Bridge Load Testing
Bridges 1-450N, 486N, 487N, 487S, 489S, 492S
Route 13
Part I

by

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Harry Shenton
William W. Finch, Jr.

Department of Civil and Environmental Engineering
University of Delaware

June 2002

DELAWARE CENTER FOR TRANSPORTATION

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355 DuPont Hall
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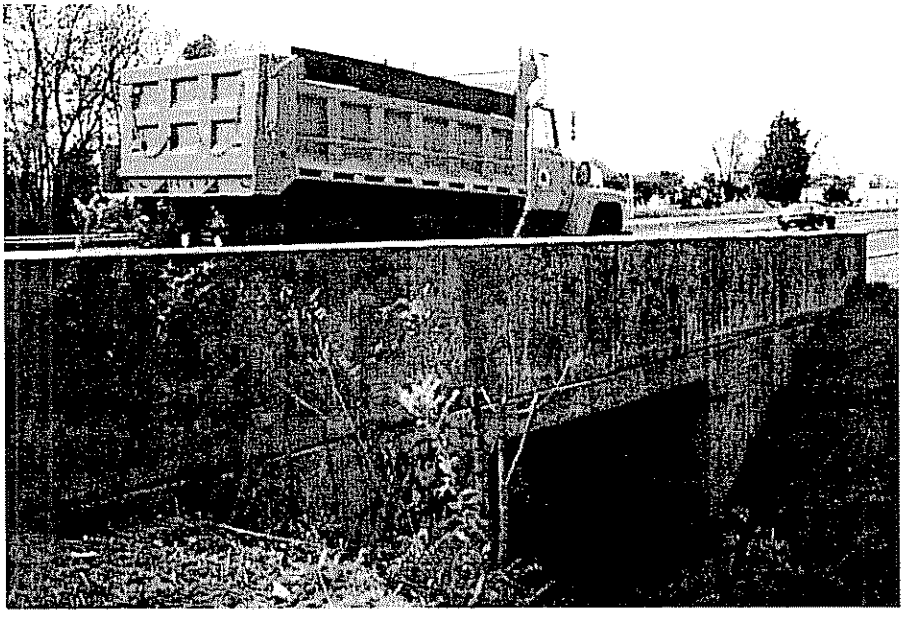
Bridge Load Testing

BRIDGES 1-450N, 486N, 487N, 487S, 489S, 492S
ROUTE 13



Final Report

Report Prepared by:

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Executive Summary

Six diagnostic load tests were conducted in November of 1999 on five of Delaware Bridges (Bridges 1-450N, 486N, 487N, 487S, 489S, 492S located on Rt. 13, N indicates northbound, S indicates southbound). The purpose of the tests was to evaluate the load carrying capacity of the short span slab bridges. One of the primary variables quantified was the transverse load distribution of the superstructure. Another very important variable was the longitudinal load distribution caused by the underlying concrete slab and fill.

The bridges, which carry State Rt. 13 north of Dover, were built in 1920's and 1930's (northbound 1931/2, southbound 1920). The bridges are essentially slab structures with spans ranging from 8 to 18 feet.

The bridges were tested using a pre-weighed 3-axle truck. The trucks used weighed roughly 30 tons. Exact weights and configurations are shown in SK1 to SK3. During each test, several load passes were conducted with strains being recorded during the passes. All passes were semi-static. Strain transducers were mounted on the underneath side of the slab to record longitudinal strains both in the span direction and across the width. Sketches SK4 to SK8 show the gage layouts used.

Results from the test indicate that the peak live-load strains were in all cases less than 10% of what was currently being predicted by the existing BRASS model (which is based on typical assumed parameters). Table 1 shows the comparison of predicted to measured peak strains. The primary reason for the low actual strains is the effect of the underlying material to distribute the load longitudinally. With the short spans, the load is distributed to the walls and does not create significant bending in the slabs.

The results also indicate better transverse load distribution. Experimentally computed effective widths are compared to those computed based on the AASHTO code in Table 2. Based on these values, distribution factors (DF) were computed and compared to code computed values in Table 3. One can see that the experimentally computed DF's are better (i.e. smaller) than suggested by the code. This is a common finding of bridge load testing since design DF's need to be somewhat conservative.

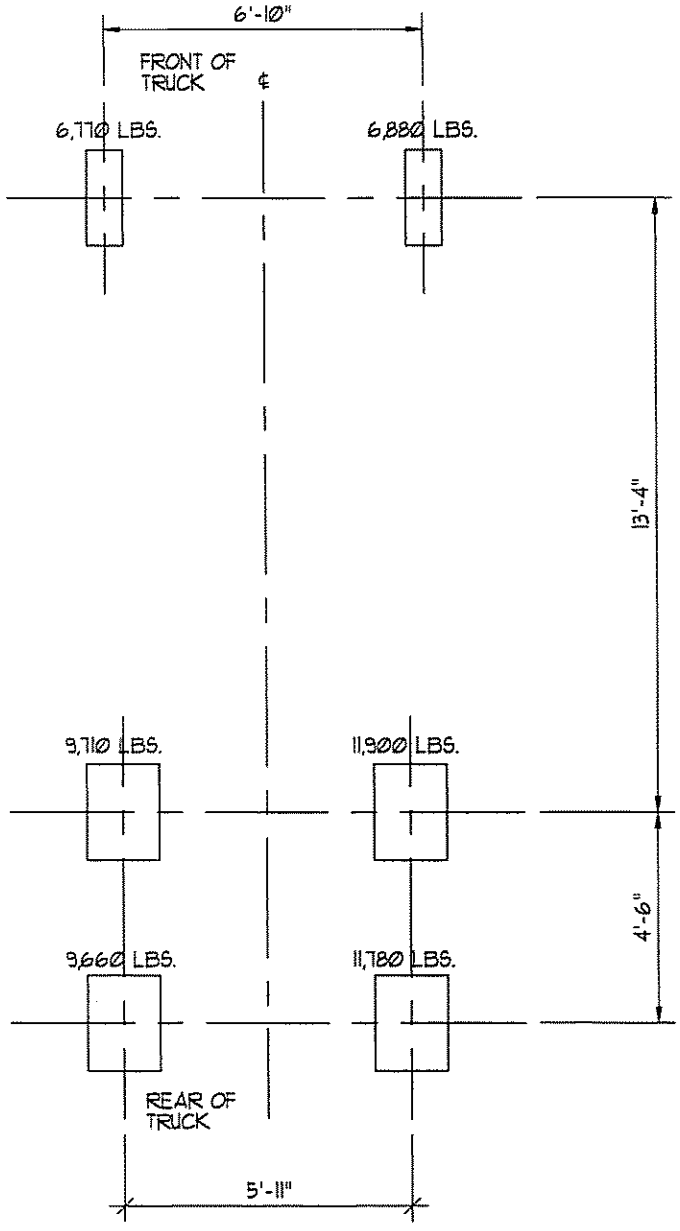
Revised bridge load ratings were computed based upon only the improved transverse load distribution by incorporating the experimental DF's into the existing BRASS files. The resulting

ratings are better in all cases and presented in Tables 1-1 through 5-2 for all six bridges. Please note that both northbound and southbound directions were not tested for all bridges (the slab is continuous across the width, carrying both directions). Based on the results of bridge 1-487 testing (both directions), and the similarity in designs of the north and southbound slabs, results from the test are used to rate both north and southbound bridges.

It should be noted that the actual bridge load carrying capacity is even higher than these ratings indicate because of the unusually high longitudinal load distribution. It was not deemed necessary to rely on this in order to get sufficient ratings. Furthermore, cores taken from some of these bridges indicate current concrete slab strengths in excess of 5,000 psi.

The remainder of this report presents the associated sketches, tables, and revised BRASS data files.

A.1 APPENDIX - SKETCHES



PLAN VIEW OF WEIGHED "TEN WHEEL" TRUCK USED TO TEST BRIDGE NUMBERS 489 & 492

N.T.S.

NOTES:

A. BOTH TESTS PERFORMED ON THE SOUTHBOUND SPANS.

B. BRIDGE TESTS PERFORMED ON NOVEMBER 13, 1998.

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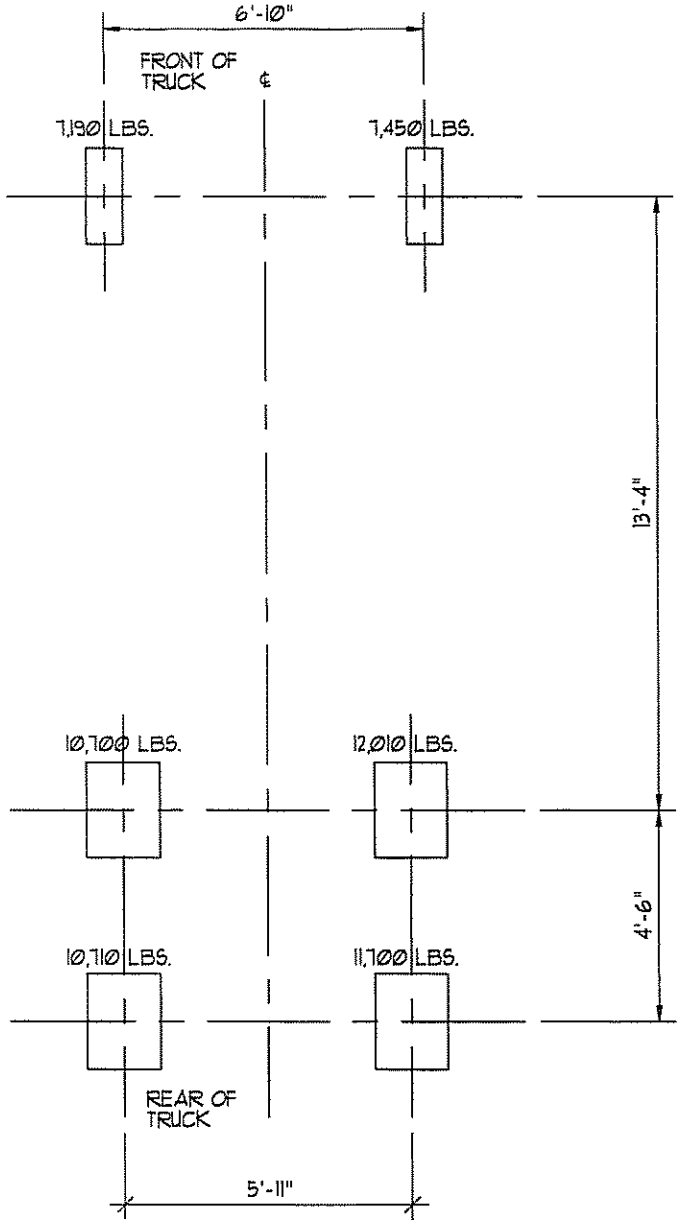

PLAN VIEW OF WEIGHED "TEN WHEEL" TRUCK USED TO TEST BRIDGE NUMBER 487, NORTH & SOUTHBOUND

N.T.S.

NOTE: BRIDGE TEST PERFORMED ON NOVEMBER 16, 1998.

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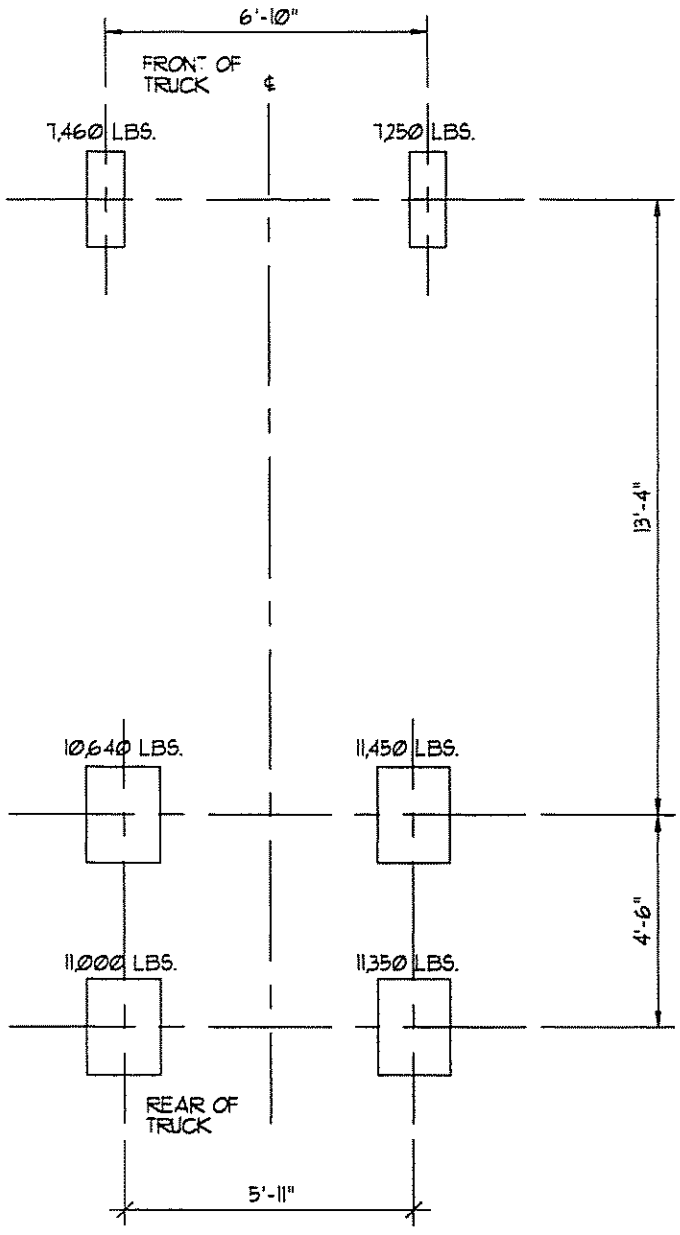

PLAN VIEW OF WEIGHED "TEN WHEEL" TRUCK USED TO TEST BRIDGE NUMBERS 450 & 486

N.T.S.

NOTES:

A. BOTH TESTS PERFORMED ON THE NORTHBOUND SPANS.

B. BRIDGE TESTS PERFORMED ON NOVEMBER 18, 1998.

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TITLE:
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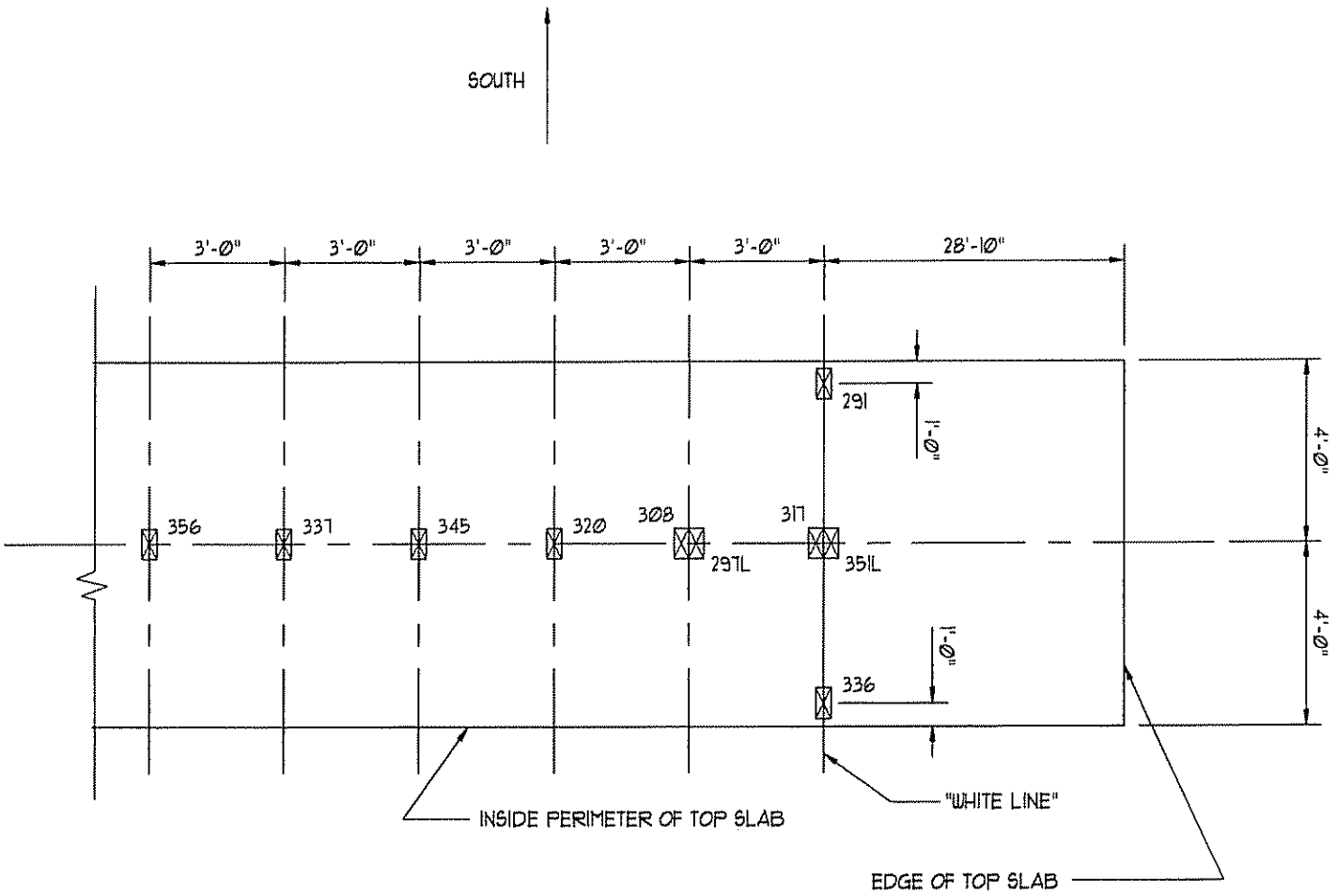
APPROVED BY:
SCALE: AS NOTED.
DATE: 11-18-98

DWG NO.
SK4

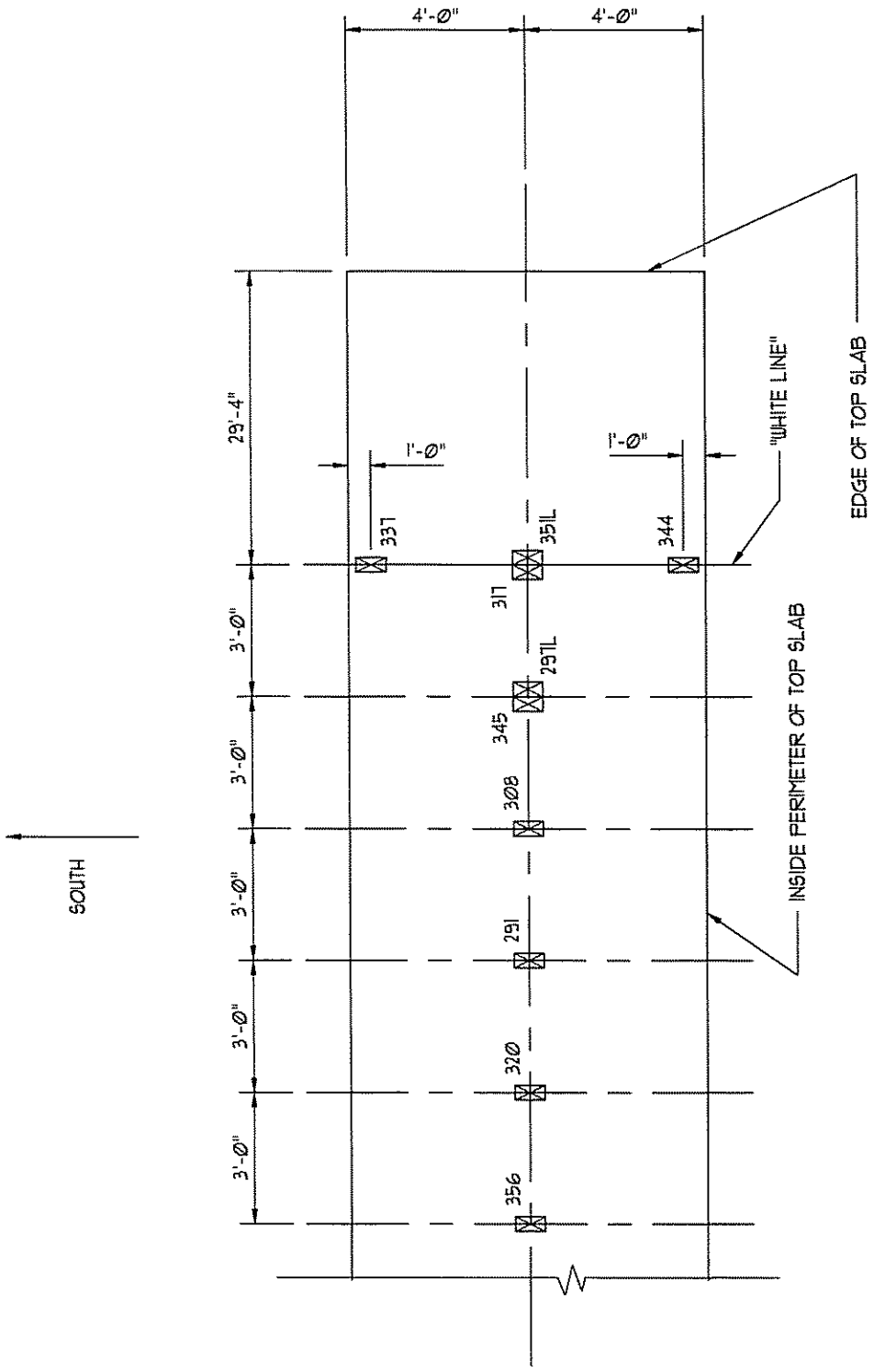


PLAN VIEW OF INSTRUMENTED TOP SLAB, BRIDGE NO. 489

N.T.S.

⊠ = LONGITUDINAL STRAIN TRANSDUCER

L = DENOTES TRANSDUCER WITH A 12" GAGE LENGTH.



PLAN VIEW OF INSTRUMENTED TOP SLAB, BRIDGE NO. 492

N.T.S.

☒ = LONGITUDINAL STRAIN TRANSDUCER

L = DENOTES TRANSDUCER WITH A 12" GAGE LENGTH.

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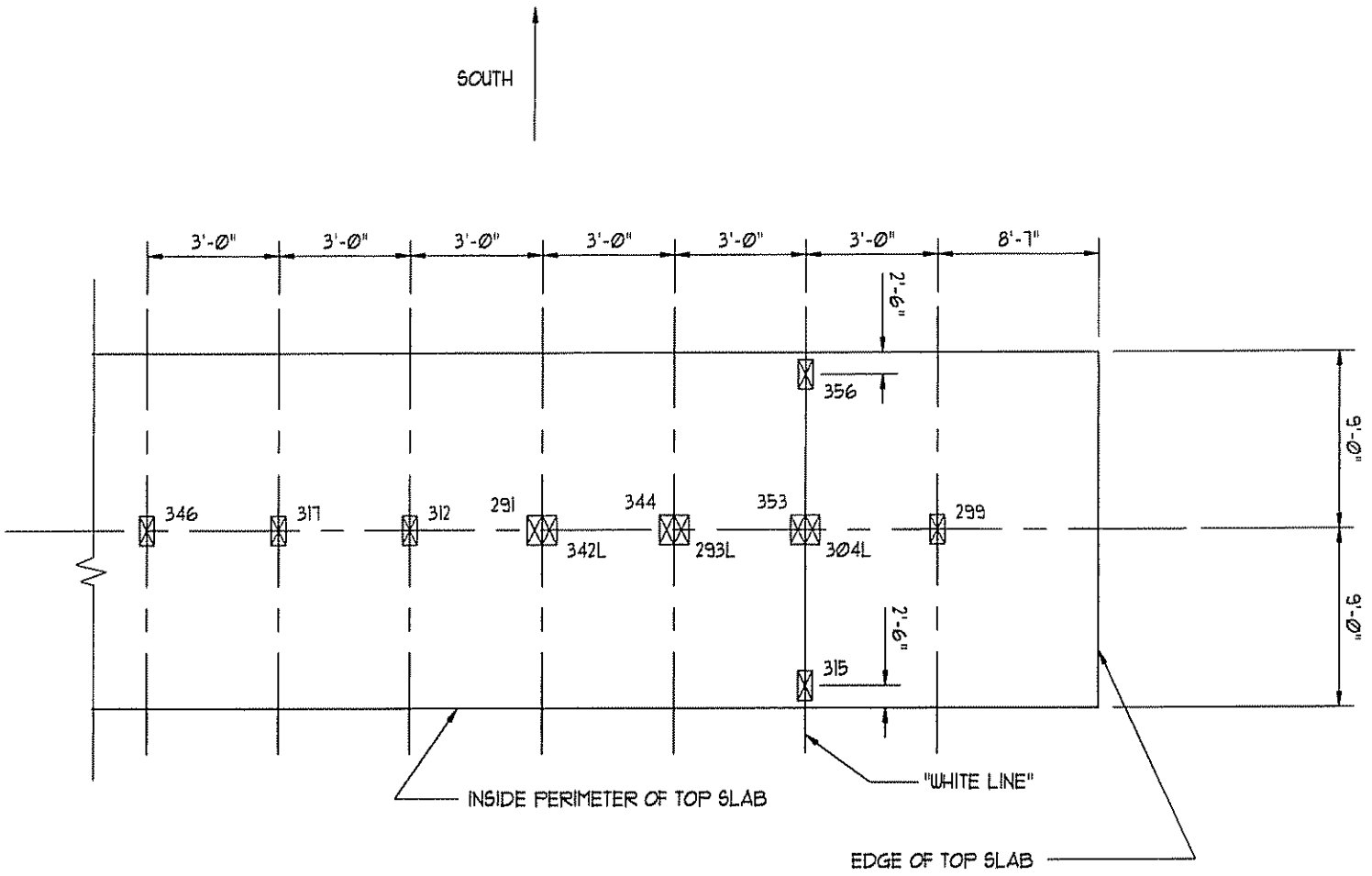
SCALE: AS NOTED.
DATE: 11-18-98

DWG NO.
SK6



PLAN VIEW OF INSTRUMENTED TOP SLAB, BRIDGE NO. 487 SOUTHBOUND

N.T.S.

⊠ = LONGITUDINAL STRAIN TRANSDUCER

L = DENOTES TRANSDUCER WITH A 12" GAGE LENGTH.

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TITLE:

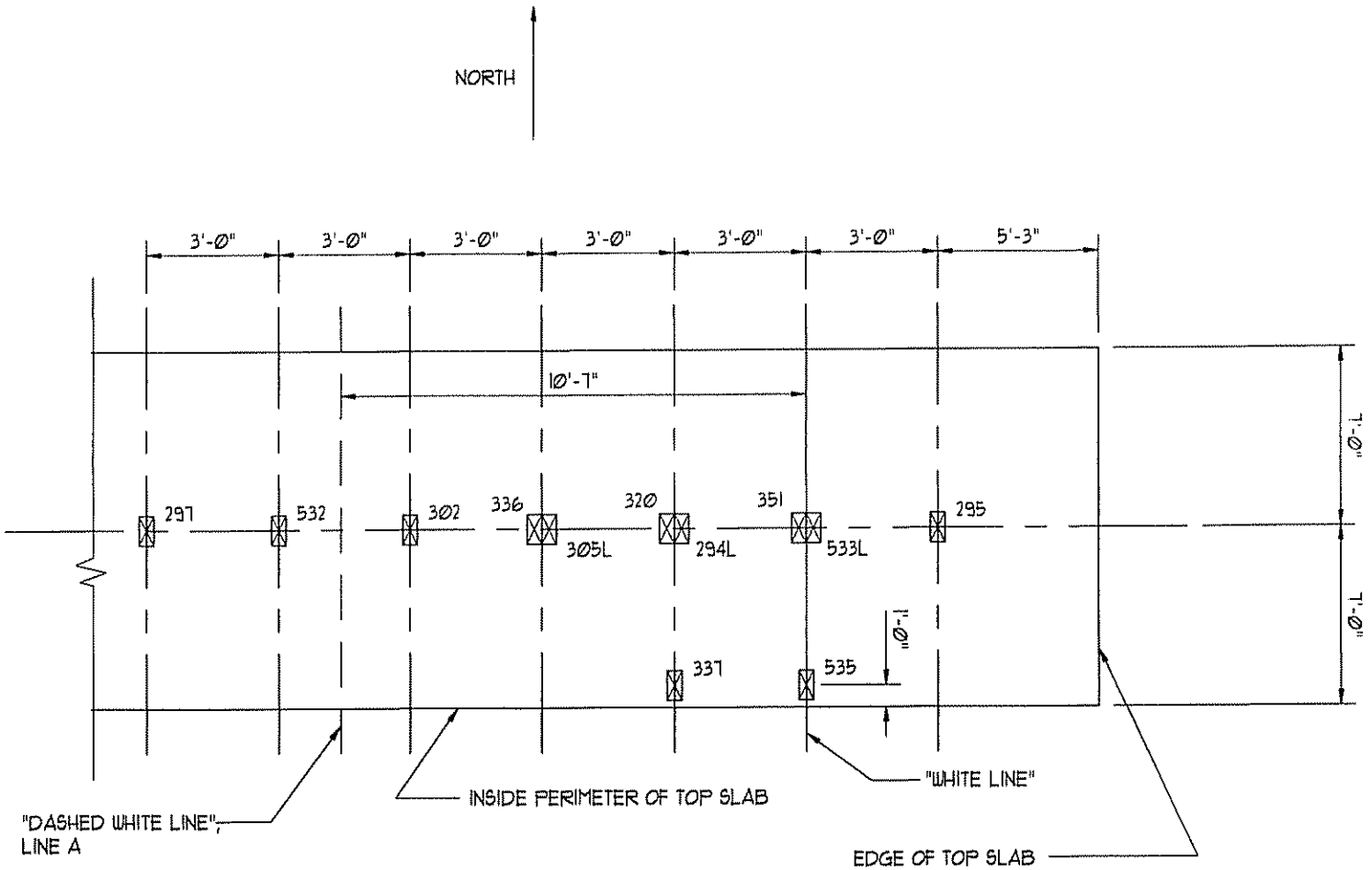
DRAWN BY:

APPROVED BY:

SCALE: AS NOTED.

DATE: 11-18-98

DWG NO. SK7



PLAN VIEW OF INSTRUMENTED TOP SLAB, BRIDGE NO. 487 NORTHBOUND

N.T.S.

⊠ = LONGITUDINAL STRAIN TRANSDUCER

L = DENOTES TRANSDUCER WITH A 12" GAGE LENGTH.

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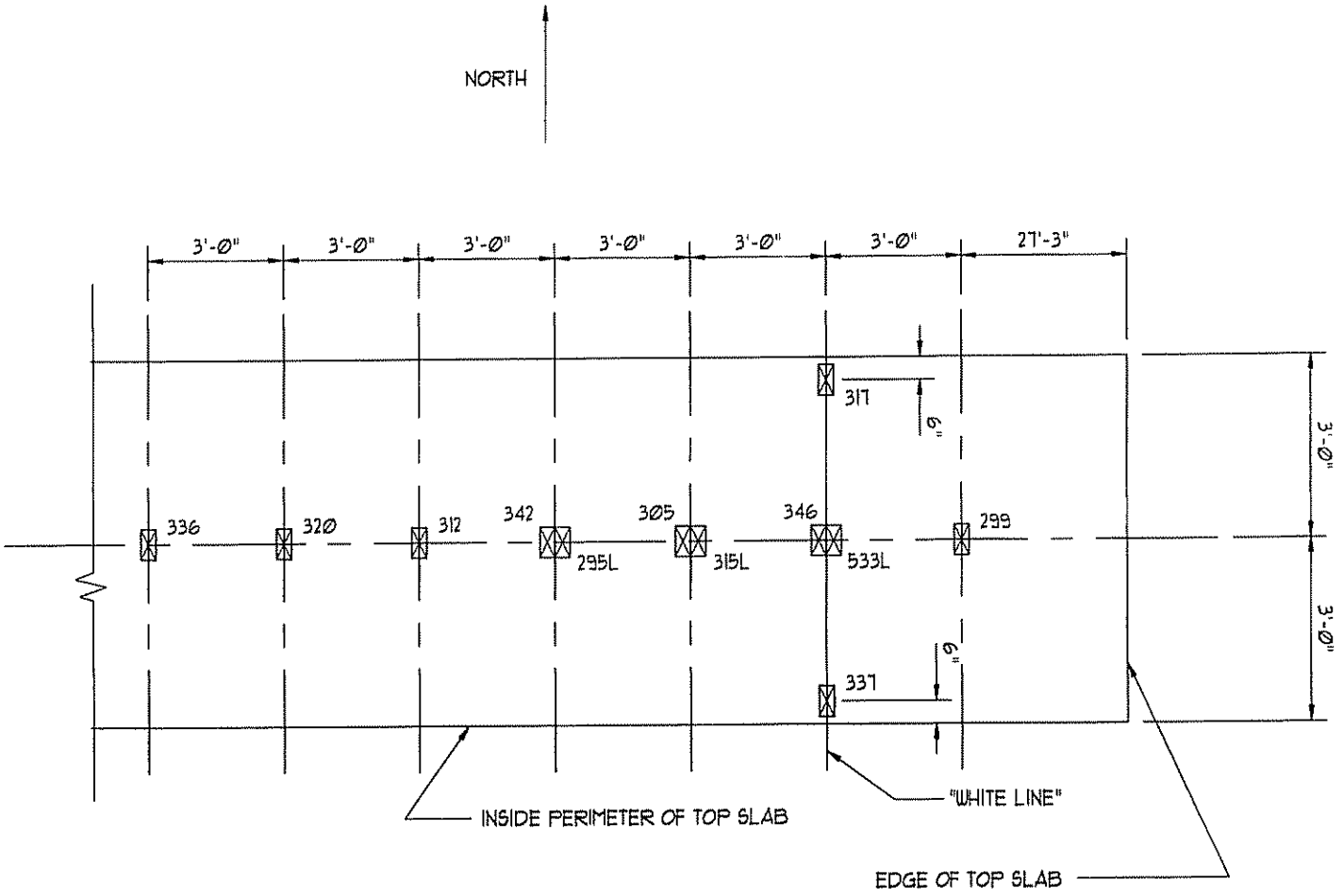
DOVER, DELAWARE

TITLE:
DRAWN BY:
APPROVED BY:
SCALE: AS NOTED.
DATE: 11-18-98
DWG NO. SK8



PLAN VIEW OF INSTRUMENTED TOP SLAB, BRIDGE NO. 486

N.T.S.

⊠ = LONGITUDINAL STRAIN TRANSDUCER

L = DENOTES TRANSDUCER WITH A 12" GAGE LENGTH.

A.2 APPENDIX - TABLES

TABLE 1: Measured vs. Predicted Strains

BRIDGE NO.	Peak Strain Measured (microstrain)	Peak Strain Predicted (microstrain)	Measured/Predicted
450 north	12	321	0.037
486 north	11	204	0.054
487 south	17	172	0.099
487 north	12	220	0.055
489 south	11	297	0.037
492 south	11	261	0.042

TABLE 2: Compilation of Effective Widths

BRIDGE NO.	Length (feet)	$AASHTO_{old}$ (multiple lanes) (feet)	$AASHTO_{new}$ (1 lane) (feet)	$AASHTO_{new}$ (multiple lanes) (feet)	EXPERIMENTAL (Pass 1) (feet)	EXPERIMENTAL (Pass 2) (feet)
450 north	10.17	4.61	6.68	4.98	8.77	9.28
486 north	6.09	4.37	5.28	4.65	9.93	10.45
487 south	16.5	4.99	8.37	5.39	15.37	13.84
487 north	14.19	4.85	7.79	5.25	12.99	17.63
489 south	8.17	4.49	6.04	4.83	7.94	7.26
492 south	8.17	4.49	6.04	4.83	8.26	12.45

TABLE 3: Compilation of Distribution Factors

BRIDGE NO.	Length (feet)	$AASHTO_{old}$ (multiple lanes)	$AASHTO_{new}$ (1 lane)	$AASHTO_{new}$ (multiple lanes)	EXPERIMENTAL (multiple lanes)
450 north	10.17	0.217	0.150	0.201	0.153
486 north	6.09	0.229	0.189	0.215	0.114
487 south	14.19	0.200	0.120	0.186	0.112
487 north	14.19	0.206	0.128	0.190	0.114
489 south	8.17	0.223	0.166	0.207	0.172
492 south	8.17	0.223	0.166	0.207	0.151

Table 1-1: Load Rating Comparisons for Bridge 450 north

Rating Vehicle	Existing Rating			New Rating		
	INV	OPER	POST	INV	OPER	POST
HS20T	0.63	1.05	1.05	0.91	1.52	1.52
S220	1.00	1.67	1.67	1.46	2.44	2.44
S335	0.66	1.11	1.11	0.96	1.61	1.61
S437	0.85	1.42	1.42	1.24	2.07	2.07
T330	1.00	1.67	1.67	1.46	2.44	2.44
T435	0.84	1.40	1.40	1.22	2.03	2.03
T540	0.81	1.35	1.35	1.18	1.96	1.96

Table 1-2: Load Rating Comparisons for Bridge 450 south

Rating Vehicle	Existing Rating			New Rating		
	INV	OPER	POST	INV	OPER	POST
HS20T	0.71	1.19	1.19	1.07	1.78	1.78
S220	1.14	1.90	1.90	1.70	2.85	2.85
S335	0.75	1.26	1.26	1.13	1.88	1.88
S437	0.97	1.61	1.61	1.45	2.42	2.42
T330	1.14	1.90	1.90	1.70	2.85	2.85
T435	0.95	1.58	1.58	1.42	2.37	2.37
T540	0.92	1.53	1.53	1.37	2.29	2.29

Table 2-1: Load Rating Comparisons for Bridge 486 north

Rating Vehicle	Existing Rating			New Rating		
	INV	OPER	POST	INV	OPER	POST
HS20T	1.20	2.00	2.00	1.77	2.95	2.95
S220	1.92	3.20	3.20	2.83	4.72	4.72
S335	1.42	2.37	2.37	2.09	3.50	3.50
S437	2.02	3.37	3.37	2.98	4.97	4.97
T330	1.92	3.20	3.20	2.83	4.72	4.72
T435	1.92	3.20	3.20	2.83	4.72	4.72
T540	1.92	3.20	3.20	2.83	4.72	4.72

Table 2-2: Load Rating Comparisons for Bridge 486 south

Rating Vehicle	Existing Rating			New Rating		
	INV	OPER	POST	INV	OPER	POST
HS20T	0.77	1.29	1.29	1.16	1.93	1.93
S220	1.24	2.07	2.07	1.85	3.09	3.09
S335	0.92	1.53	1.53	1.37	2.29	2.29
S437	1.30	2.18	2.18	1.95	3.25	3.25
T330	1.24	2.07	2.07	1.85	3.09	3.09
T435	1.24	2.07	2.07	1.85	3.09	3.09
T540	1.24	2.07	2.07	1.85	3.09	3.09

Table 3-1: Load Rating Comparisons for Bridge 487 north

Rating Vehicle	Existing Rating			New Rating		
	INV	OPER	POST	INV	OPER	POST
HS20T	0.70	1.17	1.17	1.38	2.30	2.30
S220	1.12	1.88	1.88	2.21	3.68	3.68
S335	0.61	1.02	1.02	1.20	2.01	2.01
S437	0.69	1.15	1.15	1.35	2.25	2.25
T330	1.12	1.88	1.88	2.21	3.68	3.68
T435	0.78	1.30	1.30	1.53	2.56	2.56
T540	0.78	1.30	1.30	1.53	2.56	2.56

Table 3-2: Load Rating Comparisons for Bridge 487 south

Rating Vehicle	Existing Rating			New Rating		
	INV	OPER	POST	INV	OPER	POST
HS20T	1.09	1.82	1.82	2.04	3.40	3.40
S220	1.74	2.91	2.91	3.26	5.44	5.44
S335	0.90	1.50	1.50	1.68	2.80	2.80
S437	0.95	1.59	1.59	1.79	2.98	2.98
T330	1.74	2.91	2.91	3.26	5.44	5.44
T435	1.15	1.91	1.91	2.14	3.58	3.58
T540	1.15	1.91	1.91	2.14	3.58	3.58

Table 4-1: Load Rating Comparisons for Bridge 489 north

Rating Vehicle	Existing Rating			New Rating		
	INV	OPER	POST	INV	OPER	POST
HS20T	0.57	0.95	0.95	0.75	1.25	1.25
S220	0.91	1.52	1.52	1.20	2.00	2.00
S335	0.67	1.12	1.12	0.89	1.48	1.48
S437	0.96	1.60	1.60	1.26	2.11	2.11
T330	0.91	1.52	1.52	1.20	2.00	2.00
T435	0.87	1.46	1.46	1.15	1.92	1.92
T540	0.91	1.52	1.52	1.20	2.00	2.00

Table 4-2: Load Rating Comparisons for Bridge 489 south

Rating Vehicle	Existing Rating			New Rating		
	INV	OPER	POST	INV	OPER	POST
HS20T	0.62	1.04	1.04	0.82	1.38	1.38
S220	1.00	1.67	1.67	1.32	2.20	2.20
S335	0.74	1.23	1.23	0.98	1.63	1.63
S437	1.05	1.75	1.75	1.39	2.32	2.32
T330	1.00	1.67	1.67	1.32	2.20	2.20
T435	0.96	1.60	1.60	1.27	2.12	2.12
T540	1.00	1.67	1.67	1.32	2.20	2.20

Table 5-1: Load Rating Comparisons for Bridge 492 north

Rating Vehicle	Existing Rating			New Rating		
	INV	OPER	POST	INV	OPER	POST
HS20T	0.57	0.95	0.95	0.85	1.42	1.42
S220	0.91	1.52	1.52	1.36	2.28	2.28
S335	0.67	1.12	1.12	1.01	1.69	1.69
S437	0.96	1.60	1.60	1.44	2.40	2.40
T330	0.91	1.52	1.52	1.36	2.28	2.28
T435	0.87	1.46	1.46	1.31	2.19	2.19
T540	0.91	1.52	1.52	1.36	2.28	2.28

Table 5-2: Load Rating Comparisons for Bridge 492 south

Rating Vehicle	Existing Rating			New Rating		
	INV	OPER	POST	INV	OPER	POST
HS20T	0.62	1.04	1.04	0.82	1.38	1.38
S220	1.00	1.67	1.67	1.32	2.20	2.20
S335	0.74	1.23	1.23	0.98	1.63	1.63
S437	1.05	1.75	1.75	1.39	2.32	2.32
T330	1.00	1.67	1.67	1.32	2.20	2.20
T435	0.96	1.60	1.60	1.27	2.12	2.12
T540	1.00	1.67	1.67	1.32	2.20	2.20

A.3 APPENDIX – REVISED BRASS FILES

TITLE BRIDGE NO. 1-450N, US RTE 13 NB OVER HERRON RUN
TITLE 1 SPAN CONCRETE SLAB, BUILT IN 1931 - CONTRACT NO. 220
ANL 1,0,2
XSA 1
XSB 12
XSG 1,2.4,6,1.5
SPA 1,10.17,1,10
SPC 1,10.17,1
FIX 1,1,0,1,1,0
COM *NOTE*: f'c WAS CHANGED to 4 ksi Based on Testing of Cores
PRC 150, ,11,4,33
DLD 1,0.25
COM *NOTE*: Live Load Dist. Factor WAS CHANGED to 0.153 from 0.217
COM Based on Field Test Results
LLD 3, 0.153,67.0, 50.0
TR1 HS20T,S220,S335,S437,T330,T435
TR2 T540
DES 3,1
COM POSTING LEVEL 4
OPG 1.3,1.0,1.00
PST 1.3,1.0,1.00
CR1 105.
CR2 1

TITLE BRIDGE NO. 1-450S, US RTE 13 SB OVER HERRON RUN
TITLE 1 SPAN CONCRETE SLAB, BUILT IN 1920 - CONTRACT NO. 27
ANL 1,0,2
XSA 1
XSB 12
XSG 1,2.18,6,1.5
SPA 1,10.17,1,12
SPC 1,10.17,1
FIX 1,1,0,1,1,0
COM *NOTE*: f'c WAS CHANGED to 4 ksi Based on Testing of Cores
PRC 150, ,11,4,33
DLD 1,0.25
COM *NOTE*: Live Load Dist. Factor WAS CHANGED to 0.153 from 0.217
COM Based on Field Test Results
LLD 3, 0.153, 67.0, 50.0
TR1 HS20T,S220,S335,S437,T330,T435
TR2 T540
DES 3,1
COM POSTING LEVEL 4
OPG 1.3,1.0,1.00
PST 1.3,1.0,1.00
CR1 105.
CR2 1

TITLE BRIDGE NO. 1-486N, US RTE 13 NB OVER HANGMANS RUN
TITLE 1 SPAN CONCRETE SLAB, BUILT IN 1931 - CONTRACT NO. 182
ANL 1,0,2
XSA 1
XSB 12
XSG 1,2.4,5,2.0
SPA 1,6.09,1,10
SPC 1,6.09,1
FIX 1,1,0,1,1,0
COM *NOTE*: f'c WAS CHANGED to 4 ksi Based on Testing of Cores
PRC 150, ,11,4,33
DLD 1,0.460
COM *NOTE*: Live Load Dist. Factor WAS CHANGED to 0.114 from 0.163
COM Based on Field Test Results
LLD 3, 0.114, 0.0, 50.0
TR1 HS20T,S220,S335,S437,T330,T435
TR2 T540
DES 3,1
COM POSTING LEVEL 4
OPG 1.3,1.0,1.00
PST 1.3,1.0,1.00
CR1 105.
CR2 1

TITLE BRIDGE NO. 1-486S, US RTE 13 SB OVER HANGMANS RUN
TITLE 1 SPAN CONCRETE SLAB, BUILT IN 1920 - CONTRACT NO. 28
ANL 1,0,2
XSA 1
XSB 12
XSG 1,1.935,5,2.0
SPA 1,6.09,1,10
SPC 1,6.09,1
FIX 1,1,0,1,1,0
COM *NOTE*: f'c WAS CHANGED to 4 ksi Based on Testing of Cores
PRC 150, ,11,4,30
DLD 1,0.460
COM *NOTE*: Live Load Dist. Factor WAS CHANGED to 0.114 from 0.163
COM Based on Field Test Results
LLD 3, 0.114, 0.0, 50.0
TR1 HS20T,S220,S335,S437,T330,T435
TR2 T540
DES 3,1
COM POSTING LEVEL 4
OPG 1.3,1.0,1.00
PST 1.3,1.0,1.00
CR1 105.
CR2 1

TITLE BRIDGE NO. 1-487N, US RTE 13 NB OVER SANDOM BRANCH
TITLE 1 SPAN CONCRETE SLAB, BUILT IN 1931 - CONTRACT NO. 220
ANL 1,0,2
XSA 1
XSB 12
XSG 1,2.0,7,2.0
SPA 1,14.19,1,15
SPC 1,14.19,1
FIX 1,1,0,1,1,0
COM *NOTE*: f'c WAS CHANGED to 4 ksi Based on Testing of Cores
PRC 150, ,11,4,33
DLD 1,0.25
COM *NOTE*: Live Load Dist. Factor WAS CHANGED to 0.112 from 0.206
COM Based on Field Test Results
LLD 3, 0.112, 67.0, 50.0
TR1 HS20T,S220,S335,S437,T330,T435
TR2 T540
DES 3,1
COM POSTING LEVEL 4
OPG 1.3,1.0,1.00
PST 1.3,1.0,1.00
CR1 105.
CR2 1

TITLE BRIDGE NO. 1-487S, US RTE 13 SB OVER SANDOM BRANCH
TITLE 1 CELL FRAME BUILT IN 1920, CONTRACT NO. 27
ANL 1,0,2
XSA 1
XSB 12
XSG 1,2.0,8,2.0
SPA 1,16.5,1,18
SPC 1,16.5,1
FIX 1,1,0,1,1,0
COM *NOTE*: f'c WAS CHANGED to 4 ksi Based on Testing of Cores
PRC 150, ,11,4,33
DLD 1,0.23
COM *NOTE*: Live Load Dist. Factor WAS CHANGED to 0.114 from 0.206
COM Based on Field Test Results
LLD 3, 0.114, 67.0, 50.0
TR1 HS20T,S220,S335,S437,T330,T435
TR2 T540
DES 3,1
COM POSTING LEVEL 3
OPG 1.3,1.0,1.00
PST 1.3,1.0,1.00
CR1 105.
CR2 1

TITLE BRIDGE NO. 1-489N, US RTE 13 NB OVER CREEK
TITLE 1 CELL FRAME BUILT IN 1932, CONTRACT NO. 262
ANL 1,0,2
XSA 1
XSB 12
XSG 1,2.4,5,1.5
SPA 1,8.17,1,10
SPC 1,8.17
FIX 1,1,0,1,1,0
COM *NOTE*: f'c WAS CHANGED to 4 ksi Based on Testing of Cores
PRC 150, ,11,4,33
DLD 1,0.255
COM *NOTE*: Live Load Dist. Factor WAS CHANGED to 0.172 from 0.220
COM Based on Field Test Results
LLD 3, 0.172, 67.0, 50.0
TR1 HS20T,S220,S335,S437,T330,T435
TR2 T540
DES 3,1
OPG 1.3,1.0,1.00
COM POSTING LEVEL 4
PST 1.3,1.0,1.00
CR1 105.
CR2 1

TITLE BRIDGE NO. 1-489S, US RTE 13 SB OVER CREEK
TITLE 1 CELL FRAME BUILT IN 1920, CONTRACT NO. 27
ANL 1,0,2
XSA 1
XSB 12
XSG 1,2.0,6,1.5
SPA 1,8.17,1,10
SPC 1,8.17
FIX 1,1,0,1,1,0
COM *NOTE*: f'c WAS CHANGED to 4 ksi Based on Testing of Cores
PRC 150, ,11,4,30
DLD 1,0.255
COM *NOTE*: Live Load Dist. Factor WAS CHANGED to 0.172 from 0.220
COM Based on Field Test Results
LLD 3, 0.172, 67.0, 50.0
TR1 HS20T,S220,S335,S437,T330,T435
TR2 T540
DES 3,1
OPG 1.3,1.0,1.00
COM POSTING LEVEL 4
PST 1.3,1.0,1.00
CR1 105.
CR2 1

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TITLE BRIDGE NO. 1-492N, US RTE 13 NB OVER SAWMILL BRANCH
TITLE 1 SPAN CONCRETE SLAB, BUILT IN 1932, CONTRACT NO. 262
ANL 1,0,2
XSA 1
XSB 12
XSG 1,2.4,5,1.5
SPA 1,8.17,1,10
SPC 1,8.17
FIX 1,1,0,1,1,0
COM *NOTE*: f'c WAS CHANGED to 4 ksi Based on Testing of Cores
PRC 150, ,11,4,33
DLD 1,0.255
COM *NOTE*: Live Load Dist. Factor WAS CHANGED to 0.151 from 0.220
COM Based on Field Test Results
LLD 3, 0.151, 67.0, 50.0
TR1 HS20T,S220,S335,S437,T330,T435
TR2 T540
DES 3,1
OPG 1.3,1.0,1.00
COM POSTING LEVEL 4
PST 1.3,1.0,1.00
CR1 105.
CR2 1
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TITLE BRIDGE NO. 1-492S, US RTE 13 SB OVER SAWMILL BRANCH
TITLE 1 SPAN CONCRETE SLAB, BUILT IN 1920, CONTRACT NO. 27
ANL 1,0,2
XSA 1
XSB 12
XSG 1,2.0,6,1.5
SPA 1,8.17,1,10
SPC 1,8.17
FIX 1,1,0,1,1,0
COM *NOTE*: f'c WAS CHANGED to 4 ksi Based on Testing of Cores
PRC 150, ,11,4,30
DLD 1,0.255
COM *NOTE*: Live Load Dist. Factor WAS CHANGED to 0.151 from 0.220
COM Based on Field Test Results
LLD 3, 0.151, 67.0, 50.0
TR1 HS20T,S220,S335,S437,T330,T435
TR2 T540
DES 3,1
OPG 1.3,1.0,1.00
COM POSTING LEVEL 4
PST 1.3,1.0,1.00
CR1 105.
CR2 1
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