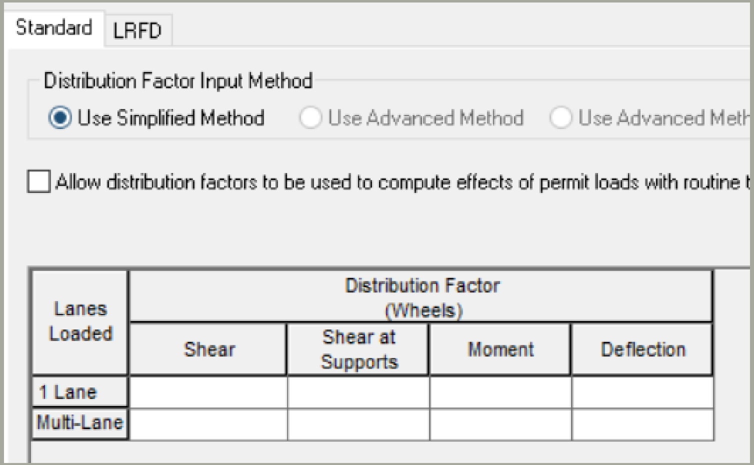
- 8 Units – 33 spans
- Total length of 4478’
- Two ramps
- Four circular curves, with spiral transitions
- In span hinge
- Width transitions from 84’ min to 145’ max
- Splayed webs
- Multi-column piers



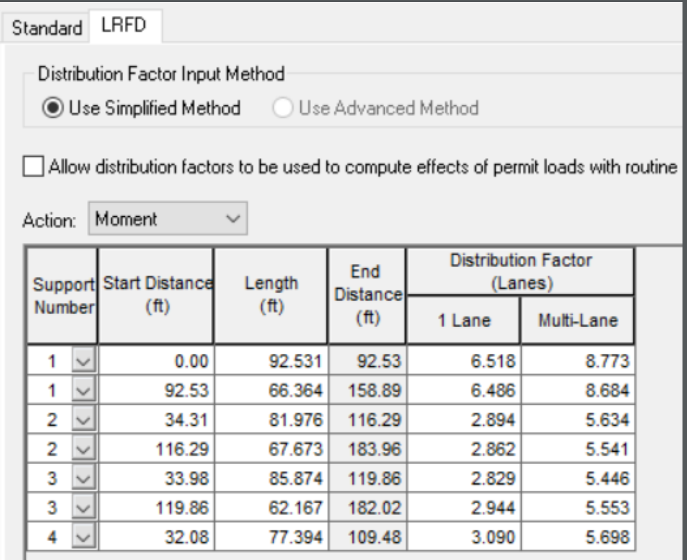


BrR Information

- BrR Version 6.8.1 used
- Bridge designed LFR
- LRFR module was used for rating:
  - LFR module was not stable
  - LRFR module has more flexibility with live load distribution factors



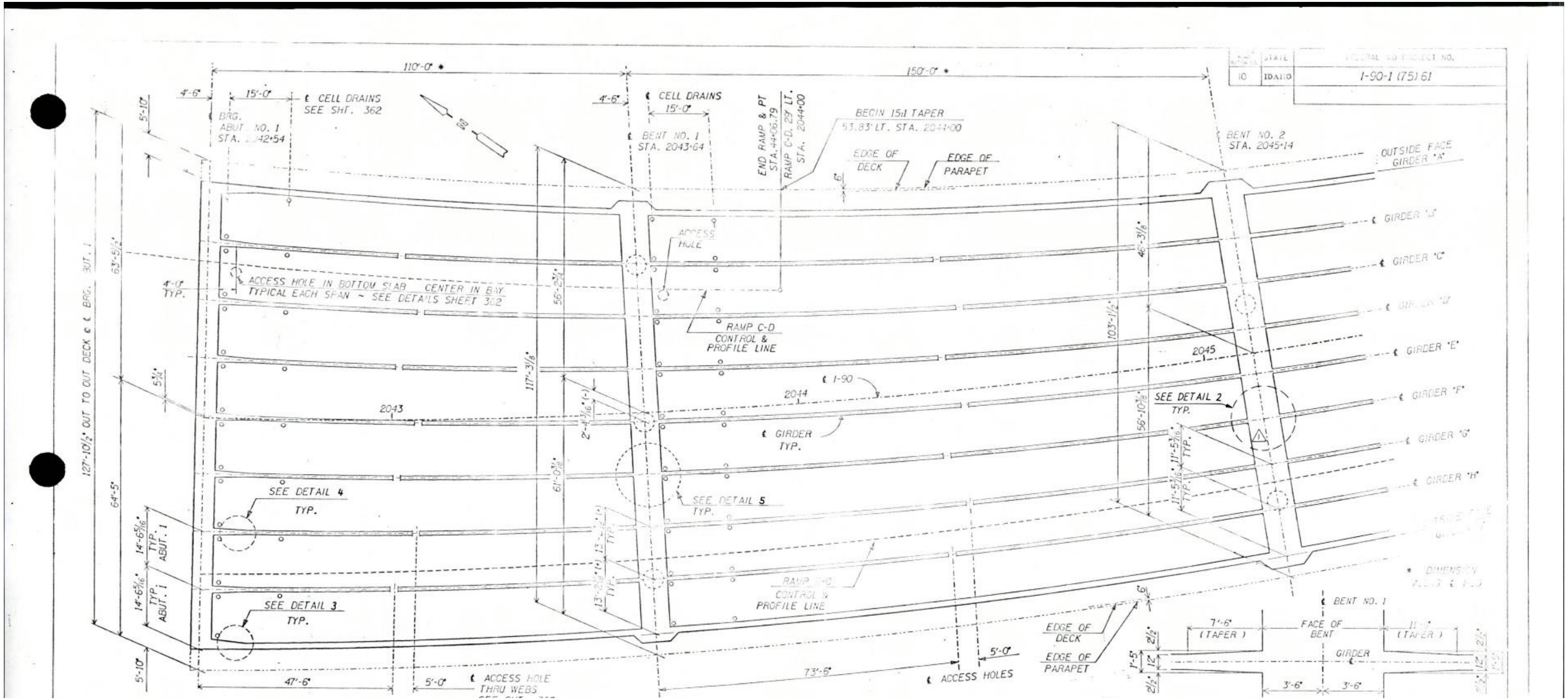
Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane				
Multi-Lane				



Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Distribution Factor (Lanes)	
				1 Lane	Multi-Lane
1	0.00	92.531	92.53	6.518	8.773
1	92.53	66.364	158.89	6.486	8.684
2	34.31	81.976	116.29	2.894	5.634
2	116.29	67.673	183.96	2.862	5.541
3	33.98	85.874	119.86	2.829	5.446
3	119.86	62.167	182.02	2.944	5.553
4	32.08	77.394	109.48	3.090	5.698

GEOMETRY CHALLENGES

- Curved superstructure
- Non-linear splayed girder webs



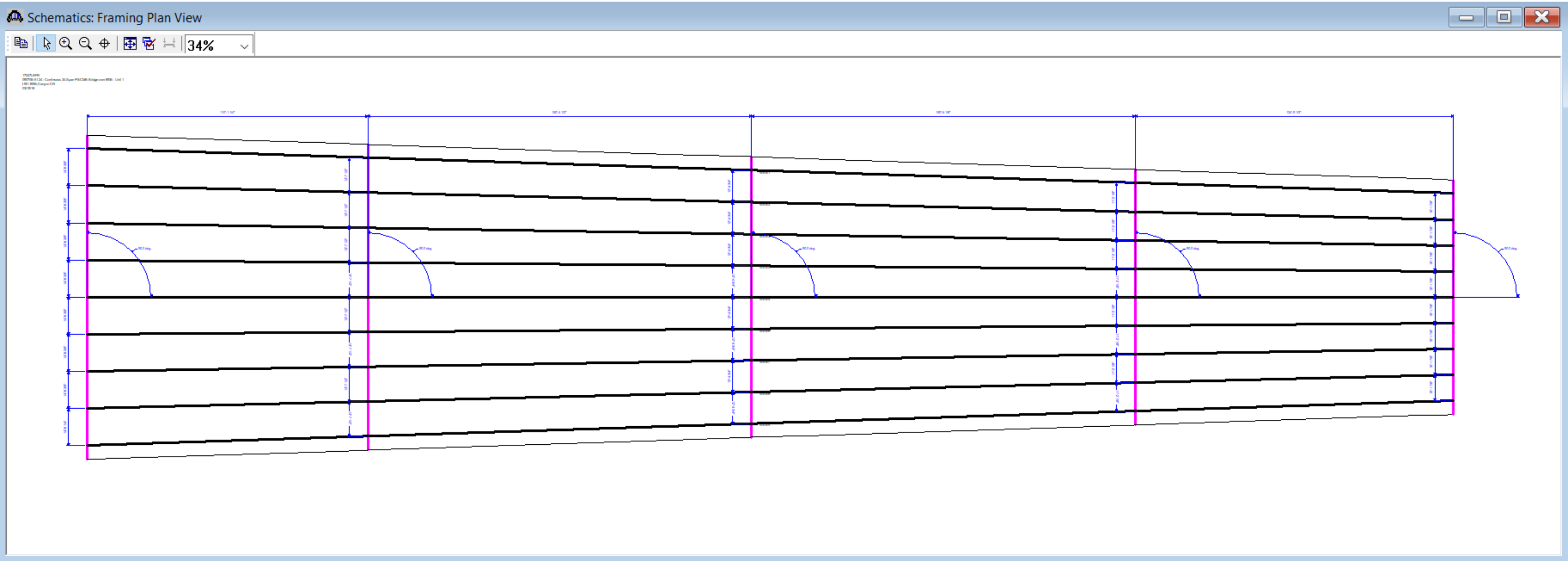
GEOMETRY SIMPLIFICATIONS

- Curved superstructure
  - Modeled as straight, per AASHTO Art. 4.6.1.2.3
    - Central angle of individual spans less than 12 degrees

- Splayed girder webs
  - BrR does not rate individual webs for shear when girder webs are splayed.
    - AASHTO 4.6.2.2 allows cast-in-place multi-cell box girders to be analyzed as full width sections
    - All piers radial, no correction factor needed for webs in obtuse corner

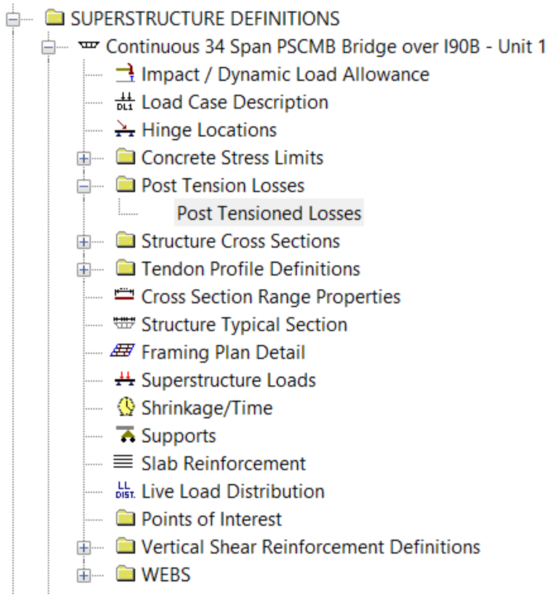
- BrR can handle splayed geometry, however it has to be linear
  - Edge of deck and CL webs follow spiral and circular curves while also transitioning width, therefore edge of deck follows non-linear path
  - Span lengths and shear stirrup spacing based on middle web dimensions in design plans

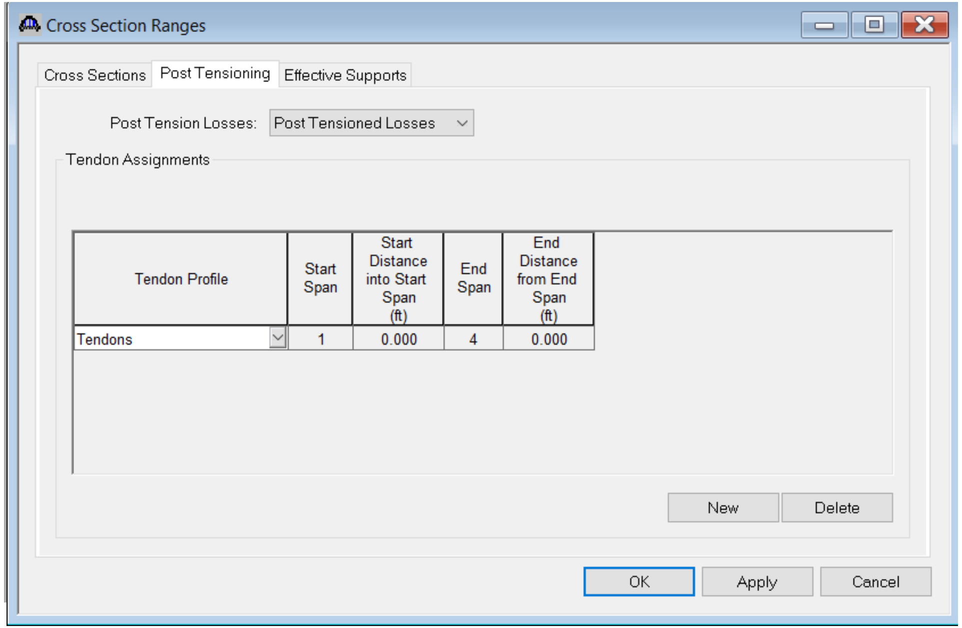
GEOMETRY SIMPLIFICATIONS



POST-TENSION LIMITATIONS

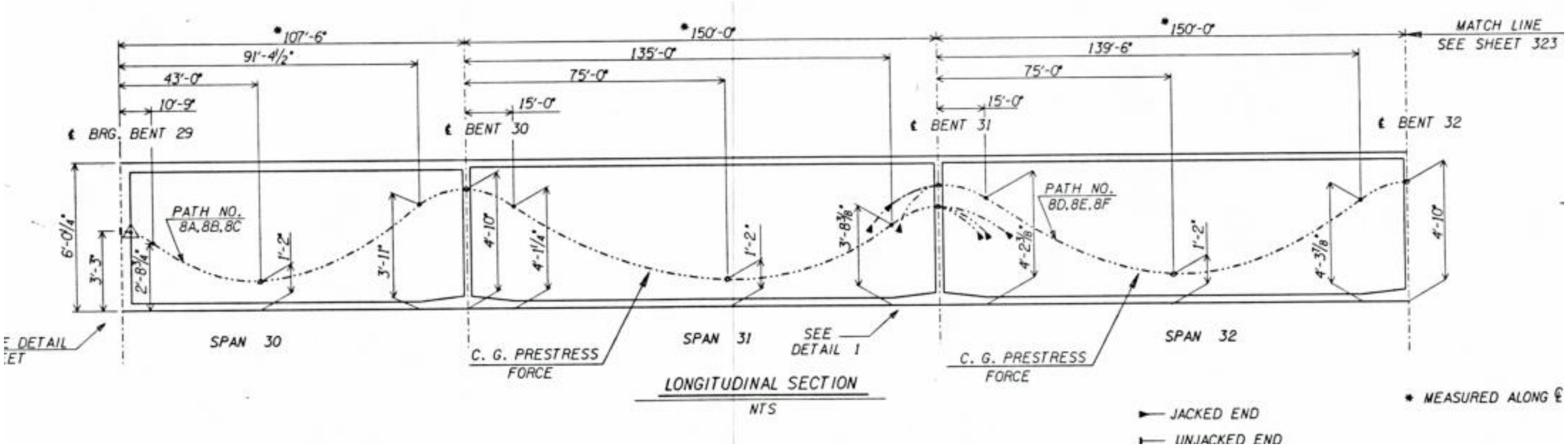
- BrR only allows one PT Loss definition per frame
  - Limits anchor set, coefficient of friction and wobble coefficient values to be the same on every profile defined in an individual frame
  - Multiple Post Tensioned Losses can be defined, but only one can be defined in the cross section ranges window





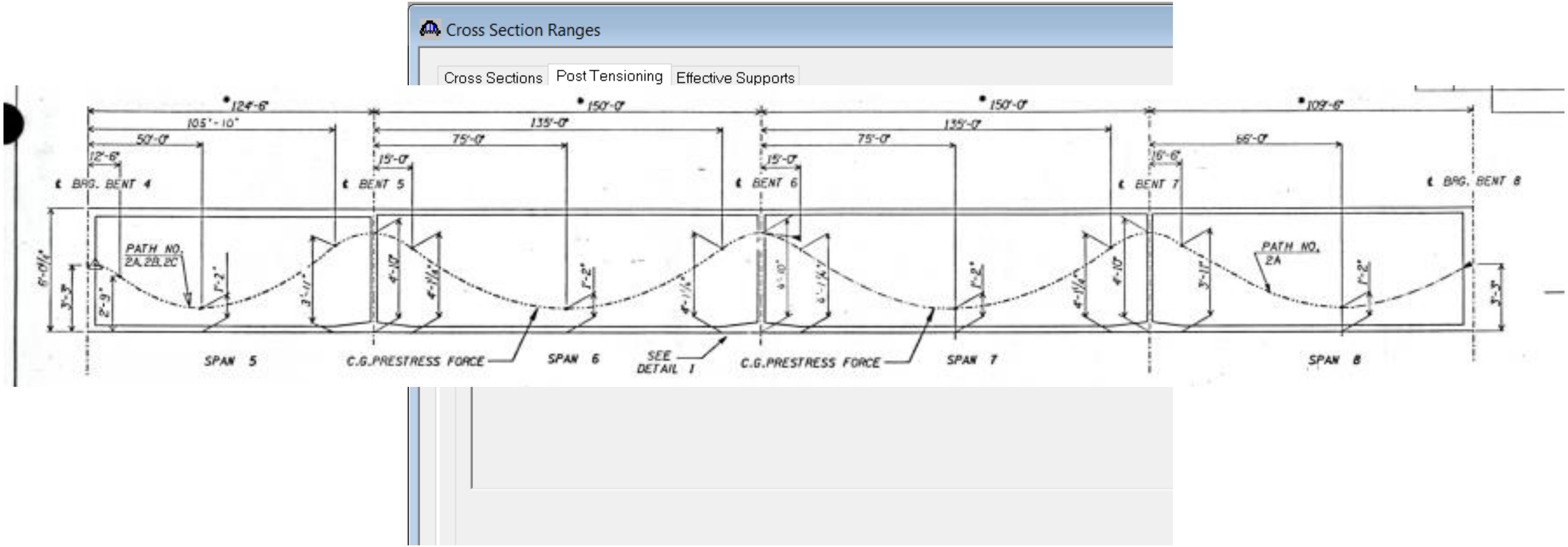
POST-TENSION LIMITATIONS

- Friction losses due to horizontal curvature
  - Hand calculations were ran to determine friction losses due to horizontal curvature
  - Wobble coefficient was modified to account for additional frictional losses
  - Only one wobble coefficient allowed per frame, worst case was used when more than one PT tendon profile was present



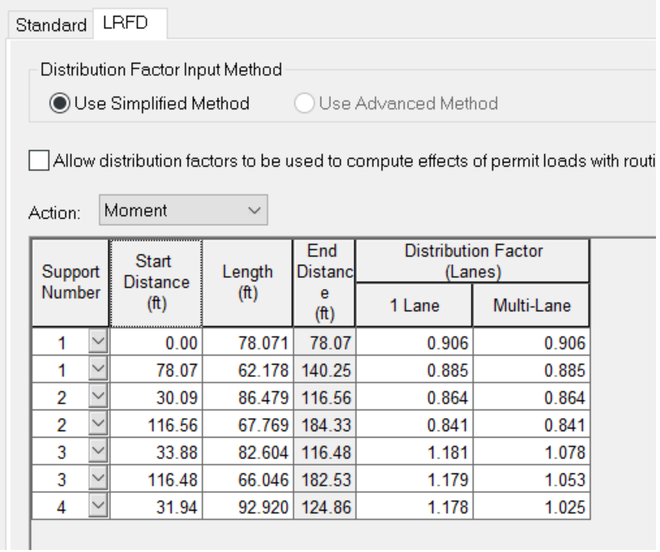
POST-TENSION LIMITATIONS

- Only one PT profile is allowed at any given location
  - PT losses are reset when a new profile is defined
  - Jacking stress ratios in BrR were modified to account for mid-frame friction loss effects
    - This causes conservative friction losses, which will cause conservative Service III ratings

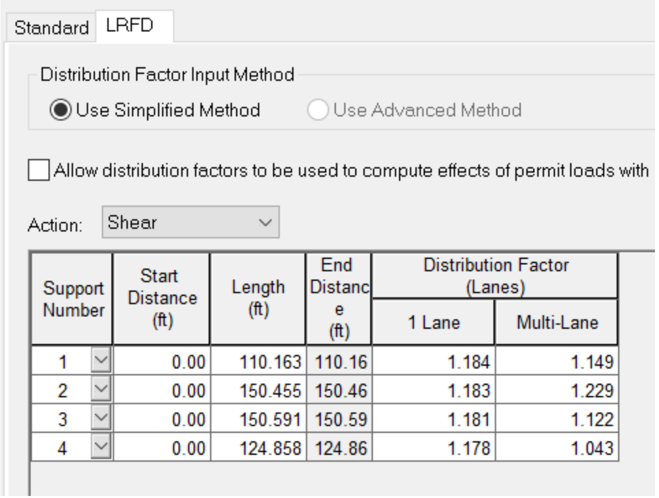


LIVE LOAD DISTRIBUTION FACTORS

- LLDF follow current AASHTO LRFD code
  - Slight discrepancies were found in exterior and first interior web from BrR calculations
    - Interior girders and independent calculations matched
  - Independent LLDF were calculated
  - Width used for LLDF was midpoint between contraflexure points for moment, and CL span for shear



Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Distribution Factor (Lanes) 1 Lane	Distribution Factor (Lanes) Multi-Lane
1	0.00	78.071	78.07	0.906	0.906
1	78.07	62.178	140.25	0.885	0.885
2	30.09	86.479	116.56	0.864	0.864
2	116.56	67.769	184.33	0.841	0.841
3	33.88	82.604	116.48	1.181	1.078
3	116.48	66.046	182.53	1.179	1.053
4	31.94	92.920	124.86	1.178	1.025



Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Distribution Factor (Lanes) 1 Lane	Distribution Factor (Lanes) Multi-Lane
1	0.00	110.163	110.16	1.184	1.149
2	0.00	150.455	150.46	1.183	1.229
3	0.00	150.591	150.59	1.181	1.122
4	0.00	124.858	124.86	1.178	1.043

SOLID SECTIONS

- When defining solid sections at the pier locations, BrR uses the gross area and section properties of the solid concrete section for Service III stress calculations
  - This results in an erroneous result, since P/A + Mc/I for a solid section will result in far smaller compressive stresses than the hollow section that it was designed for.
  - Recommend not using solid section check box for pier locations

Cross Section Ranges

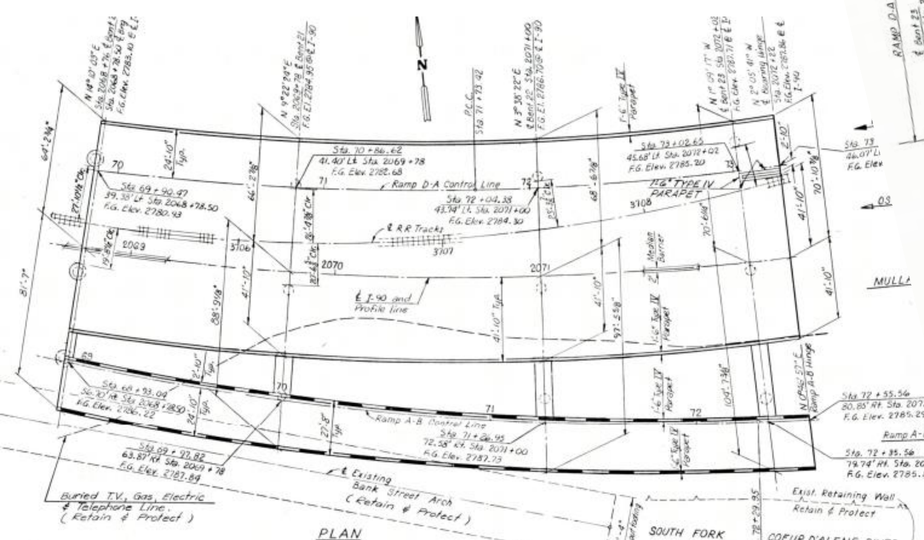
Cross Sections | Post Tensioning | Effective Supports

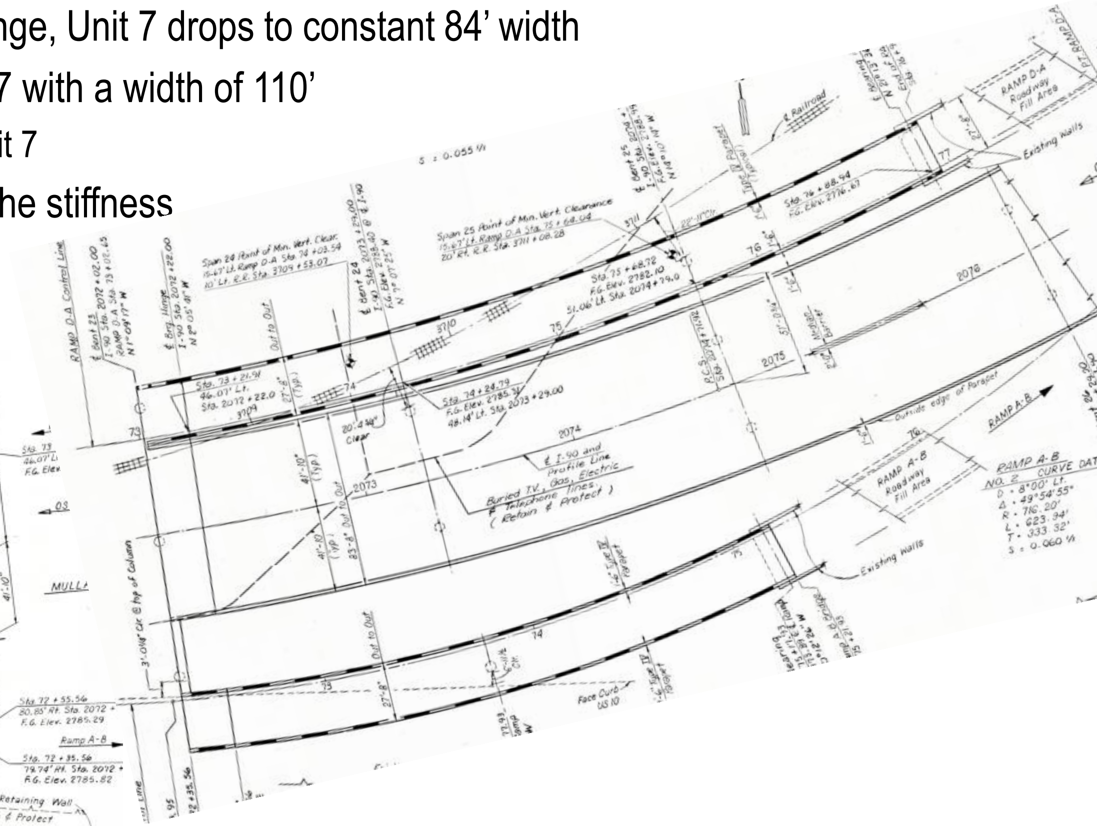
Left end projection: 24.000 in   Right end projection: 26.250 in

Start Section	End Section	Depth Vary	Solid Section	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)
CL Abut. 1	Abut. 1 - Face	None	☐	1	0.000	3.000	3.000
Abut. 1 - Face	Abut. 1 - Transition	None	☐	1	3.000	8.500	11.500
Abut. 1 - Transition	Pier 1 - BS Transition	None	☐	1	11.500	87.604	99.104
Pier 1 - BS Transition	Pier 1 - BS Face	None	☐	1	99.104	7.500	106.604
Pier 1 - BS Face	Pier 1 - FS Face	None	☐	1	106.604	7.000	113.604
Pier 1 - FS Face	Pier 1 - FS Transition	None	☐	2	3.500	11.500	15.000
Pier 1 - FS Transition	Pier 2 - BS Transition	None	☐	2	15.000	114.125	129.125
Pier 2 - BS Transition	Pier 2 - BS Face	None	☐	2	129.125	17.250	146.375
Pier 2 - BS Face	Pier 2 - FS Face	None	☐	2	146.375	8.000	154.375
Pier 2 - FS Face	Pier 2 - FS Transition	None	☐	3	4.000	17.250	21.250
Pier 2 - FS Transition	Pier 3 - BS Transition	None	☐	3	21.250	114.260	135.510
Pier 3 - BS Transition	Pier 3 - BS Face	None	☐	3	135.510	11.000	146.510
Pier 3 - BS Face	Pier 3 - FS Face	None	☐	3	146.510	8.000	154.510
Pier 3 - FS Face	Pier 3 - FS Transition	None	☐	4	4.000	8.500	12.500
Pier 3 - FS Transition	Pier 4 - Transition	None	☐	4	12.500	99.792	112.292
Pier 4 - Transition	Pier 4 - Face	None	☐	4	112.292	8.688	120.979
Pier 4 - Face	Pier 4 - BS Brg	None	☐	4	120.979	3.813	124.792

HINGE

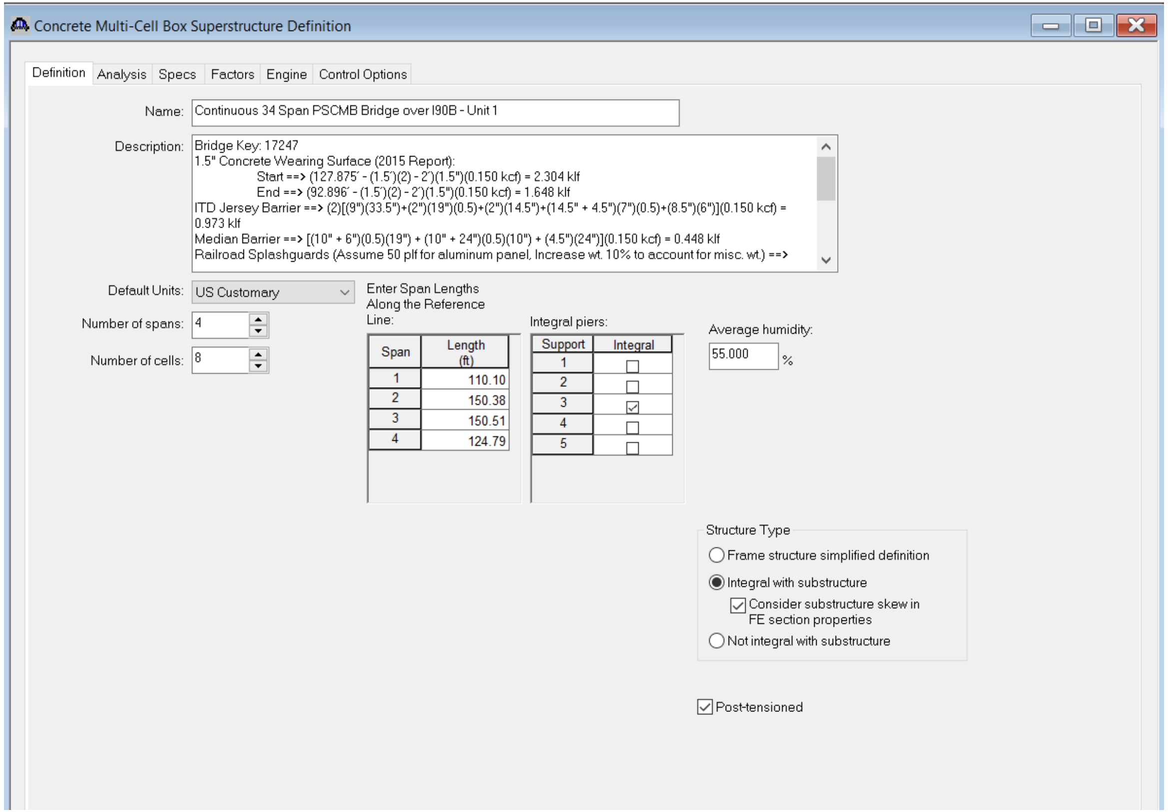
- Hinge input into BrR with simplifications:
  - Unit 6 varies in width from 106' to 112', at hinge, Unit 7 drops to constant 84' width
  - Unit 6 modeled with all spans from Unit 6 & 7 with a width of 110'
    - Loads adjusted to account for differences in Unit 7
  - Unit 7 modeled as 84' constant width using the stiffness of Unit 6 at hinge





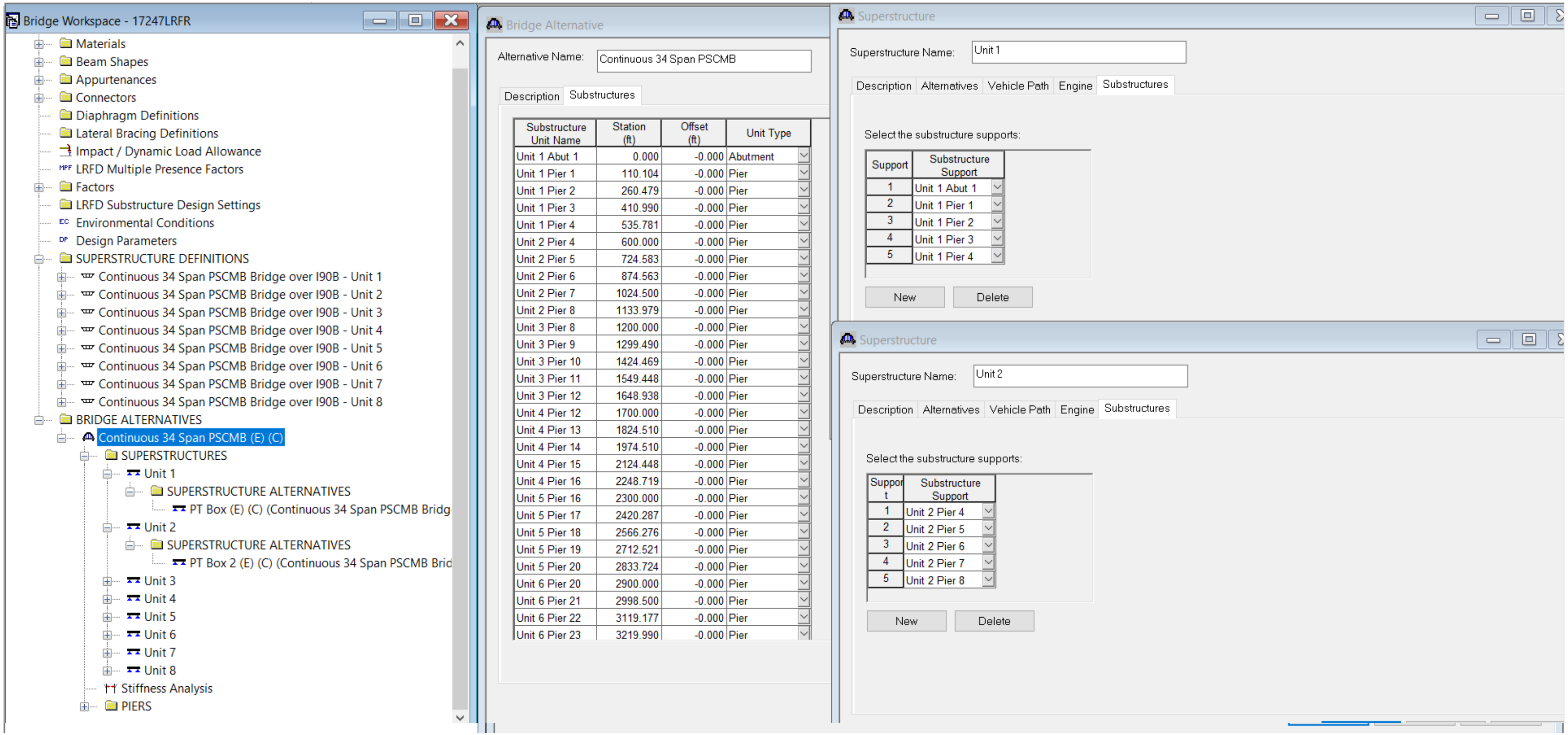
PIERS

- Piers input into BrR using Integral piers input in the superstructure definition



PIER INPUT

- Bridge Alternative input to run multiple superstructure definitions with piers



Substructure Unit Name	Station (ft)	Offset (ft)	Unit Type
Unit 1 Abut 1	0.000	-0.000	Abutment
Unit 1 Pier 1	110.104	-0.000	Pier
Unit 1 Pier 2	260.479	-0.000	Pier
Unit 1 Pier 3	410.990	-0.000	Pier
Unit 1 Pier 4	535.781	-0.000	Pier
Unit 2 Pier 4	600.000	-0.000	Pier
Unit 2 Pier 5	724.583	-0.000	Pier
Unit 2 Pier 6	874.563	-0.000	Pier
Unit 2 Pier 7	1024.500	-0.000	Pier
Unit 2 Pier 8	1133.979	-0.000	Pier
Unit 3 Pier 8	1200.000	-0.000	Pier
Unit 3 Pier 9	1299.490	-0.000	Pier
Unit 3 Pier 10	1424.469	-0.000	Pier
Unit 3 Pier 11	1549.448	-0.000	Pier
Unit 3 Pier 12	1648.938	-0.000	Pier
Unit 4 Pier 12	1700.000	-0.000	Pier
Unit 4 Pier 13	1824.510	-0.000	Pier
Unit 4 Pier 14	1974.510	-0.000	Pier
Unit 4 Pier 15	2124.448	-0.000	Pier
Unit 4 Pier 16	2248.719	-0.000	Pier
Unit 5 Pier 16	2300.000	-0.000	Pier
Unit 5 Pier 17	2420.287	-0.000	Pier
Unit 5 Pier 18	2566.276	-0.000	Pier
Unit 5 Pier 19	2712.521	-0.000	Pier
Unit 5 Pier 20	2833.724	-0.000	Pier
Unit 6 Pier 20	2900.000	-0.000	Pier
Unit 6 Pier 21	2998.500	-0.000	Pier
Unit 6 Pier 22	3119.177	-0.000	Pier
Unit 6 Pier 23	3219.990	-0.000	Pier

SUMMARY

- Location/Geometry
- BrR Information
- Geometry Challenges
- Post-Tension Limitations
- Live Load Distribution Factors
- Solid Sections
- Pier Input

Questions?