16 State House Station
Augusta, Maine 04333

Transportation Research Division

Technical Report 14-12

Advanced Bridge Safety Initiative

Investigation of Floor Beam Performance in Three Steel Through-Truss Bridges

Task 7

Technical Report Documentation Page

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The Advanced Structures and Composites Center at the University of Maine (UMaine) performed live load testing and rating adjustment factor analysis for three truss bridges. The Maine Department of Transportation (DOT) indicated that the floor beams are not sufficient for carrying the legal loads for these bridges. Each bridge is a steel through-truss bridge with floor beams, stringers and a variable depth concrete slab that was not designed to be composite with the steel framing. The bridges were all located in Maine in Brownville, Chester and T-3 Indian Purchase. Live load testing was conducted on April 8th, April 10th and April 15th, 2014 by UMaine with assistance from Maine DOT personnel to evaluate the performance of typical floor beams. Stringers were considered to be of secondary concern to the Maine DOT, and were not heavily instrumented.

The strain measurements were consistent, and the results appear reliable. Measured floor beam strains were less than expected based on a lever rule analysis for live load distribution. If the MaineDOT agrees with our assessment, a conventional, lever rule load rating of the floor beams for these three structures that accounts for the condition of the floor beams including section losses must be completed. The rating factors determined from these analyses can then be increased by the values of K reported. Any existing cracking near copes or connections and remaining fatigue life have not been considered as part of this analysis, and should also be considered given the age of these structures.

Investigation of Floor Beam Performance in Three Steel Through-Truss Bridges

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University of Maine's Advanced Structures and Composites Center
Report Number: 15-6-979

August 14, 2014

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Test Setup & Instrumentation

Each bridge was instrumented with strain gages using a semi-wireless structural testing system. These gages were generally located on the bottom flange, mid-height and under the top flange of the steel members. On each bridge, two floor beams and one stringer were instrumented. Eighteen gages were used for both the Brownville and Chester bridges each and 24 gages were installed on the Indian Purchase bridge test. Gage locations at each cross section are shown in Figure 1, Figure 2, and Figure 3.

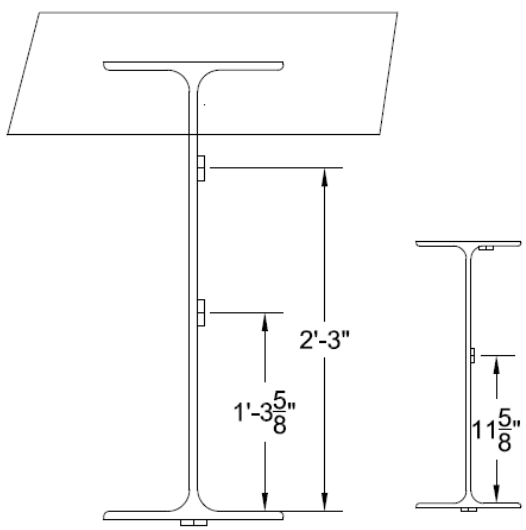

Figure 1 - Gage location on Brownville cross section of floor beams and stringers respectively

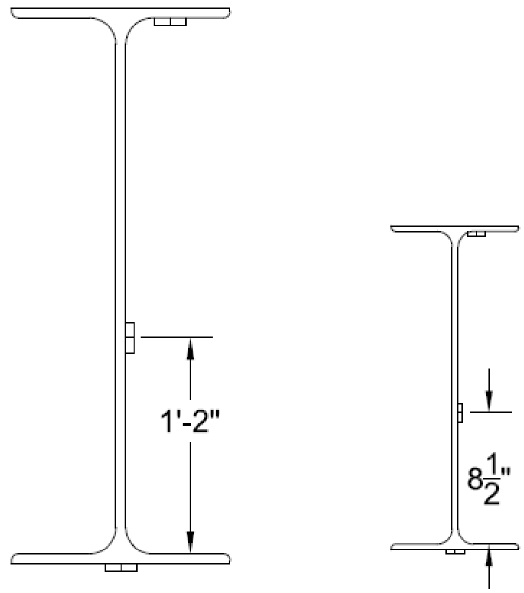

Figure 2 - Gage location on Chester cross section of floor beams and stringers respectively

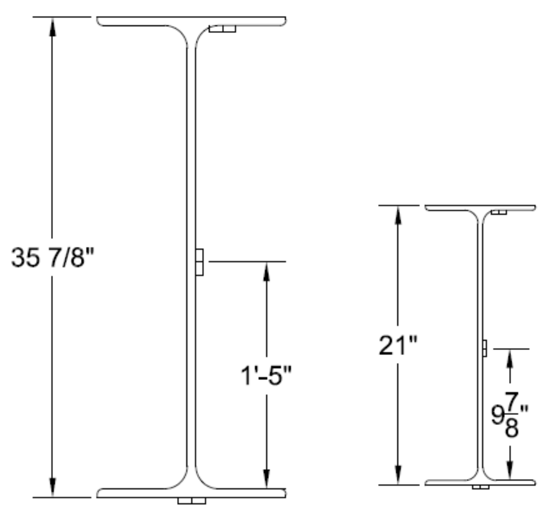

Figure 3 - Gage location on Indian Purchase cross section of floor beams and stringers respectively

Bridge number 3222 in Brownville had 6 cross sections with three gages each. Four cross-sections were on the floor beams and two on the centerline stringer spanning between the instrumented floor beams. The third and fourth floor beams from the south abutment were instrumented and can be seen in Figure 4. The bridges in Chester and Indian Purchase are instrumented similarly and are shown in Figure 5 and Figure 6 respectively.

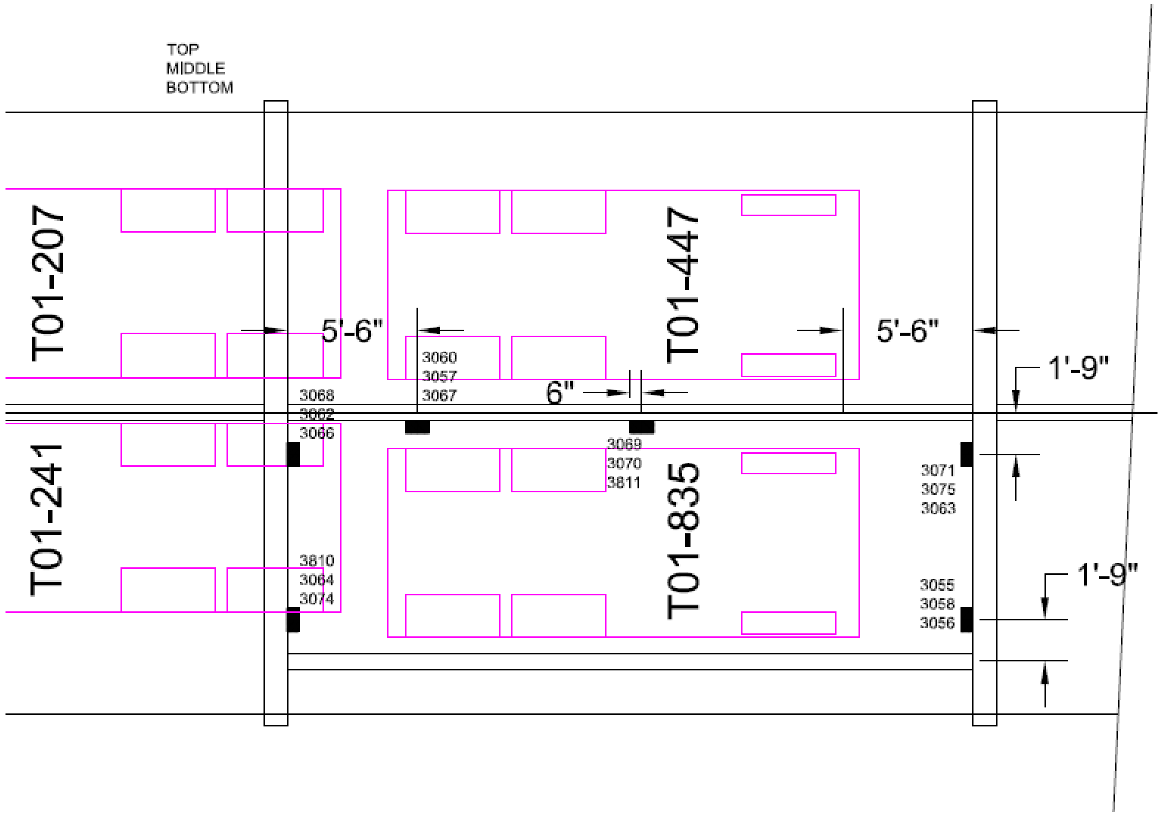

Figure 4 – Gage locations for Bridge No. 3222 in Brownville, ME

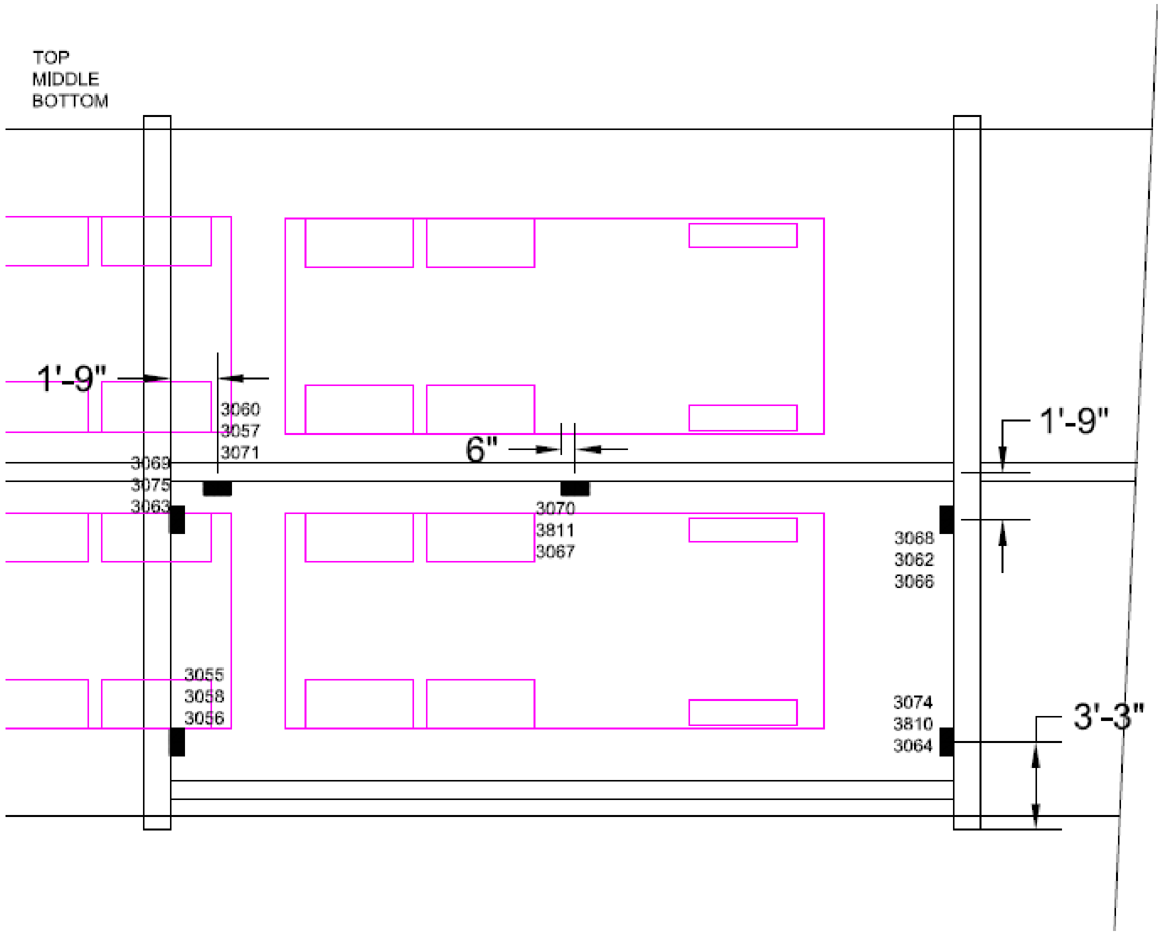

Figure 5 – Gage locations for Bridge No. 3790 in Chester, ME

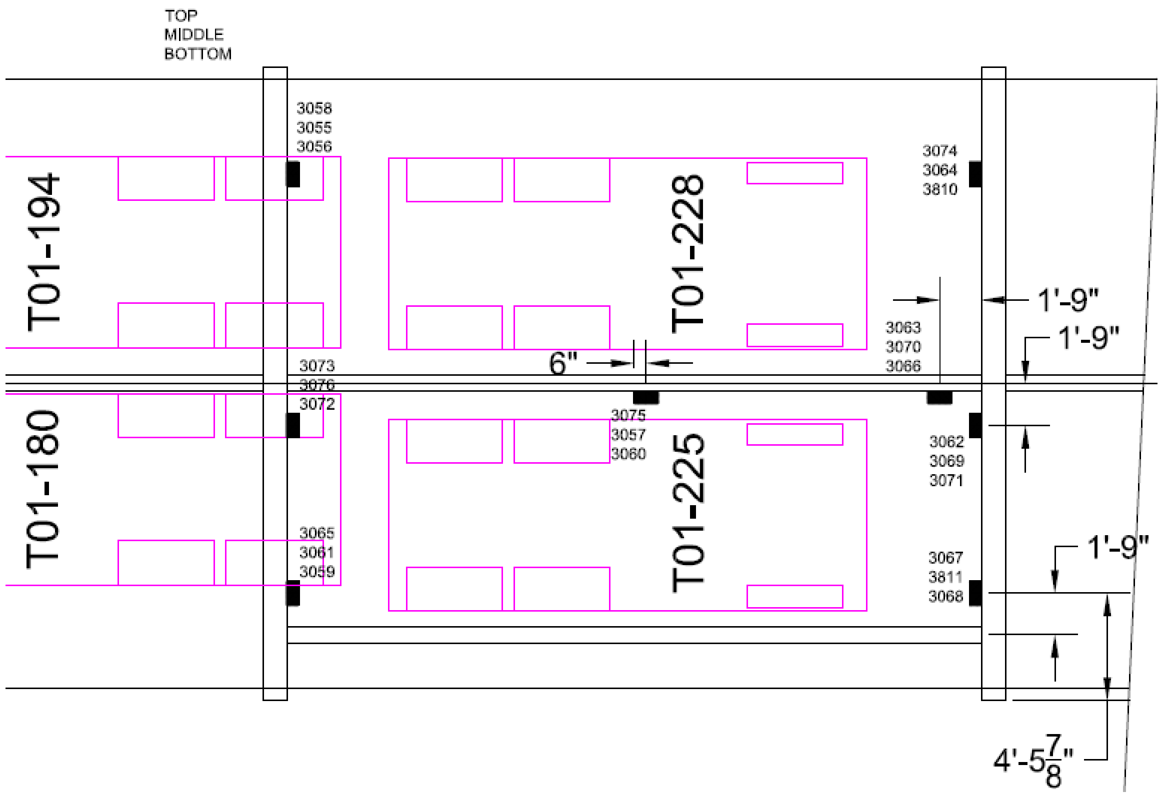

Figure 6 – Gage locations for Bridge No. 3666 in T-3 Indian Purchase, ME

Test Vehicles

Four loaded, dual rear axle dump trucks were used to load each bridge. The weight of each set of wheels and the spacing of the axles and wheels were recorded on site prior to loading the bridge. These measurements are given in Appendix A. The average weight of the trucks is shown in Table 1 and a typical truck can be seen in Figure 7.

Table 1 – Average truck weight during bridge testing

	Brownville (#3222)	Chester (#3790)	T3-Indian Purchase (#3366)
Average truck weight	54,840 lb.	64,050	60,825

Figure 7 – Typical test truck

TESTING

Three series of tests were conducted at each bridge, each with increasing loads to the bridge members. Initially, a single truck was driven across the bridge at low speed (see Figure 7). The second test had two trucks traveling side by side at low speed across the bridge. The final series consisted of two static tests with four trucks positioned to maximize load to the floor beams of interest. Truck position was captured during the rolling tests with the AutoClicker, which records tire revolutions from a starting point on the bridge.

The load cases for the Brownville bridge are shown in Figure 8, Figure 9 and Figure 10. Similarly, the load cases for Chester are shown in Figure 11, Figure 12 and Figure 13 and Indian Purchase in Figure 14, Figure 15, and Figure 16.

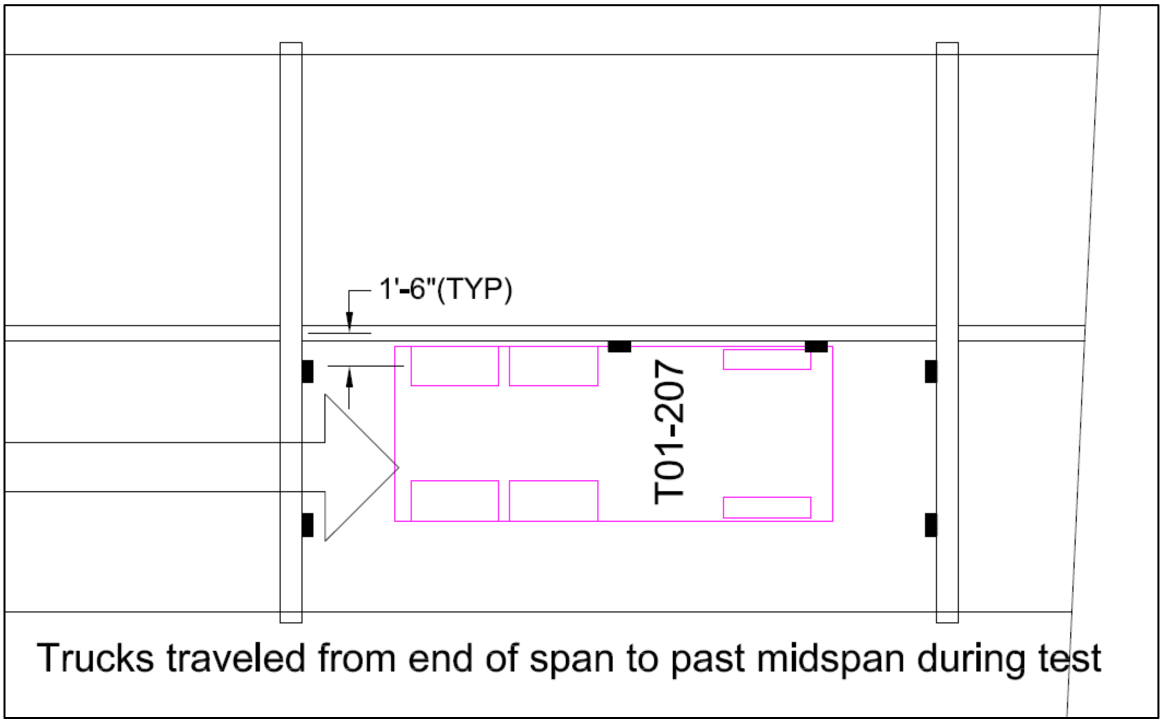

Figure 8 – One truck loading of Brownville

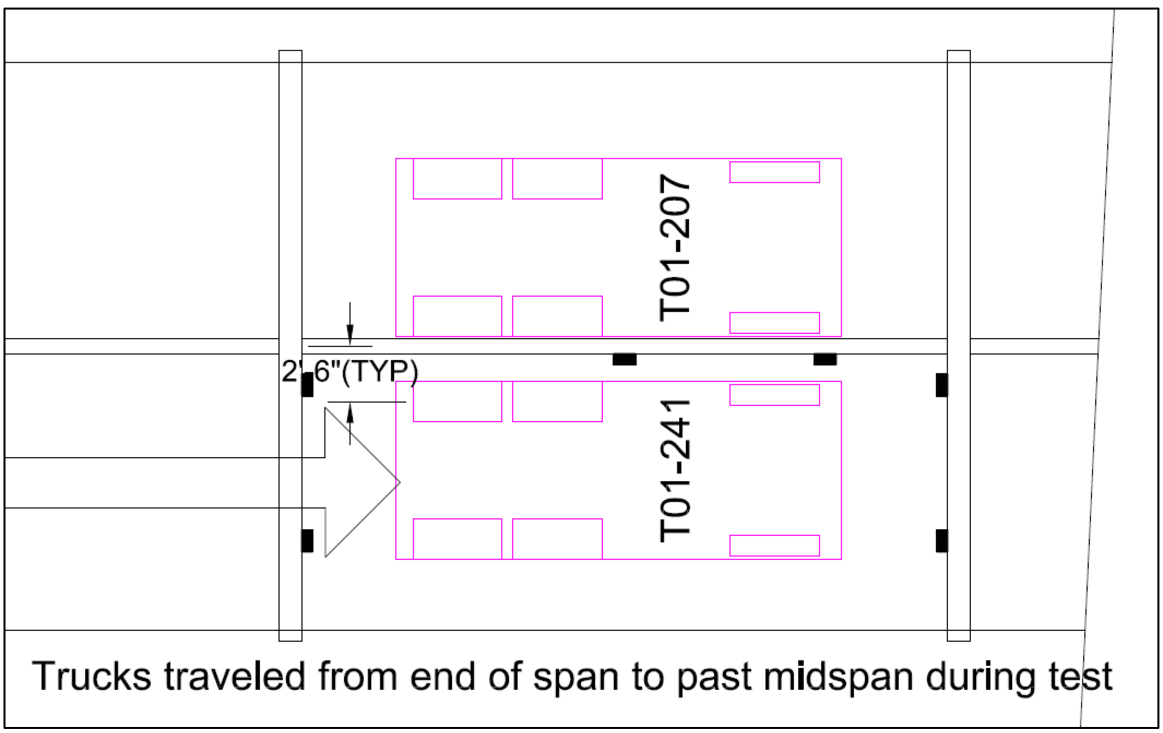

Figure 9 – Two truck loading of Brownville

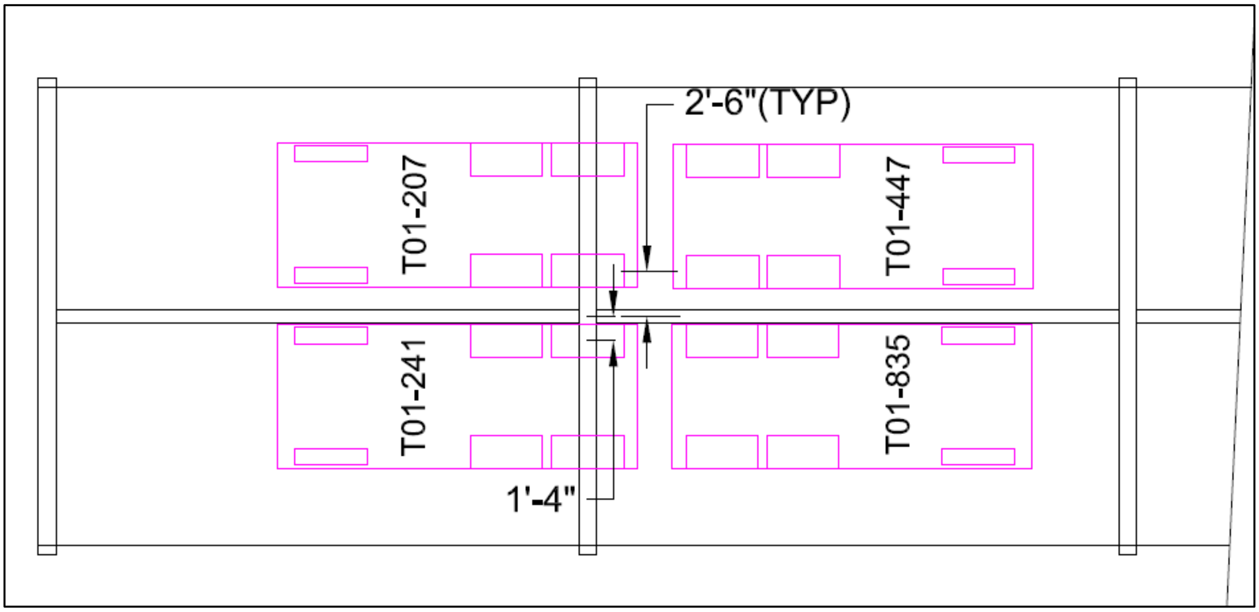

Figure 10 – Four truck loading of Brownville

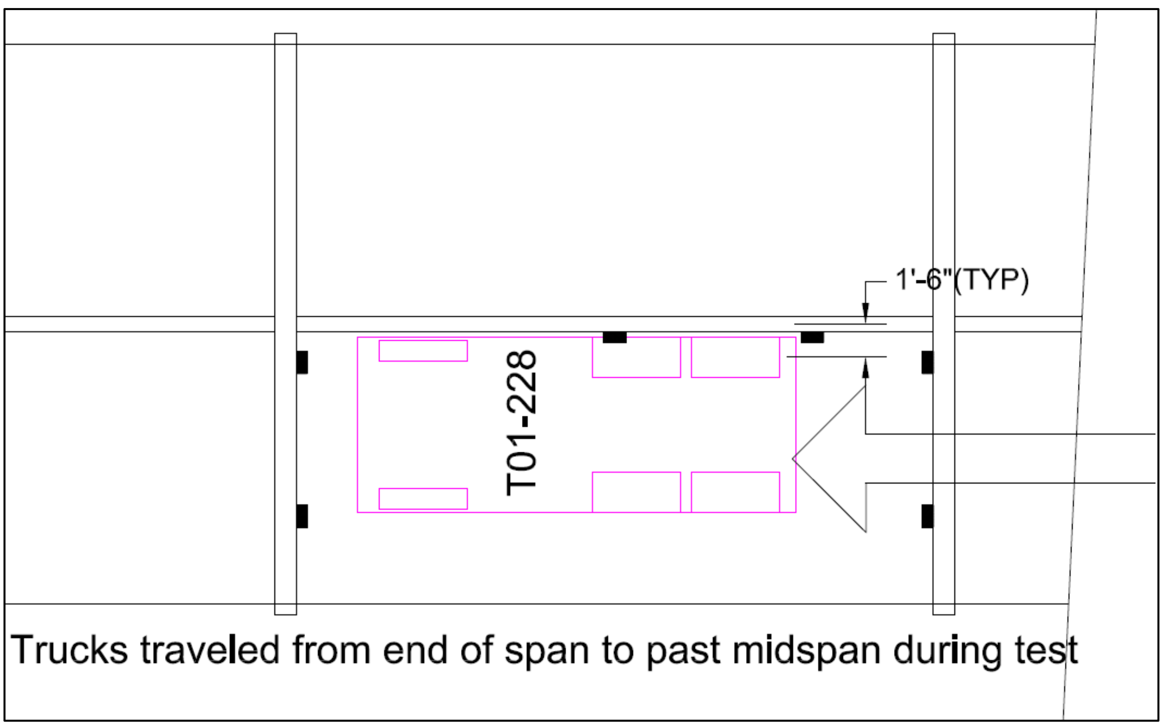

Figure 11- One truck loading of Chester

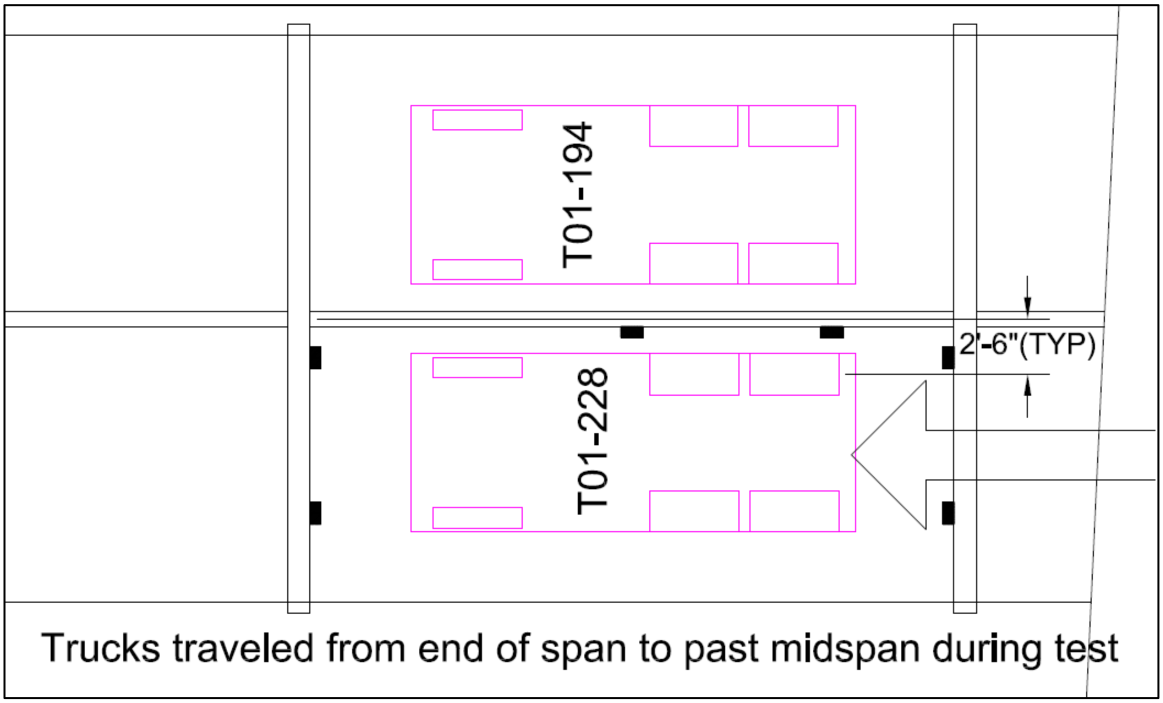

Figure 12 – Two truck loading of Chester

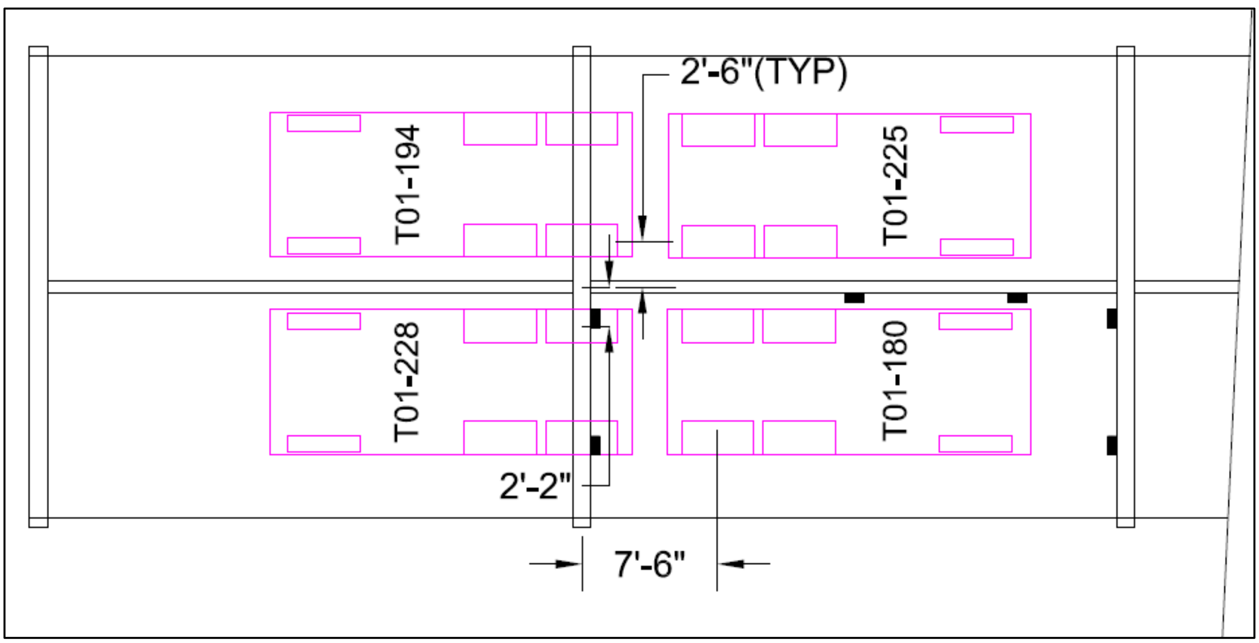

Figure 13 – Four truck loading of Chester

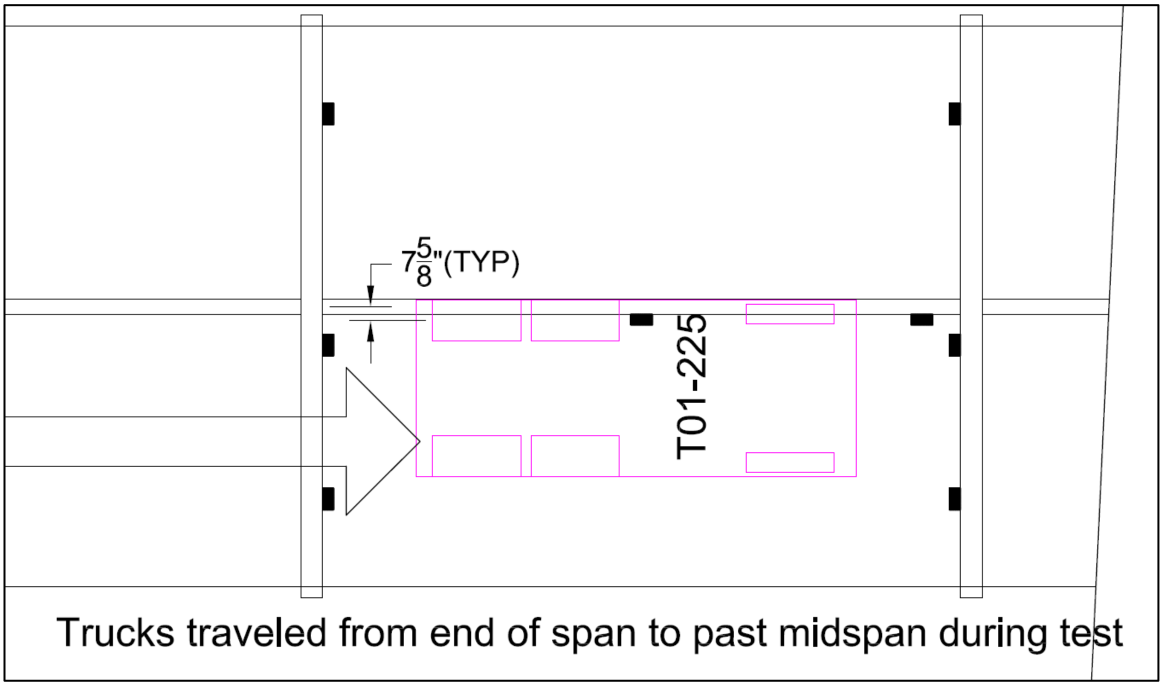

Figure 14 – One truck loading of Indian Purchase bridge

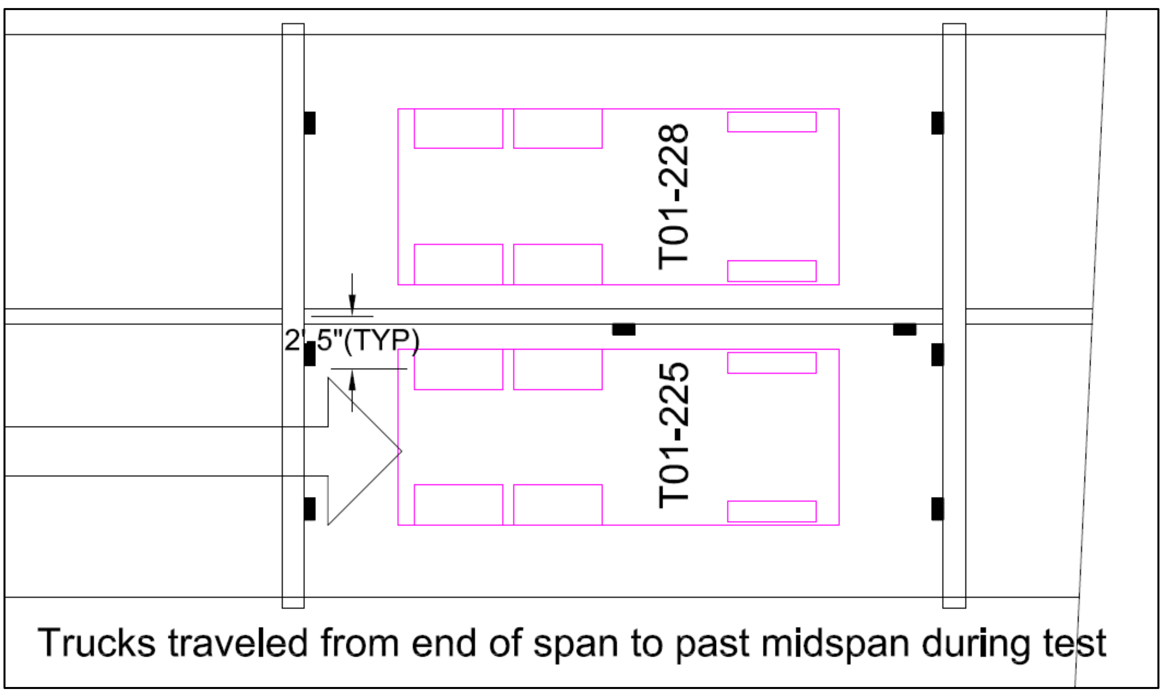

Figure 15 – Two truck loading at Indian Purchase bridge

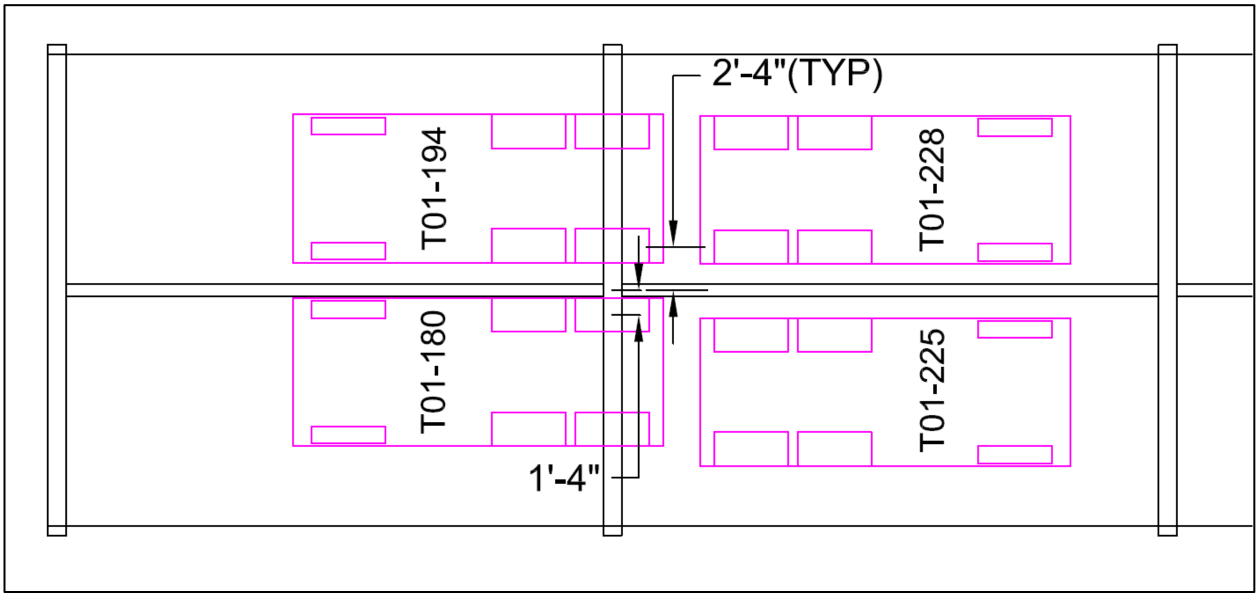

Figure 16 – Four truck loading at Indian Purchase bridge

RESULTS

Strain data were collected with three different loadings at each bridge. Representative strain plots for key locations and peak values for all gages are detailed as follows for each structure.

BROWNVILLE (NO. 3222)

Data for the rolling single truck load case for Brownville is shown in Figure 17 and Table 2. The peak strain values for the rolling two truck case is given in

Table 3 and the peak values for Brownville's static four truck loading is given in Table 4. A plot of critical strain gage data during the four truck loading is also shown Figure 18.

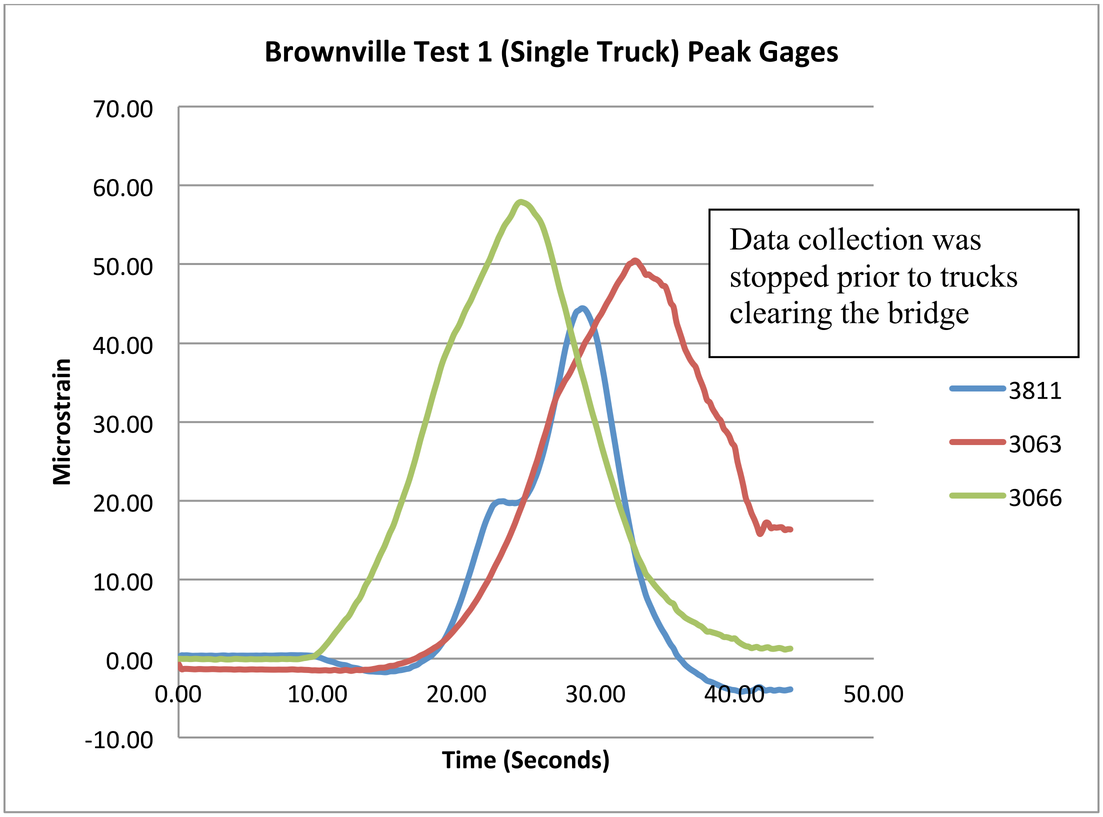

Figure 17 – Plot of strain during first test at Brownville (Bridge No. 3222)

Table 2 - Peak Values for Single Truck Loading of the Brownville Bridge (No. 3222)

Sensor	B3060	B3057	B3062	B3068	B3069	B3070	B3811	B3067	B3075
Max Strain (με)	4.68	20.32	30.78	13.12	4.49	20.31	44.42	37.59	31.33
Min Strain (με)	-1.49	-2.86	0.52	1.03	-4.58	-0.79	-4.20	-7.52	1.24
Sensor	B3055	B3058	B3056	B3063	B3066	B3074	B3064	B3810	B3071
Max Strain (με)	3.79	16.31	32.73	50.48	57.91	21.57	16.42	6.79	11.80
Min Strain (με)	0.14	-1.09	-1.21	-1.56	-0.13	0.91	-2.08	0.65	0.54

Table 3 - Peak Values for Two Truck Loading of the Brownville Bridge (No. 3222)

Sensor	B3060	B3057	B3062	B3068	B3069	B3070	B3811	B3067	B3075
Max Strain (με)	9.93	38.20	47.19	18.09	12.07	36.61	84.13	77.18	48.21
Min Strain (με)	-2.14	-5.43	-1.44	-0.94	-8.35	-5.15	-8.91	-10.40	-1.15
Sensor	B3055	B3058	B3056	B3063	B3066	B3074	B3064	B3810	B3071
Max Strain (με)	4.72	22.77	42.41	84.39	92.76	24.17	23.40	7.85	17.32
Min Strain (με)	-0.10	-0.40	-1.54	-1.50	-3.16	-1.72	-1.15	-0.10	-0.29

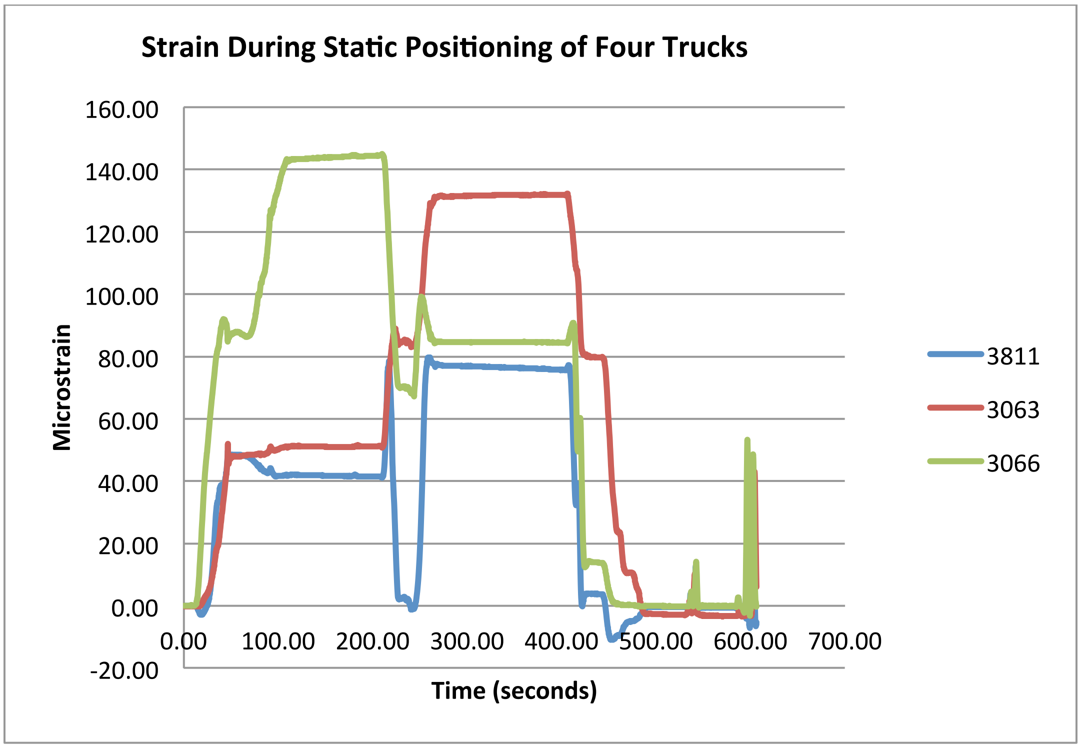

Figure 18 – Plot of peak strain during static positioning of four trucks across two floor beams for Brownville (No. 3222)

Table 4 - Peak Values for Four Truck Loading of the Brownville Bridge (No. 3222)

Sensor	B3060	B3057	B3062	B3068	B3069	B3070	B3811	B3067	B3075
Max Strain (με)	12.44	39.91	72.26	25.53	13.03	34.73	79.71	75.02	74.95
Min Strain (με)	-1.84	-3.92	-2.35	-2.05	-5.90	-4.52	-10.97	-9.53	-3.64
Sensor	**B3055**	**B3058**	**B3056**	**B3063**	**B3066**	**B3074**	**B3064**	**B3810**	**B3071**
Max Strain (με)	6.53	36.82	66.52	132.37	144.91	29.90	35.37	11.81	26.23
Min Strain (με)	-0.21	-0.48	-2.55	-3.45	-3.20	-4.94	-1.70	-0.01	-2.11

CHESTER (NO. 3790)

Data for the rolling single truck load case for Chester is shown in Table 5. The peak strain values for the rolling two truck case is given in Table 6 and the peak values for Chester's static four truck loading is given in Table 7.

Table 5 - Peak Values for Single Truck Loading of the Chester bridge (No. 3790)

Sensor	B3067	B3811	B3070	B3060	B3064	B3066	B3062	B3068	B3071
Max Strain (με)	145.37	13.36	12.65	31.09	67.77	136.52	3.95	1.68	40.63
Min Strain (με)	-18.64	-11.31	116.09	-36.84	-2.78	-3.53	-113.01	-111.86	-26.07
Sensor	**B3057**	**B3075**	**B3069**	**B3810**	**B3074**	**B3063**	**B3056**	**B3058**	**B3055**
Max Strain (με)	18.22	10.69	-0.67	5.00	2.10	136.99	73.07	4.55	13.34
Min Strain (με)	-41.94	-11.01	122.62	-2.49	-59.63	-3.53	-5.59	-4.70	-68.90

Table 6 – Peak Values for Two Truck Loading of the Chester bridge (No. 3790)

Sensor	B3067	B3811	B3070	B3060	B3064	B3066	B3062	B3068	B3071
Max Strain (με)	230.52	17.44	13.14	22.39	90.81	229.31	10.57	2.72	55.80
Min Strain (με)	-25.45	-18.27	-171.95	-15.09	-6.41	-5.18	-10.48	-165.74	-43.07
Sensor	**B3057**	**B3075**	**B3069**	**B3810**	**B3074**	**B3063**	**B3056**	**B3058**	**B3055**
Max Strain (με)	28.93	5.03	-0.02	2.85	0.40	219.17	99.91	6.14	20.13
Min Strain (με)	-41.23	-18.42	-195.18	-5.44	-85.95	-2.66	-5.86	-4.34	-90.80

Table 7 – Peak Values for Four Truck Loading at the Chester bridge (No. 3790)

Sensor	B3067	B3811	B3070	B3060	B3064	B3066	B3062	B3068	B3071
Max Strain (με)	225.63	24.29	15.72	43.21	165.02	410.24	5.33	1.25	77.32
Min Strain (με)	-20.80	-5.80	-137.77	-66.54	-4.22	-1.99	-25.58	-333.20	-53.66
Sensor	B3057	B3075	B3069	B3810	B3074	B3063	B3056	B3058	B3055
Max Strain (με)	38.59	0.62	0.57	8.58	0.00	375.49	176.99	0.42	14.10
Min Strain (με)	-43.01	-25.86	-317.32	-7.87	-162.46	-1.88	-6.88	-12.94	-156.08

Indian Purchase (No. 3666)

Data for the rolling single truck load case for Indian Purchase is shown in Figure 19 and Table 8. The peak strain values for the rolling two truck case is given in Table 9 and the peak values for Brownville's static four truck loading is given in Table 10. A plot of critical strain gage data during the four truck loading is also shown Figure 20.

Table 8 – Peak strain values during 1 truck loading of Indian Purchase bridge (No. 3666)

Sensor	B3068	B3811	B3067	B3062	B3056	B3055	B3058	B3072
Max Strain (με)	63.79	1.91	1.94	3.92	40.68	1.85	5.15	97.43
Min Strain (με)	-4.11	-6.56	-64.82	-100.15	-2.66	-0.72	-36.43	-2.15
Sensor	B3060	B3057	B3075	B3076	B3066	B3810	B3064	B3074
Max Strain (με)	78.56	42.70	7.51	0.22	54.07	35.17	0.78	0.67
Min Strain (με)	-9.77	-2.89	-10.74	-3.81	-11.80	-3.72	-2.96	-29.13
Sensor	B3073	B3059	B3061	B3065	B3071	B3069	B3070	B3063
Max Strain (με)	1.44	64.59	0.80	4.78	108.78	3.02	13.50	15.11
Min Strain (με)	-93.05	-3.15	-7.25	-61.76	-3.17	-2.53	-6.18	-35.28

Table 9 – Peak strain values during 2 truck loading of Indian Purchase bridge (No. 3666)

Sensor	B3068	B3811	B3067	B3062	B3056	B3055	B3058	B3072
Max Strain (με)	94.08	3.38	2.30	7.26	103.80	6.99	10.87	147.69
Min Strain (με)	-8.28	-10.82	-92.09	-147.56	-6.93	-6.59	-89.01	-5.19
Sensor	B3060	B3057	B3075	B3076	B3066	B3810	B3064	B3074
Max Strain (με)	121.91	52.55	11.73	-0.06	71.62	91.07	7.07	0.43
Min Strain (με)	-14.73	-6.11	-24.91	-5.80	-17.15	-8.68	-9.23	-72.91
Sensor	B3073	B3059	B3061	B3065	B3071	B3069	B3070	B3063
Max Strain (με)	1.94	89.27	0.81	9.37	163.14	6.81	31.84	20.08
Min Strain (με)	-138.78	-6.68	-9.82	-86.45	-7.35	-4.18	-8.95	-36.58

Table 10 – Peak strain values during 4 truck loading of Indian Purchase bridge (No. 3666)

Sensor	B3068	B3811	B3067	B3062	B3056	B3055	B3058	B3072
Max Strain (με)	168.24	0.57	7.14	17.53	195.84	8.01	4.24	300.32
Min Strain (με)	-3.33	-15.14	-164.21	-190.15	-6.90	-8.09	-171.33	-5.65
Sensor	B3060	B3057	B3075	B3076	B3066	B3810	B3064	B3074
Max Strain (με)	144.23	66.58	27.71	0.79	94.82	176.02	5.99	6.33
Min Strain (με)	-11.62	-5.23	-48.97	-13.68	-20.87	-2.64	-10.72	-126.12
Sensor	B3073	B3059	B3061	B3065	B3071	B3069	B3070	B3063
Max Strain (με)	1.18	166.06	3.89	1.70	330.49	9.49	62.88	33.45
Min Strain (με)	-270.39	-5.65	-12.24	-162.22	-2.88	-21.26	-4.77	-33.46

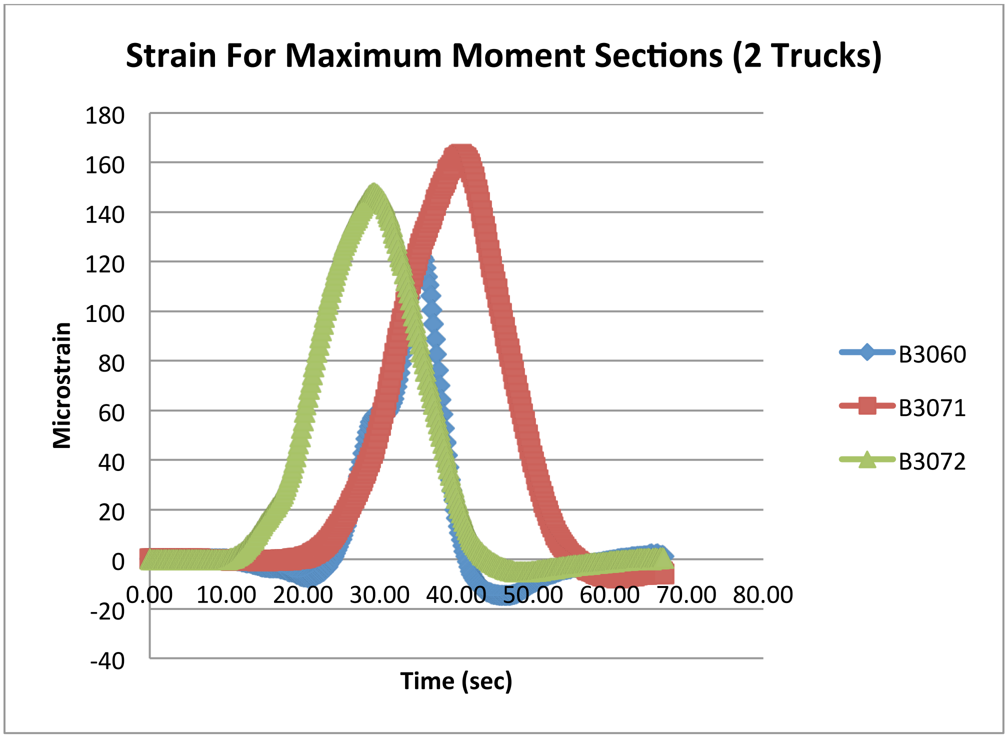

Figure 19 – Chart of strain during 2 truck load case for Indian Purchase (No. 3666)

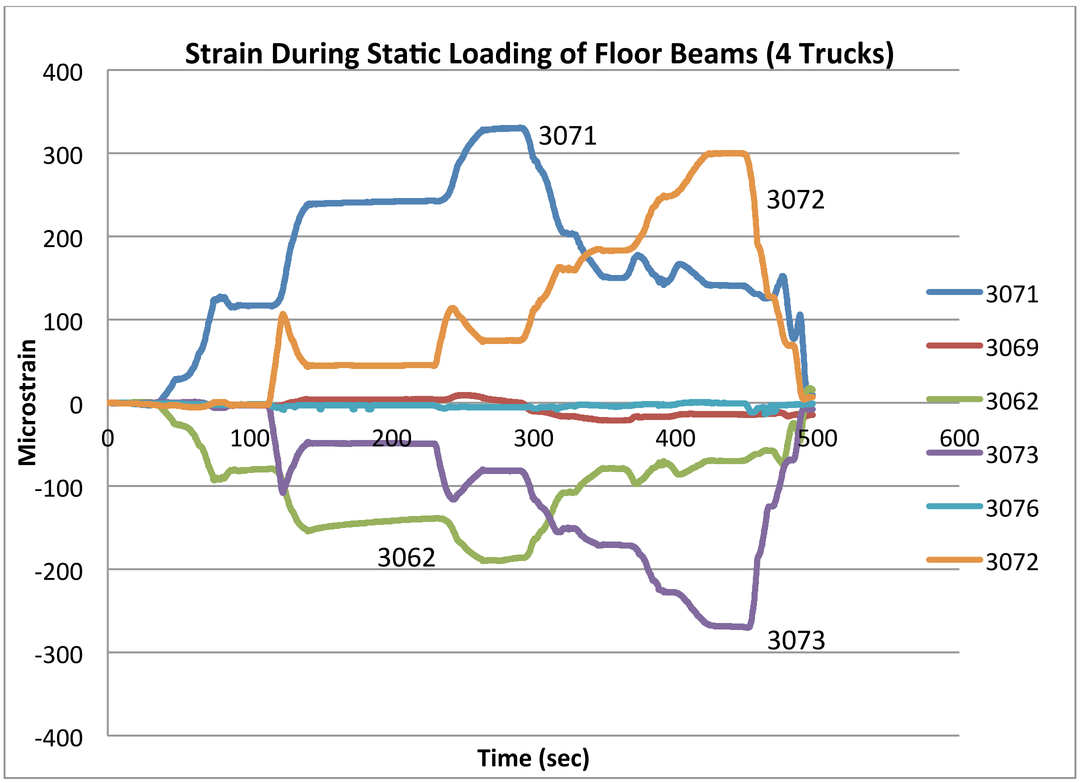

Figure 20 – Plot of strain versus time for Indian Purchase (No. 3666)

Analysis of Strain Data and Calculation of the Rating Factor Modifier

Calculations in Appendix B detail the analysis of the truss bridge floorbeams in Chester, Brownville and Indian Purchase under both the test loading and HL-93 tandem and lane loading, which would control the flexural rating of the floorbeams. Important assumptions of the analyses are detailed below:

1) The lever rule was used to distribute all loads. The deck was assumed simply supported and spanning one way between stringers, and the simply supported stringers carried live load to the floorbeams.
2) Floorbeam spans were calculated based on available drawings provided by the MaineDOT.
3) Nominal properties were assumed for all the floorbeams, and no section loss was accounted for.

The field-measured strains indicate full composite action for the Brownville truss during the test, and no significant composite action at either Indian Purchase or Chester. These responses are consistent with details in the design drawings and visual inspection of the structures, which show significant floorbeam top flange slab embedment at Brownville and very little or no floorbeam top flange embedment in the slab for Chester or Indian Purchase. The measured strains indicate no significant rotational fixity at the floorbeam end connections for all three structures. Response for all structures remained linearly elastic, and measured strains produced by the two truck and four truck loading were approximately proportional to the increase in applied moment. The peak moments produced at Chester due to the four-truck loading were approximately 90% of the calculated moment due to an HL-93 loading with impact; at Brownville and Indian Purchase 81% and 102% of the calculated moment due to HL-93 loading with impact was applied, respectively.

Based on the calculations in Appendix B, floorbeam rating factors calculated per a conventional AASHTO lever rule analysis can be increased by the following: $K = 1.30$ for Chester; $K = 1.30$ for Brownville; $K = 1.46$ for Indian Purchase. The calculations show that composite action cannot be relied upon at Brownville at higher loads, and this is reflected in the value of 1.30. These calculated values are likely influenced by less conservative live load distribution than predicted using the lever rule. The factor of safety against yielding was calculated for Chester under full service DL + HL-93 with impact to be approximately 1.56. This calculation was performed for Chester since it has the lightest floorbeams of all three structures, and the measured floorbeam strains were significantly larger than those measured at the other two bridges. While this value of 1.56 does not account for any section loss, it does indicate that these floorbeams may have substantial residual capacity beyond that required to carry current design loads.

Conclusions

The strain measurements were consistent, and the results appear reliable. Measured floorbeam strains were less than expected based on a lever rule analysis for live load distribution. If the MaineDOT agrees with our assessment, a conventional, lever rule load rating of the floorbeams for these three structures that accounts for the condition of the floorbeams including section losses must be completed. The rating factors determined from these analyses can then be increased by the values of K reported above. Any existing cracking near copes or connections and remaining fatigue life have not been considered as part of this analysis, and should also be considered given the age of these structures.

References

1. The Manual for Bridge Evaluation, 2nd Ed. with interim revisions. AASHTO. Washington D.C. 2011.
2. Brownville Junction Bridge Plans (#3222). November 1983. Provided by Maine DOT.
3. Penobscot River Bridge Plans (#3790). January 1948. Provided by Maine DOT.
4. West Branch Bridge Plans (#3666). November 1939. Provided by Maine DOT.

Appendix A: Truck Measurements – Brownville, Chester, T3 Indian Purchase

Insert 3 PDFs (12 pages total)

"Brownville_Truck_Wts.pdf"

"Chester_Truck_Wts.pdf"

"T3_Indian_Purchase_Truck_Wts.pdf"

AEWC
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www.aewc.umaine.edu

Page:	Project No.:

Project:	By:	Date:
Bridge Load Testing/Rating -Brownville	KMG	4/8/14

Subject:	Checked:	Date:
Test Vehicle Measurements		

License Plate Number TOI- 447
Truck Designation (~~1 or 2~~) 4

Weighed By: DOT
Dimensions by: CF

9450 9,100

Axle Weight 18,550

Axle Spacing
50"

10,300 8,500

Axle Weight 18,800

22"

Axle Spacing
177"

7,900 6,600

Axle Weight 14,500

9"

Wheel Spacing 91"

Total Vehicle Weight 51,850

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Page:	
Project No.:	
Project: Bridge Load Testing/Rating -Brownville	By: KMG Date: 4/8/14
Subject: Test Vehicle Measurements	Checked: Date:

License Plate Number 701-835
Truck Designation (1 or 2) 3

Weighed By: DoT
Dimensions by: CD

9,000 9,200
Axle Weight 18,200

Axle Spacing 53"

10,400 9,100
Axle Weight 19,500

21"

Axle Spacing 174"

8,300 7,000
Axle Weight 15,300

8½"

Wheel Spacing 95"

Total Vehicle Weight 53,000

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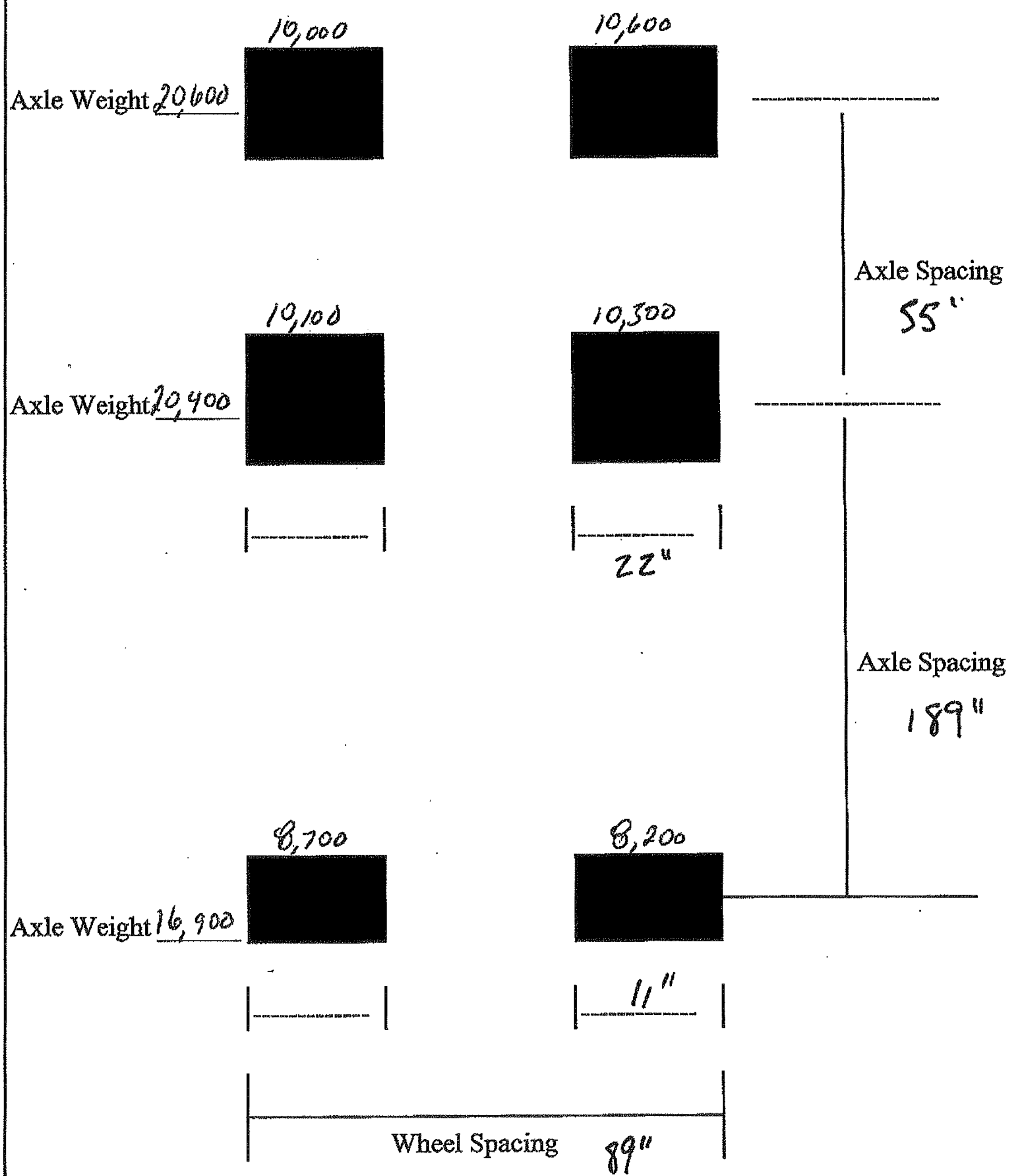
Page:	
Project No.:	
Project: Bridge Load Testing/Rating - Brownville	By: KMG Date: 4/8/14
Subject: Test Vehicle Measurements	Checked: Date:

License Plate Number TO 1-241
Truck Designation (1 or 2) 2
Weighed By: DOT
Dimensions by: CF



Total Vehicle Weight 57,900

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Page:

Project No.:

Project: Bridge Load Testing/Rating -Brownville

By: KMG Date: 4/8/14

Subject: Test Vehicle Measurements

Checked: Date:

License Plate Number T01-707

Truck Designation (1 or 2) 1

Weighed By: DOT

Dimensions by: CF

9,700 10,300

Axle Weight 20,000

Axle Spacing 53"

10,800 8,900

Axle Weight 19700

22"

Axle Spacing 191"

8,500 8,400

Axle Weight 16900

11½"

Wheel Spacing 91"

Total Vehicle Weight 56,600

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Page:	Project No.:
Project: Chester Bridge Test	By: KMG Date: 4/10/14
Subject: Test Vehicle Measurements	Checked: Date:

DWAYNE

License Plate Number 701-194 Weighed By: CSF

Truck Designation (1 or 2) 2 Dimensions by: KMG

95"

Axle Weight 9600 10300

53"

Axle Spacing

Axle Weight 10200 10400

22" 22"

#2

190"

Axle Spacing

Axle Weight 7500 7500

11 1/2 11 1/2

91

27300 Wheel Spacing 28200

Front

Total Vehicle Weight 55500

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Page:	
Project No.:	
Project: Chester Bridge	By: KMG Date: 4/10/14
Subject: Test Vehicle Measurements	Checked: Date:

MARTIN

License Plate Number T01-228 Weighed By: CJF
Truck Designation (1 or 2) 1 Dimensions by: KMG

7'-9"
=93"

Axle Weight 9100 11750

54"
Axle Spacing

#1

Axle Weight 10000 11100

22" 22"

16'-0"
Axle Spacing

52'-3"
for 5 revolutions

FRONT

Axle Weight 7400 8700

12" 12"

26500 90" 31550
Wheel Spacing

Total Vehicle Weight 58050

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Project: CHESTER BRIDGE TEST	Page:
Subject: Test Vehicle Measurements	Project No.:
	By: KMG Date:
	Checked: Date:

License Plate Number 701-225 Weighed By: CSF
Truck Designation (1 or 2) ______ Dimensions by: CSF

94"

Axle Weight 12400 14700

56
Axle Spacing

Axle Weight 12500 14700

22 22

190"
Axle Spacing

Axle Weight 7400 8400

10 1/2 10 1/2

32300 91 37800
Wheel Spacing

#3

Total Vehicle Weight 70100

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Project: CHESTER BRIDGE TEST	Page:
	Project No.:
	By: KMG Date:
Subject: Test Vehicle Measurements	Checked: Date:

License Plate Number T01-180
Weighed By: CSF
Truck Designation (1 or 2) ______
Dimensions by: CSF

94

Axle Weight 12700 15,300

55
Axle Spacing

Axle Weight ~~12600~~ 700 14950

22" 22

217
Axle Spacing

Axle Weight 8000 8900

8½ 8½

33400 90½ 39150
Wheel Spacing

Total Vehicle Weight 72550

#4

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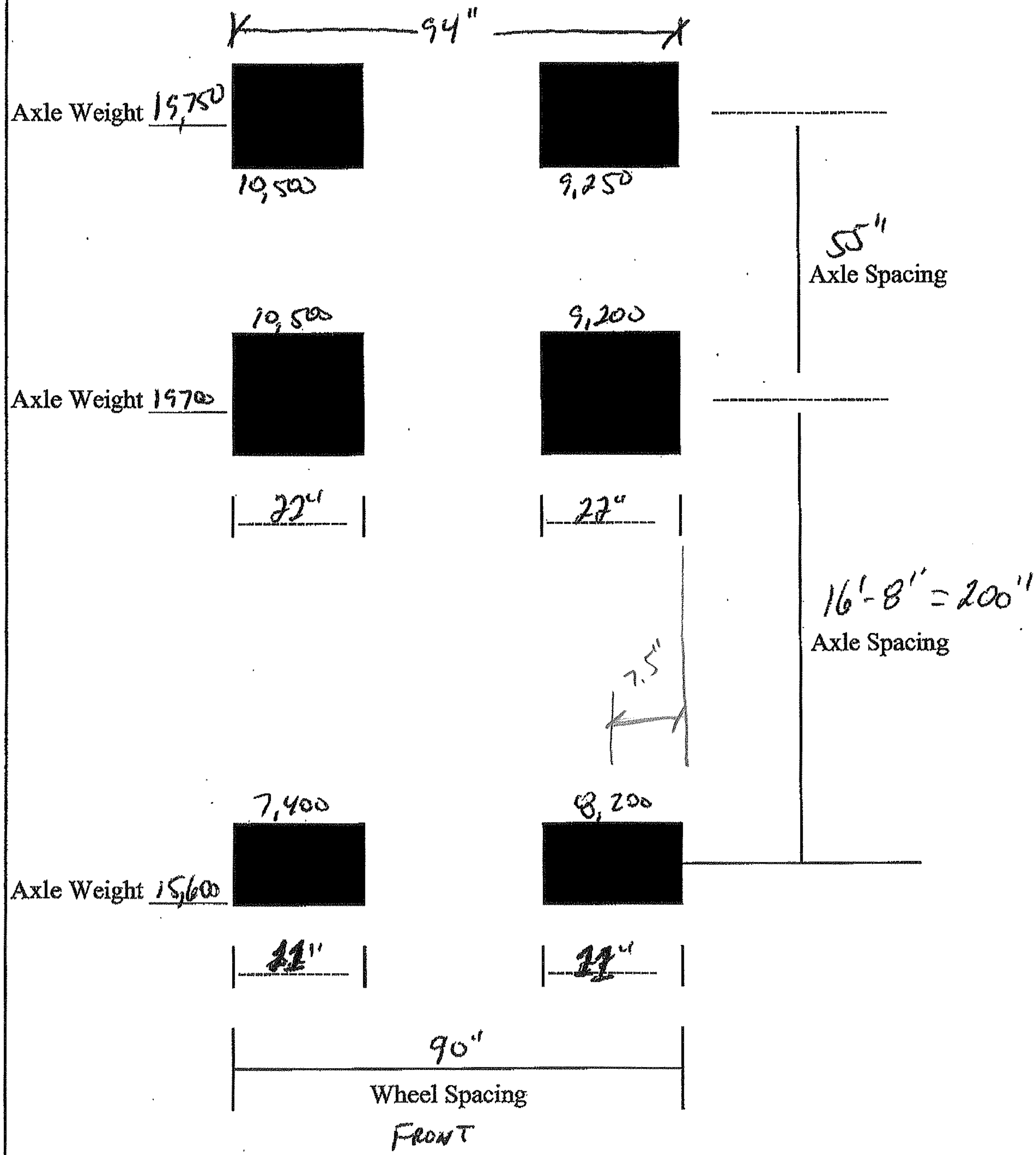
Page:	
Project No.:	979
Project: T3 - INDIAN PURCHASE LL TEST	By: KMG Date: 4/15/14
Subject: Test Vehicle Measurements	Checked: Date:

License Plate Number T01 - 228
Truck Designation (1 or 2) #2
Weighed By: KMG
Dimensions by: KMG



Total Vehicle Weight 55,050

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Page:

Project No.: 979

Project: Bridge Load Testing/Rating T3- Indian Purchase

By: KMG Date: 4/15/14

Subject: Test Vehicle Measurements

Checked: Date:

License Plate Number 701-180

Truck Designation (1 or 2) 4

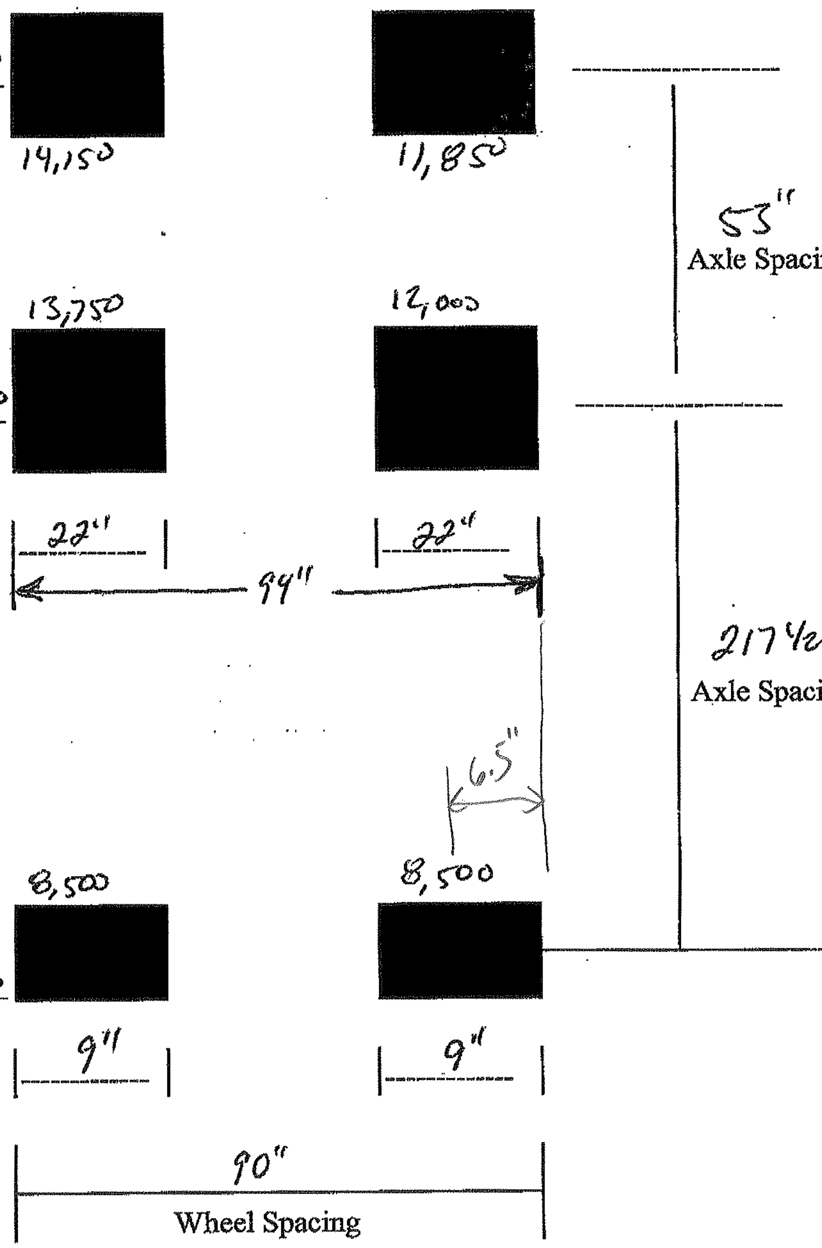
Weighed By: KMG

Dimensions by: KMG

Axle Weight 26,000

Axle Weight 25,750

Axle Weight 17,000



Total Vehicle Weight 68,750

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Page:	
Project No.:	
Project: Bridge Load Testing/Rating T3 INDIAN PURCHASE	By: KMG Date: 4/15/14
Subject: Test Vehicle Measurements	Checked: Date:

License Plate Number T01-194
Truck Designation (1 or 2) ____
Weighed By: KMG
Dimensions by: C8F

94

Axle Weight 22,600 — 22,600

12,200 10,400

Axle Spacing 55"

12650 10,850

Axle Weight 23,500

21" 21"

75"

Axle Spacing 191

8,000 7,250

Axle Weight 15,250

11" 11"

89 1/2 Say 90"

Wheel Spacing

#3

Total Vehicle Weight 61,350

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Page:

Project No.: 979

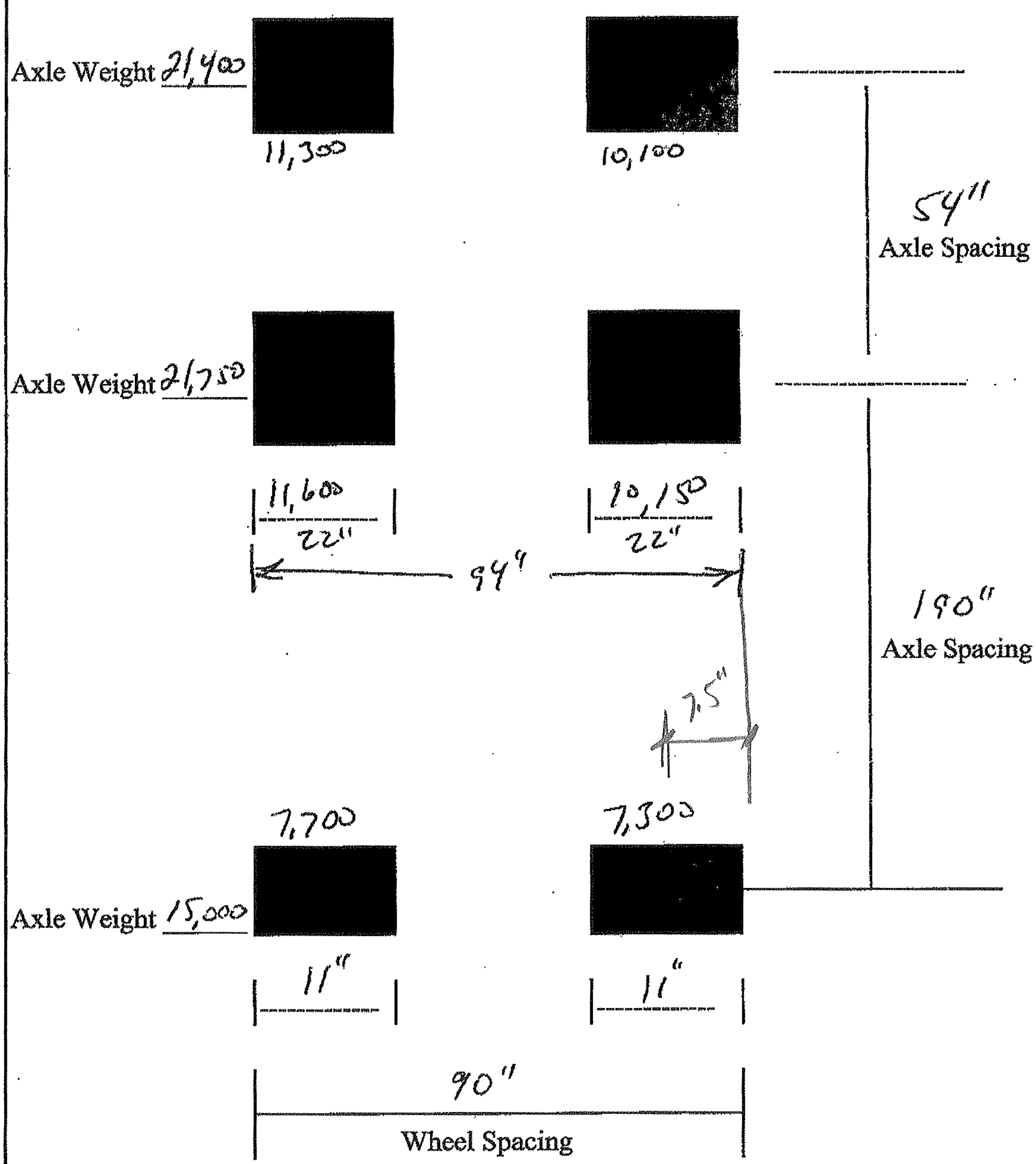
Project: Bridge Load Testing/Rating T3 - Indian Purchase

By: KMG Date: 4/15/14

Subject: Test Vehicle Measurements

Checked: Date:

License Plate Number T01-225
Weighed By: KMG
Truck Designation (1 or 2) #1
Dimensions by: KMG



Total Vehicle Weight 58,150

APPENDIX B: TEST CALCULATIONS

“Brownville_calcs_05_14_2014.pdf”

“Chester_FB_Analysis.pdf”

“T3_Indian_Purchase_FB_analysis_04_24_2014.pdf”

W. DAVIDS
4/28/14
1/

BROWNVILLE

BRIDGE PROPERTIES

- STRINGERS: W21×73.5 (interior) @ 5'-6" (5'-0" exterior), 23.21' span
- FB: W33×130, span = 28'-7" - 4 1/2" = 23'-2 1/2" = 23.21'
- DECK: 11" CONCRETE (4" ws)

MAX MEASURED FB STRAINS:

- 145 $\mu\epsilon$ max w/ 4 trucks
- 92.8 $\mu\epsilon$ max w/ 2 trucks
- Strains very linear, high degree of composite action observed.
- top flange cast at least over flange edges in slab.

FB MOMENTS DUE TO TRUCK LOADS:

- Computed using lever rule, field-measured wheel loads, previously verified spreadsheet

- 2 truck moment = 220.3 ft·k
- 4 truck moment = 368.2 ft·k

$\Big\}$ @ gage location.

- HL-93+IM (tandem + lane) =

(see pp. 3 & 4)

-

BROWNVILLE

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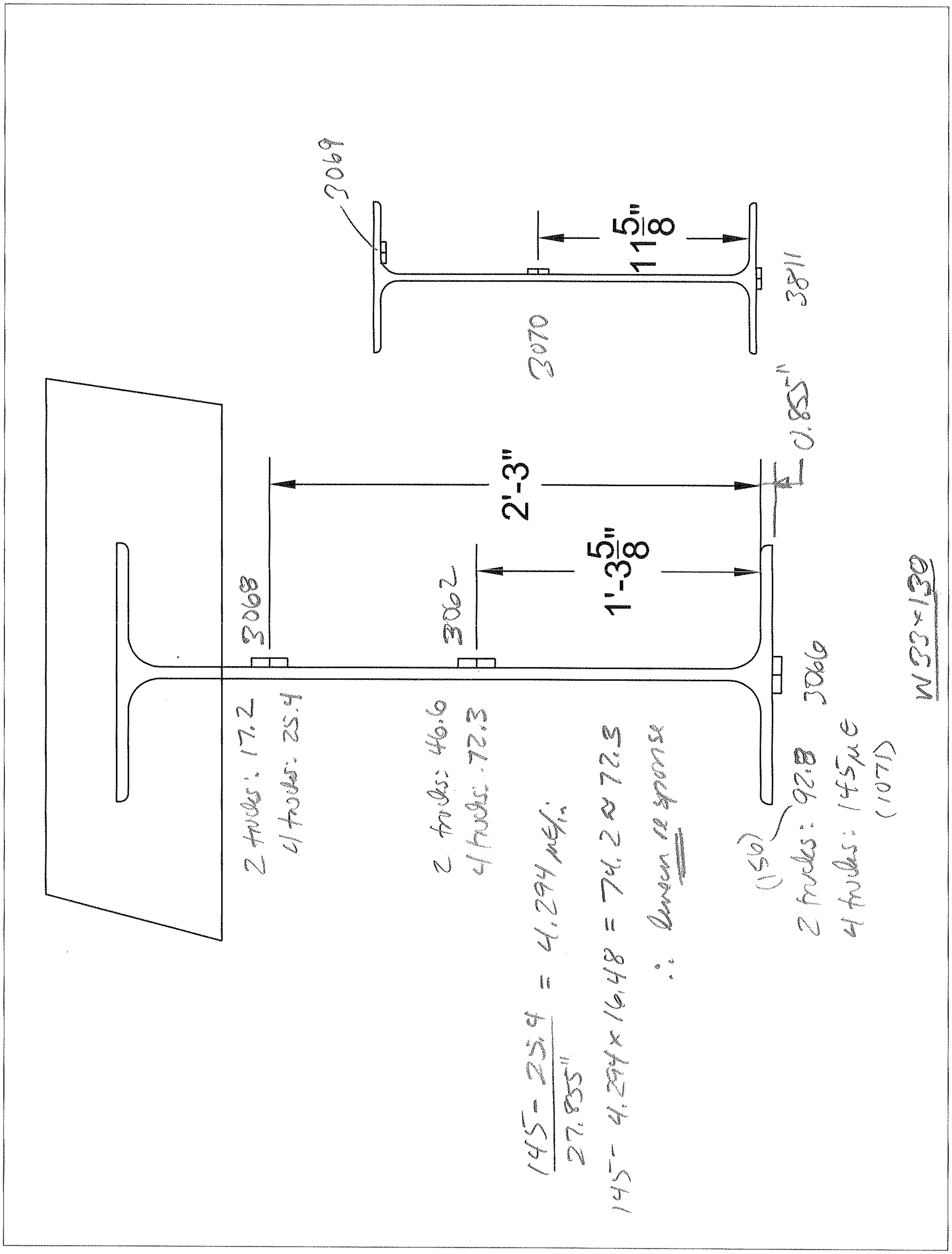
2/



BROWNVILLE

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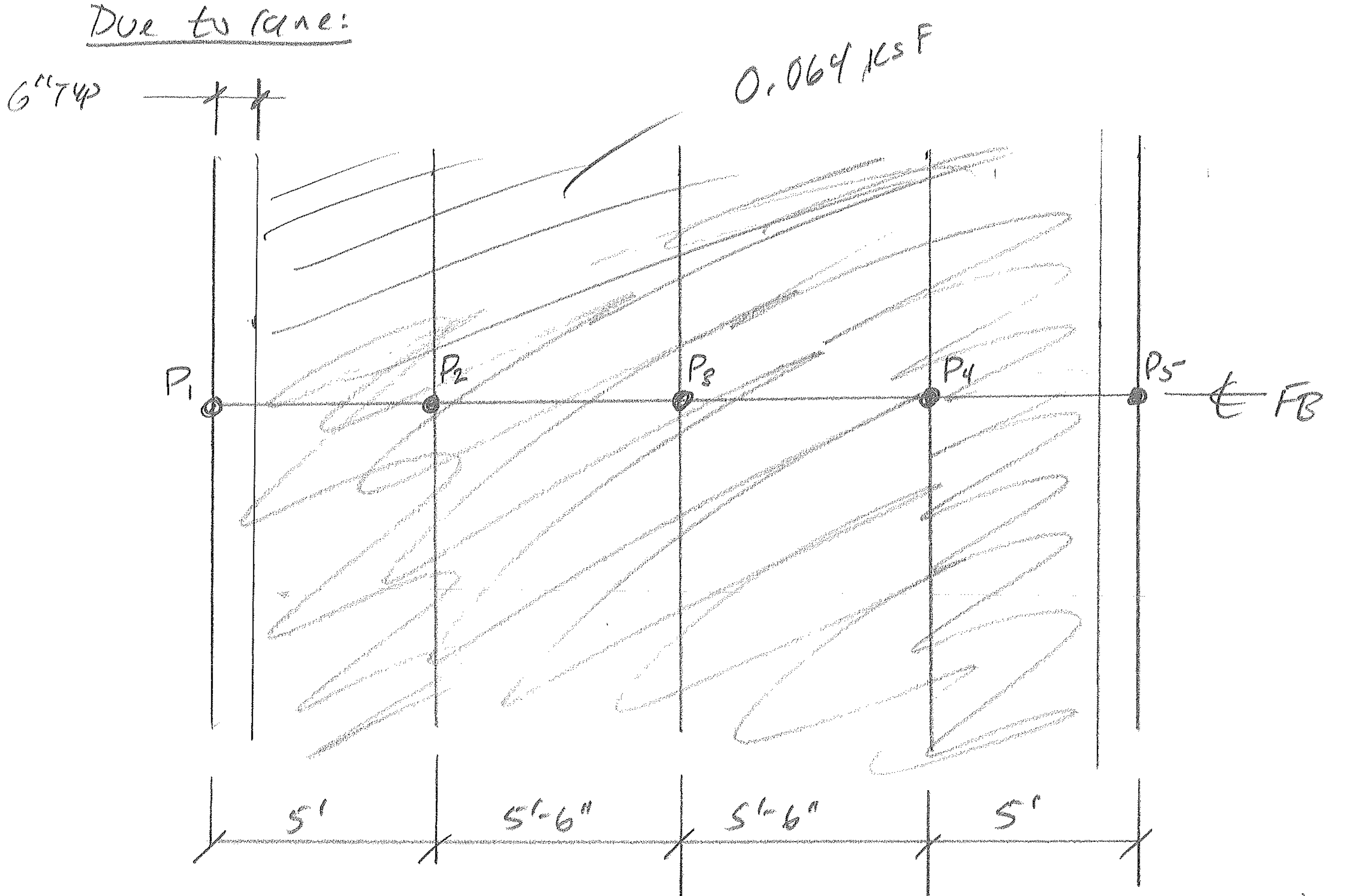
3/

HL-93 + IM LOAD

Tandem moments computed w/ spreadsheet = 301.8 k-ft (@ midspan)
(two lanes, no IM)

Due to lane:



$P_1 = P_5 = \left(0.064 \times 4.5' \times \frac{4.5}{2} \times \frac{1}{5}\right) \times 23.21' = 3.01^k$ $(\times 2 = 6.02)$

$P_2 = P_4 = 0.064 \times \left(4.5 \times \frac{2.75}{5} + \frac{5.5}{2}\right) \times 23.21 = 7.76^k$ $(\times 2 = 15.52)$

$P_3 = 0.064 \times 5.5' \times 23.21' = 8.17^k$ $(\times 1 = 8.17)$

$\Sigma\ 29.71^k$

$0.064 \times 23.21 \times 20' = 29.71^k$ ✓

$M_{lane} = 8.17 \times \frac{23.21}{4} \longrightarrow 47.4$

$+ \frac{15.52 \times 6.11 \times 17.11}{23.21} \times \frac{11.61}{17.11} \rightarrow 47.4$

$+ \frac{6.02 \times 1.11 \times 22.11}{23.21} \times \frac{11.61}{22.11} \rightarrow 3.34$

$98.2^{k\text{-ft}}$

BROWNVILLE

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HL 93 + IM LOADS

$M_{LL+IM} = 1.33 \times 301.8 + 98.2 = 500^{'k}$

Max 4-truck moment $= 403.3^{'k}$; $T/W = \frac{403.3}{500} = 0.81 > 0.7$ ✓ OK

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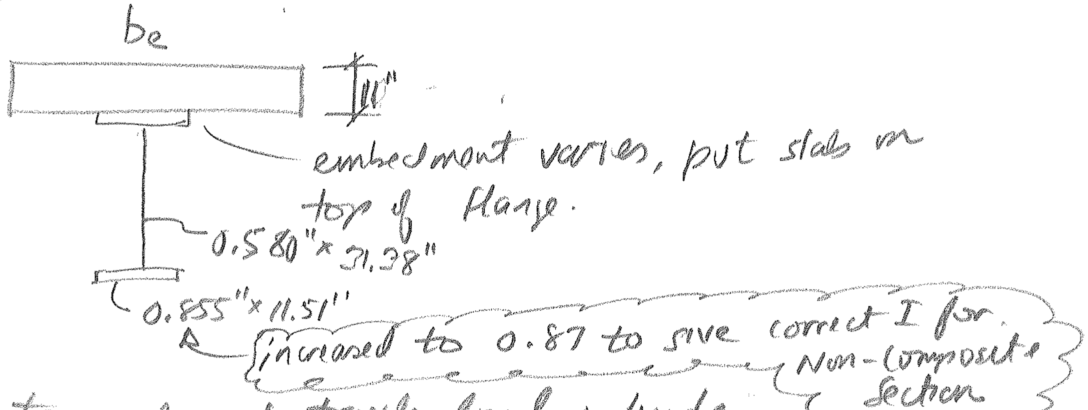
5/

BROWNVILLE

ASSESS STRAIN RESPONSE

- FB flange is embedded in 11" deck, girder is exhibiting composite action.

- Assume $f'_c = 3^{ksi}$, $n = 10$, eff flange width TBD.



- Strain measurements under 4-truck load indicate
  $\bar{y} = 27.855" + 25.4^{\mu\epsilon}/4.29\ \mu\epsilon/in = 33.8"$ = top of girder, just in slab

b_e	calculated $\bar{y}$
60"	30.5"
80"	31.9"
120"	33.7" ≈ 33.8" ← say b_e = 120"

- w/ b_e = 120"; $I = 22473\ in^4$, $S_{bot} = 6625\ in^3$; $Q_{deck} = 654\ in^3$
  (see next page)

- Computed strain: $\epsilon_c = \dfrac{368.2\ \text{ft-k} \times 12}{29000 \times 6625} \times 10^6 = 230\,\mu\epsilon$ vs $\epsilon_t = 145$ measured

  $\epsilon_c/\epsilon_T = 230/145 = 1.59$

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4/28/14
6/

Girder Section Properties -- W33x130

interior girder, slab = 8.76" at girder CL

haunch = 0

component	width	thickness	modular ratio	transf. area	y	Area*y	I_bar	A*y^2
Slab	120.00	11	10	132.00	38.62	5098.1	1331.0	3242.9
Top Bars	0	0	1	0.00	38.62	0.0	0.0	0.0
Top Flange	11.51	0.87	1	10.03	32.69	327.7	0.6	9.6
Web	31.38	0.58	1	18.20	16.56	301.4	1493.5	5324.8
Bot. Flange	11.51	0.87	1	10.03	0.44	4.4	0.6	11070.2
				170		5731.6	2825.8	19647.4

Note: flange thicknesses increased slightly to give correct I for non-composite section

y_bar =	33.7	in from bottom		
Moment of Inertia =	22473	in^4		
Q_deck =	654		654	654 in^3 -- three calculcations, all the same
S_bottom	667.5			

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4/28/14
7/

BROWNVILLE

ASSESS STRAIN RESPONSE:

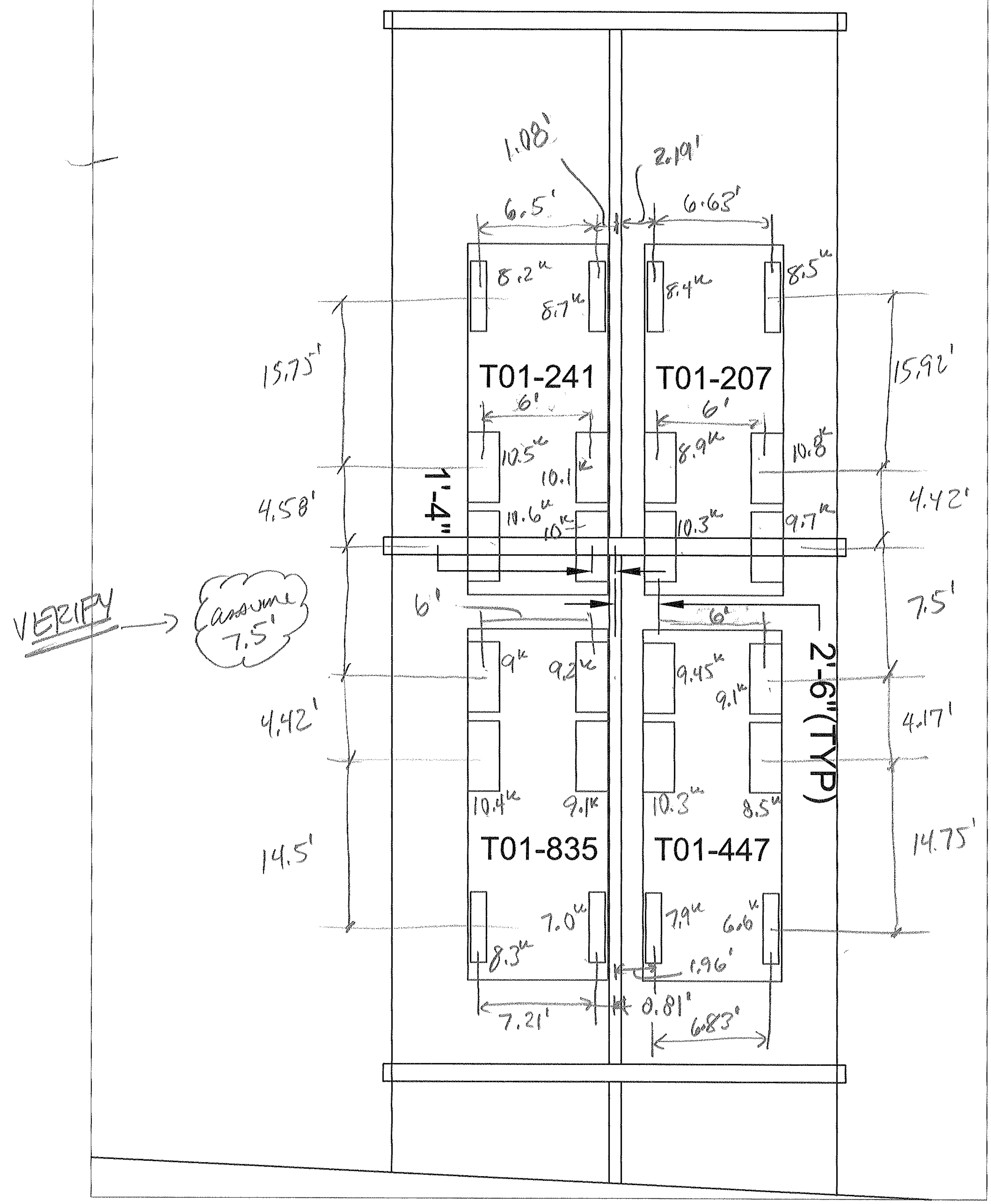
Can we extrapolate composite action to 1.33W?

- per NCHRP Research Results Digest 234, 100 psi bond stress can be reliably developed @ interface
- Max FB shear from test = 63.0^k
- $\frac{VQ}{Ib} \simeq \frac{63 \times 654 in^3}{22473 \times 11.51''} \times 1000^{\#/k} = 159 psi > 100 psi$

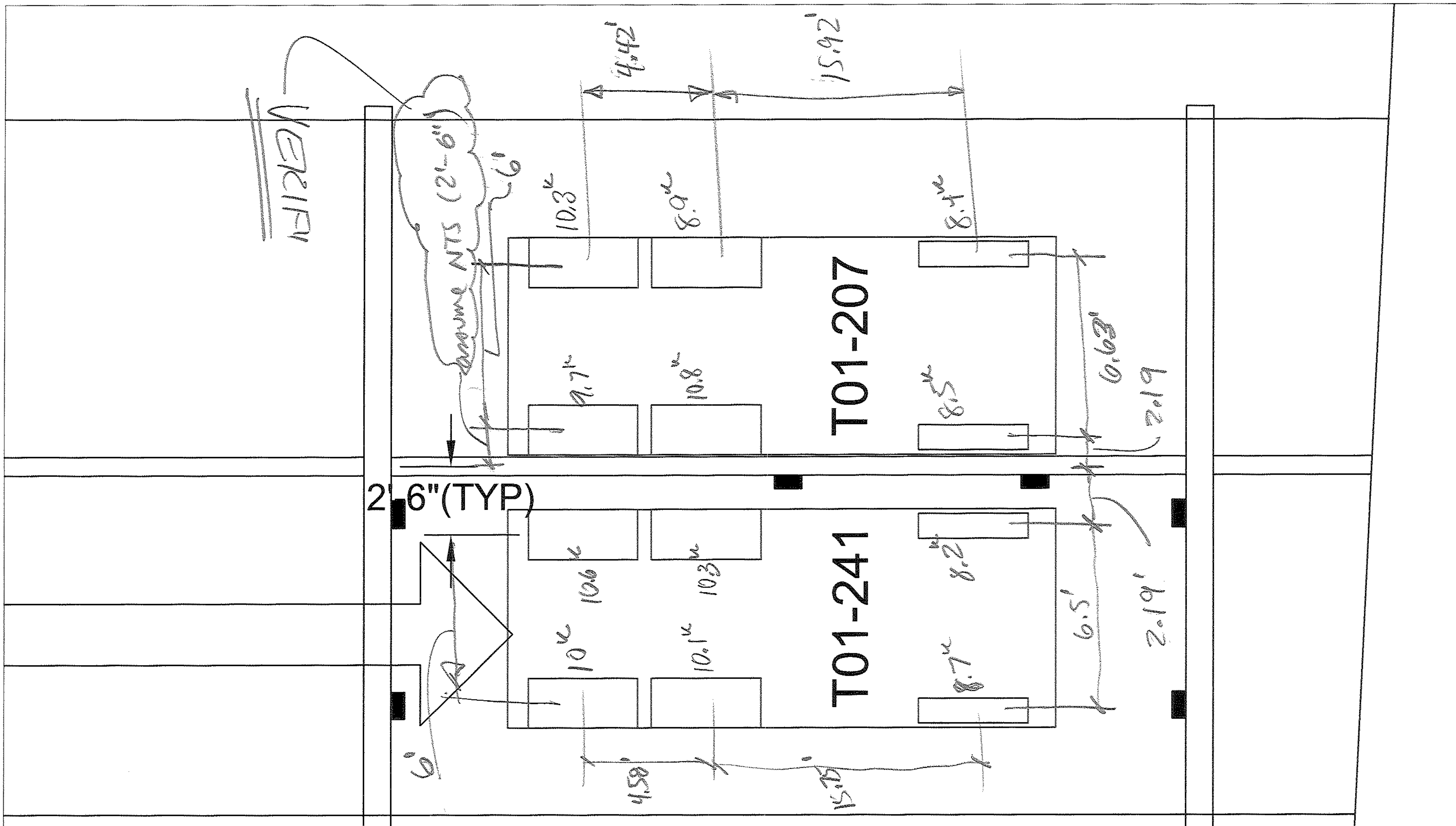
  ∴ composite action is NOT reliable

- However, the ratio $\epsilon_C / \epsilon_T = 1.59$ is correctly (and conservatively) based on the presence of composite action.
- T/W ≥ 0.7; results cannot be directly extrapolated to 1.33W, since composite action was observed but is not likely to be reliable
- Girder flange is clearly fully braced against LTB, and capacity calculations can be based on the section developing Mp.
- A safe estimate of the RF modifier is

$$K = 1 + 0.5 \times (1.59 - 1) = \underline{1.30}$$



T01-241
T01-207
T01-835
T01-447
1.08'
2.19'
6.5'
6.63'
8.2k
8.7k
8.4k
8.5k
15.75'
15.92'
6'
6'
10.5k
10.1k
8.9k
10.8k
4.58'
4.42'
1'-4"
10.6k
10k
10.3k
9.7k
7.5'
6'
6'
2'-6"(TYP)
VERIFY
assume 7.5'
9k
9.2k
9.45k
9.1k
4.42'
4.17'
10.4k
9.1k
10.3k
8.5k
14.5'
14.75'
7.0k
8.3k
7.9k
6.6k
1.96'
7.21'
0.81'
6.83'



Trucks traveled from end of span to past midspan during test

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Page:	
Project No.:	

Project: Bridge Load Testing/Rating -Brownville	By: KMG Date: 4/8/14
Subject: Test Vehicle Measurements	Checked: Date:

License Plate Number TOL-447
Truck Designation (~~1 or 2~~) 4

Weighed By: DOT
Dimensions by: CF

9450 9,100

Axle Weight 18,550

Axle Spacing 50"

10,300 8,500

Axle Weight 18,800

22"

Axle Spacing 177"

7,900 6,600

Axle Weight 14,500

9"

Wheel Spacing 91"

Total Vehicle Weight 51,850

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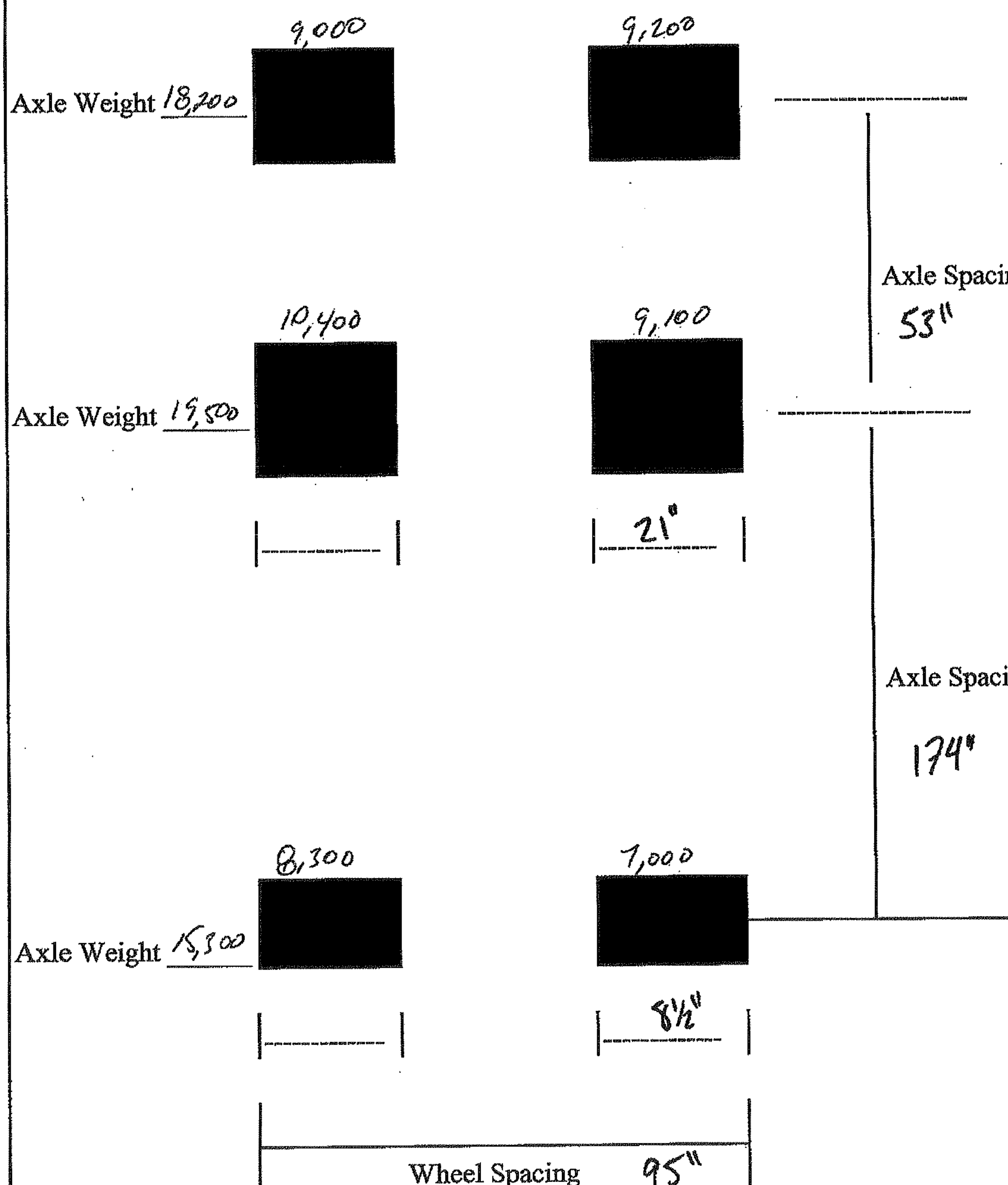
Page:	
Project No.:	
Project: Bridge Load Testing/Rating -Brownville	By: KMG Date: 4/8/14
Subject: Test Vehicle Measurements	Checked: Date:

License Plate Number 701-835
Truck Designation (~~1 or 2~~) 3

Weighed By: DOT
Dimensions by: CD



Total Vehicle Weight 53,000

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Page:	
Project No.:	
Project: Bridge Load Testing/Rating - Brownville	By: KMG Date: 4/8/14
Subject: Test Vehicle Measurements	Checked: Date:

License Plate Number TO 1-241
Truck Designation (1 or 2) 2

Weighed By: DOT
Dimensions by: CF

10,000 10,600

Axle Weight 20,600

Axle Spacing
55"

10,100 10,300

Axle Weight 20,400

22"

Axle Spacing
189"

8,700 8,200

Axle Weight 16,900

11"

Wheel Spacing 89"

Total Vehicle Weight 57,900

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Project: Bridge Load Testing/Rating -Brownville	By: KMG	Date: 4/8/14
Subject: Test Vehicle Measurements	Checked:	Date:

Page:
Project No.:

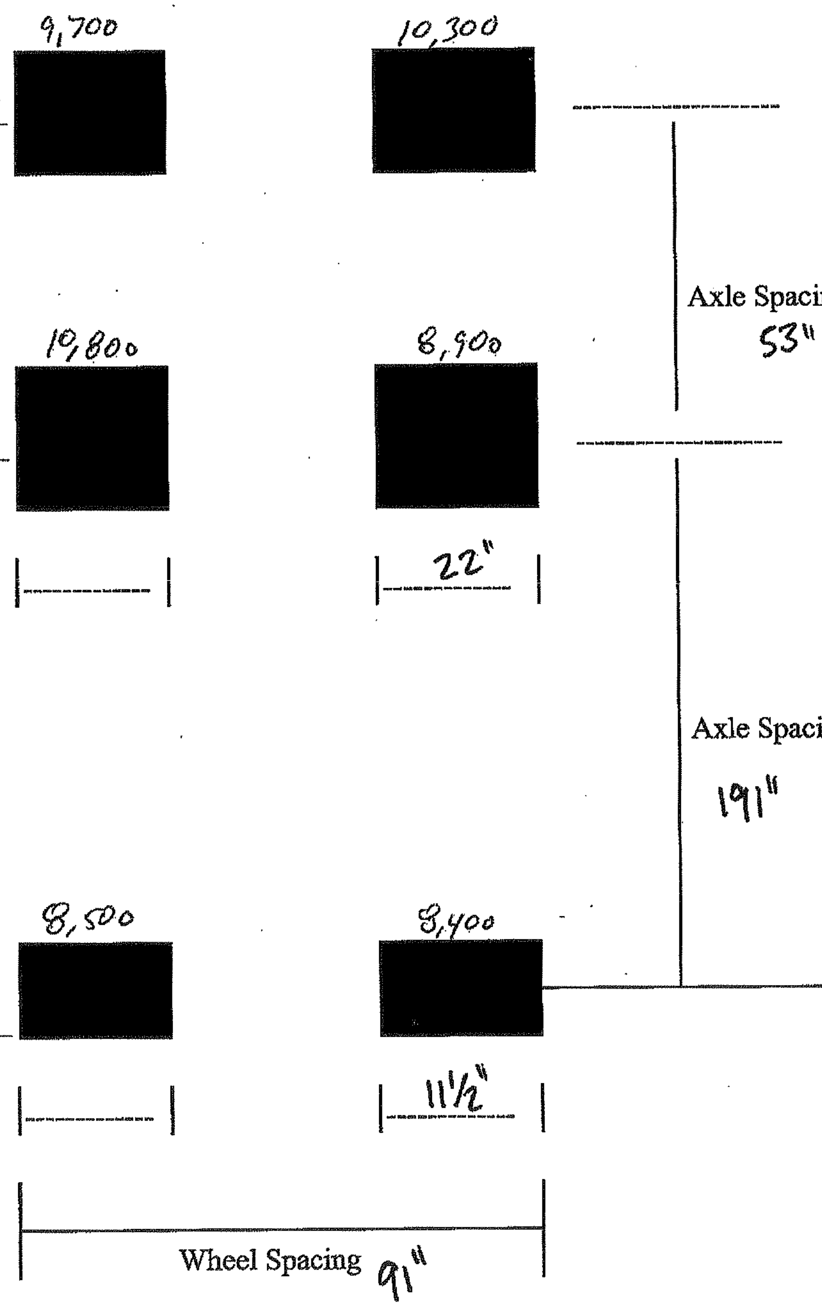
License Plate Number T01-707
Truck Designation (1 or 2) 1

Weighed By: DOT
Dimensions by: CF

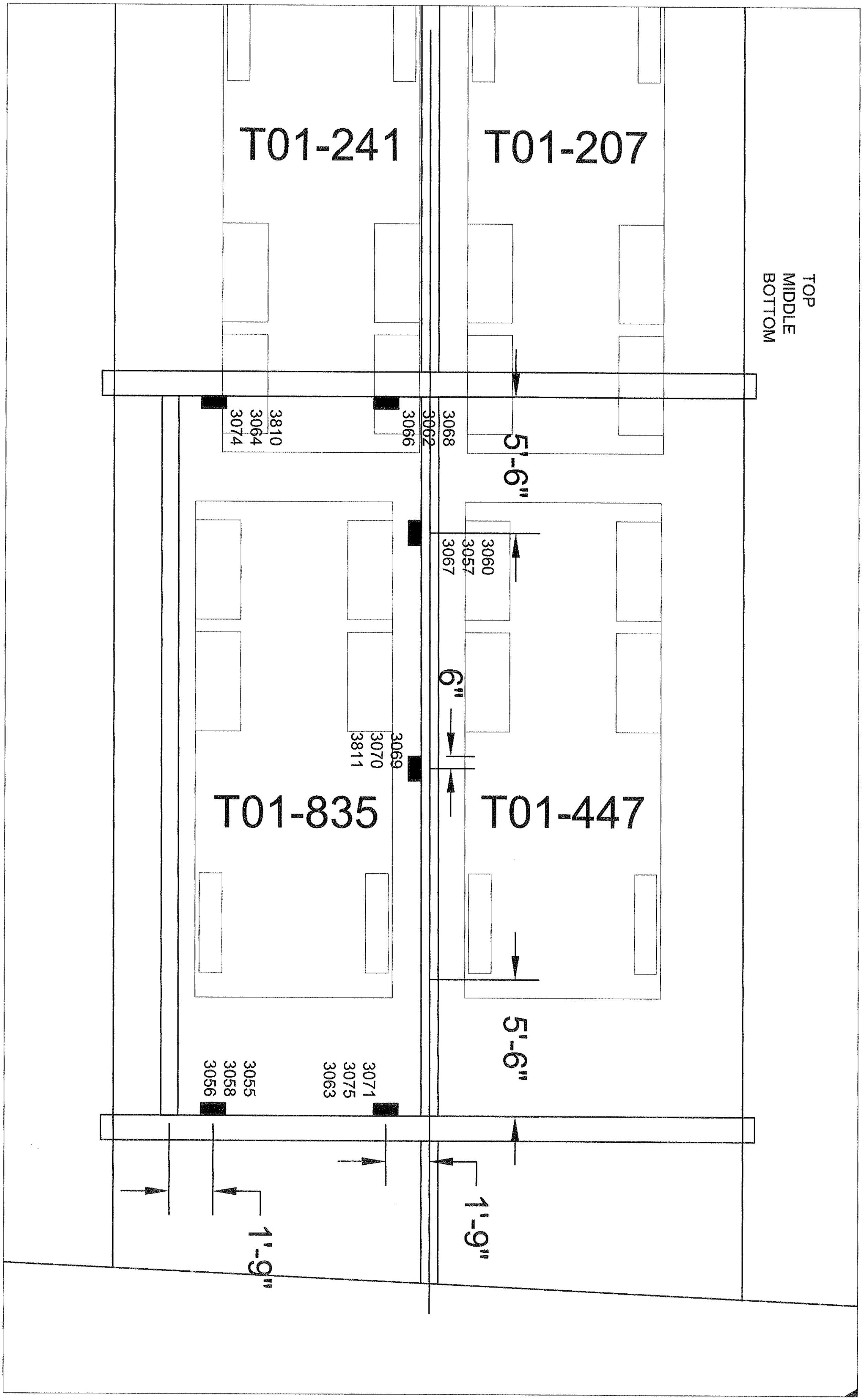
Axle Weight 20,000

Axle Weight 19700

Axle Weight 16900



Total Vehicle Weight 56,600



T01-241
T01-207
TOP
MIDDLE
BOTTOM
3810
3064
3074
3066
3062
3068
5'-6"
3060
3057
3067
6"
3069
3070
3811
T01-835
T01-447
5'-6"
3055
3058
3056
3071
3075
3063
1'-9"
1'-9"

W. DAVIDS
4/28/14

CHESTER

BRIDGE PROPERTIES:

STRINGERS - W18×55 (interior) @ 5'-0", 2' to FBs and

FBs - W30×124, span ≈ 24', spaced @ 25'-0"

DECK - 5 3/4" CONCRETE + 2" ASPHALT WS.

MAX MEASURED FB STRAINS

- 410.3 $\mu\epsilon$ max w/ 4 trucks
- 229.3 $\mu\epsilon$ max w/ 2 trucks

see p. 2

Strains @ mid-depth ≈ 0, large compression @ top, girders are non-composite. Consistent with construction details. moments near ends do not indicate fixity.

FB MOMENTS DUE TO TRUCK LOADS:

- Computed using lever rule, field-measured wheel loads, previously verified spread sheet.
- 2 truck moment: 289.6 ft·k @ gage location, 258.0 @ midspan
- 4 truck moment: 457.2 ft·k @ gage location, 487.3 @ mid-span
- HL-93+IM: 540'k @ mid-span (see p. 3)

CHESTER

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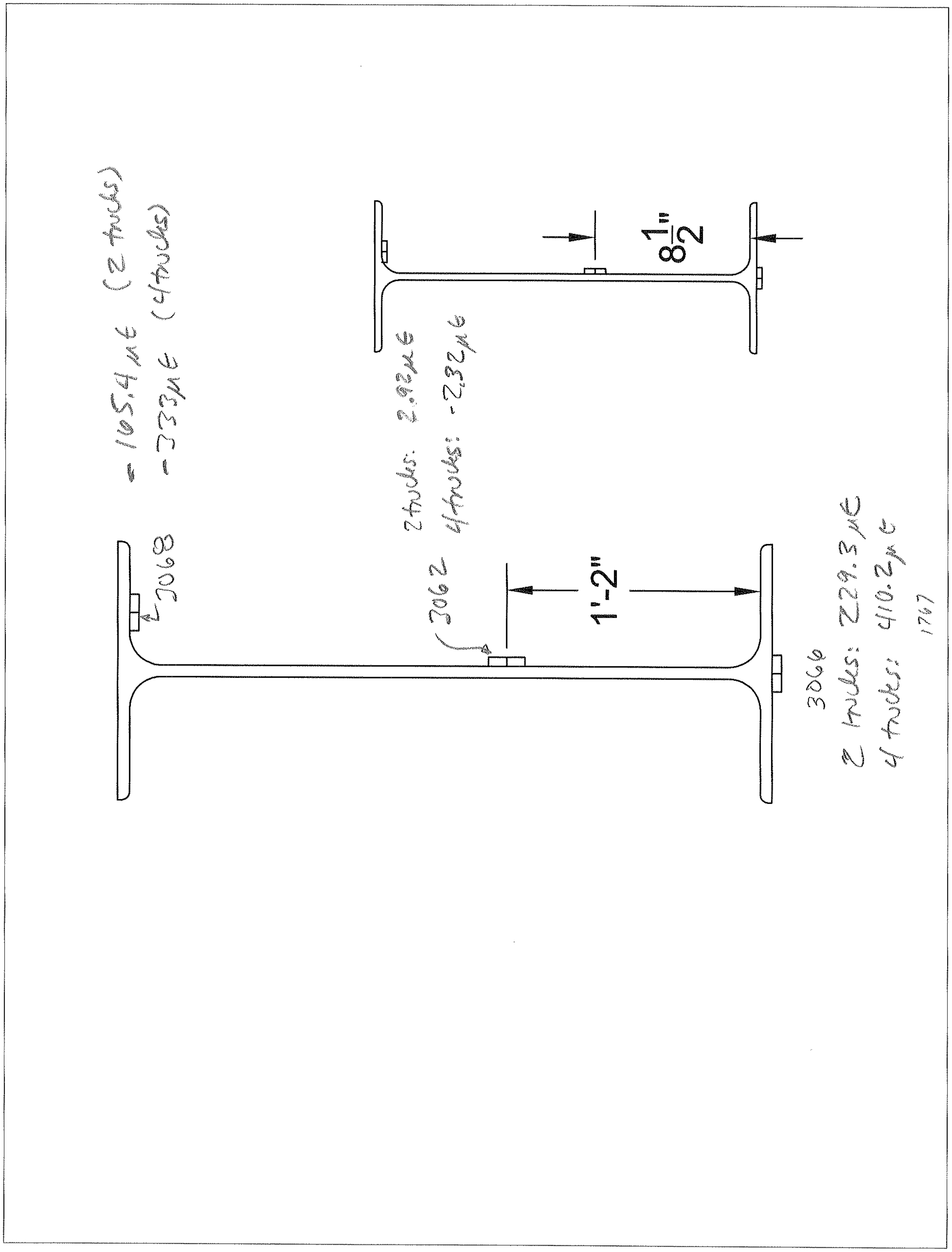
4/20/2014
2/



CHESTER

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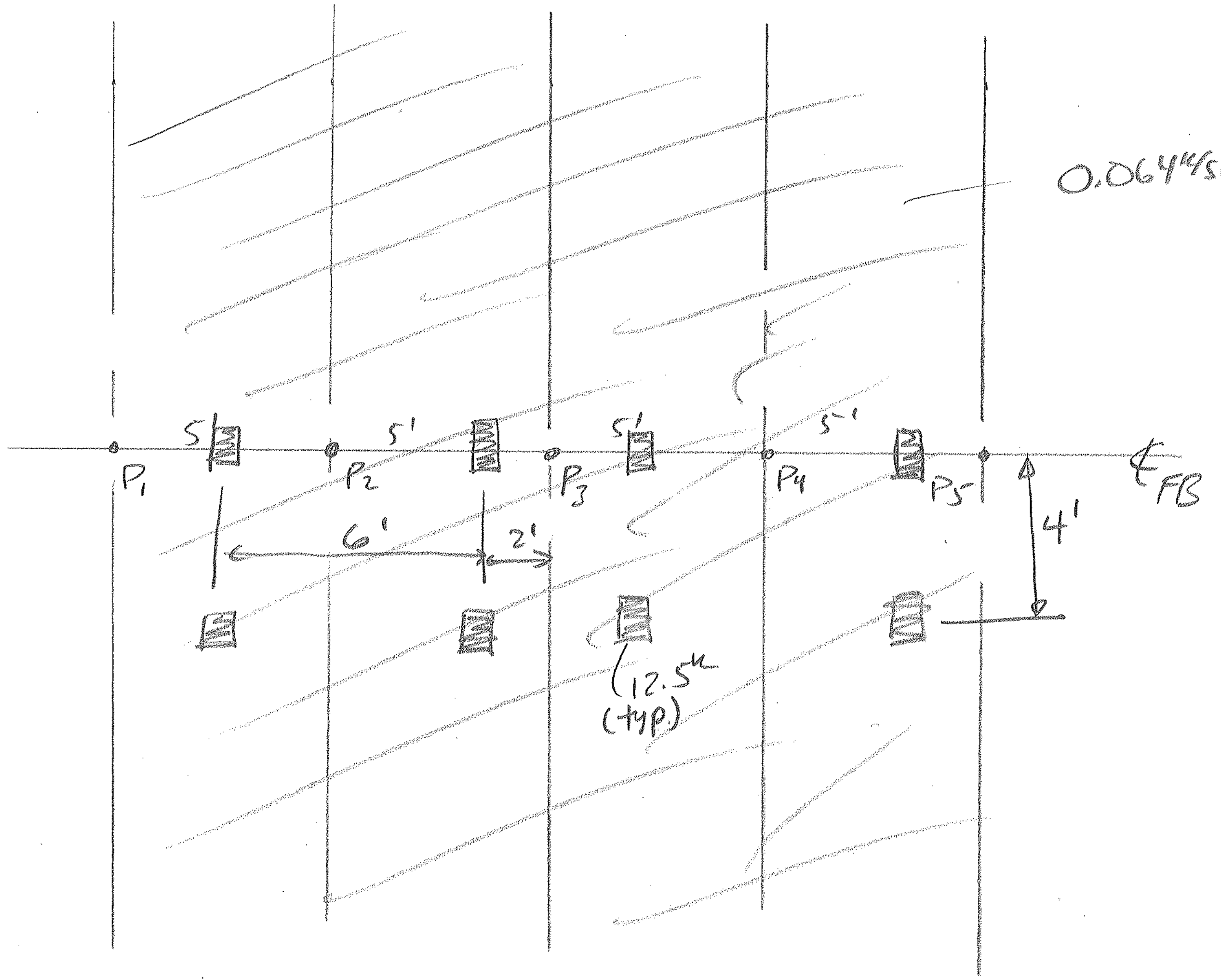
4/20/14
31

HL-93 LOADING



LANE LOAD: $P_1 = P_5 = 0.064 \times 2.5 \times 25' = 4^k$

$P_2 = P_3 = P_4 = 0.064 \times 5 \times 25' = 8^k$

2×4
$+\ 3 \times 8$
$\Sigma\ 32 = 0.064 \times 25 \times 20 = 32$ ✓

$$M_{lane} = 2 \times \frac{4 \times 22 \times 2}{24} \times \frac{12}{22} + 2 \times \frac{8 \times 17 \times 7}{24} \times \frac{12}{17} + \frac{8 \times 24}{4}$$

$= 8\ ft{\cdot}k + 56 + 48 = 112\ ft{\cdot}k$ (mid-span)

$M_{tandem} = 322^{'k}$ @ mid-span (No IM)

$M_{HL93+IM} = 1.33 \times 322 + 112 = 540^{'k}$

our 4-truck moment $= 487.3^{'k}$ @ mid-span

$T/W = 487.3/540. = 0.90 > 0.70$ ✓ OK

CHESTER

W. DAVIDS
5/1/14
4/

ASSESS STRAIN RESPONSE

2 trucks: $M/s = \frac{239.6 \times 12}{29000 \times 355 in^3} \times (1 \times 10^6) = 279 \mu\epsilon$ vs. $229.2 \mu\epsilon$ measured

4 trucks: $M/s = \frac{457.2 \times 12}{29000 \times 355} \times 10^6 = 533 \mu\epsilon$ vs. $410.2 \mu\epsilon$ measured

$\frac{279.2}{239.6} = 1.16 \mu\epsilon/ft \cdot k$

$\frac{533 \mu\epsilon}{457.2} = 1.16 \mu\epsilon/ft \cdot k$

Very linear response, consistent w/ non-composite section @ all load levels.
∴ can extrapolate

$\epsilon_c/\epsilon_T = 533/410.2 = 1.30$

RF modifier: $K = 1 + K_a K_b = 1 + (1.30 - 1.0) \times 1.0 = 1.30$

∴ Can increase RF by 1.30

EXAMINE RESIDUAL CAPACITY: say 3" WS; 2" m plank + 5 3/4" SLAB

DL @ each FB $\cong \left(\frac{8.75''}{12} \times 150 pcf \times 5' + 55^{\#} \right) \frac{\times 25'}{1000} = 15.0^k/\text{stringer}$

$M_{DL} \cong \frac{15 \times 24}{4} + 2 \times 15 \times \frac{7 \times 17}{24} \times \frac{12}{17} + 2 \times 15 \times \left(\frac{2 \times 22}{24}\right) \times \frac{12}{22} + \frac{0.124 \times 24^2}{8}$

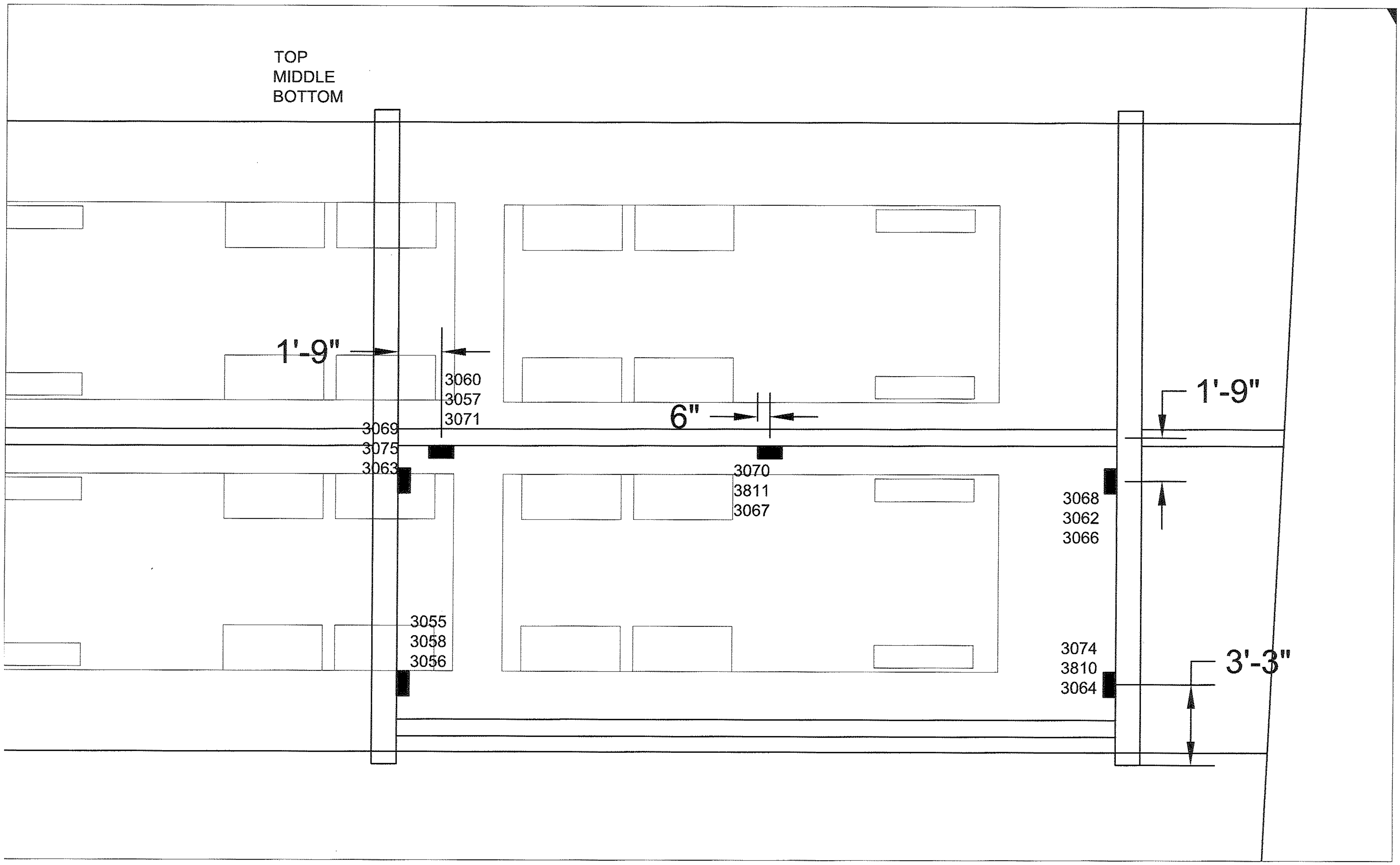
$= 90 + 105 + 30 + 9 = 234 ft \cdot k$

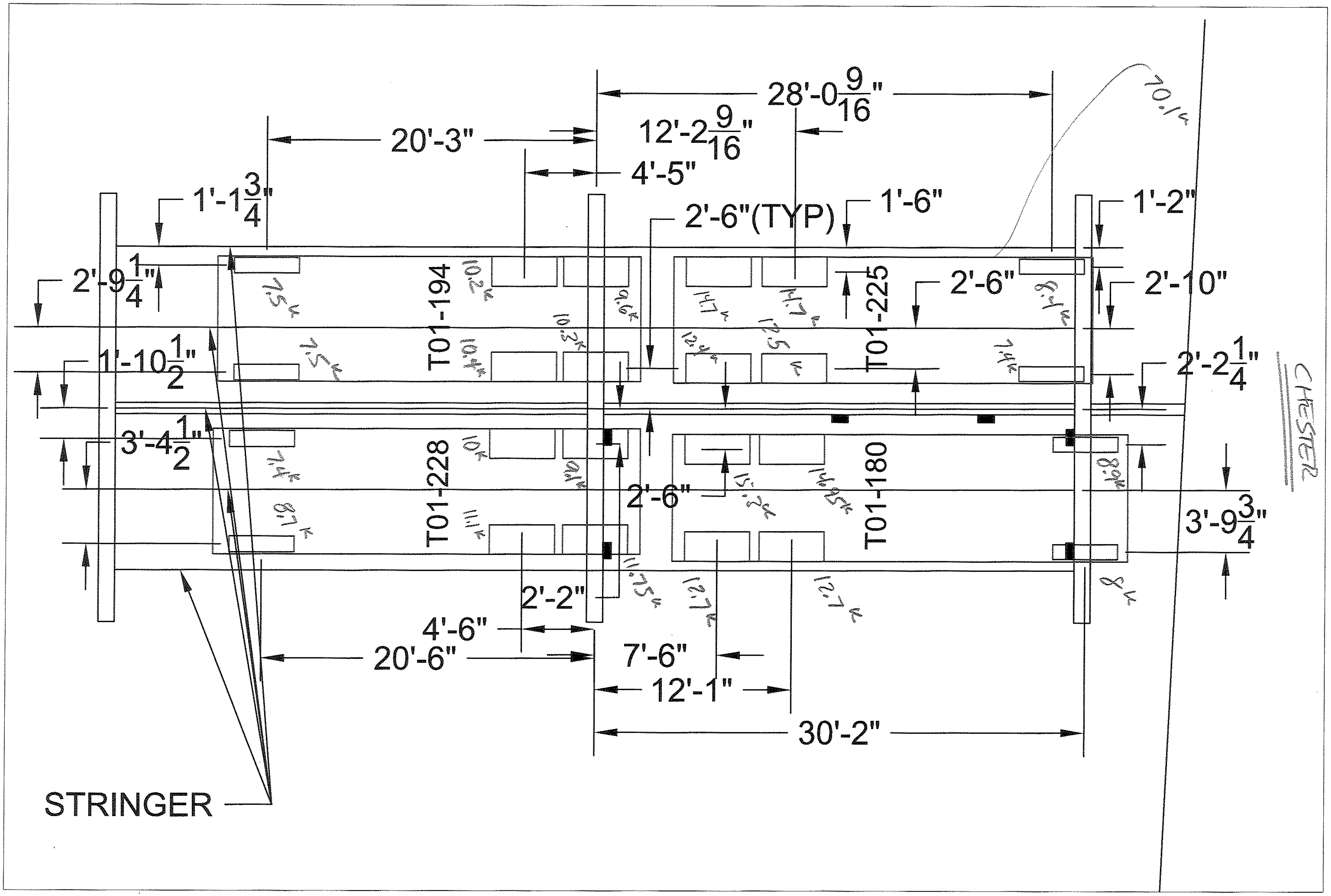
expected stress @ $M_{DL} + 1.33 HL93 + IM$:

$\frac{234 \times 12}{355} + 410.2 \mu\epsilon \times \left(\frac{540''^k}{487''^k}\right) \times \frac{29000}{1 \times 10^6} = 7.9^{ksi} + 13.2^{ksi} = 21.1^{ksi}$

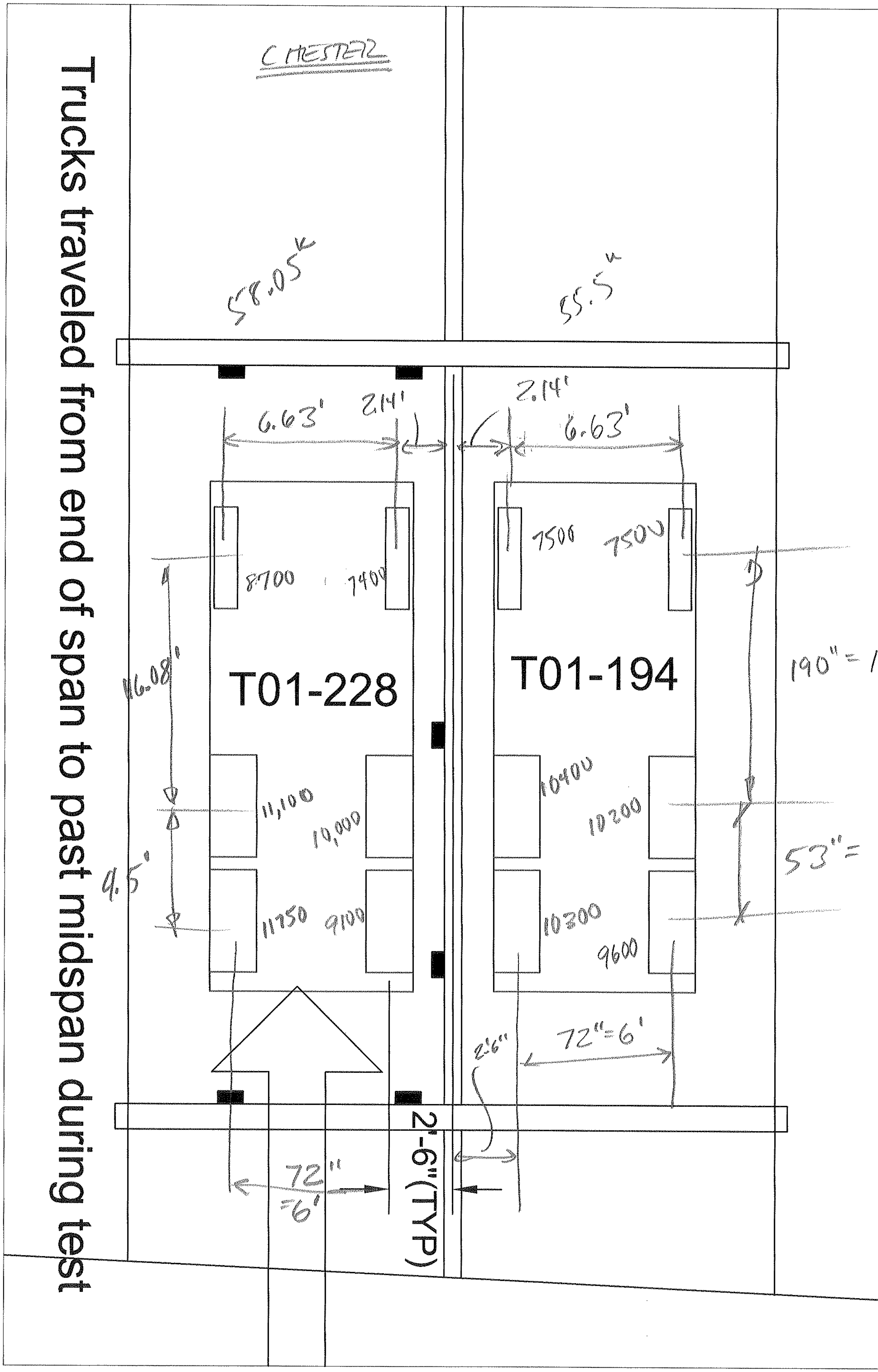
ratio up to HL-93+IM

$FS = \frac{33}{21.1} = \underline{1.56}$


TOP
MIDDLE
BOTTOM
1'-9"
3060
3057
3071
3069
3075
3063
6"
3070
3811
3067
1'-9"
3068
3062
3066
3055
3058
3056
3074
3810
3064
3'-3"


28'-0 9/16"
20'-3"
12'-2 9/16"
4'-5"
70.1k
1'-1 3/4"
2'-6"(TYP)
1'-6"
1'-2"
2'-9 1/4"
2'-6"
2'-10"
1'-10 1/2"
2'-2 1/4"
T01-194
T01-225
T01-228
T01-180
3'-4 1/2"
2'-6"
3'-9 3/4"
2'-2"
4'-6"
20'-6"
7'-6"
12'-1"
30'-2"
STRINGER
7.5k
7.5k
10.2k
10.4k
9.6k
10.3k
14.7k
14.7k
12.4k
12.5k
8.4k
7.4k
7.4k
8.7k
10k
11.1k
9.1k
11.75k
15.3k
14.95k
12.7k
12.7k
8.9k
8k

CHESTER



Trucks traveled from end of span to past midspan during test

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Page:
Project No.:

Project: Chester Bridge Test
By: KMG Date: 4/10/14
Subject: Test Vehicle Measurements
Checked: Date:

DWAYNE

License Plate Number 701-194
Truck Designation (1 or 2) 2
Weighed By: CSF
Dimensions by: KMG

93"

Axle Weight 9600 — 10300

53"
Axle Spacing

Axle Weight 10200 — 10400

22" 22"

#2

190"
Axle Spacing

Axle Weight 7500 — 7500

11 1/2 11 1/2

91
Wheel Spacing
27300 28200

Front

Total Vehicle Weight 55500

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MAINTIP

License Plate Number T01-228
Weighed By: CJF
Truck Designation (1 or 2) 1
Dimensions by: KMG

7'-9" = 93"

Axle Weight 9100 — 11750

54" Axle Spacing

#1

Axle Weight 10000 — 11100

22" 22"

16'-0" Axle Spacing

52'-3" for 5 revolutions

FRONT

Axle Weight 7400 — 8700

12" 12"

26500 — 90" Wheel Spacing — 31550

Total Vehicle Weight 58050

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By: KMG Date:

Subject: Test Vehicle Measurements

Checked: Date:

License Plate Number 701-22 5

Weighed By: CJF

Truck Designation (1 or 2)

Dimensions by: CJF

94"

Axle Weight 12400 | 14700

56 Axle Spacing

Axle Weight 12500 | 14700

22 | 22

#3

190" Axle Spacing

Axle Weight 7400 | 8400

10 1/2 | 10 1/2

32300 | 91 Wheel Spacing | 37800

Total Vehicle Weight 70100

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Page:

Project No.:

Project: CHESTER BRIDGE TEST

By: KMG Date:

Subject: Test Vehicle Measurements

Checked: Date:

License Plate Number T01-180
Weighed By: CSF
Truck Designation (1 or 2)
Dimensions by: CSF

94

Axle Weight 12700 — 15,300

55
Axle Spacing

Axle Weight ~~12600~~ 12700 — 14950

22" — 22

217
Axle Spacing

Axle Weight 8000 — 8900

8½ — 8½

33400 — 90½ — 39150
Wheel Spacing

Total Vehicle Weight 72550

#4

W. DAVIDS
4/23/14

T3- INDIAN PURCHASE

BRIDGE PROPERTIES:

- STRINGERS: W21x68 x 5'-3" O/C (Exterior smaller)
- FB: W36x150 SPACED @ 30'-0", 26.16' SPAN
- DECK: 8 1/4" (INCL 3" CONCR WS, FIELD VERIFIED)

MAX. MEASURED FB STRAINS:

- 330με tension w/ 4 trucks
- 163με tension w/ 2 trucks

} see p. 2

- strains @ mid-depth ≈ 0, significant compression top, girders are non-composite. Consistent w/ construction details, which shows no flange embedment in deck.
- strains nearer ends indicate no fixity @ FB spts.

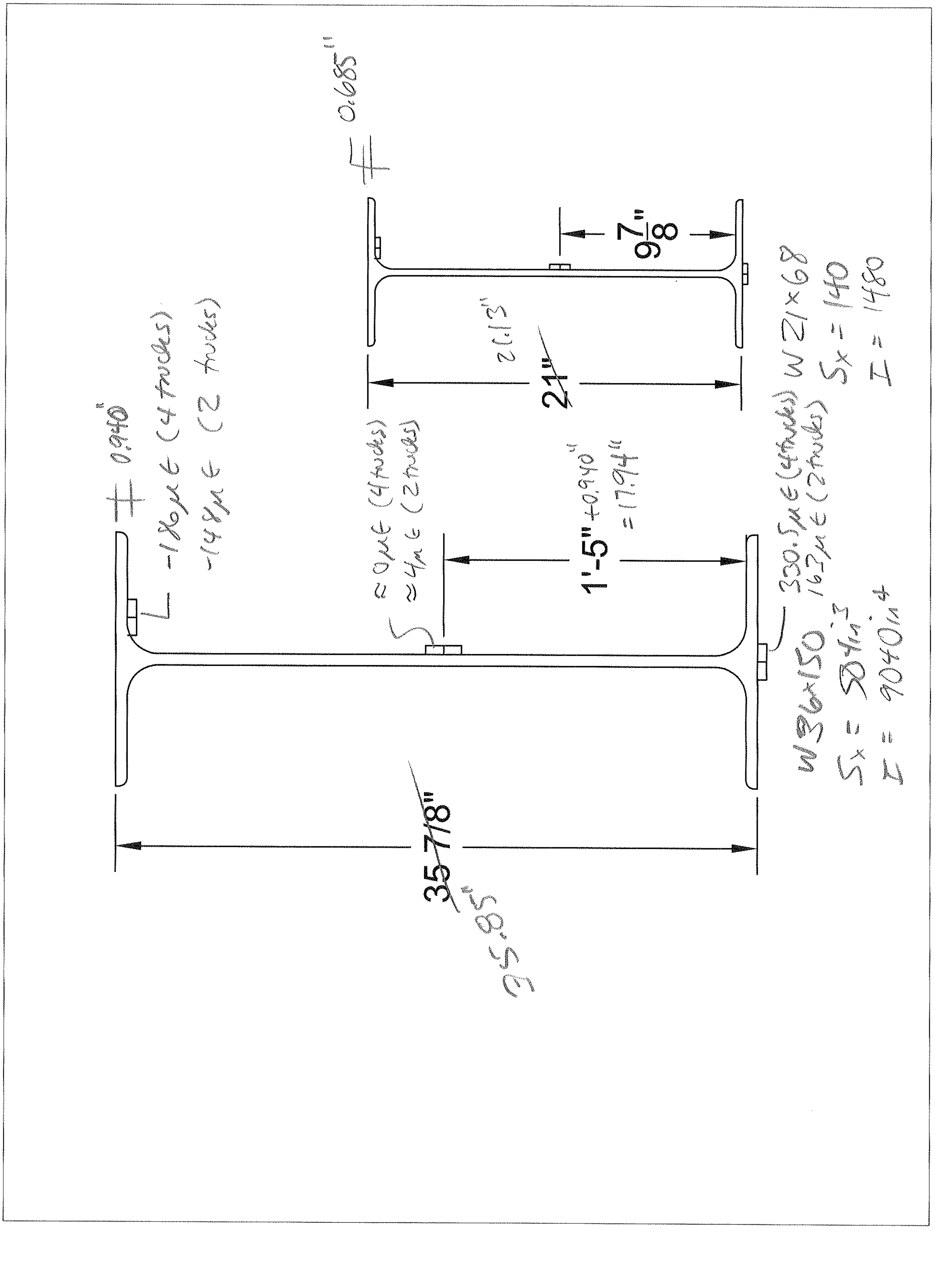
FB MOMENTS DUE TO TRUCK LOADS:

- Computed using lever rule, field-measured wheel loads, previously verified spread sheet

- 4 truck moment = 587.44'k @ gage location (21" off midspan)
- 2 truck moment = 314.5'k @ gage location.

- HL-93 + IM (tandem + lane) = 624.4'k @ mid-span (see pp. 3&4)

T3- INDIAN PURCHASE



T-3 INDIAN PURCHASE

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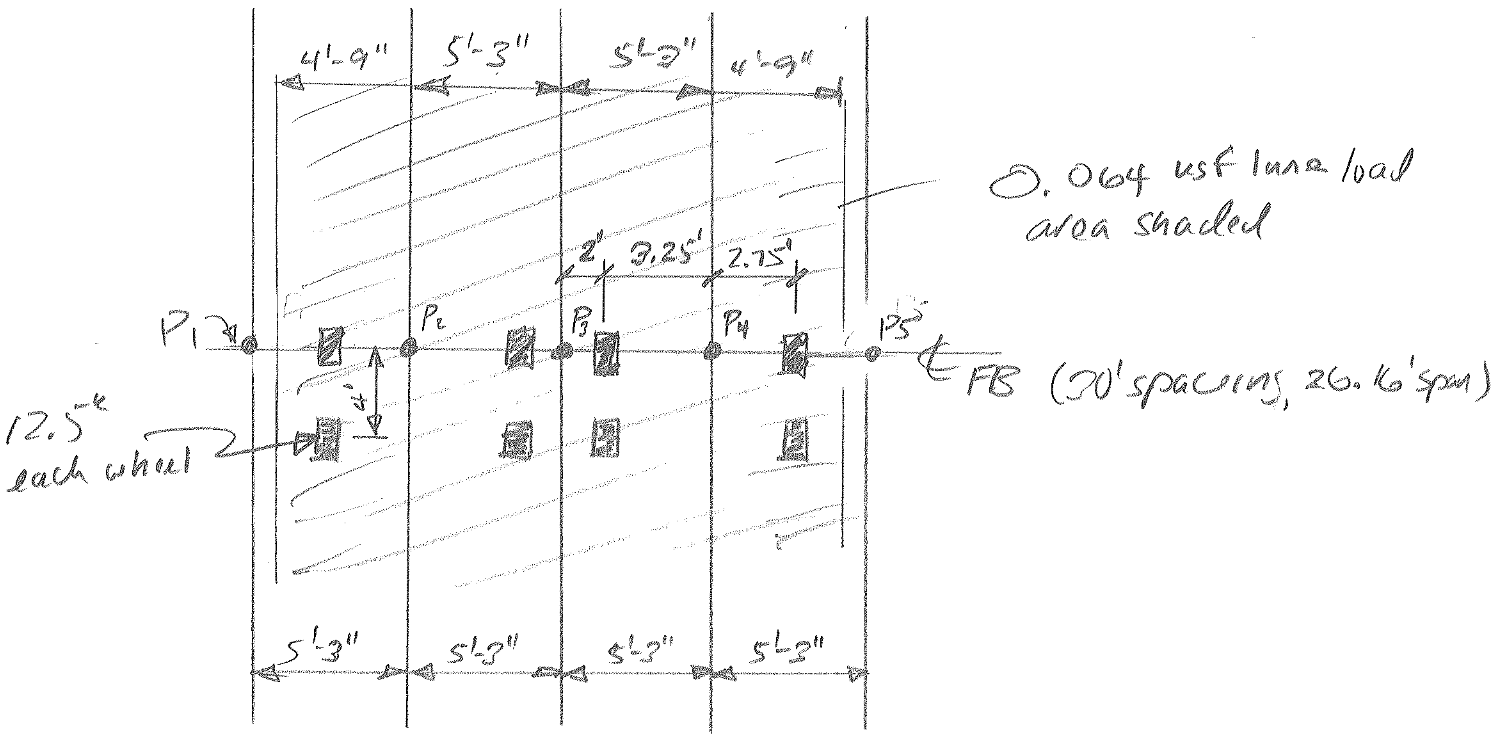
4/23/14
3/

HL93 + IM LOAD:



Due to Tandems:

$$P_1 = \overbrace{\left(1 + 26/30\right)}^{1.866} \times \frac{2.75}{5.25} \times 12.5 = 12.22 = P_5$$

$$P_2 = 1.866 \times \left(\frac{2.5}{5.25} + \frac{2}{5.25}\right) \times 12.5 = 20^k = P_4$$

$$P_3 = 1.866 \times 2 \times \frac{3.25}{5.25} \times 12.5 = 28.89^k \checkmark$$

agree w/ spreadsht

$$M_{tandem} = 352 \text{ ft-k (spreadsht)}$$

Due to lane:

$$P_1 = P_5 = \left(0.064 \times 4.75 \times \frac{4.75}{2} \times \frac{1}{5.25}\right) \times 30' = 4.13^k$$

$$P_2 = P_4 = 0.064 \times \left(4.75 \times \frac{2.875}{5.25} + \frac{5.25}{2}\right) \times 30' = 10.03^k$$

$$P_1 = 0.064 \times 5.25 \times 30' = 10.08^k$$

$2 \times 4.13 + 2 \times 10.03 + 10.08 = 38.4^k$

$0.064 \times 30' \times 20' = 38.4^k$

$$M_{lane} = \frac{10.08 \times 26.16}{4} + 2 \times \overbrace{\left(\frac{10.03 \times 18.33 \times 7.83}{26.16} \times \frac{13.08}{18.33}\right)}^{P_2 + P_4} + 2 \overbrace{\left(\frac{4.13 \times 2.58 \times 23.58}{26.16} \times \frac{13.08}{23.58}\right)}^{P_1 + P_5}$$

$$= 65.92 + 2 \times 39.27 + 2 \times 5.33 = 155.1^{k}$$

W. DAVIDS
4/23/14
4/

T3 - INDIAN PURCHASE

TOTAL HL-93 + IM LOAD:

$1.33 \times 352^{k} + 155.1^{k} = 624.4^{k}$ (peak @ mid-span)

Using lever rule calculations, test produced 634^{k} > HL-93!

T3- INDIAN PURCHASE

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4/23/14
5/

ASSESS STRAIN RESPONSE

2 trucks: $M = 314.5^{k'}$; $\epsilon_c = \frac{M}{ES} = \frac{314.5 \times 12}{29000 \times 504} \times 1 \times 10^6 = 258\mu\epsilon$

measured strain $= \epsilon_t = 163\mu\epsilon$; $\frac{\epsilon_c}{\epsilon_T} = 1.58$

4 trucks; $M = 587.4^{k'}$; $\epsilon_c = \frac{587.4 \times 12}{29000 \times 504} \times 1 \times 10^6 = 482\mu\epsilon$

measured strain $= \epsilon_t = 330\mu\epsilon$; $\frac{\epsilon_c}{\epsilon_t} = 1.46$

linearity of strain response: $\frac{587.4}{314.5} \times 163 = 304\mu\epsilon$ vs. $330\mu\epsilon$

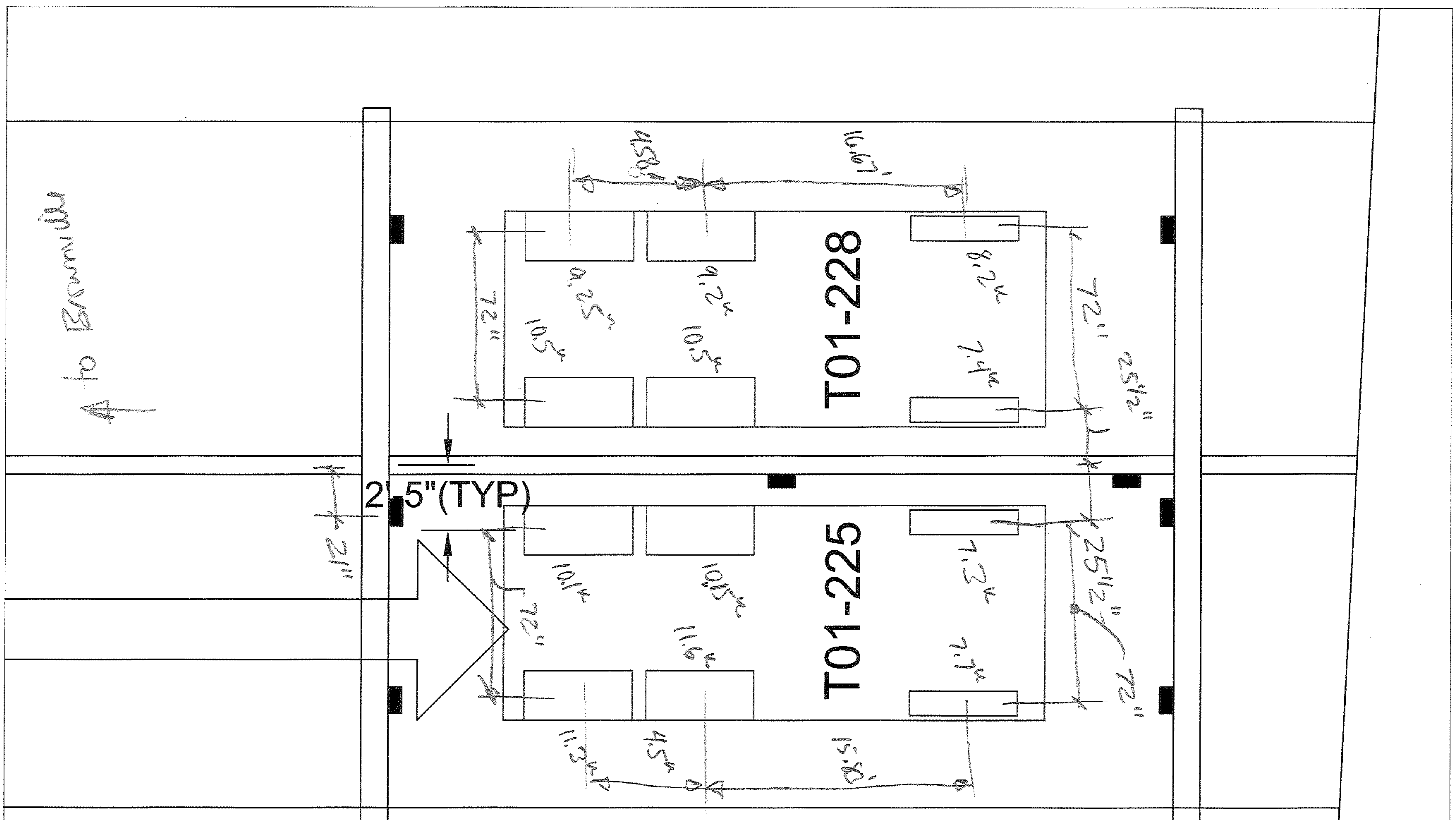
$\frac{330-304}{304} \times 100 = 8.6\%$

very close to linear increase

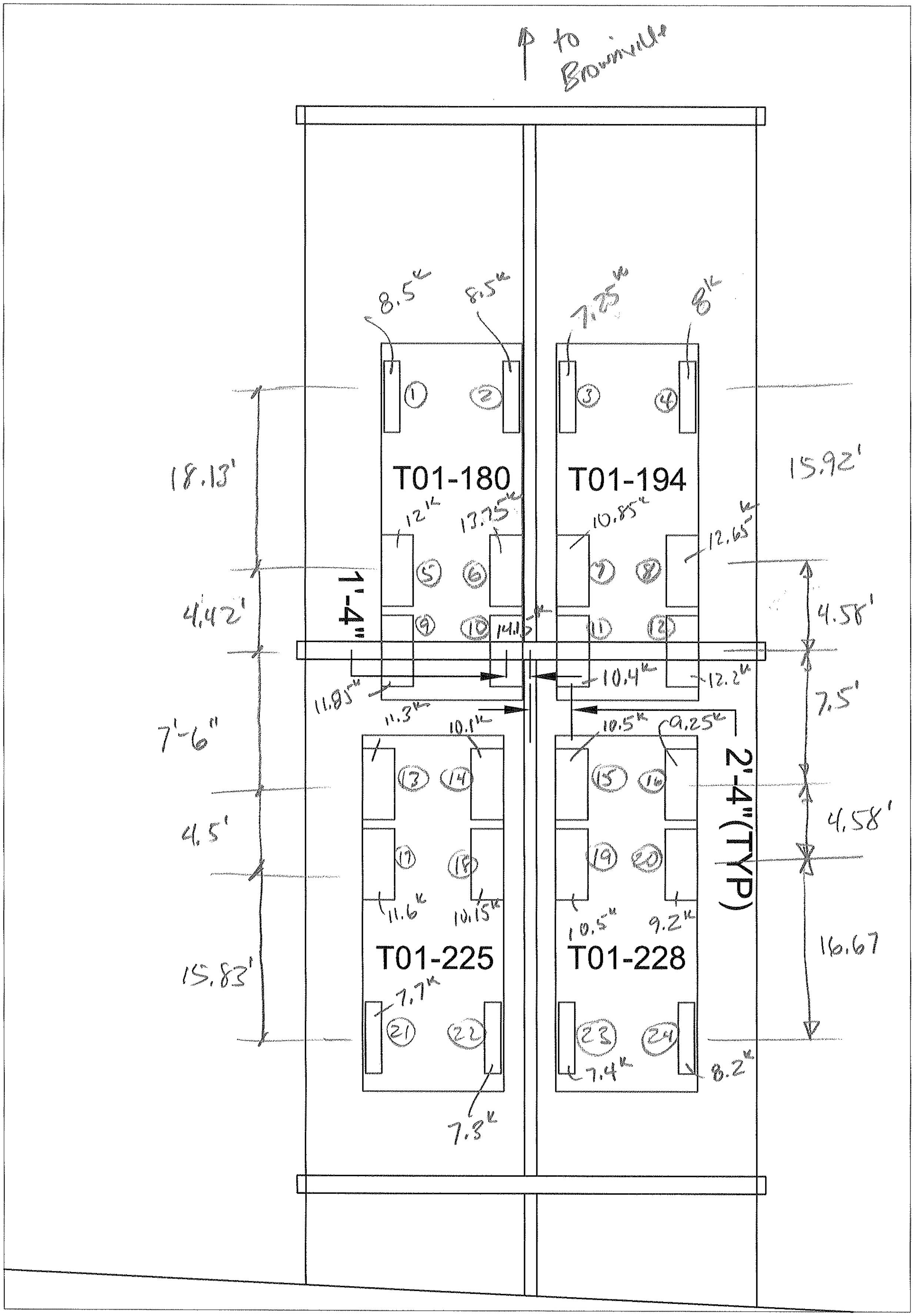
- Given that 4-truck load produced moment in excess of HL93 + IM, the nearly linear increase in measured strain when going from 2 truck to 4 truck loading, & the lack of composite action, extrapolation to 1.33W is reasonable.

- RF modifier = $K = 1 + K_a K_b = 1 + (1.46 - 1) \times 1 = \underline{1.46}$

T7- INDIAN PURCHASE

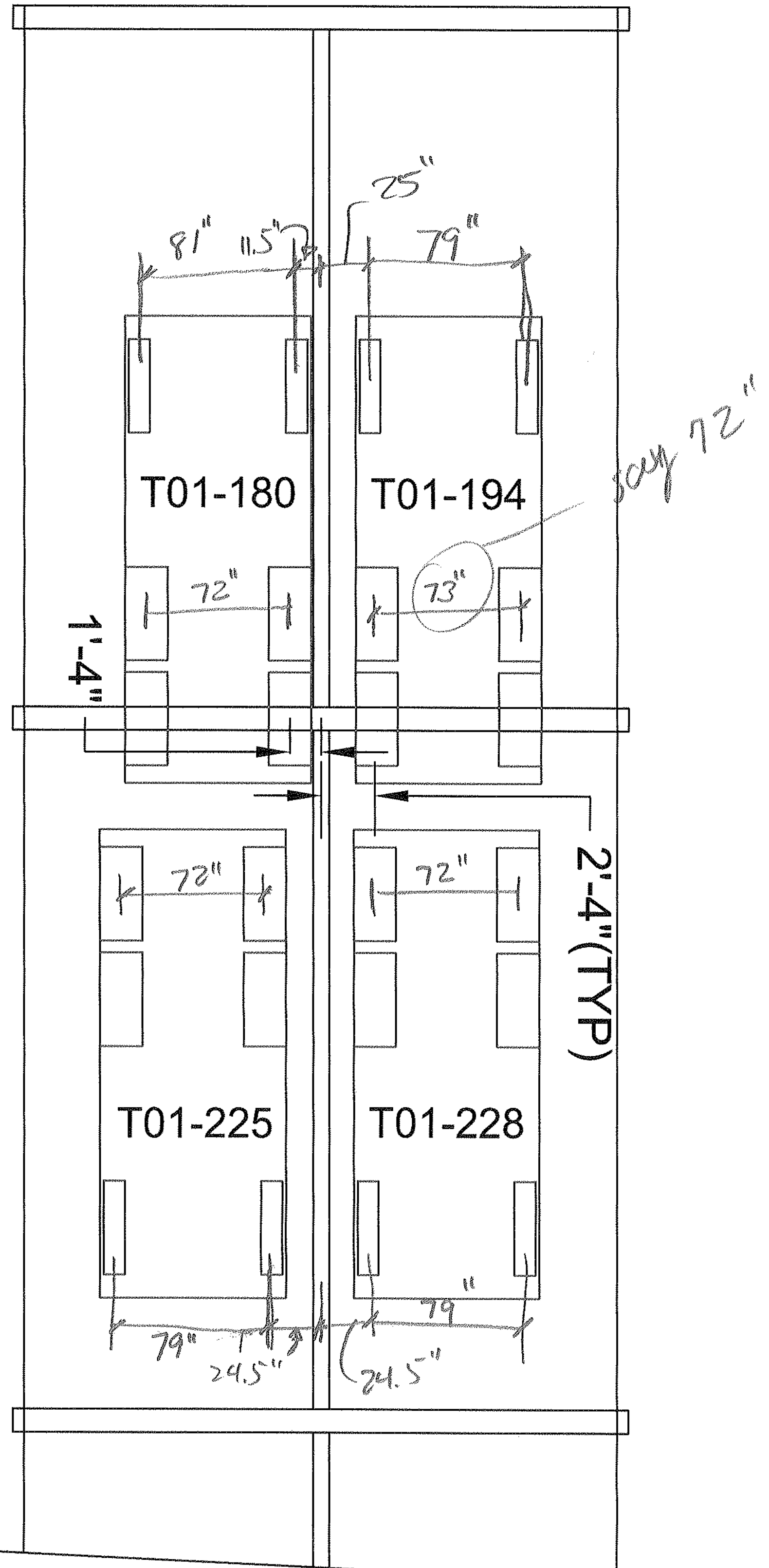


Trucks traveled from end of span to past midspan during test



to Brownville
T3- INDIAN PURCHASE
T3- INDIAN PURCHASE
T01-180
T01-194
T01-225
T01-228
8.5k
8.5k
7.25k
8k
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
12k
13.75k
10.85k
12.65k
14.15k
10.4k
12.2k
11.85k
11.3k
10.1k
10.5k
9.25k
11.6k
10.15k
10.5k
9.2k
7.7k
7.4k
8.2k
7.8k
1'-4"
2'-4"(TYP)
18.13'
4.42'
7'-6"
4.5'
15.83'
15.92'
4.58'
7.5'
4.58'
16.67

T3 - INDIAN PURCHASE



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Page:	
Project No.:	979
By: KMG	Date: 4/15/14
Checked:	Date:

Project:
T3 - INDIAN PURCHASE LL TEST

Subject:
Test Vehicle Measurements

License Plate Number 101 - 228
Truck Designation (1 or 2) #2
Weighed By: KMG
Dimensions by: KMG

94"

Axle Weight 19,750
10,500
9,250

55"
Axle Spacing

10,500
9,200
Axle Weight 19700

22"
22"

16'-8" = 200"
Axle Spacing

7.5"

7,400
8,200
Axle Weight 15,600

11"
11"

90"
Wheel Spacing
FRONT

Total Vehicle Weight 55,050

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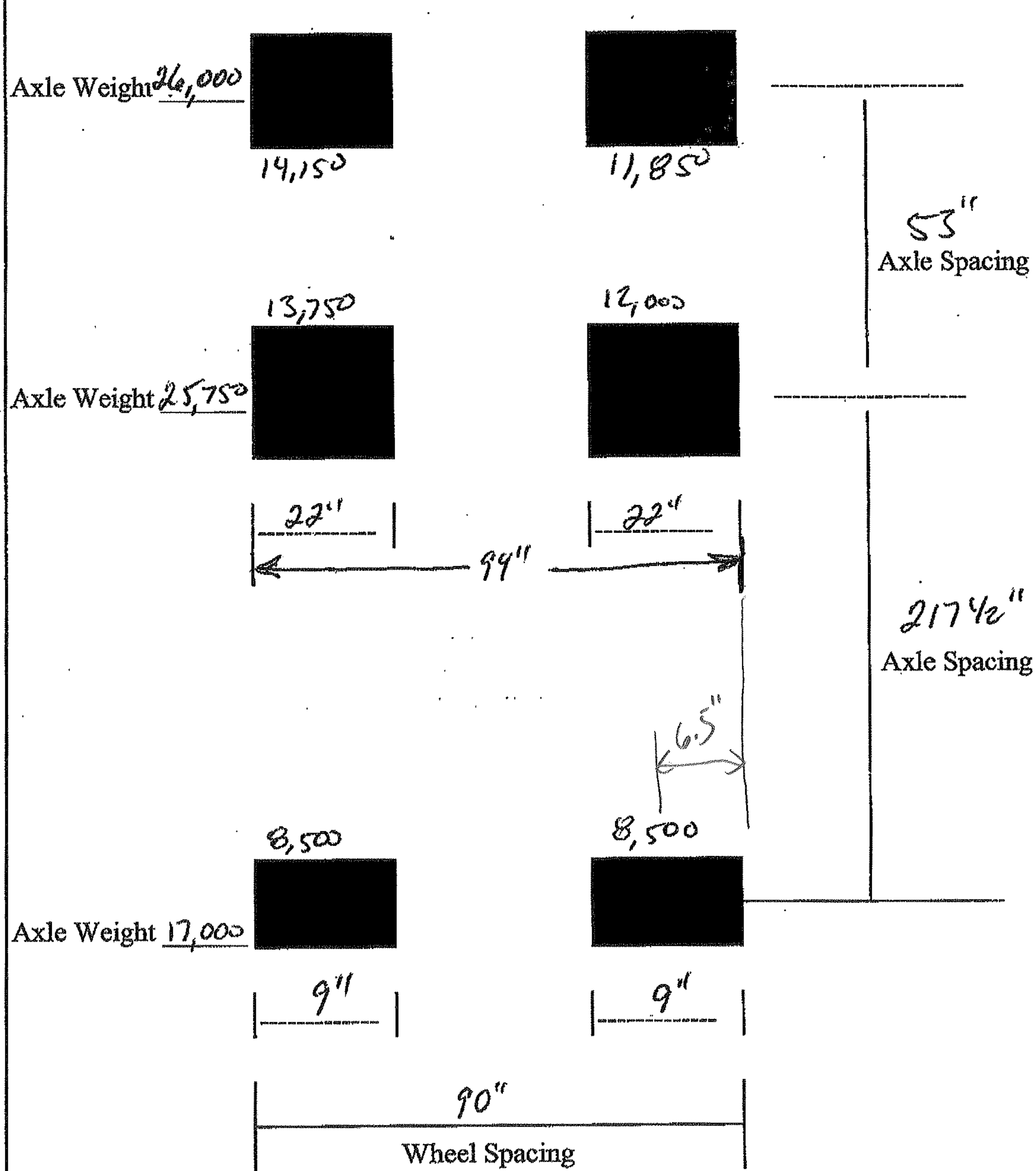
Page:	
Project No.: 979	
Project: Bridge Load Testing/Rating T3- Indian Purchase	By: KMG Date: 4/15/14
Subject: Test Vehicle Measurements	Checked: Date:

License Plate Number 701-180
Truck Designation (1 or 2) 4
Weighed By: KMG
Dimensions by: KMG



Total Vehicle Weight 68,750

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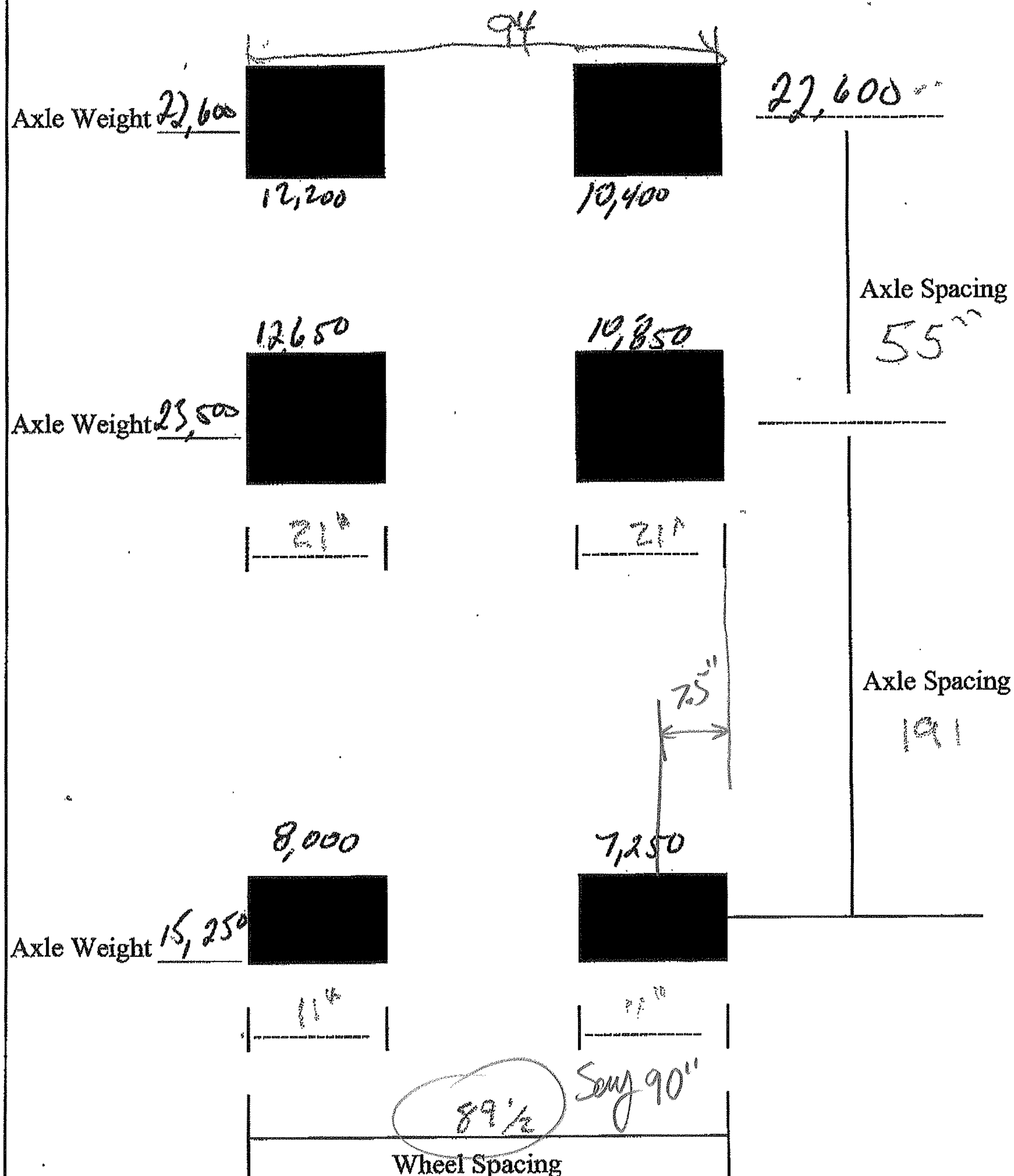
Page:	
Project No.:	
Project: Bridge Load Testing/Rating T3 INDIAN PURCHASE	By: KMG Date: 4/15/14
Subject: Test Vehicle Measurements	Checked: Date:

License Plate Number T01-194
Truck Designation (1 or 2) ______
Weighed By: KMG
Dimensions by: C&F



#3

Total Vehicle Weight 61,350

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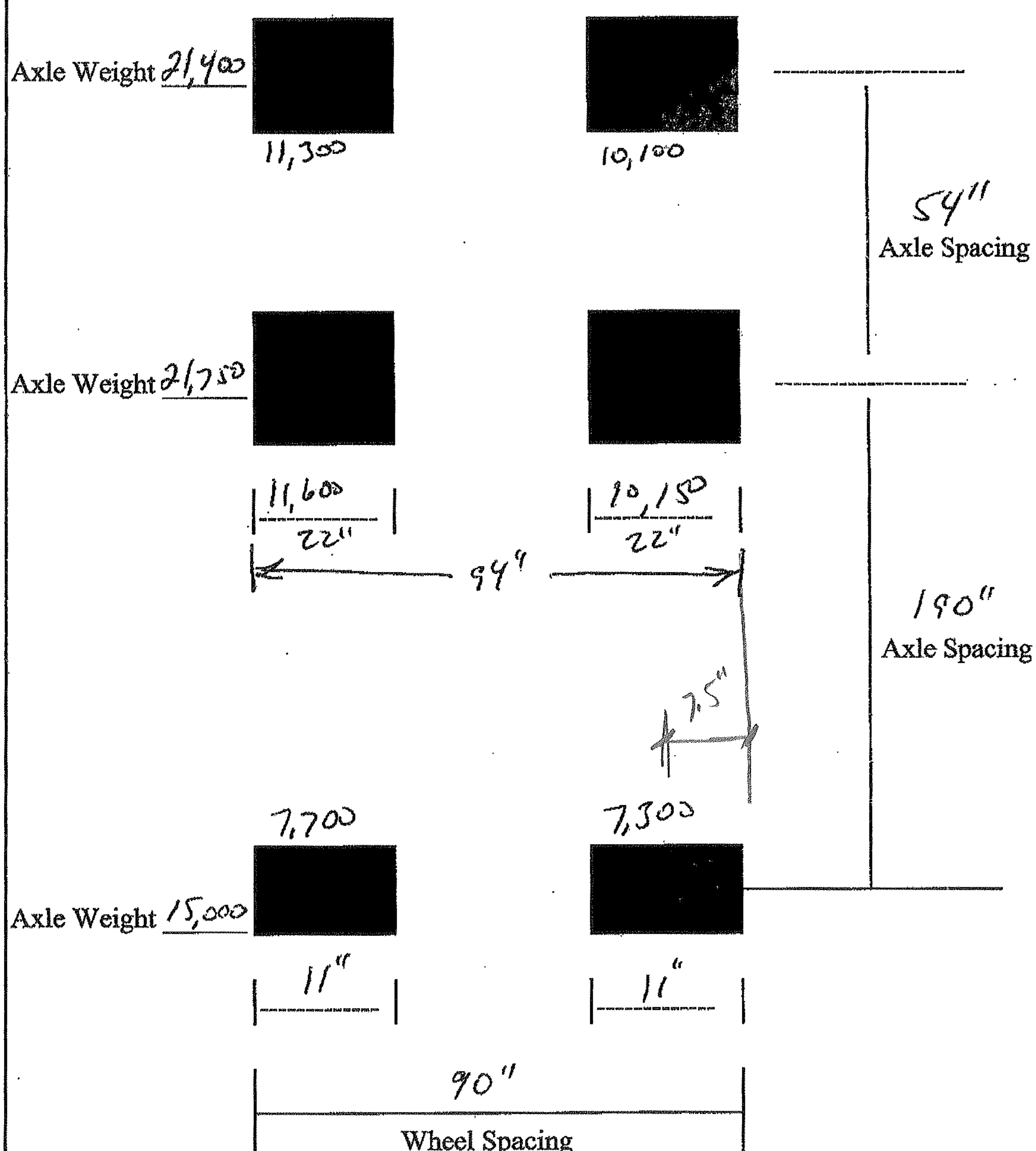
Page:	
Project No.:	979
By: KMG	Date: 4/15/14
Checked:	Date:

Project: Bridge Load Testing/Rating T3 - Indian Purchase

Subject: Test Vehicle Measurements

License Plate Number T01-225
Weighed By: KMG
Truck Designation (1 or 2) #1
Dimensions by: KMG



Total Vehicle Weight 58,150

APPENDIX C: PRELIMINARY CALCULATIONS

"preliminary_FB_analysis.pdf"

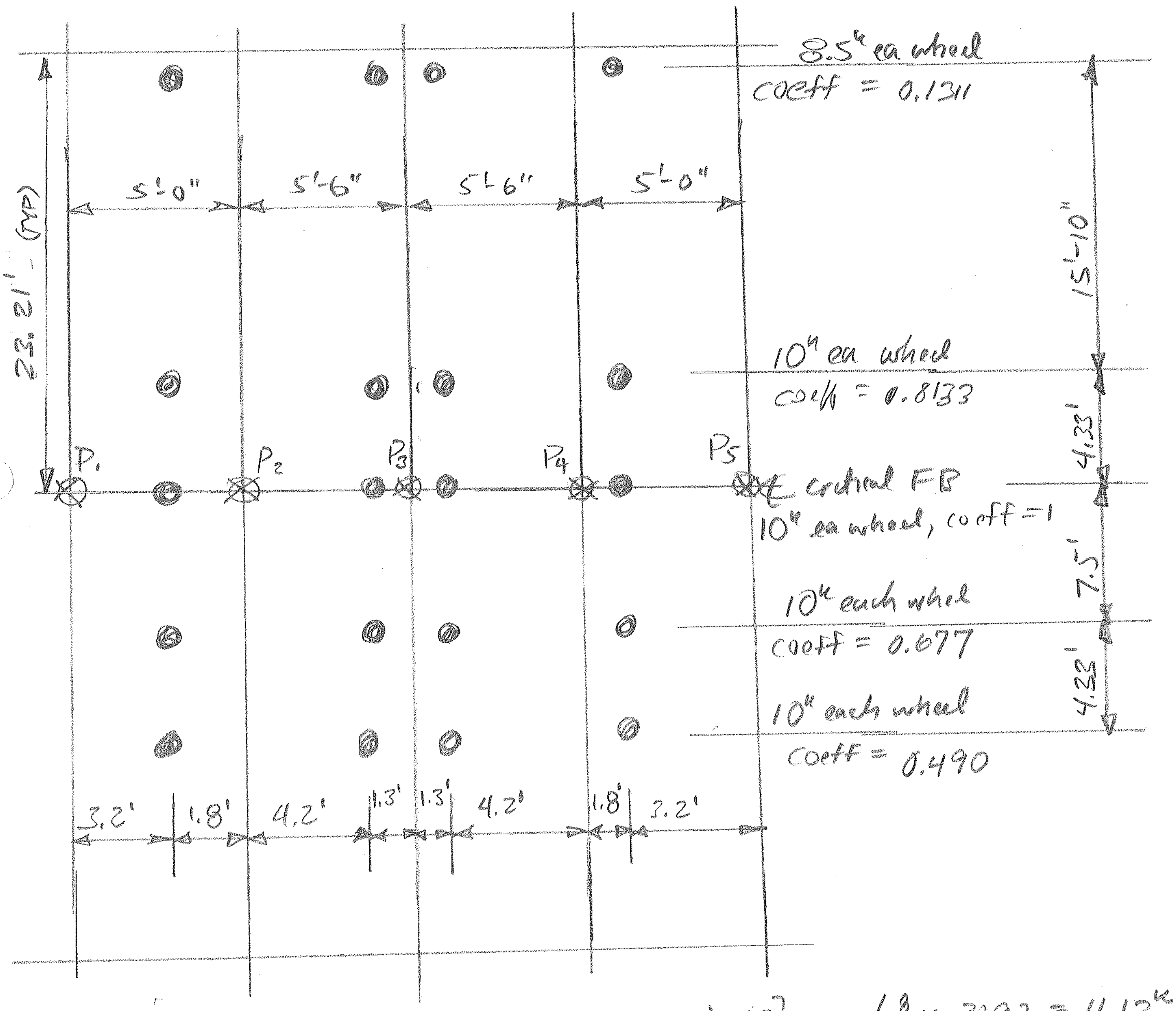
W. Davids
3/10/2014

1

Brownville – Preliminary FB Analysis

FB ≈ W33×130, span ≈ 23'

Heaviest 4-truck loading:



$$P_1 = \frac{1.8}{5}\left[0.131\times 8.5 + (0.8133 + 1 + 0.677 + 0.490)\times 10\right] = \frac{1.8}{5}\times 30.92 = 11.13^k$$

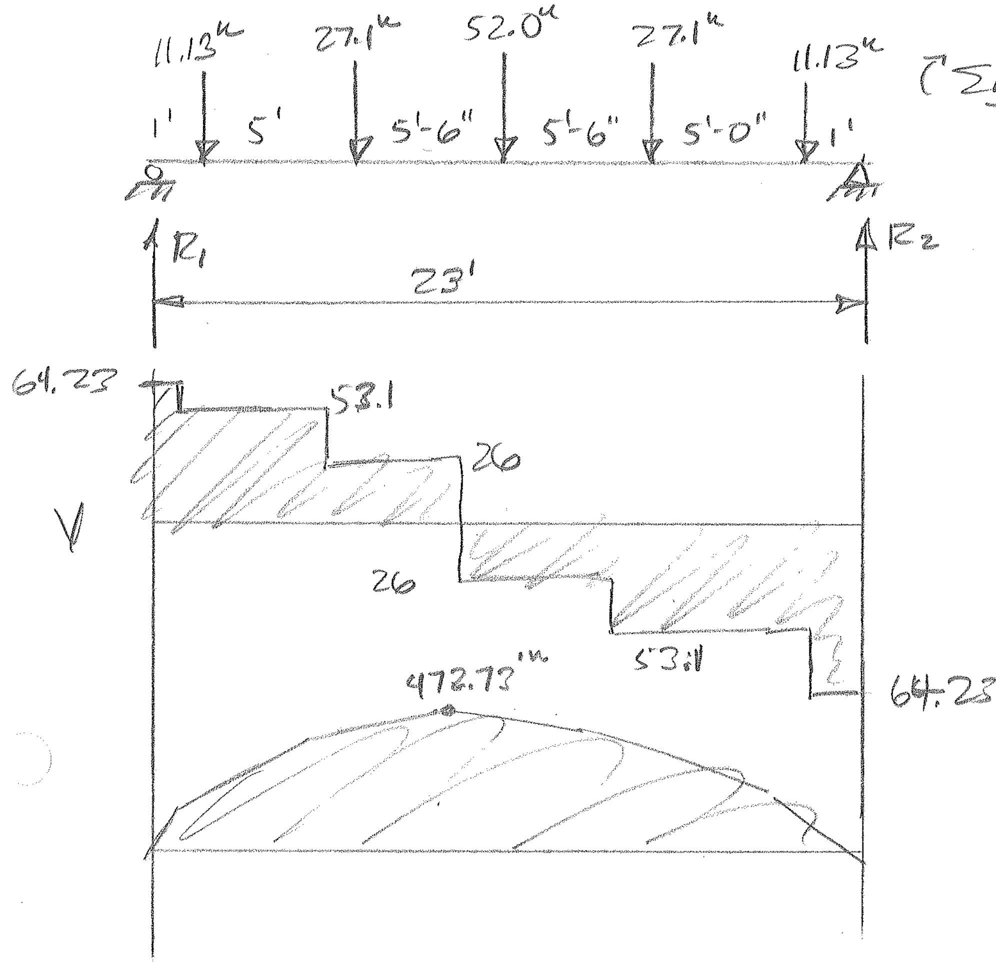
$$P_2 = \left(\frac{3.2}{5} + \frac{1.3}{5.5}\right)\times 30.92 = 27.1^k \quad ; \quad P_3 = \left(\frac{4.2}{5} + \frac{4.2}{5}\right)\times 30.92 = 51.95^k$$

$$P_4 = \left(\frac{1.3}{5.5} + \frac{3.2}{5}\right)\times 30.92 = 27.1^k \quad ; \quad P_5 = \frac{1.8}{5}\times 30.92 = 11.13^k$$

W. Davids

3/10/2014

BROWNVILLE - PRELIMINARY FB ANALYSIS



$\circlearrowleft \Sigma M_1 = 0:$

$$\begin{aligned}
&11.13\times 1 &\rightarrow\ & 11.13\\
+\ &27.1\times 6 &\rightarrow\ & 162.6\\
+\ &52.0\times 11.5 &\rightarrow\ & 598\\
+\ &27.1\times 17 &\rightarrow\ & 460.7\\
+\ &11.13\times 22 &\rightarrow\ & \underline{244.9}\\
& & & 1477.3\\
-\ &R_2\times 23 & & -R_2\times 23\\
=\ &0 & &
\end{aligned}$$

$\Rightarrow R_2 = 64.23$

$R_1 = 64.23$ ✓

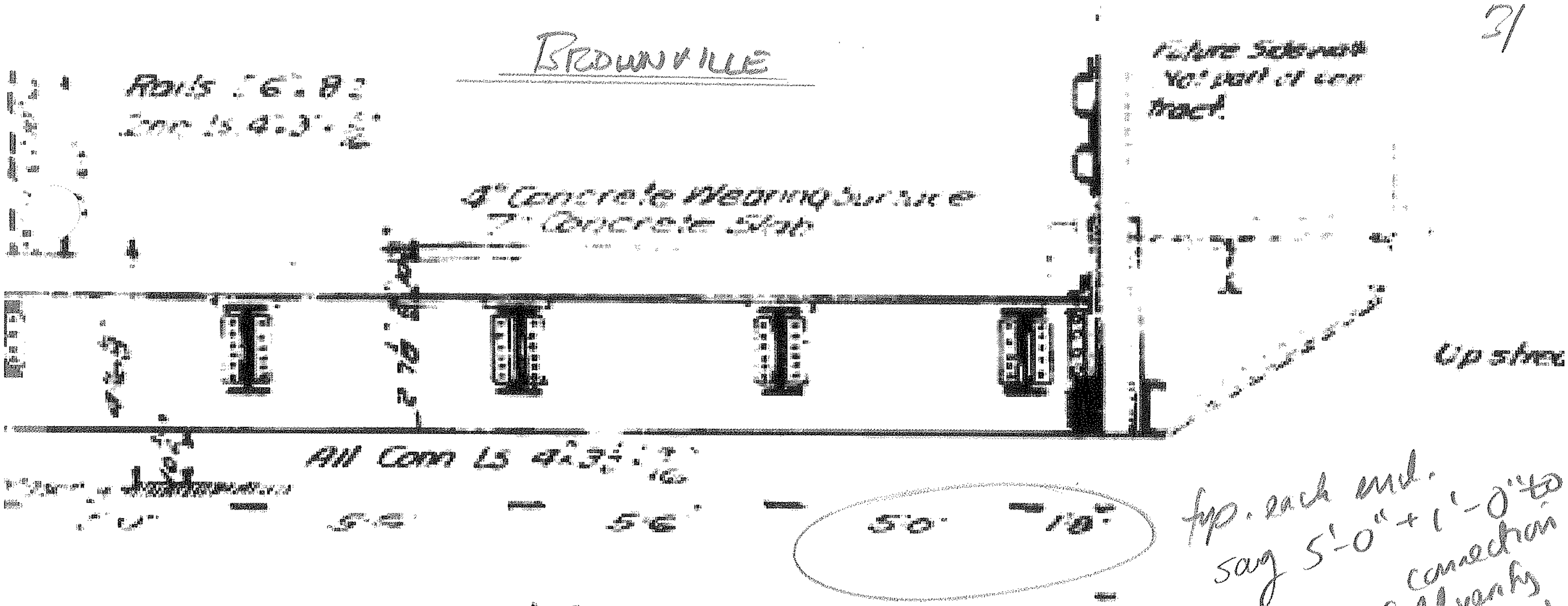
$M_{test} = 472.73 \Rightarrow \sigma_{test} \simeq \dfrac{472.73\times 12}{406} = 14.0^{ksi} \Rightarrow \epsilon_{test} = \underline{483\mu\epsilon}$

(peak @ Howland = 245 $\mu\epsilon$, observed; predicted $\dfrac{707\times 12}{580\times 29000} = \underline{\underline{504}}$)

σ_{DL} (plans) $\simeq \dfrac{3356700/1000}{406} \simeq \dfrac{8.27}{22.3^{ksi}}$

FS against yield $\simeq \dfrac{30.0}{22.3} = 1.35$ 1935

BROWNVILLE



typ. each end. say 5'-0" + 1'-0" to connection (field verify 1'-0")

9"Ø holes through webs of end Floor beams between all stringers to facilitate painting

TYPICAL SECTIONS

FB spacing = 23'-2½"

= 23.21'

FB span ≈ 11'+5'+5'+1'+1' ≈ 23'

ROADWAY STRINGERS

INTERIOR

Slab	479
WS	275
Beam	73
	827
D.L.M.	656600
L.L.M.	1012000
Imp	302100
100%	1350100
	3364800

S = 140.2 B21 x 73 S = 150.7

EXTERIOR ROADWAY

Slab	300
WS	150
Curb	81
Beam	55
	586
D.L.M.	468500
L.L.M.	662400
Imp	223900
100%	886300
	2241100

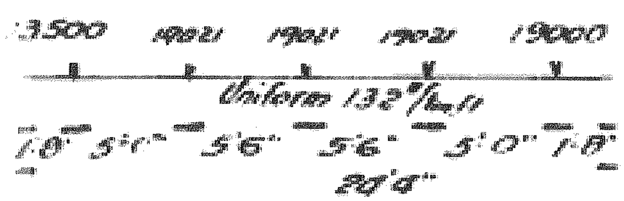
S = 93.4 B18 x 55 S = 98.2

EXTERIOR SIDEWALK

Slab	300
WS	150
Curb	81
SW	236
Beam	59
	826
D.L.M.	655800
L.L.M.	662400
Imp	223700
100%	886300
	2428400

S = 101.2 B21 x 59 S = 1[illegible]

FLOOR BEAM



DEAD LOAD

$R_L = \frac{19000 \times 1.67 + 19021 \times 36.51 + 13500 \times 22.67}{24.33} = 42426$

LIVE LOAD

$R_L = 24660$

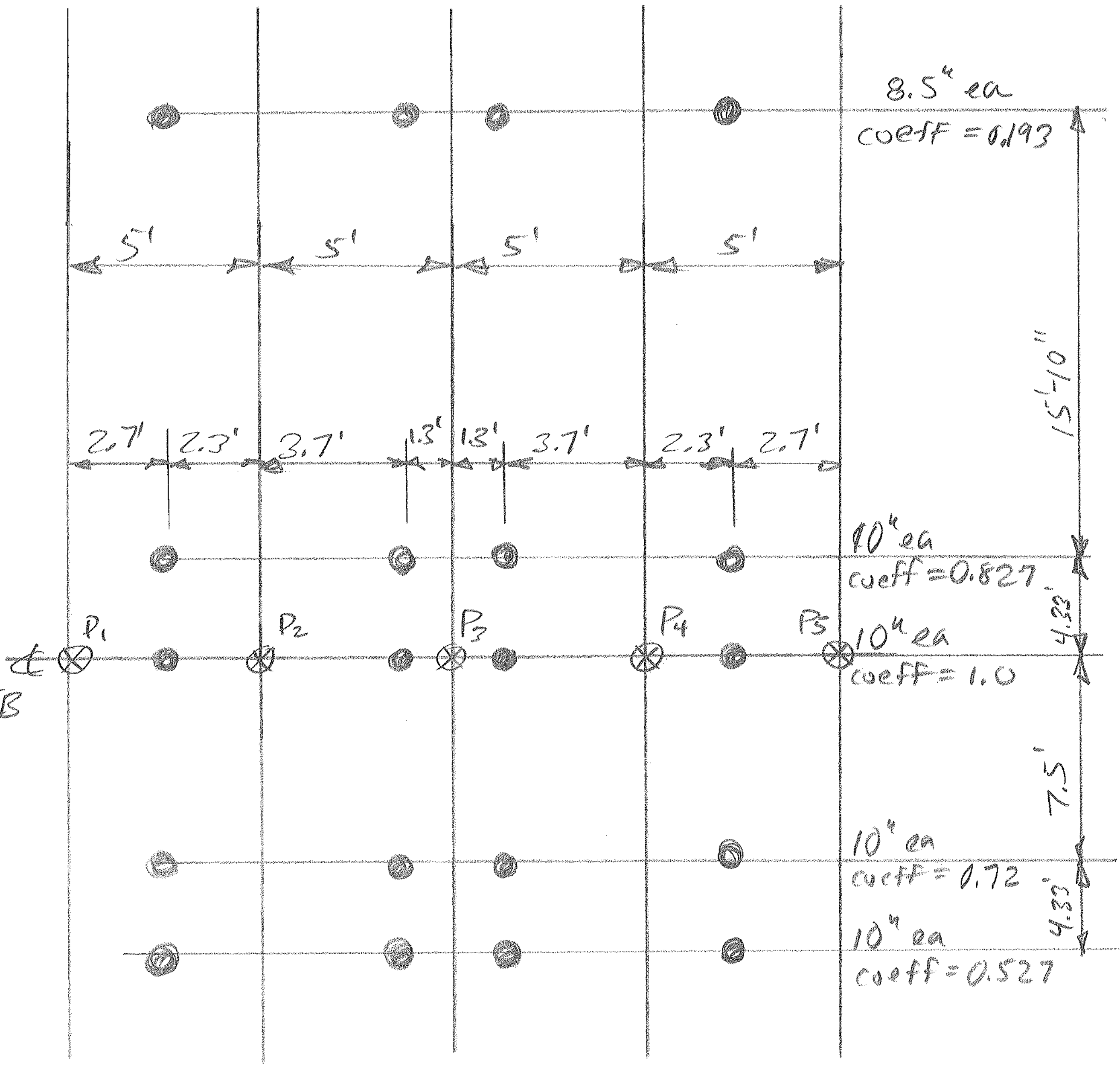
(≈ W33×130 S = 406 in³

D.L.M.	42426 × 12.11 − 19021 × 5.5 − 13500 × 10.5 × 12	5239500
Uniform Mom	132 × 24.33² × 1.5	117200
		5356700
L.L.M.		2430950
Imp		709850
100%		3100800
		9638300

S = 401.6 B33 × 132 S = 4[illegible]

CHESTER - PRELIMINARY FB ANALYSIS

W. DAVIDS
3/10/2014



$$P_1 = \frac{2.3}{5}\left(0.193 \times 8.5 + (0.827 + 1.0 + 0.72 + 0.527) \times 10\right) = \frac{2.3}{5} \times 32.4 = 14.9^k$$

$$P_2 = \left(\frac{2.7}{5} + \frac{1.3}{5}\right) \times 32.4 = 25.9^k$$

$$P_3 = \left(\frac{3.7}{5} + \frac{3.7}{5}\right) \times 32.4 = 48.0^k$$

$$P_4 = \left(\frac{1.3}{5} + \frac{2.7}{5}\right) \times 32.4 = 25.9^k$$

$$P_5 = \frac{2.3}{5} \times 32.4 = 14.9^k$$

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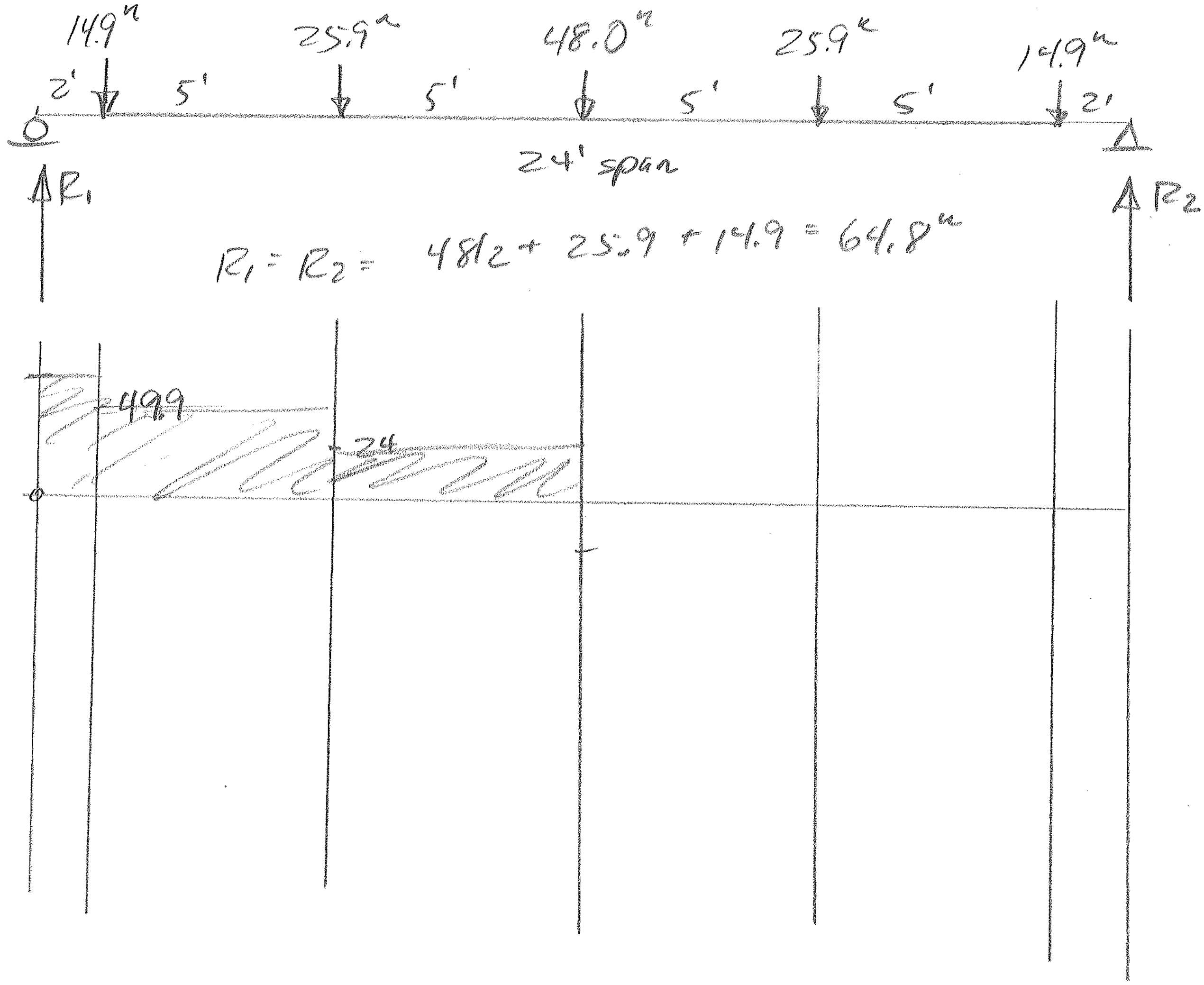
CHESTER - PRELIMINARY FB ANALYSIS



$R_1 = R_2 = 48/2 + 25.9 + 14.9 = 64.8^k$

$M_{LL} = 64.8 \times 2 + 49.9 \times 5 + 24 \times 5 = 499.1$ ft·k

$\sigma_{LL} = \dfrac{499.1 \times 12}{355 \text{ in}^3} = 16.9^{ksi} \Rightarrow \epsilon_{test} = \underline{583 \mu\epsilon}$

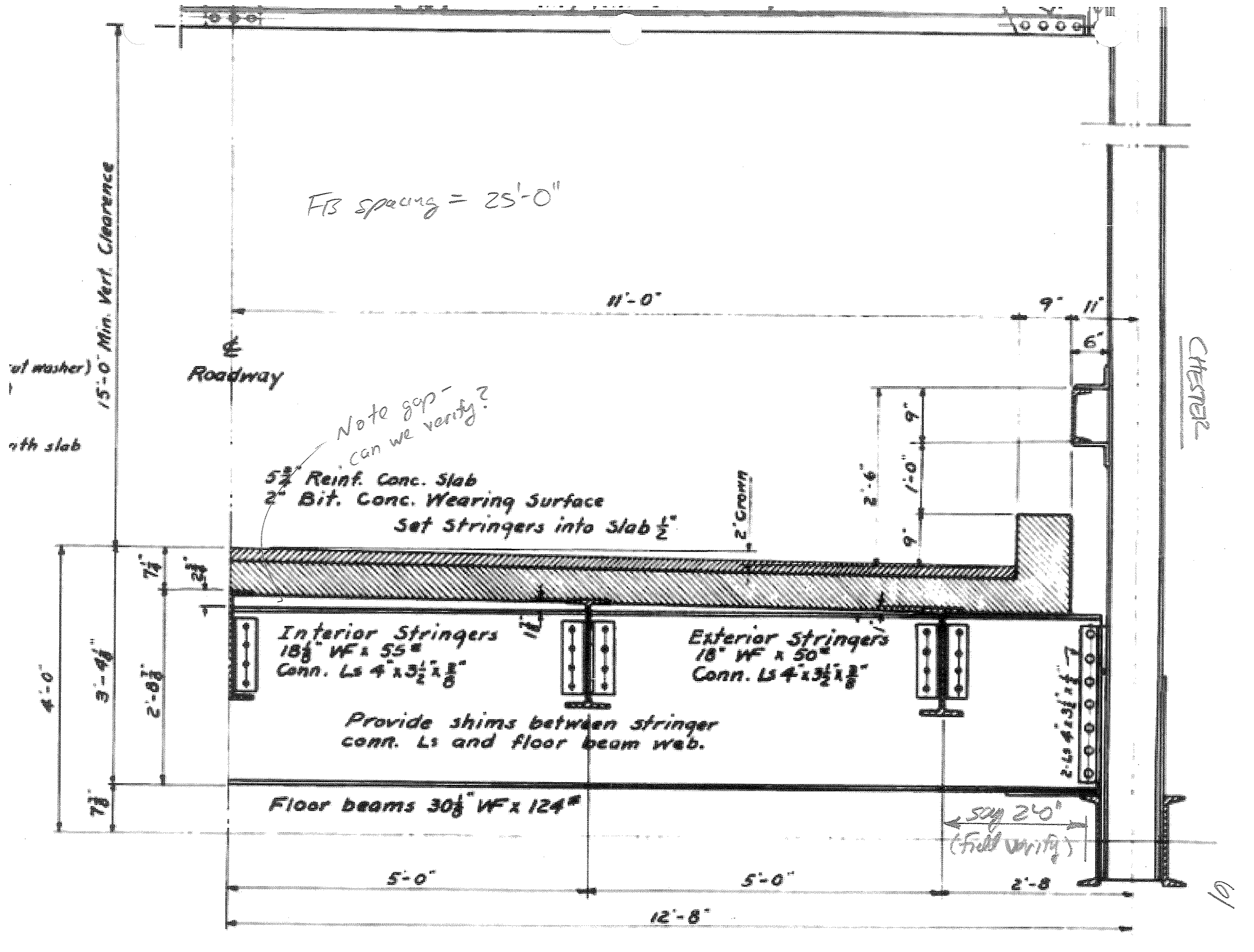
– say 3" ws today

$DL \simeq \left(\dfrac{8.75}{12} \times 150 \times 5' + 55\right) \dfrac{\times 25'}{1000} = 15^k/\text{stringer}$

$M_{DL} = \dfrac{15 \times 24}{4} + 2 \times 15 \times \left(\dfrac{7 \times 17}{24} \times \dfrac{12}{17}\right) + 2 \times 15 \times \left(\dfrac{2 \times 22}{24} \times \dfrac{12}{22}\right) + \dfrac{0.124 \times 24^2}{8}$

$= 90 + 105 + 30 + 8.93 = 234$ ft·k

$\sigma_{DL} = \dfrac{234 \times 12}{355} = 7.91^{ksi} \sim \quad FS \simeq \dfrac{33}{16.9 + 7.91} = 1.33$



CHESTER
FB spacing = 25'-0"
15'-0" Min. Vert. Clearance
℄ Roadway
11'-0"
9"
11"
6"
9"
1'-0"
9"
2'-6"
2" Crown
Note gap - can we verify?
5¾" Reinf. Conc. Slab
2" Bit. Conc. Wearing Surface
Set Stringers into Slab ½"
Interior Stringers
18⅛" WF x 55#
Conn. Ls 4" x 3½" x ⅜"
Exterior Stringers
18" WF x 50#
Conn. Ls 4" x 3½" x ⅜"
2-Ls 4" x 3½" x ⅜"
Provide shims between stringer conn. Ls and floor beam web.
Floor beams 30⅛" WF x 124#
say 2'0" (field verify)
4'-0"
3'-4⅝"
2'-8⅞"
7¼"
7⅜"
5'-0"
5'-0"
2'-8"
12'-8"
al washer)
nth slab

T? - INDIAN PURCHASE - PRELIMINARY FB ANALYSIS

W. DAVIDS
3/11/2014

REFER TO P.4 – stringer spacing = 5'-3" & FB SP. = 30'

COEFF. TOP-TO-BOTTOM =

$$\frac{30-15.83'-4.33'}{30} = 0.328$$

$$\frac{30-4.33}{30} = 0.856$$

$$1.0$$

$$\frac{30-7.5}{30} = 0.75$$

$$\frac{30-7.5-4.33}{30} = 0.606$$

$$\frac{30-7.5-4.33-15.83'}{30} = 0.078$$ (steer axle on lower truck contributes)

3.45 — 3.212×10 = 32.12

$$P_1 = \frac{2.05}{5.25}\left((0.328+0.078)\times 8.5 + (0.856+1.0+0.75+0.606)\times 10\right) = \frac{2.05}{5.25}\times 35.6 = 13.9^k$$

$$P_2 = \left(\frac{3.2}{5.25} + \frac{1.3}{5.25}\right)\times 35.6 = 30.5^k$$

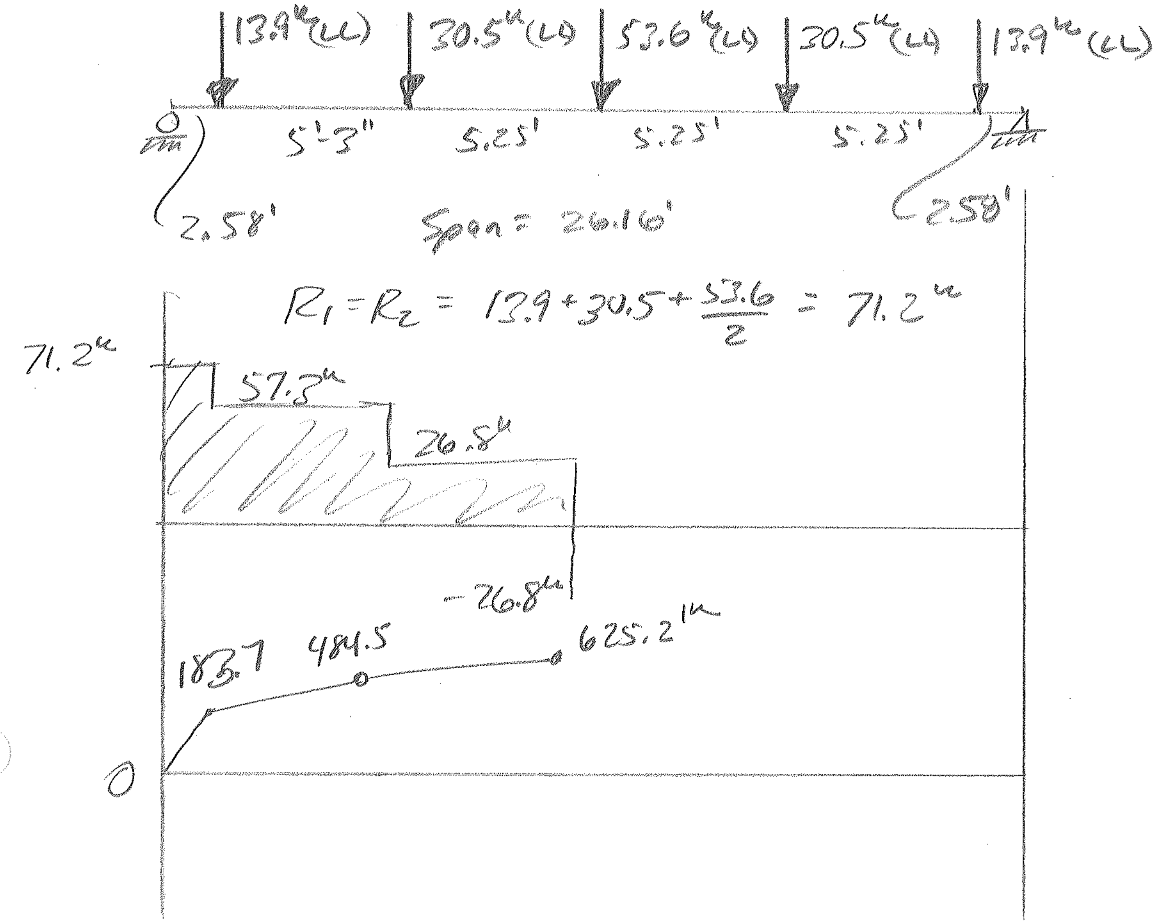
$$P_3 = \left(\frac{3.95}{5.25} + \frac{3.95}{5.25}\right)\times 35.6 = 53.6^k$$

$$P_4 = \left(\frac{1.3}{5.25} + \frac{3.2}{5.25}\right)\times 35.6 = 30.5^k$$

$$P_5 = \frac{2.05}{5.25}\times 35.6 = 13.9^k$$

T3 - INDIAN PURCHASE - PRELIMINARY FS ANALYSIS

W. DAVIDS
3/11/2014



$$\sigma_{LL} = \frac{625.2 \times 12}{504 \text{ in}^3} = 14.9^{ksi} \Rightarrow \epsilon \approx 514\mu\epsilon$$

(W36×150

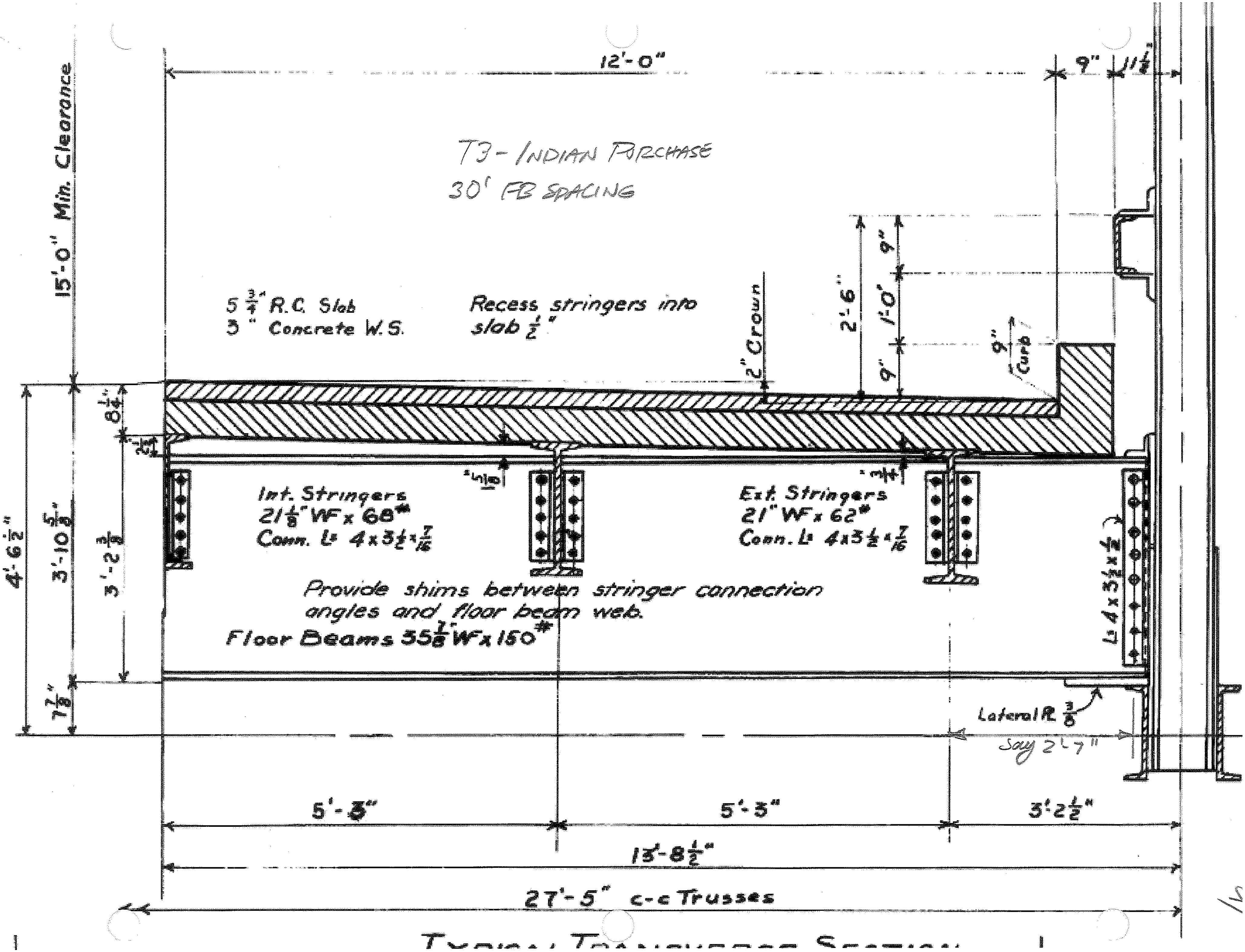
$$DL/\text{stringer} \approx \left(\frac{8.75''}{12} \times 5.25' \times 150 + 68\right) \frac{\times 30'}{1000} \approx 19.3^k$$

$$M_{DL} \approx \frac{19.3^k \times 26.2'}{4} + \left(\frac{19.3 \times 7.25 \times 18.35}{26.2} \times \frac{13.1}{18.75}\right) \times 2 + \frac{19.3 \times 2.6 \times 23.6}{26.2} \times \frac{13.1}{23.6} \times 2$$

$$+ \frac{0.150 \times 26.2^2}{8} \approx 126.4 + 141.1 + 50.2 + 12.9 = 331^{k'}$$

$$\sigma_{DL} = \frac{331 \times 12}{504} = 7.9^{ksi}$$

$$FS \approx \frac{33}{14.9 + 7.9} = 1.45 \leftarrow \underline{OK}$$



T3 - INDIAN PURCHASE
30' FB SPACING
12'-0"
9"
$11\frac{1}{4}$"
15'-0" Min. Clearance
$5\frac{3}{4}$" R.C. Slab
3" Concrete W.S.
Recess stringers into slab $\frac{1}{2}$"
2" Crown
2'-6"
9"
1'-0"
9"
9" Curb
$8\frac{1}{4}$"
Int. Stringers
$21\frac{1}{8}$" WF x 68#
Conn. Ls $4 \times 3\frac{1}{2} \times \frac{7}{16}$
Ext. Stringers
21" WF x 62#
Conn. Ls $4 \times 3\frac{1}{2} \times \frac{7}{16}$
Ls $4 \times 3\frac{1}{2} \times \frac{1}{2}$
Provide shims between stringer connection angles and floor beam web.
Floor Beams $35\frac{1}{8}$" WF x 150#
$4'\text{-}6\frac{1}{2}$"
$3'\text{-}10\frac{5}{8}$"
$3'\text{-}2\frac{3}{8}$"
$7\frac{7}{8}$"
Lateral Pl. $\frac{3}{8}$
Say 2'-7"
5'-3"
5'-3"
$3'\text{-}2\frac{1}{2}$"
$13'\text{-}8\frac{1}{2}$"
27'-5" c-c Trusses