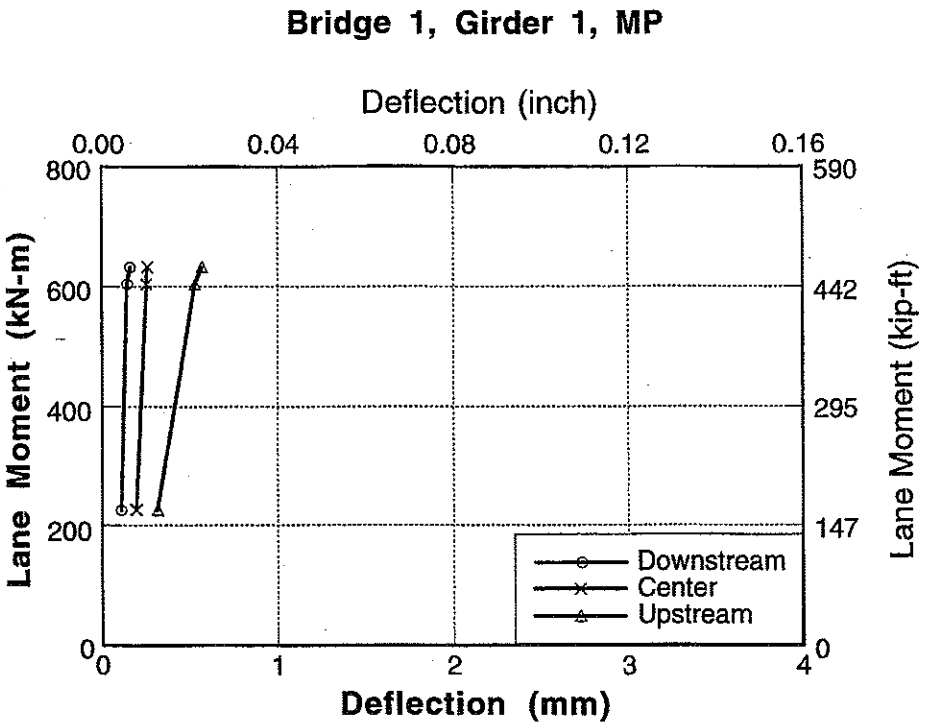
APPENDIX A - RESULTS FOR BRIDGE NO. 1

MDOT ID # B06-08052

M-66 bridge over Mud Creek located just southwest of Woodburry, Michigan.
Simply supported reinforced concrete T-beam structure.

Results for this bridge contain:

- Measured deflections vs calculated lane moment.
- Measured deflections vs analytical deflections.
- Girder distribution of measured deflections.



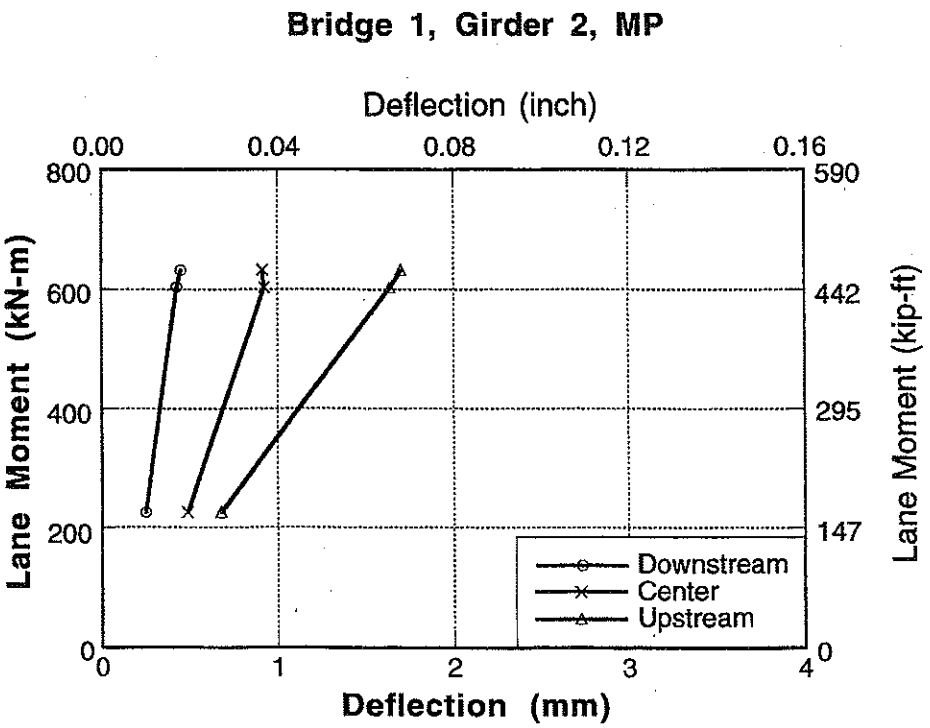
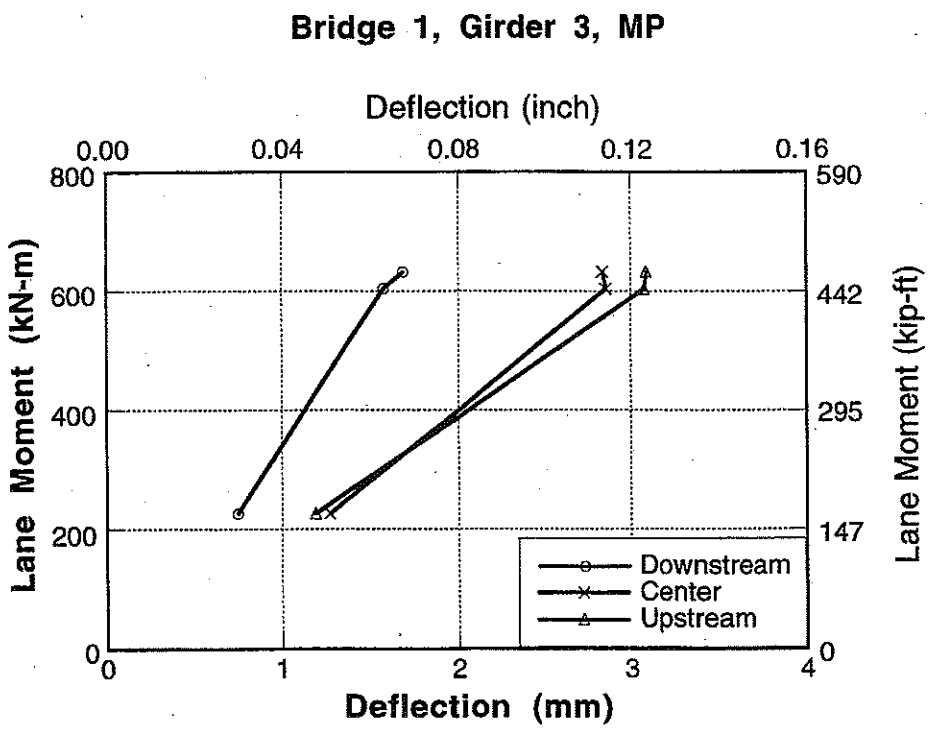


Figure A-1 : Deflection vs Lane Moment for Bridge No. 1, Girder 1 and 2.



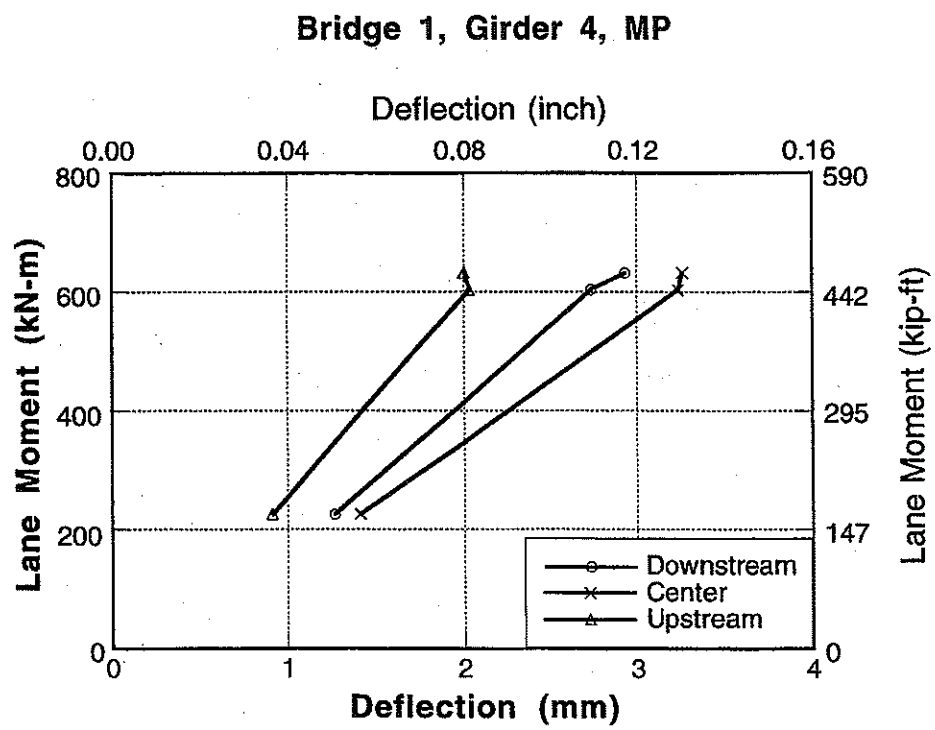
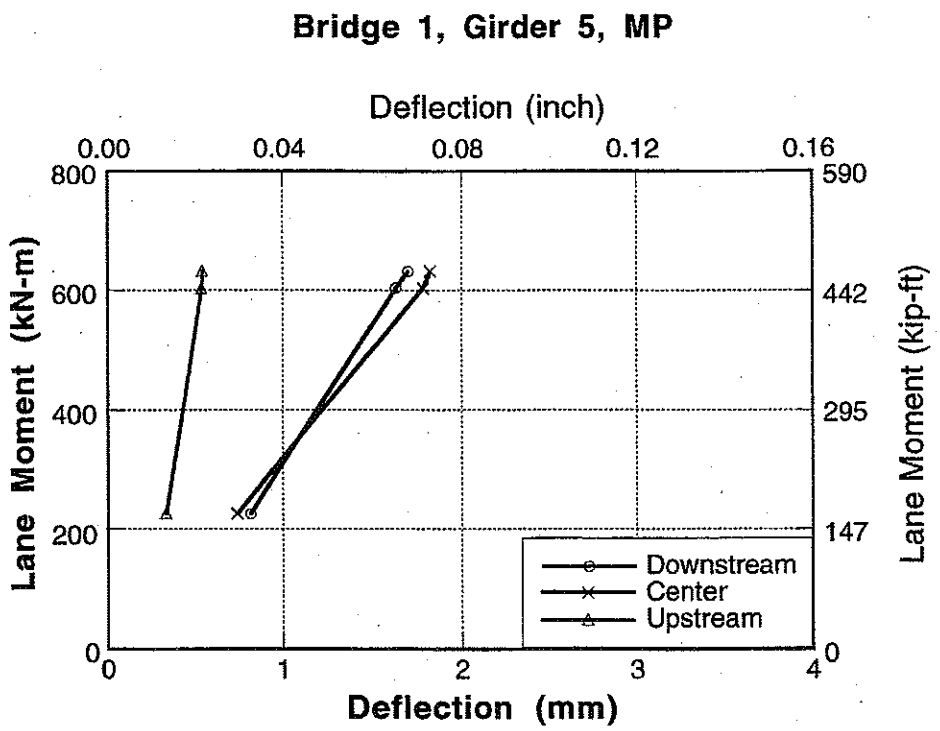


Figure A-2 : Deflection vs Lane Moment for Bridge No. 1, Girder 3 and 4.



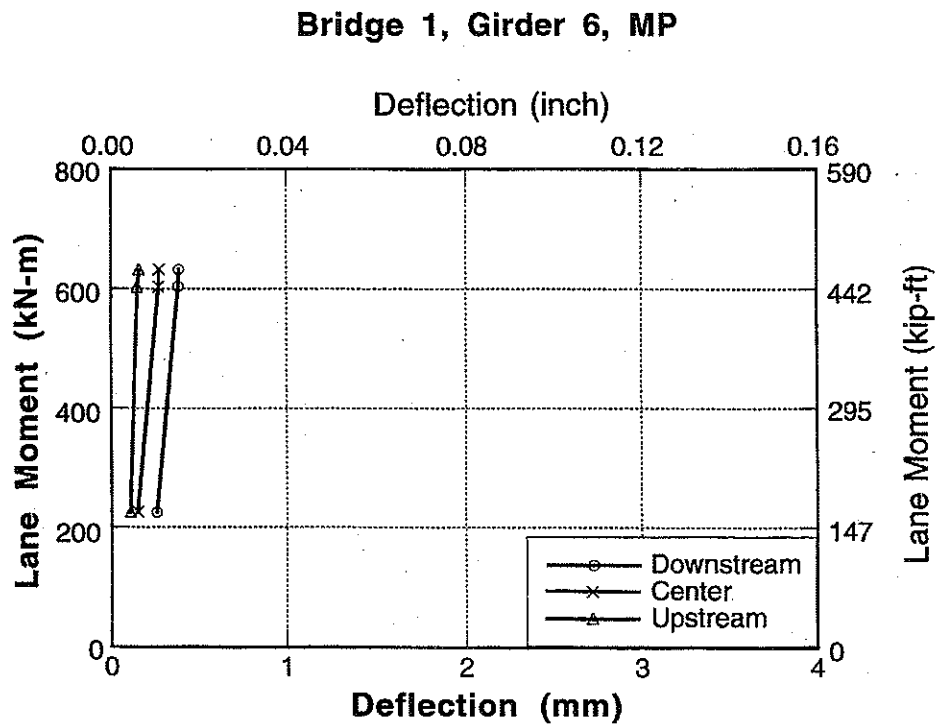
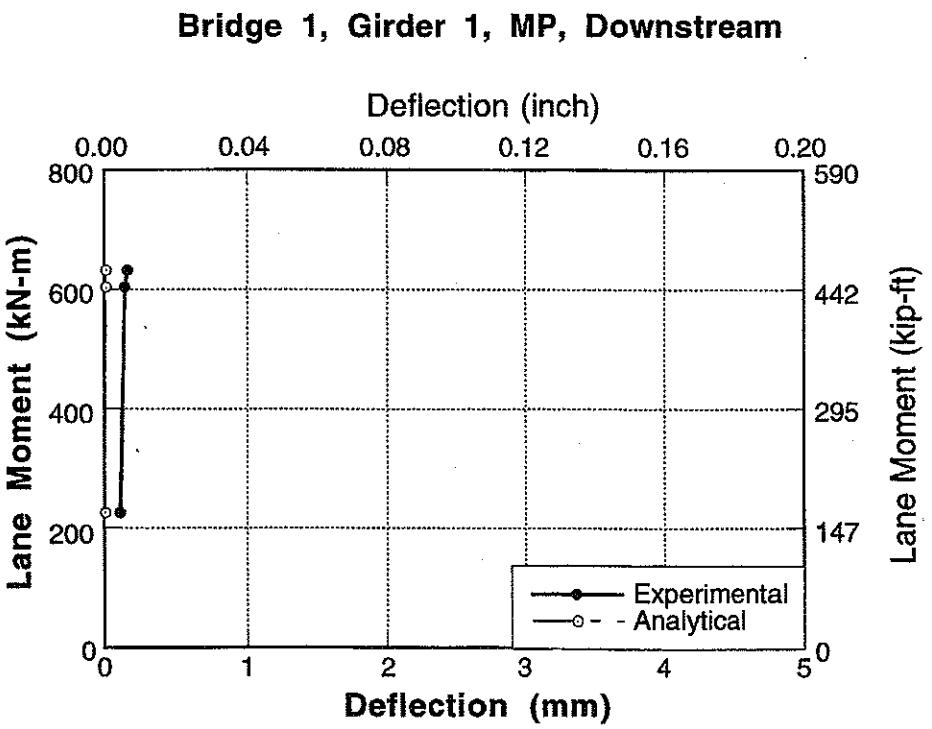


Figure A-3 : Deflection vs Lane Moment for Bridge No. 1, Girder 5 and 6.



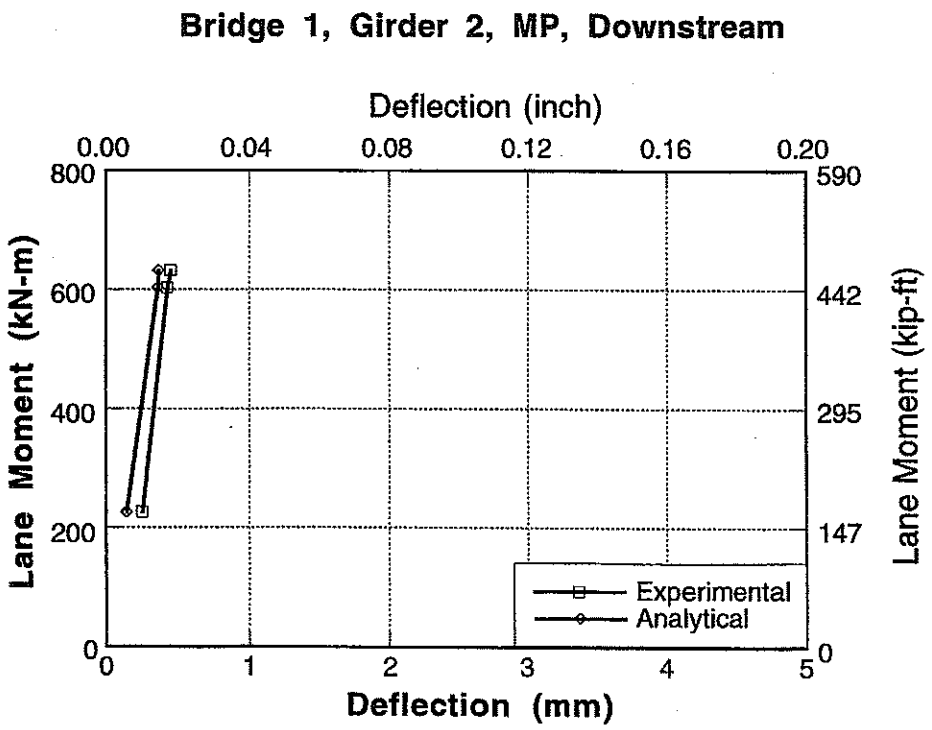
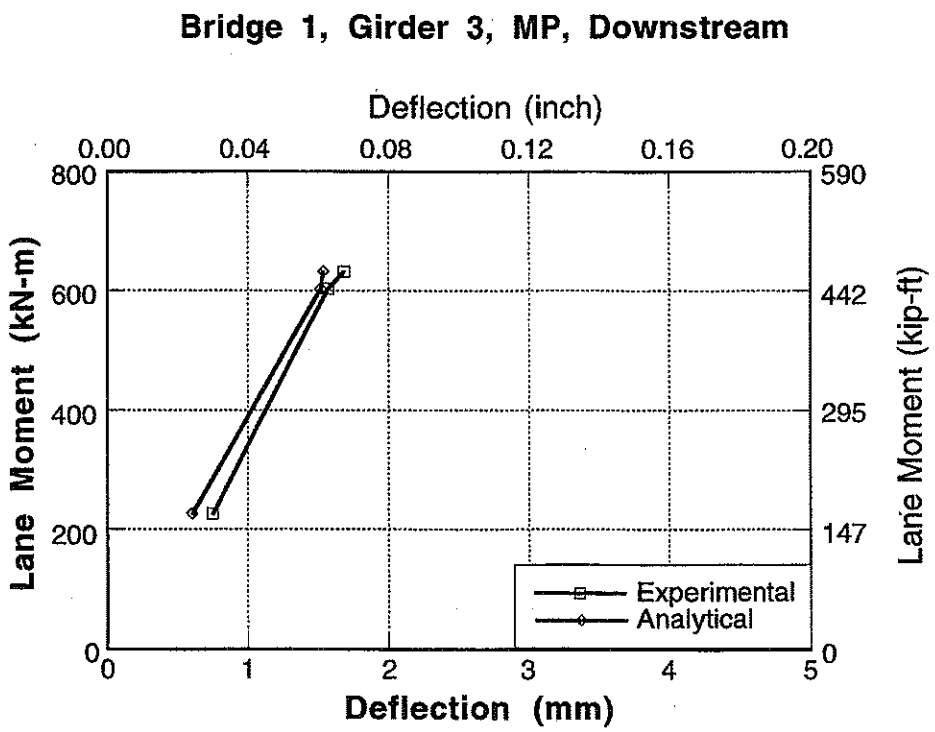


Figure A-4 : Experimental and Analytical Deflections for Bridge No. 1, Girder 1 and 2 for Downstream Loading.



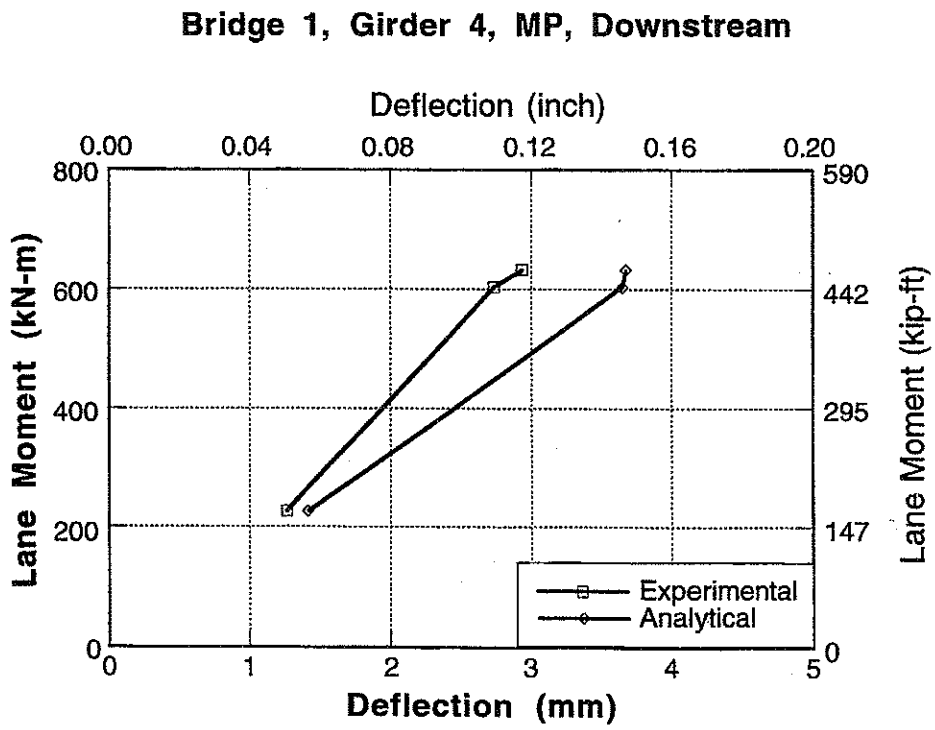
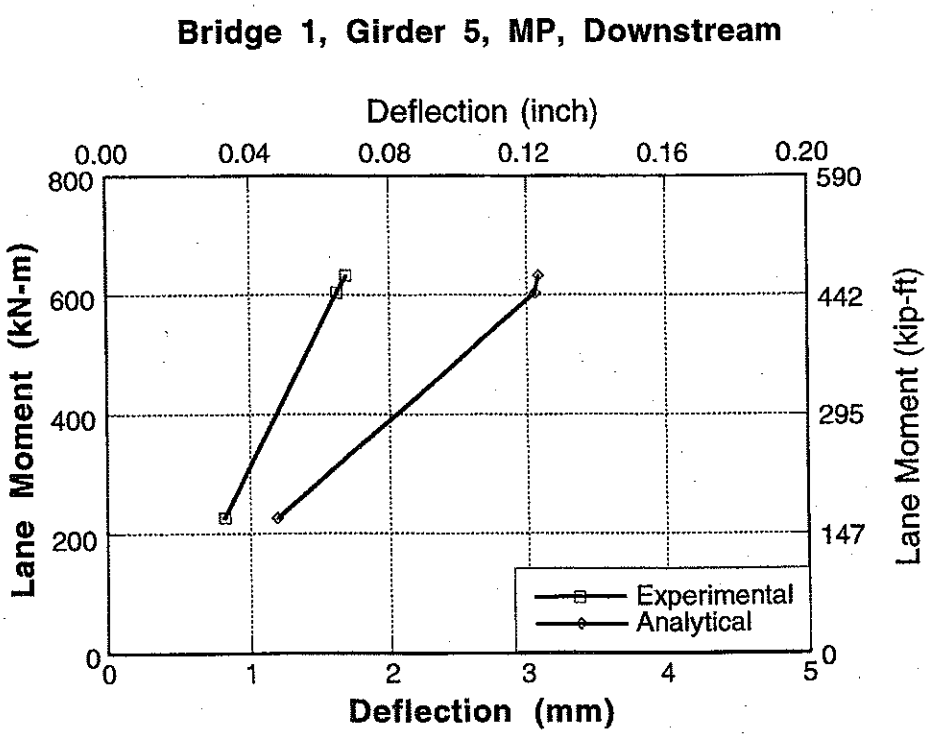


Figure A-5 : Experimental and Analytical Deflections for Bridge No. 1, Girder 3 and 4 for Downstream Loading.



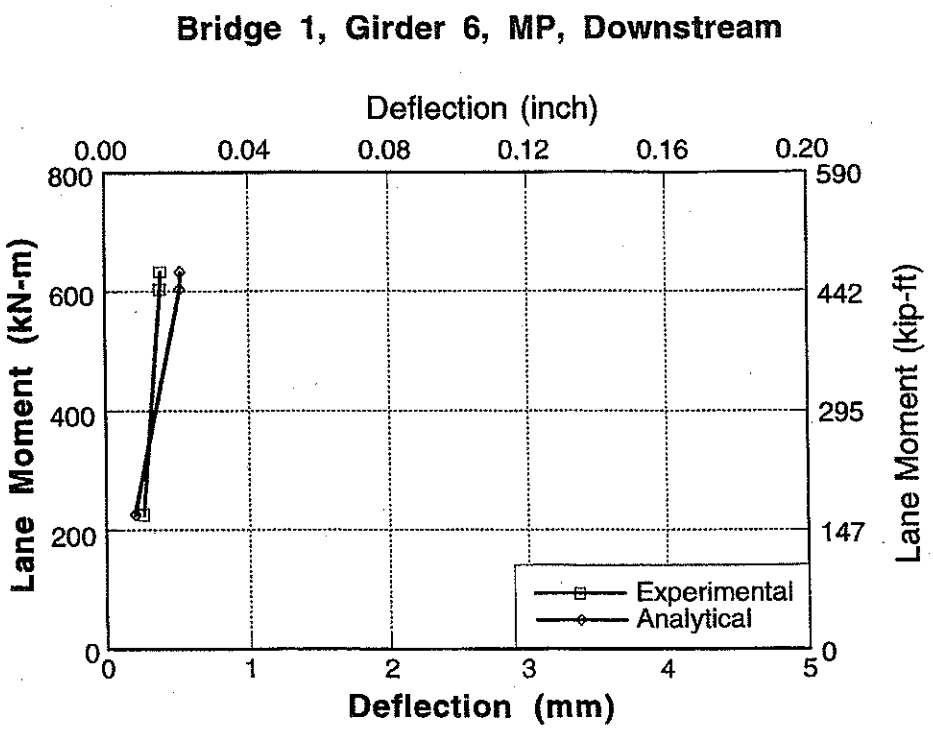
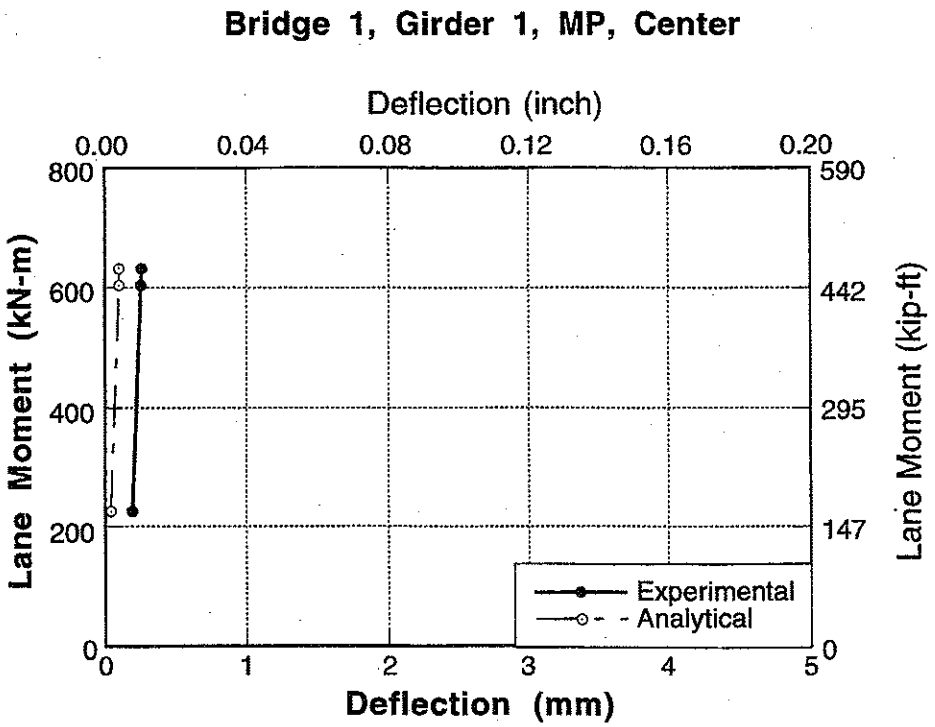


Figure A-6 : Experimental and Analytical Deflections for Bridge No. 1, Girder 5 and 6 for Downstream Loading.



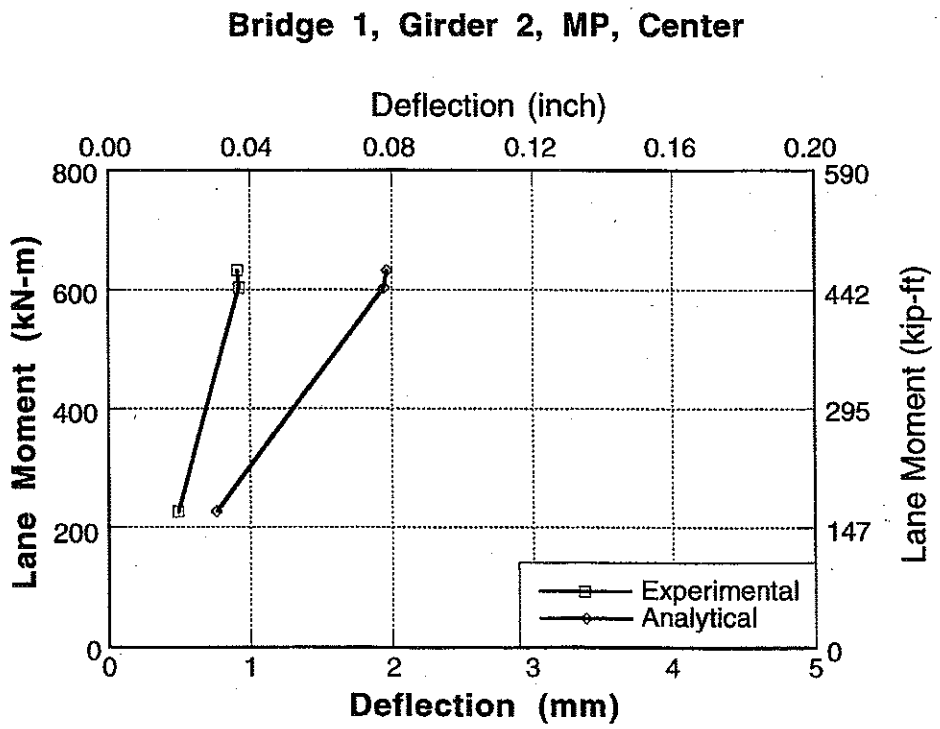
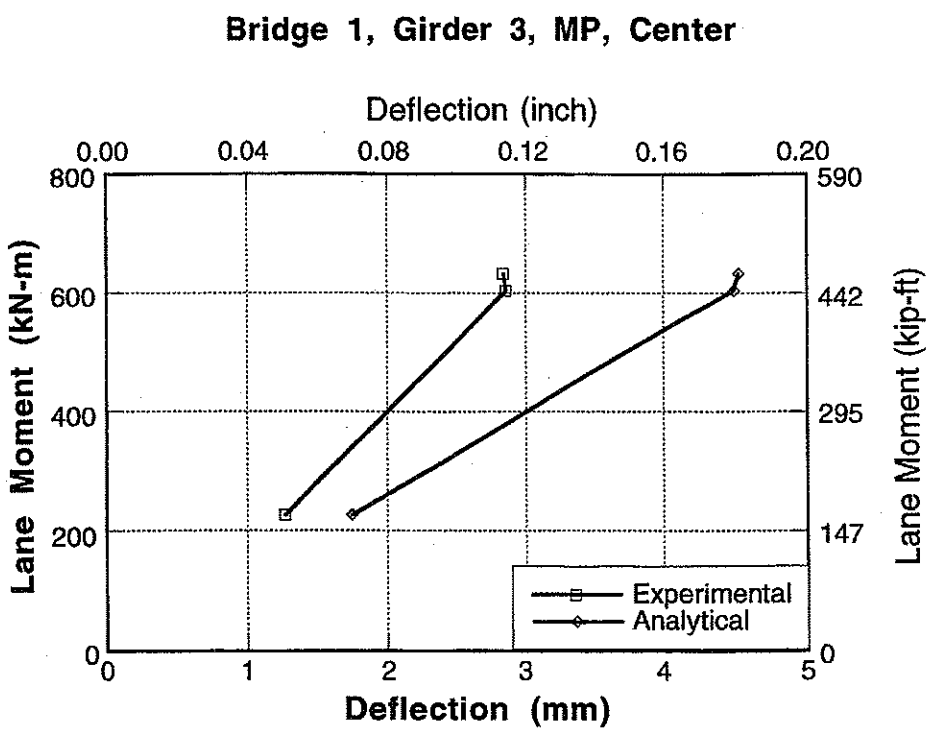


Figure A-7 : Experimental and Analytical Deflections for Bridge No. 1, Girder 1 and 2 for Center Loading.



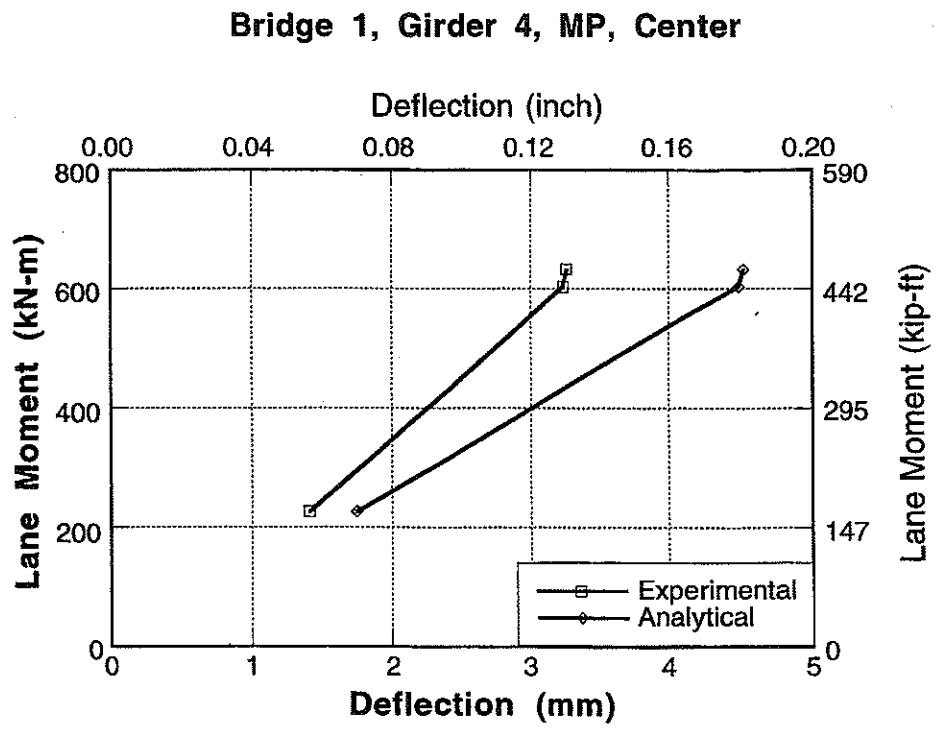
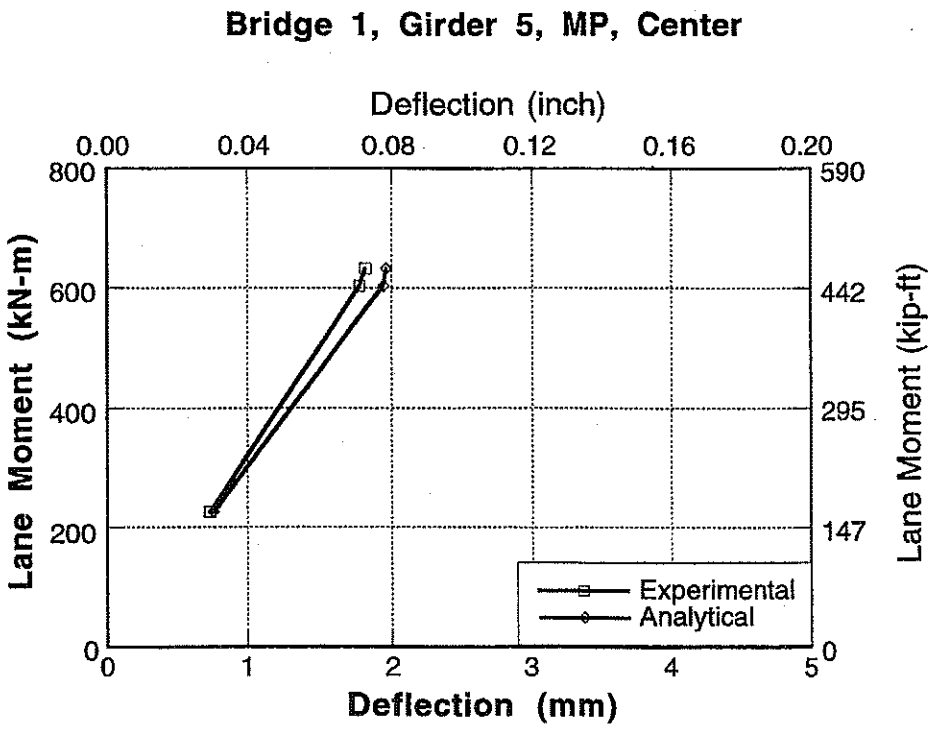


Figure A-8 : Experimental and Analytical Deflections for Bridge No. 1, Girder 3 and 4 for Center Loading.



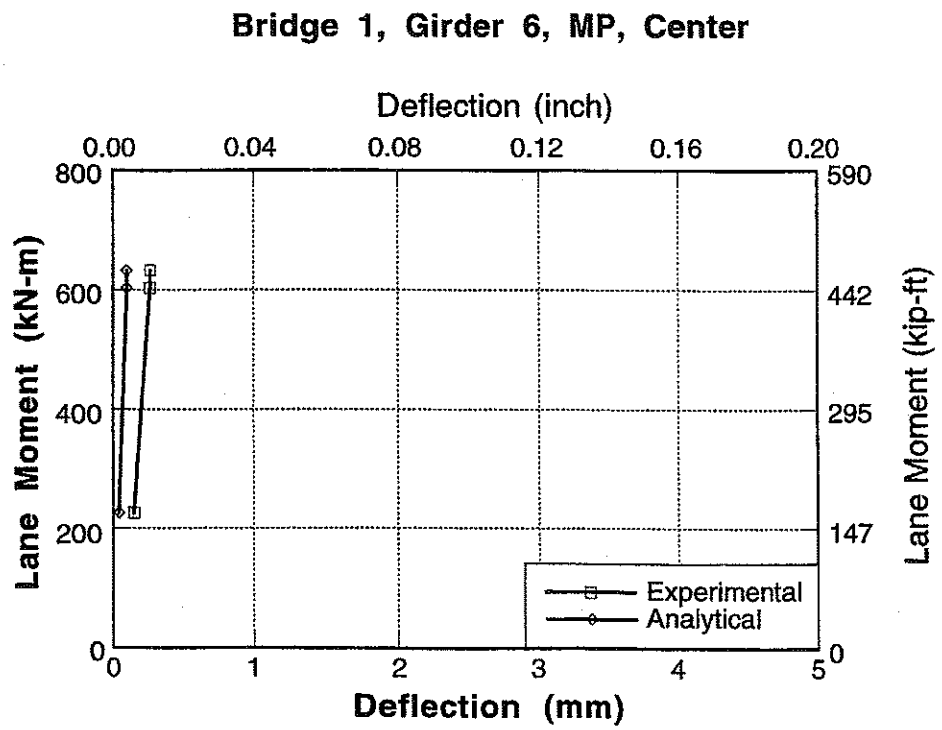
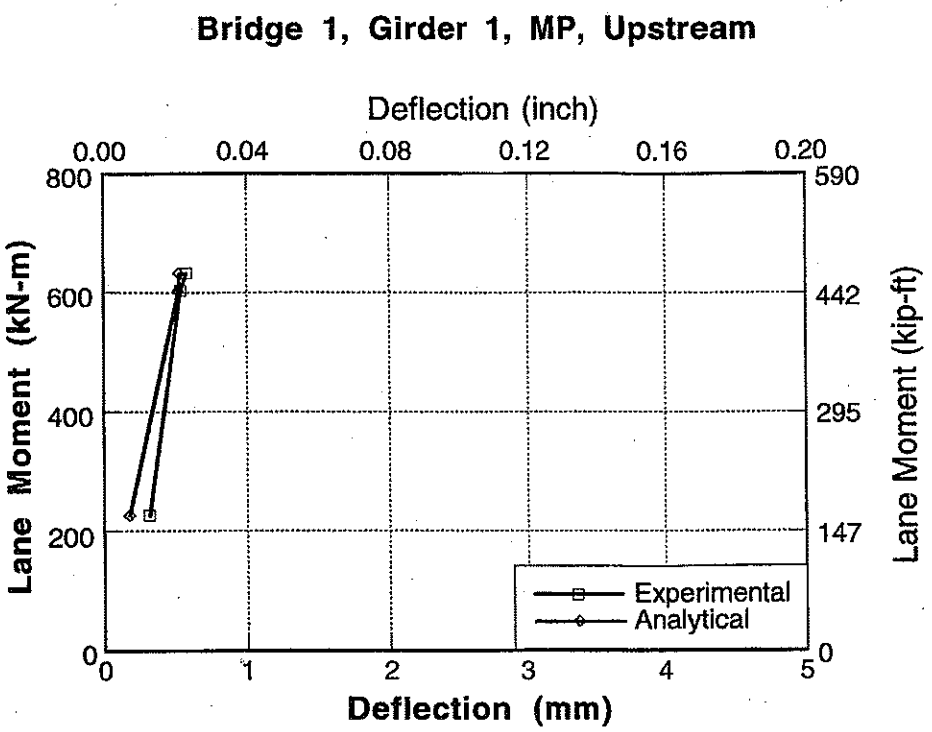


Figure A-9 : Experimental and Analytical Deflections for Bridge No. 1, Girder 5 and 6 for Center Loading.



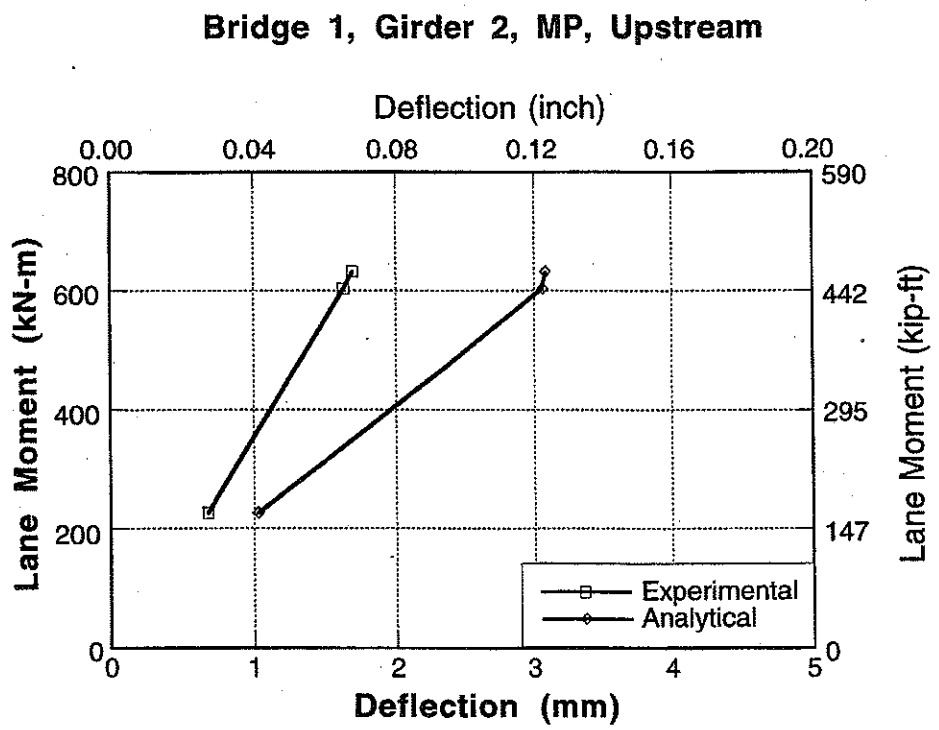
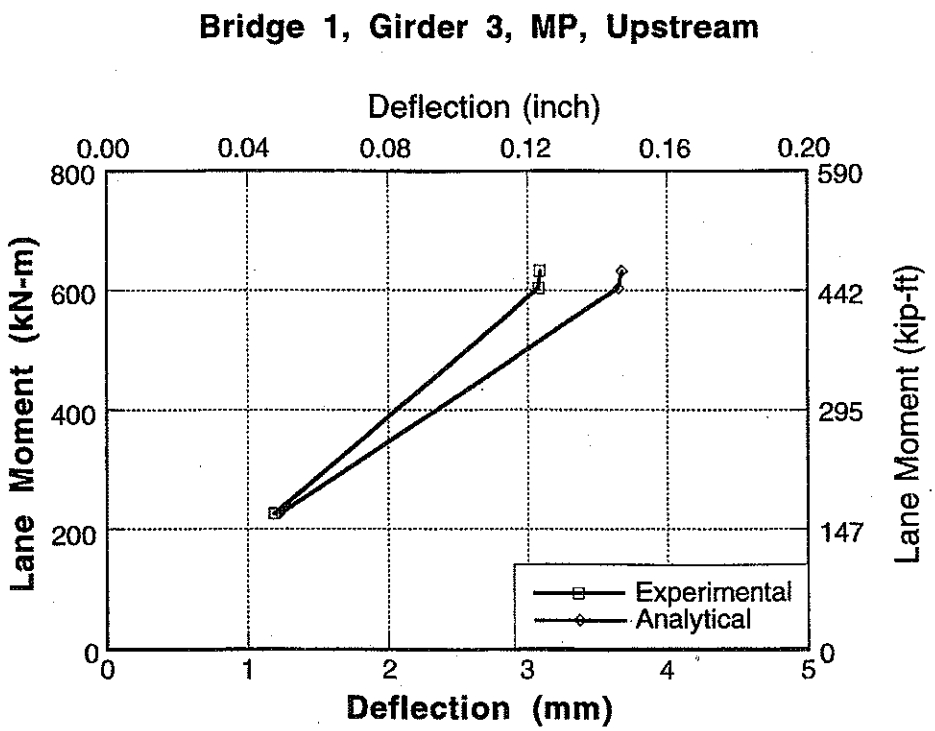


Figure A-10 : Experimental and Analytical Deflections for Bridge No. 1, Girder 1 and 2 for Upstream Loading.



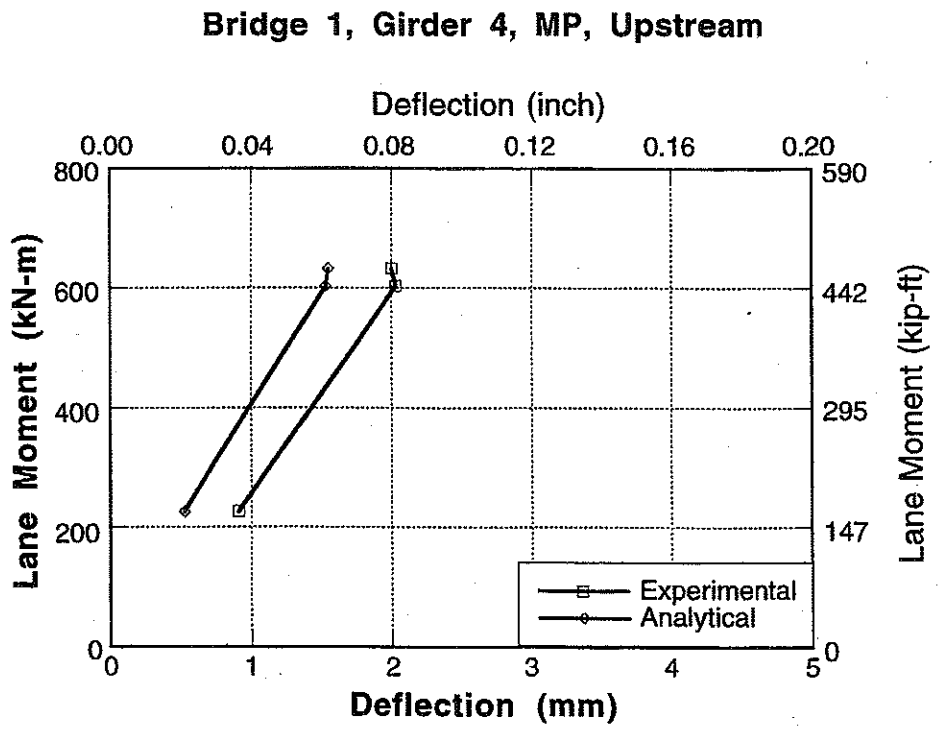
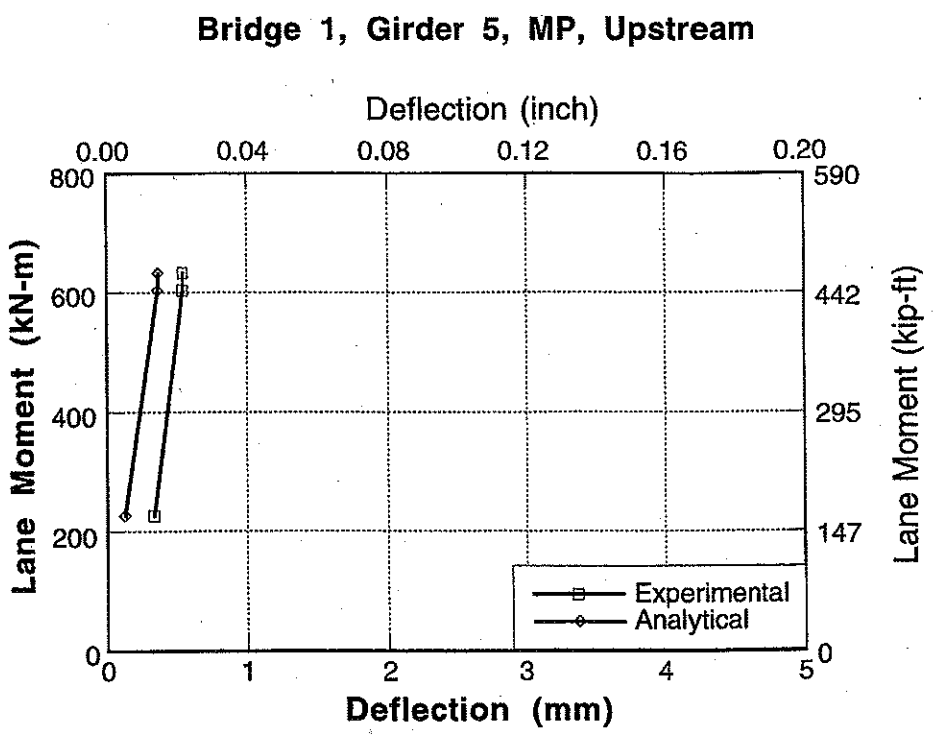


Figure A-11 : Experimental and Analytical Deflections for Bridge No. 1, Girder 3 and 4 for Upstream Loading.



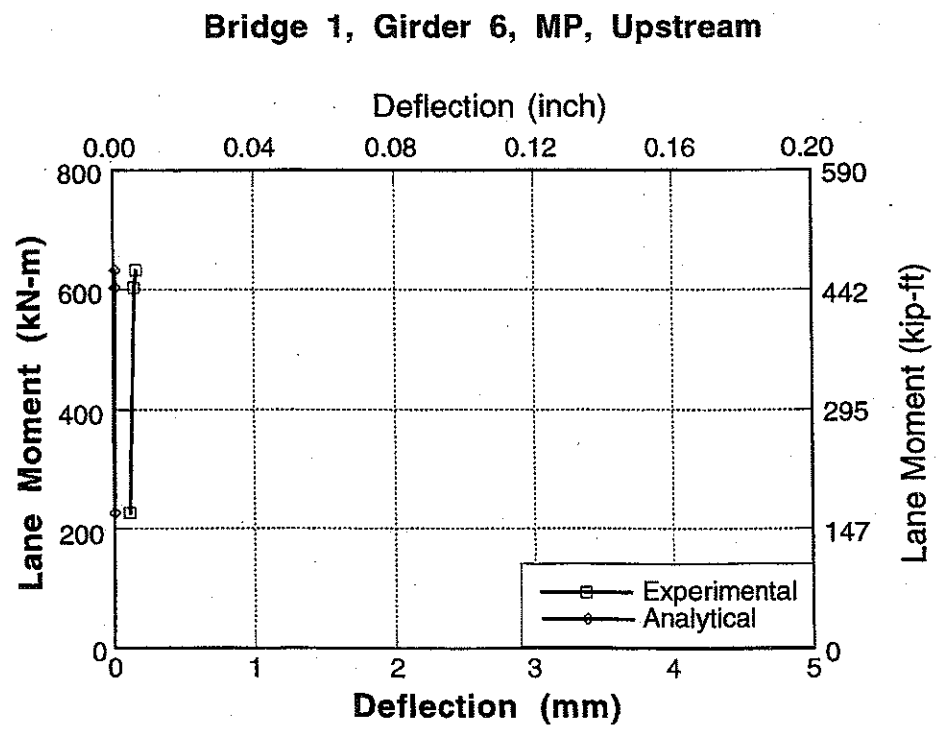


Figure A-12 : Experimental and Analytical Deflections for Bridge No. 1, Girder 5 and 6 for Upstream Loading.

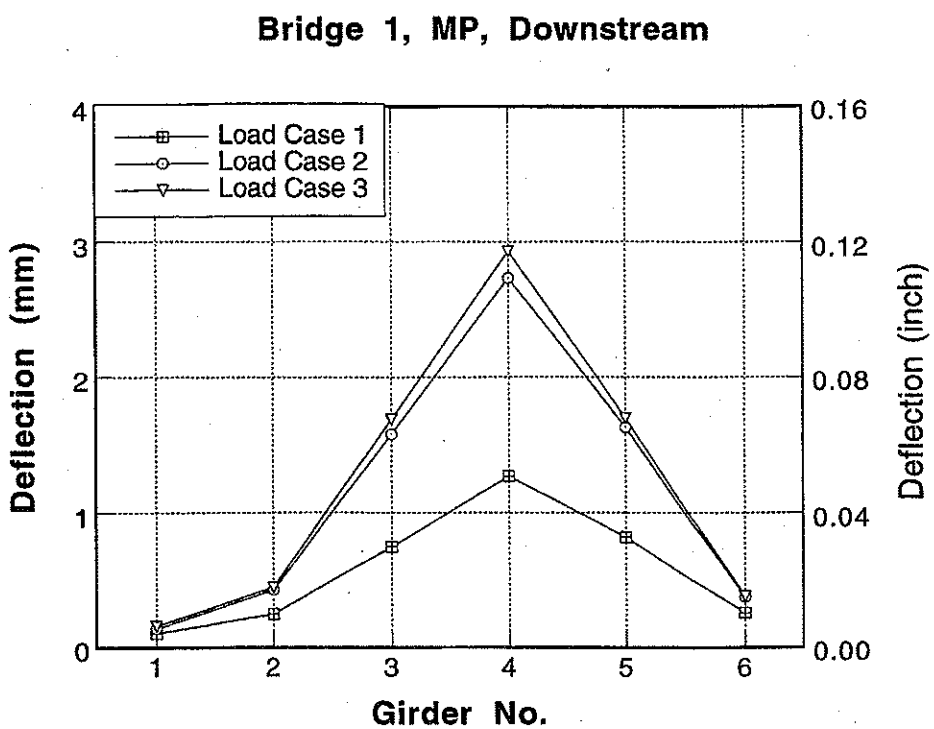


Figure A-13 Girder Distribution of Deflections for Bridge No. 1 due to Downstream Loading.

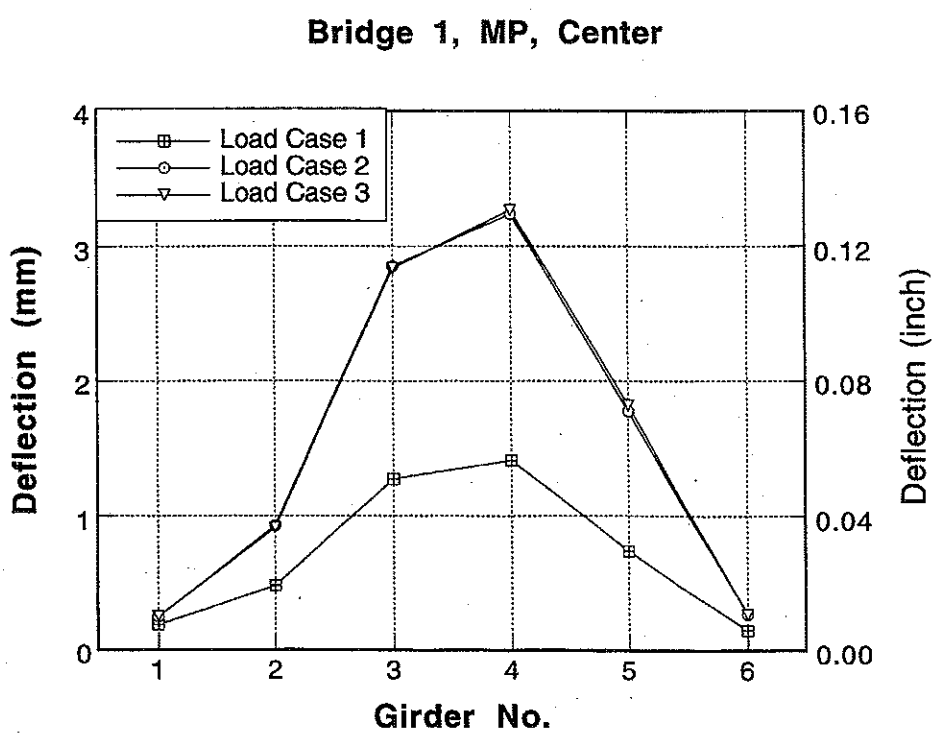


Figure A-14 Girder Distribution of Deflections for Bridge No. 1 due to Center Loading.

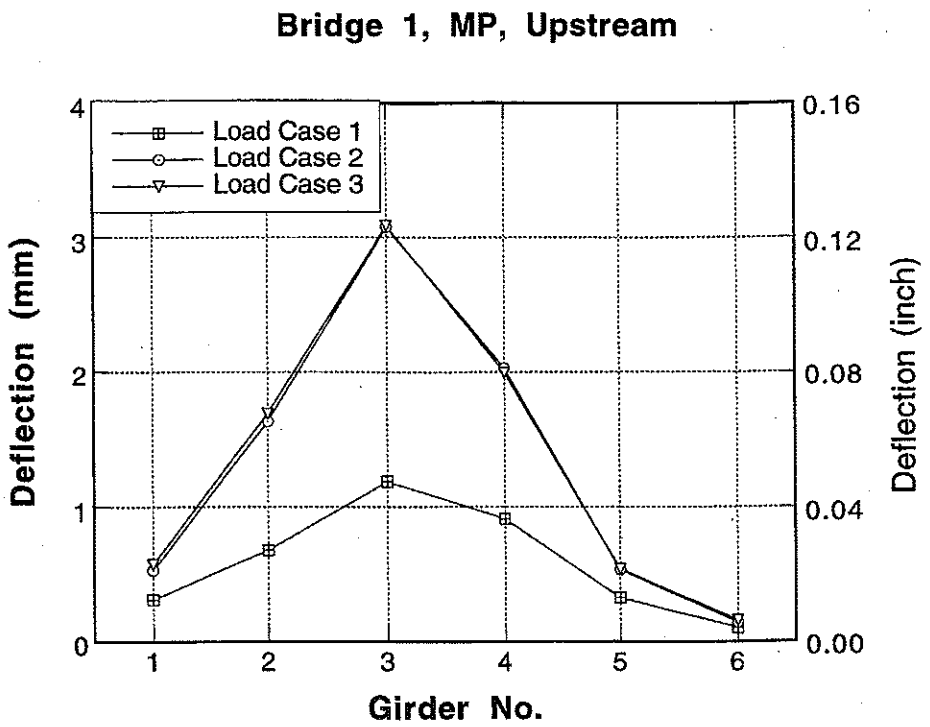


Figure A-15 : Girder Distribution of Deflections for Bridge No. 1 due to Upstream Loading.

Note:

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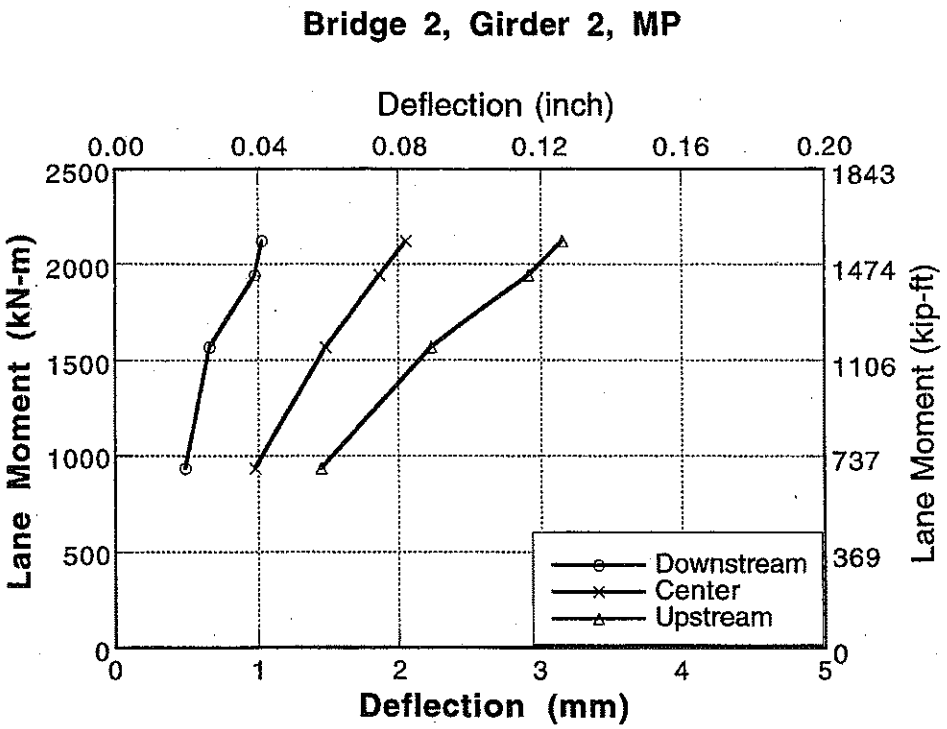
APPENDIX B - RESULTS FOR BRIDGE NO. 2

MDOT ID # B02-38071

M-50 bridge over Grand River located in Jackson County, Michigan. Simply supported steel girder bridge.

Results for this bridge contain:

- Measured deflections vs calculated lane moment.
- Measured deflections vs analytical deflections.
- Girder distribution of measured deflections.
- Longitudinal distribution of measured deflections.
- Measured stresses vs calculated lane moment.
- Measured stresses vs analytical stresses.
- Girder distribution of measured stresses.
- Longitudinal distribution of measured stresses.



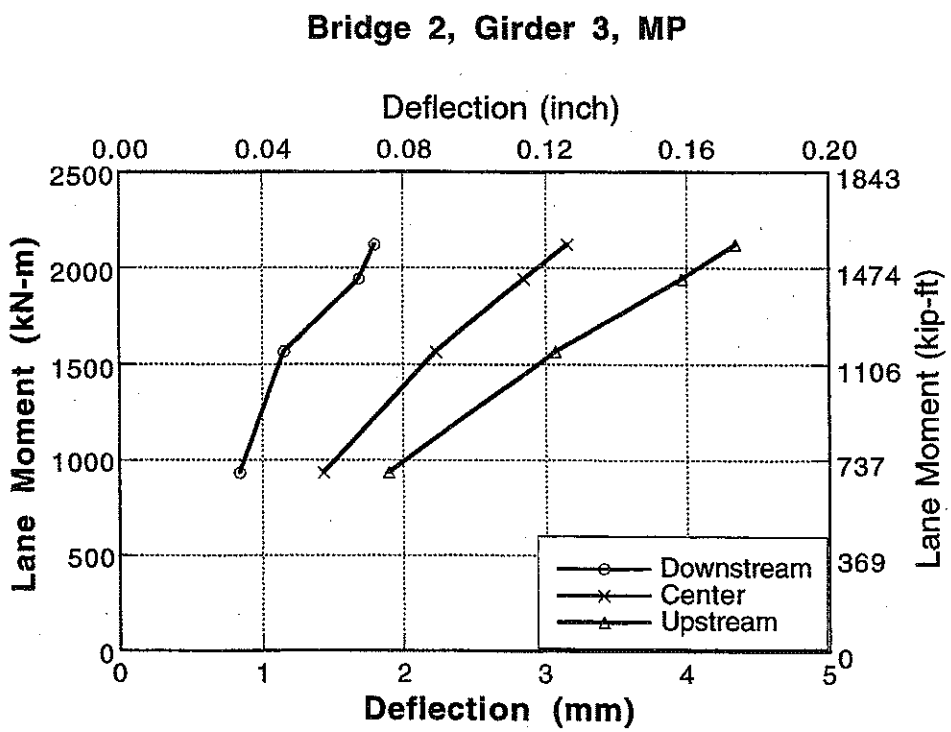
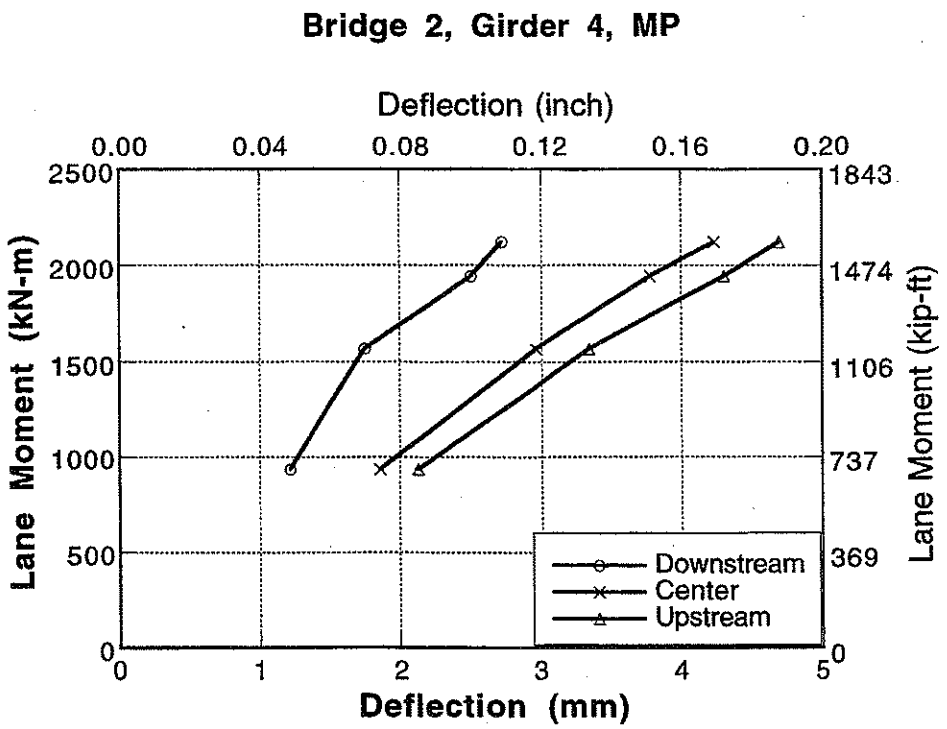


Figure A-16: Deflection vs Lane Moment for Bridge No. 2, Girder 2 and 3.



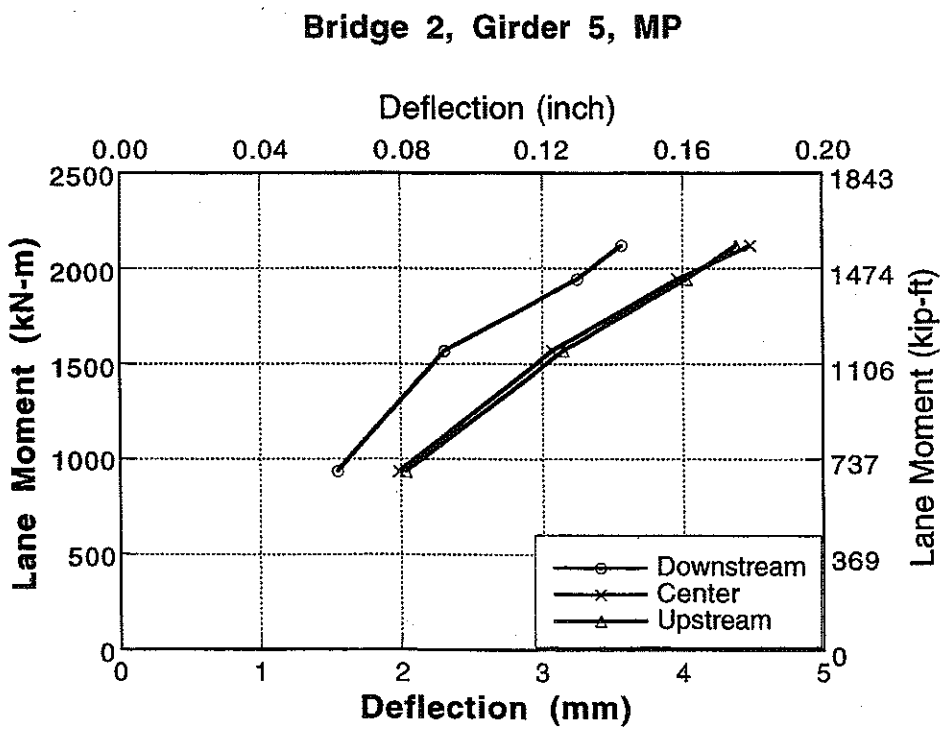
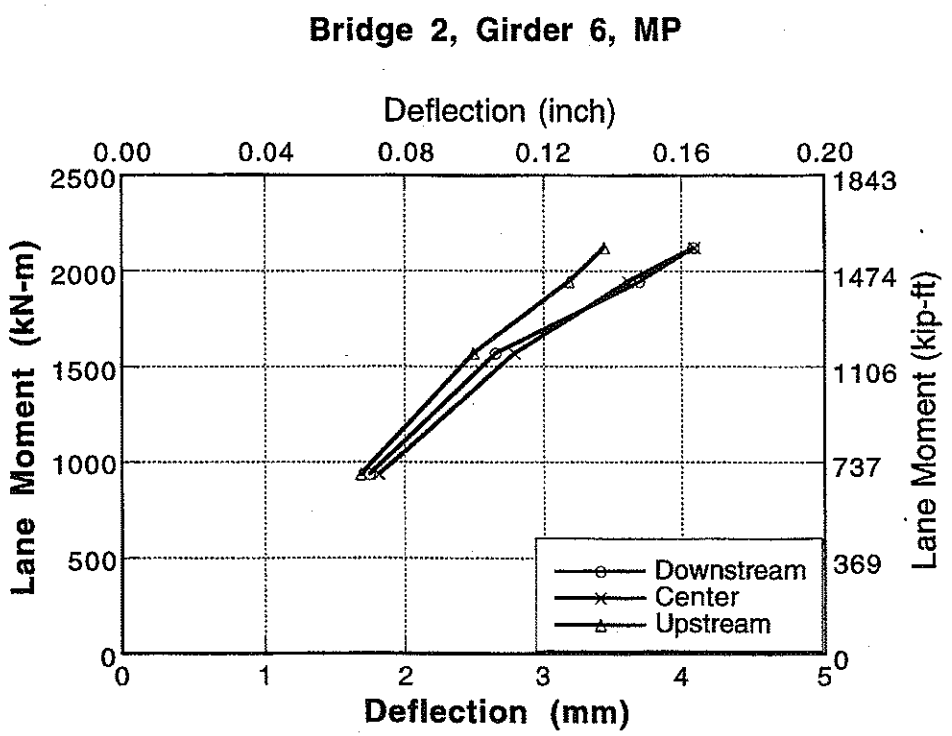


Figure A-17: Deflection vs Lane Moment for Bridge No. 2, Girder 4 and 5.



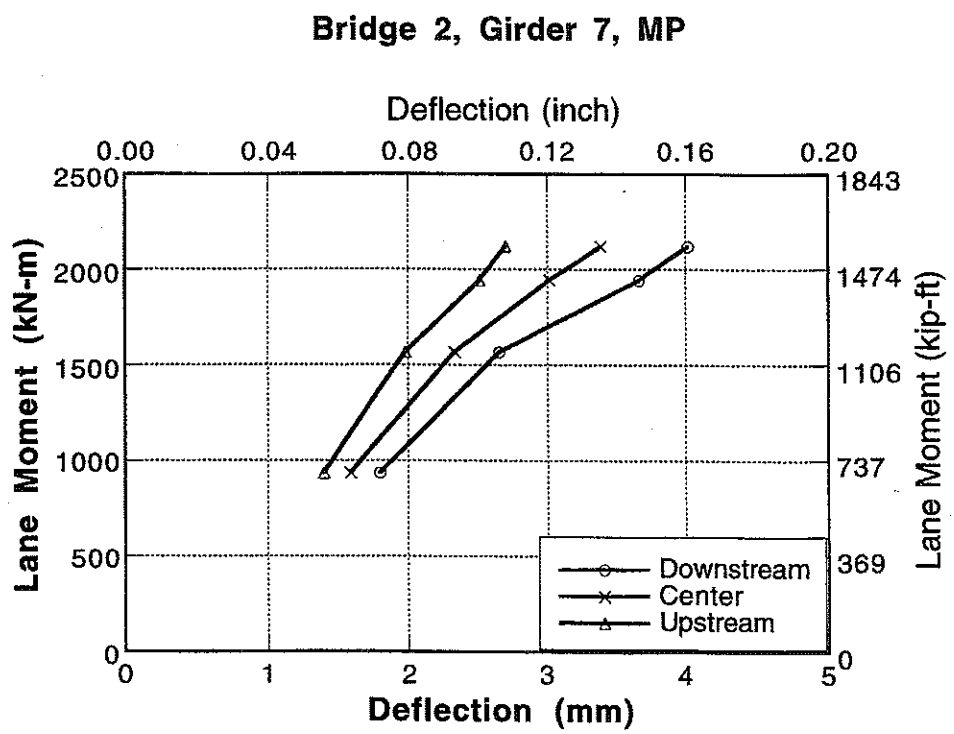
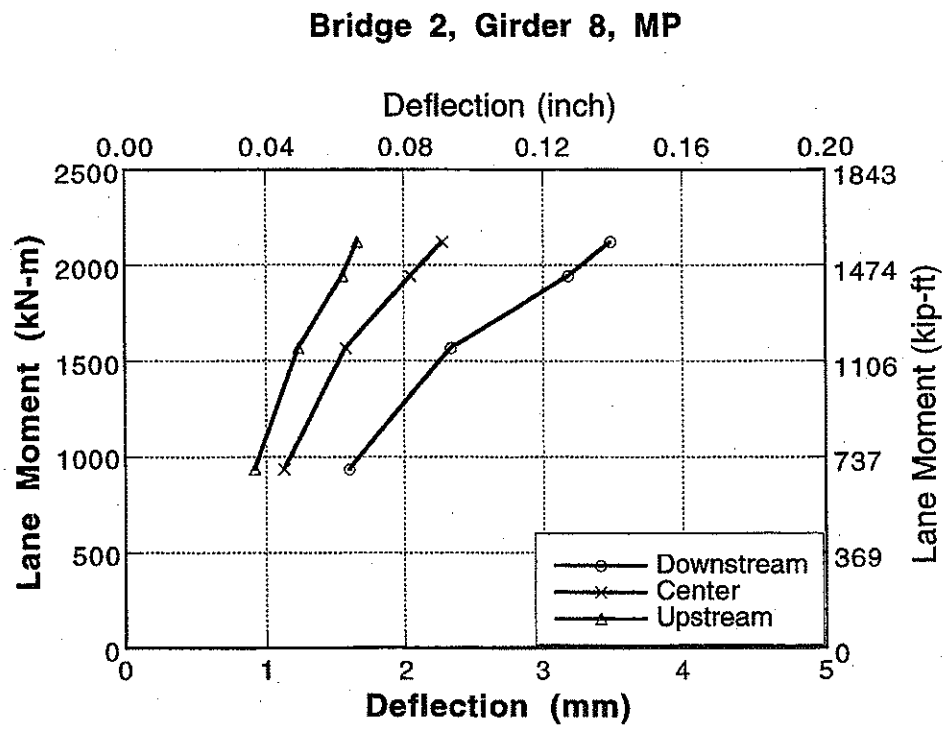


Figure A-18: Deflection vs Lane Moment for Bridge No. 2, Girder 6 and 7.



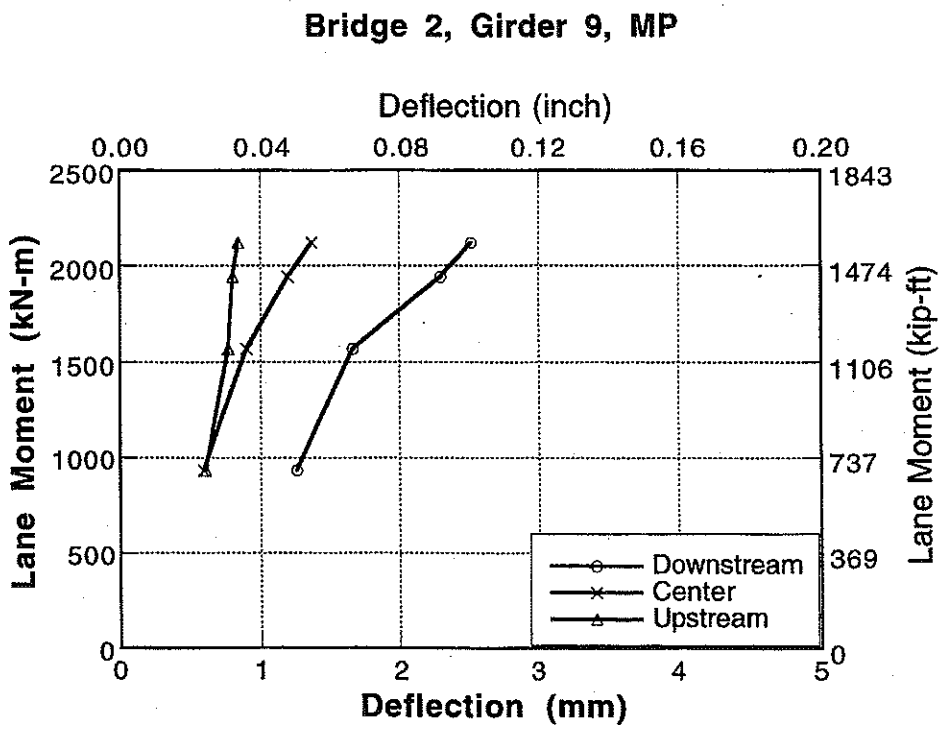
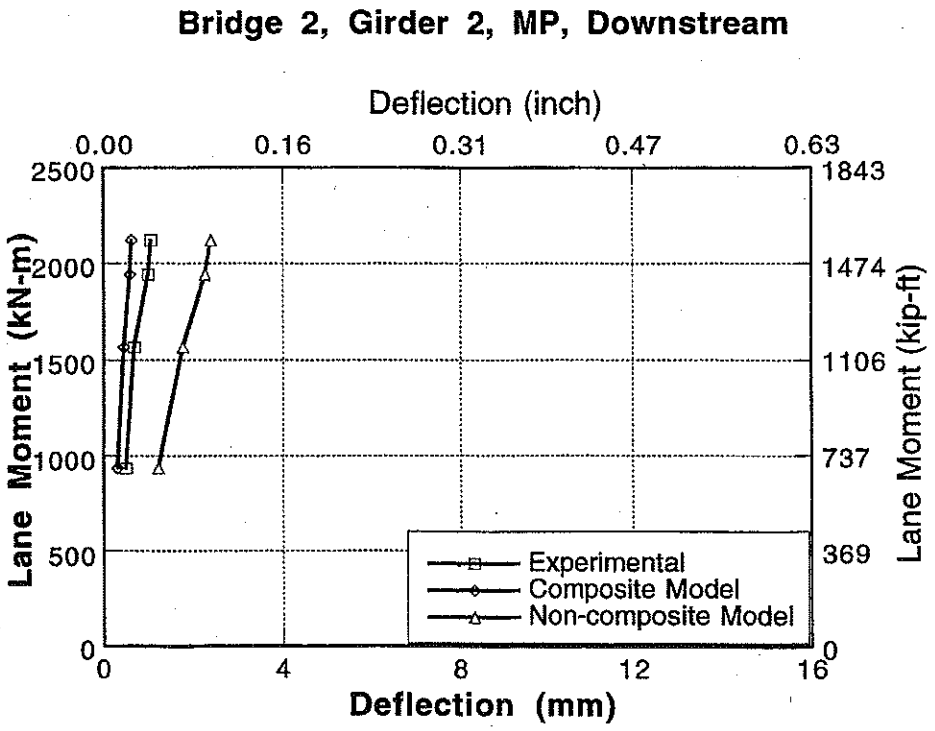


Figure A-19: Deflection vs Lane Moment for Bridge No. 2, Girder 8 and 9.



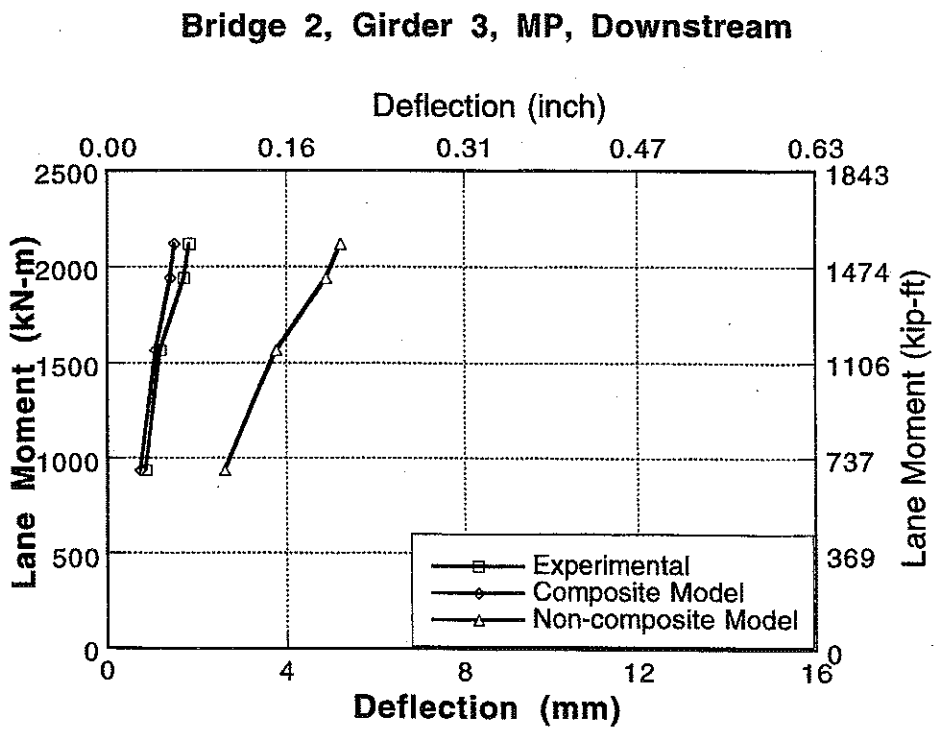
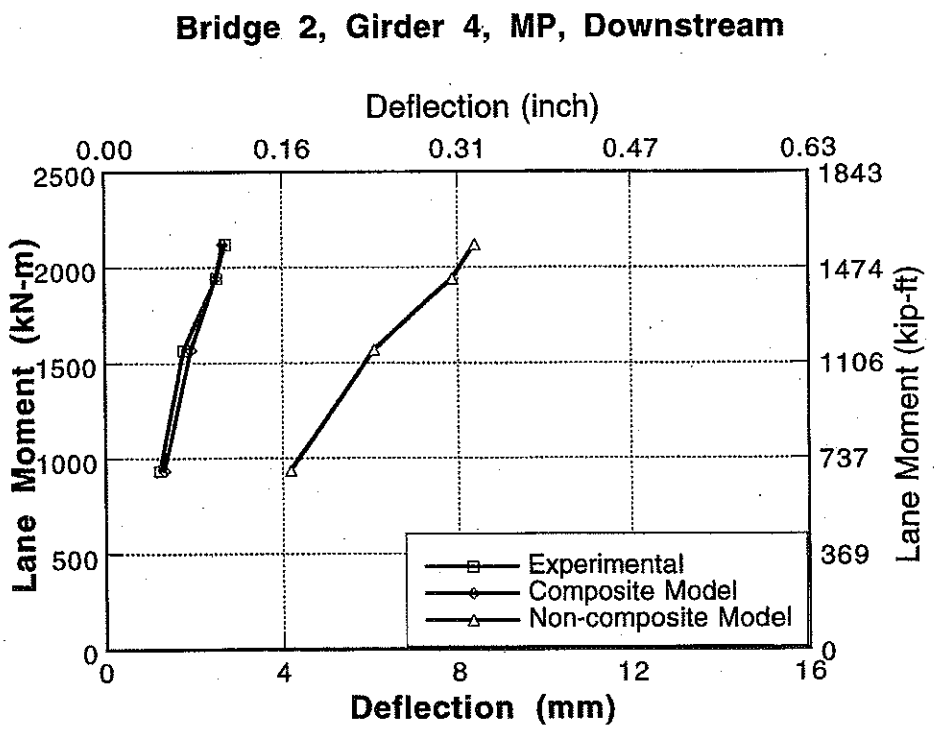


Figure A-20 : Experimental and Analytical Deflections for Bridge No. 2, Girder 2 and 3 for Downstream Loading.



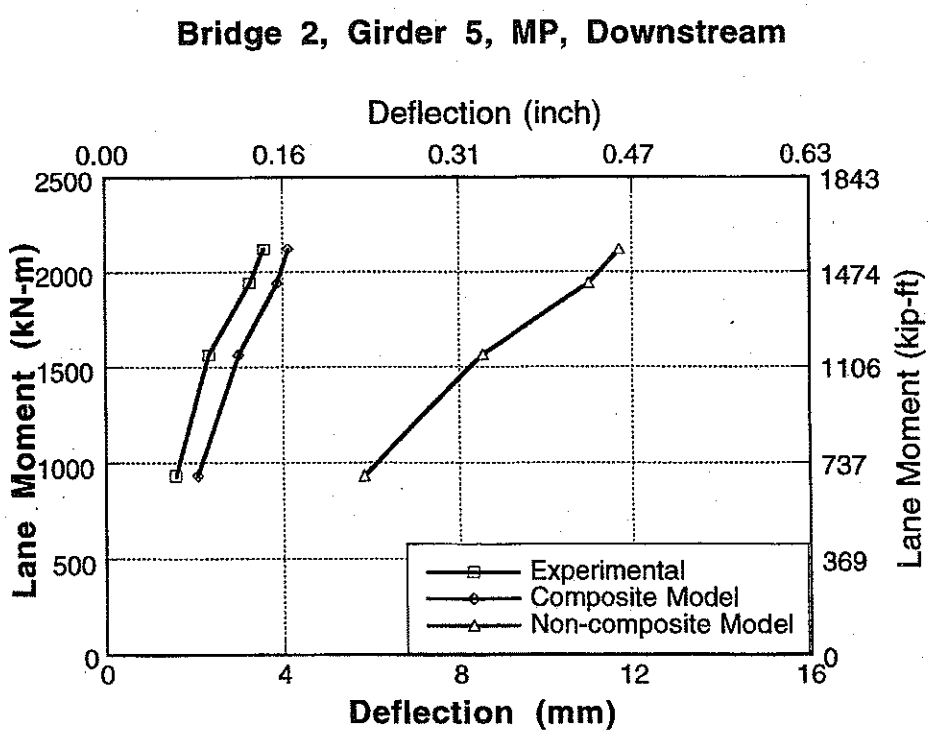
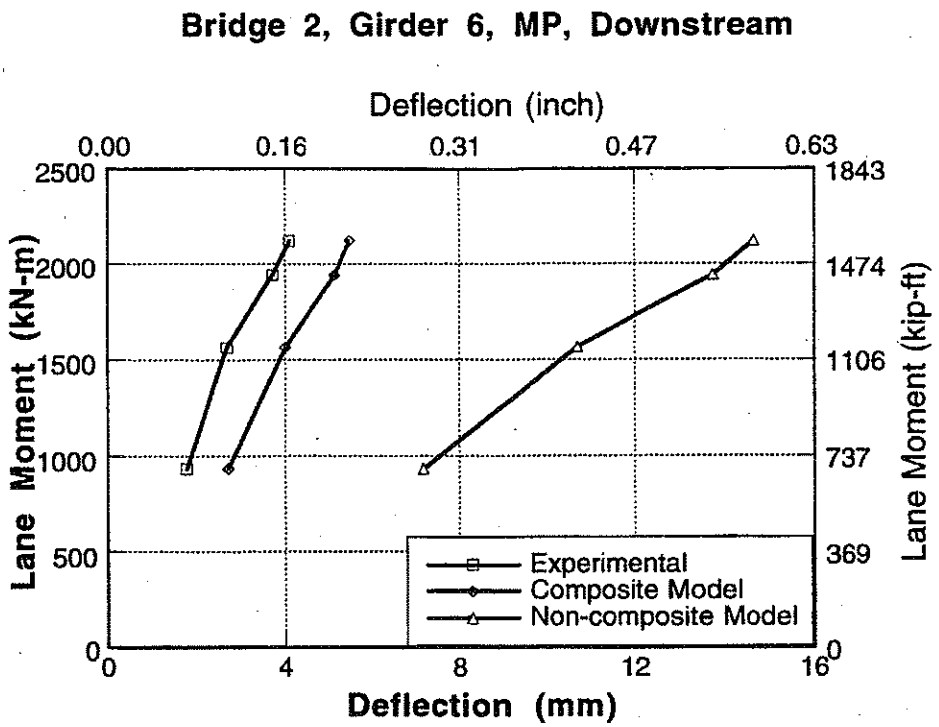


Figure A-21 : Experimental and Analytical Deflections for Bridge No. 2, Girder 4 and 5 for Downstream Loading.



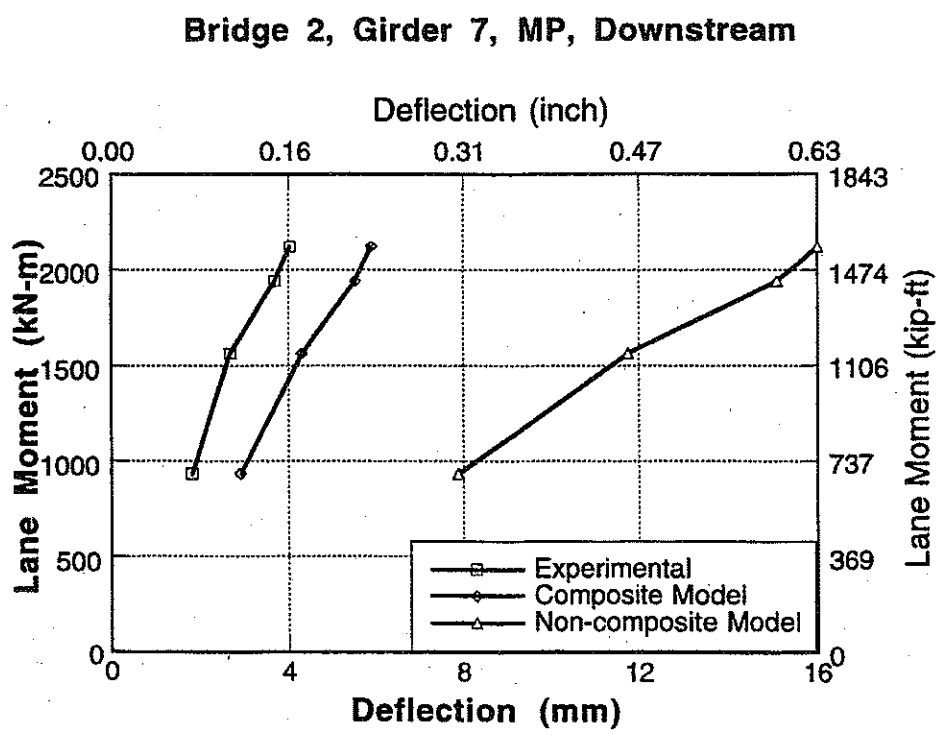
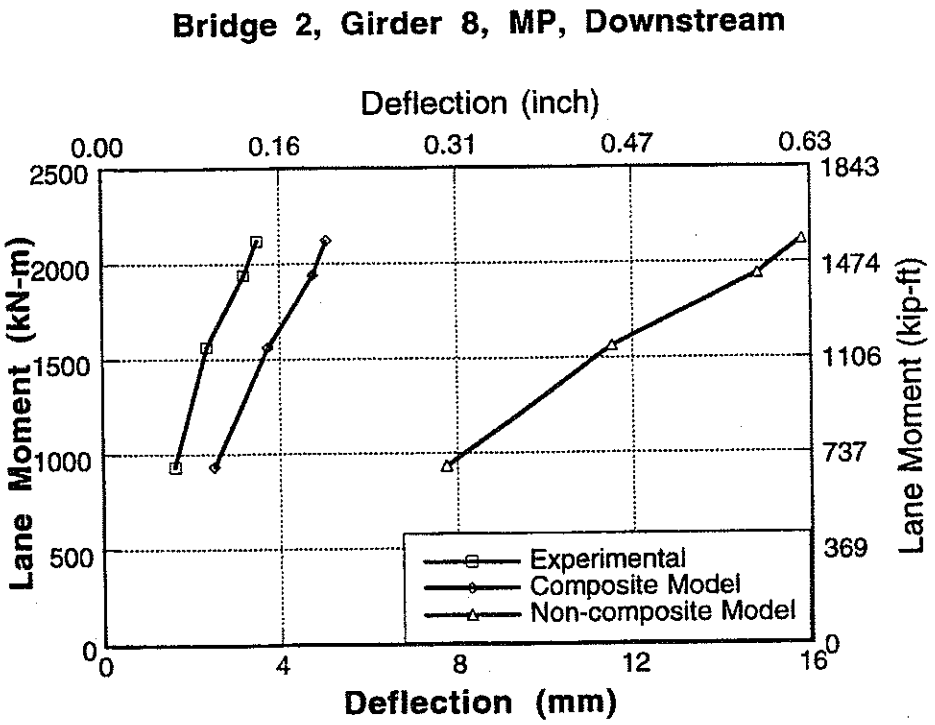


Figure A-22 : Experimental and Analytical Deflections for Bridge No. 2, Girder 6 and 7 for Downstream Loading.



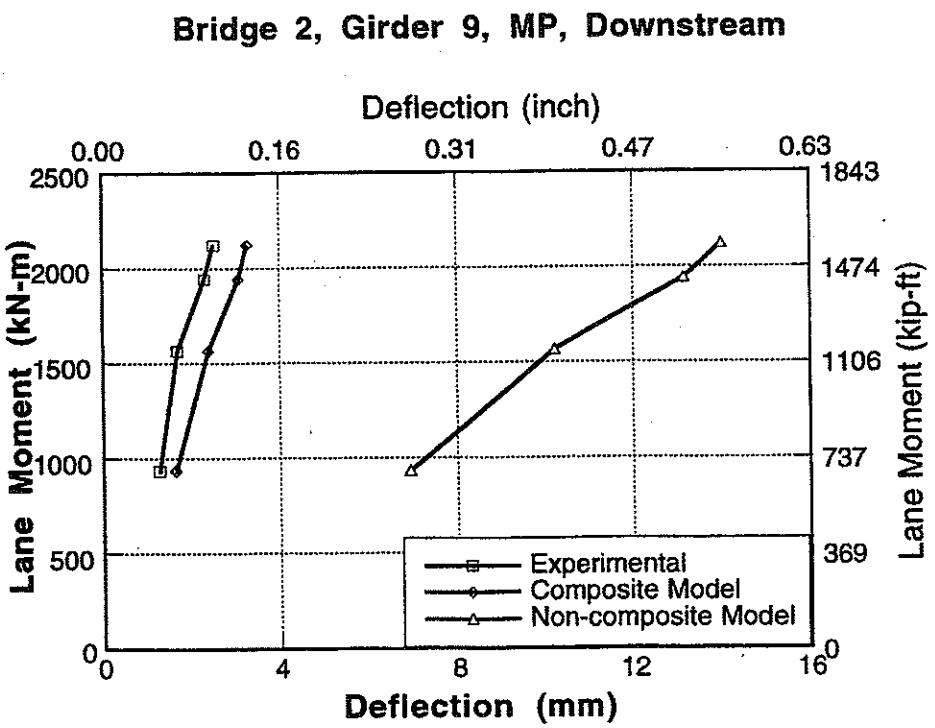
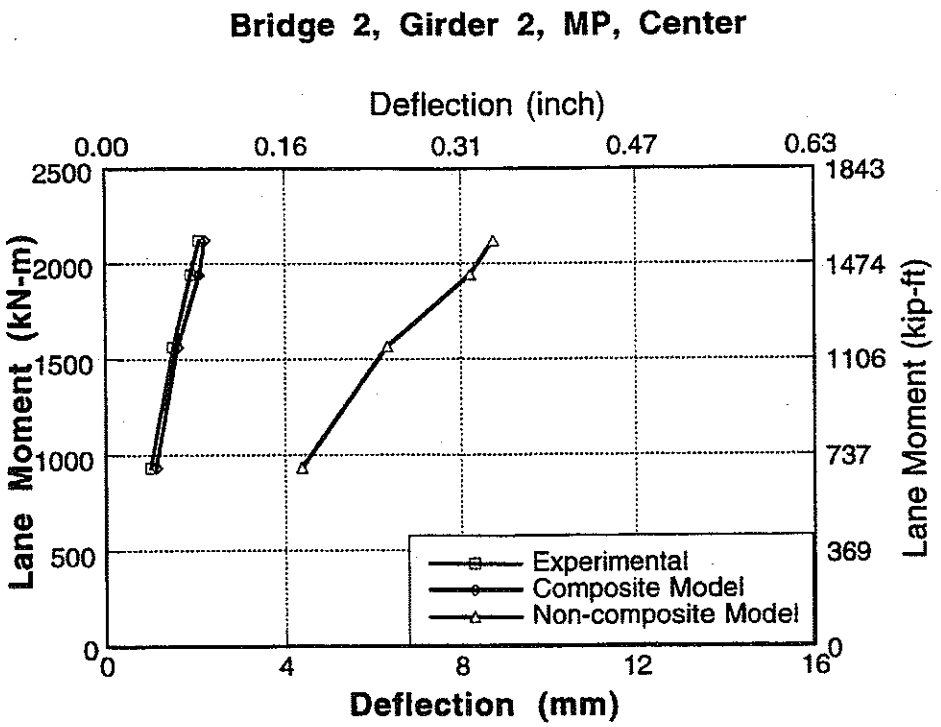


Figure A-23 : Experimental and Analytical Deflections for Bridge No. 2, Girder 8 and 9 for Downstream Loading.



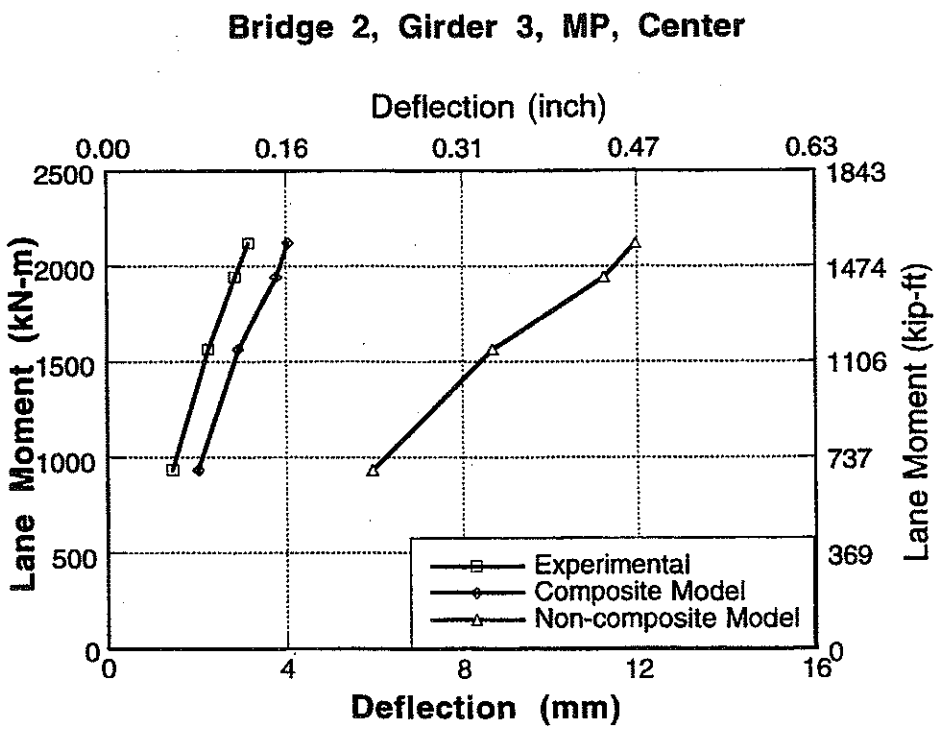
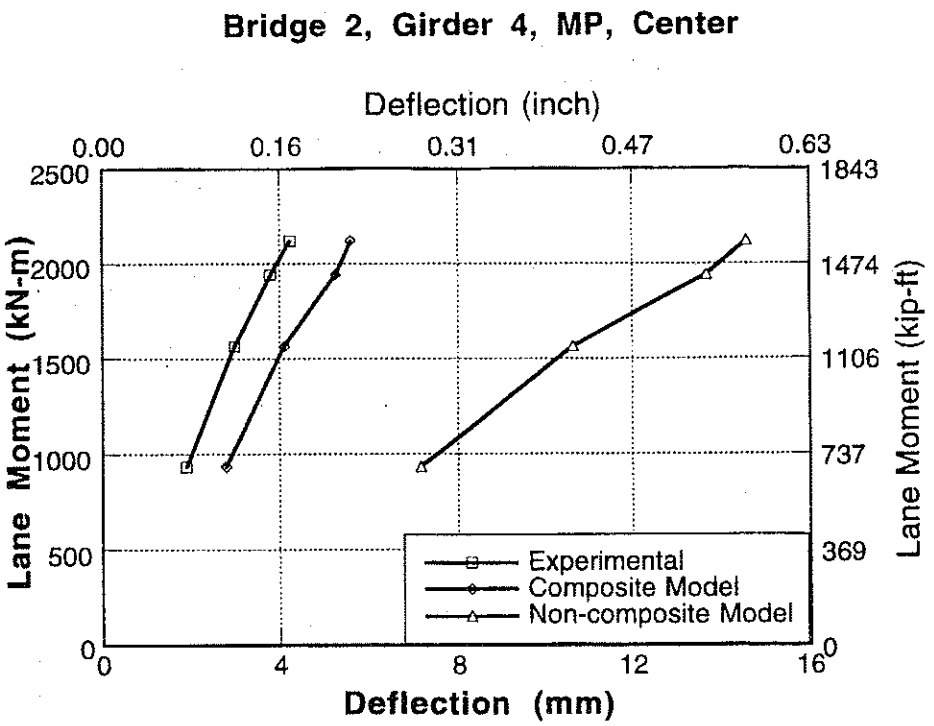


Figure A-24 : Experimental and Analytical Deflections for Bridge No. 2, Girder 2 and 3 for Center Loading.



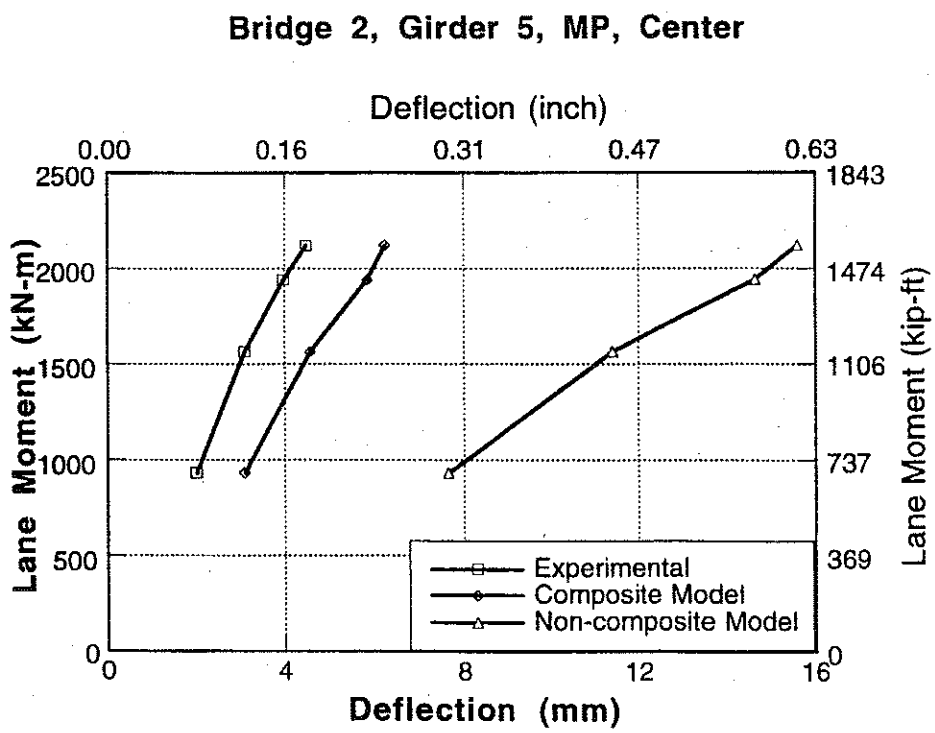
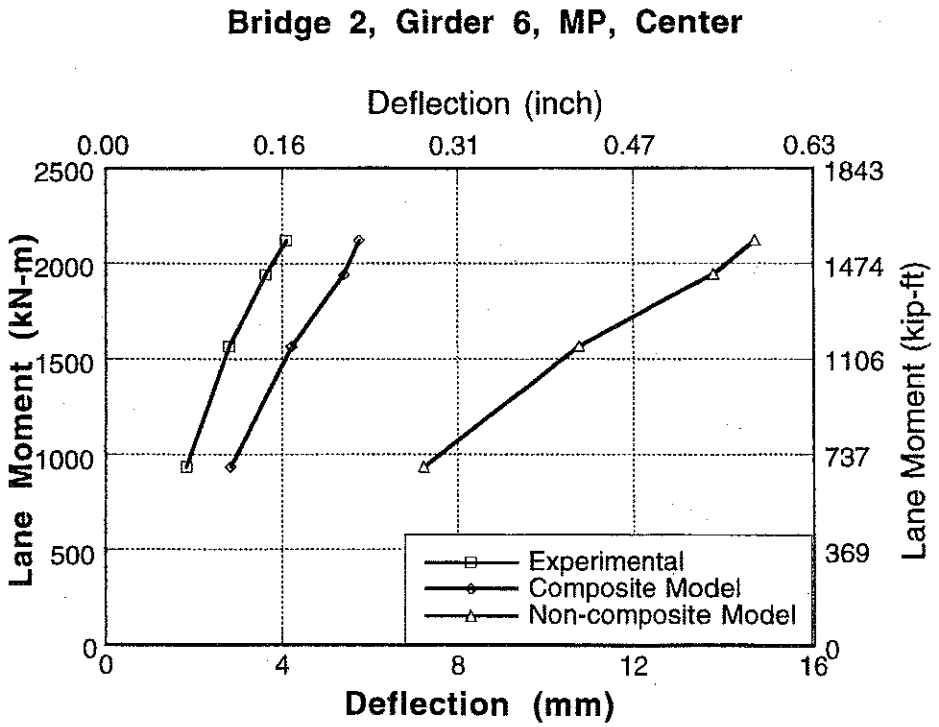


Figure A-25 : Experimental and Analytical Deflections for Bridge No. 2, Girder 4 and 5 for Center Loading.



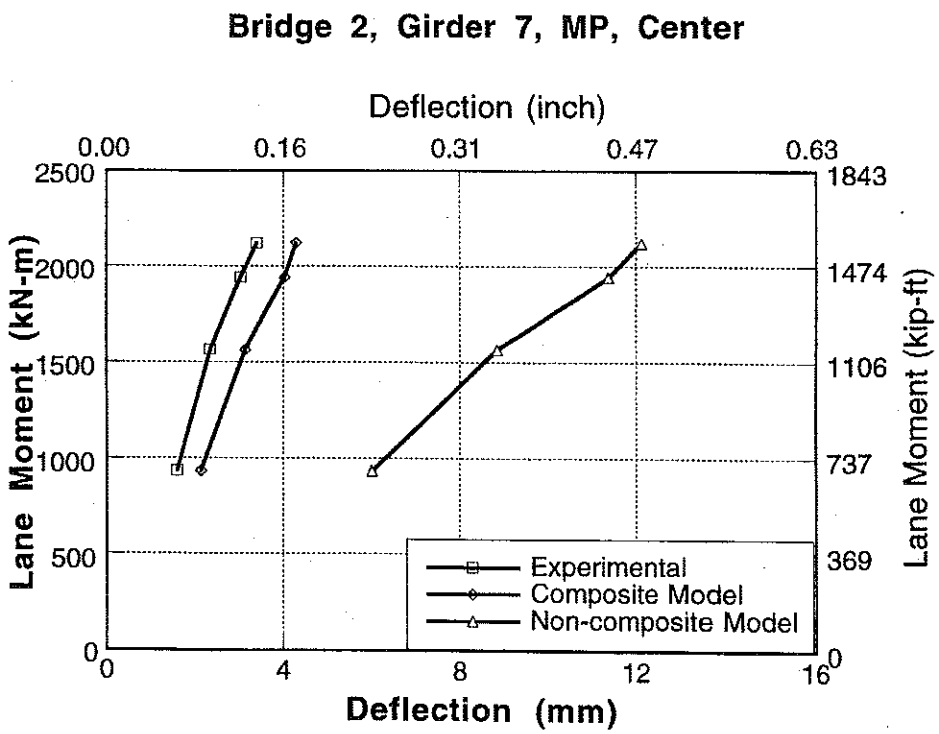
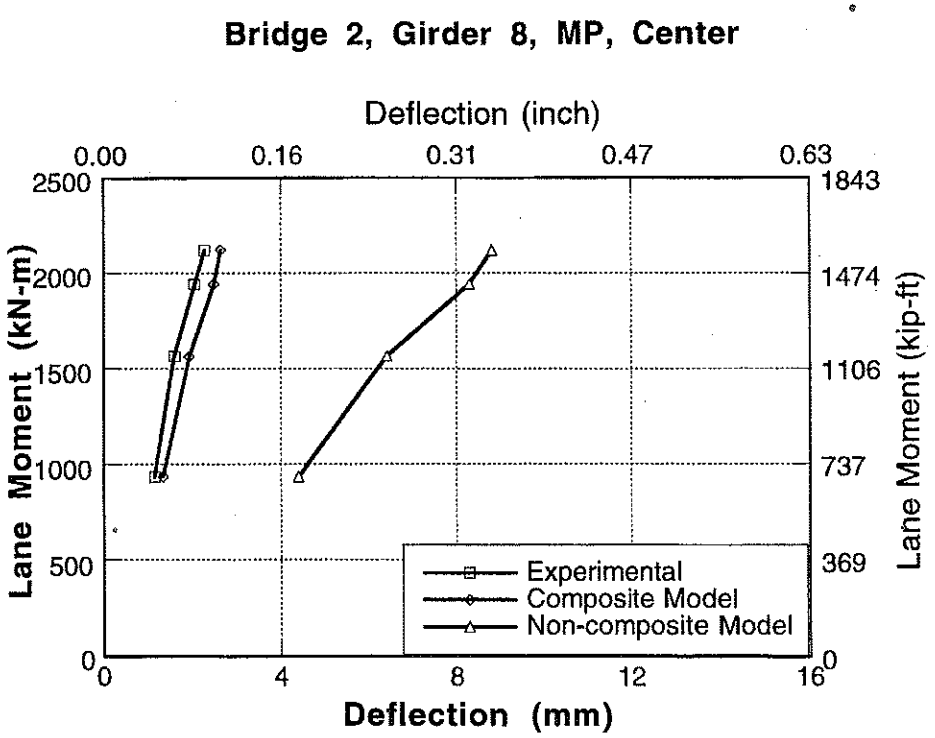


Figure A-26 : Experimental and Analytical Deflections for Bridge No. 2, Girder 6 and 7 for Center Loading.



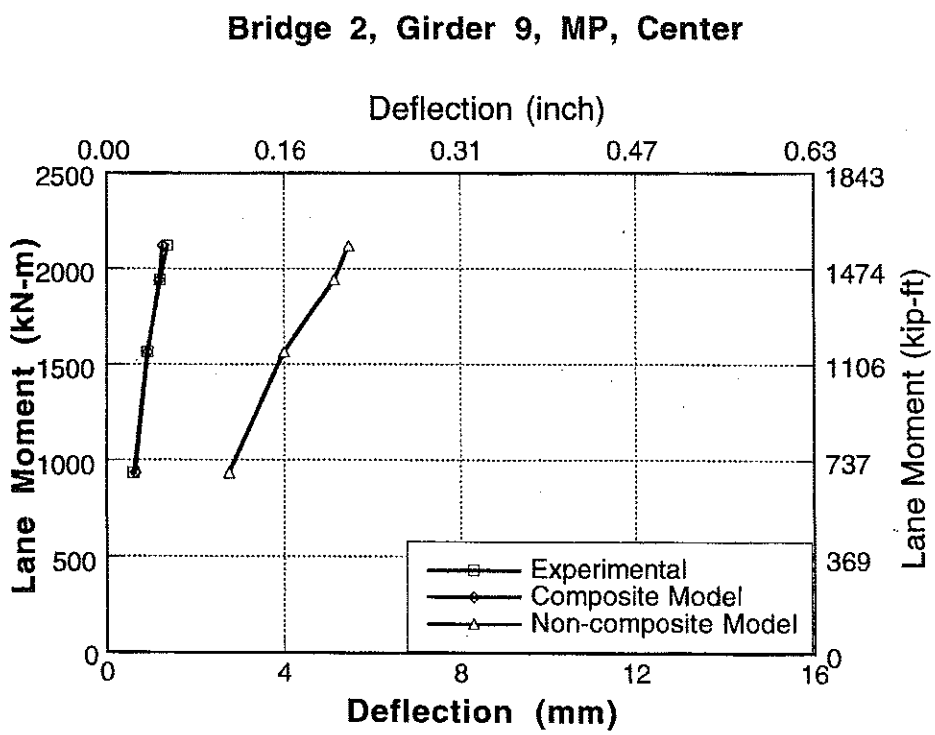
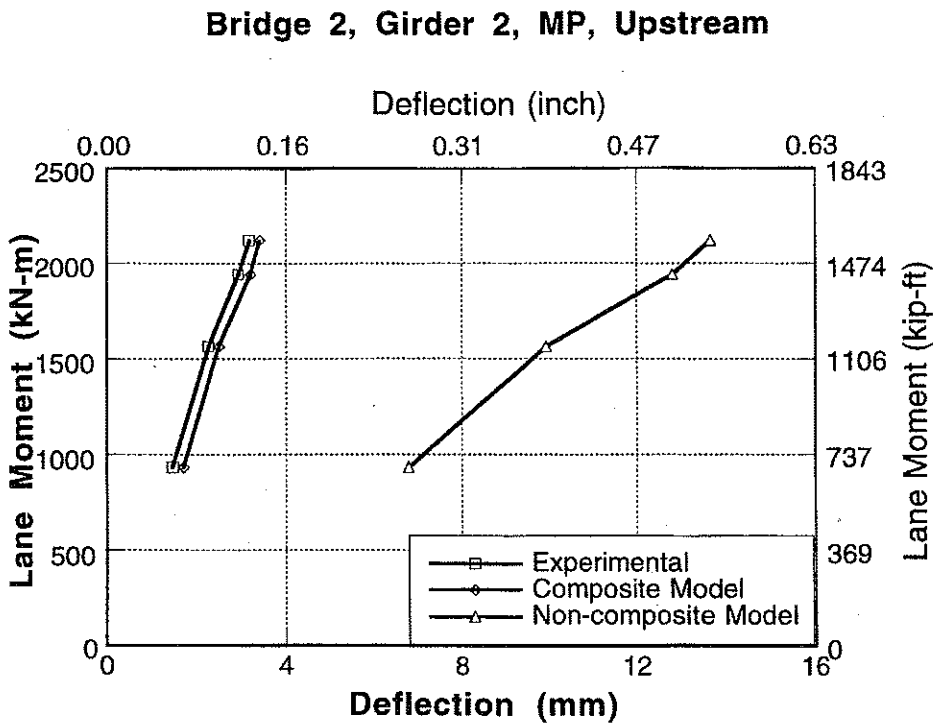


Figure A-27 : Experimental and Analytical Deflections for Bridge No. 2, Girder 8 and 9 for Center Loading.



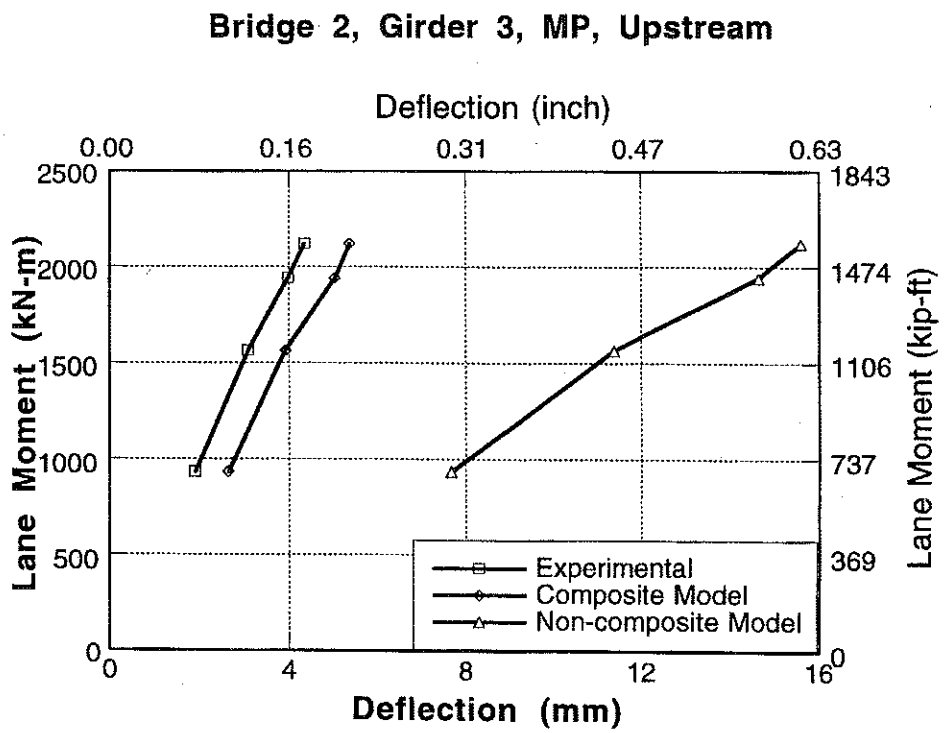
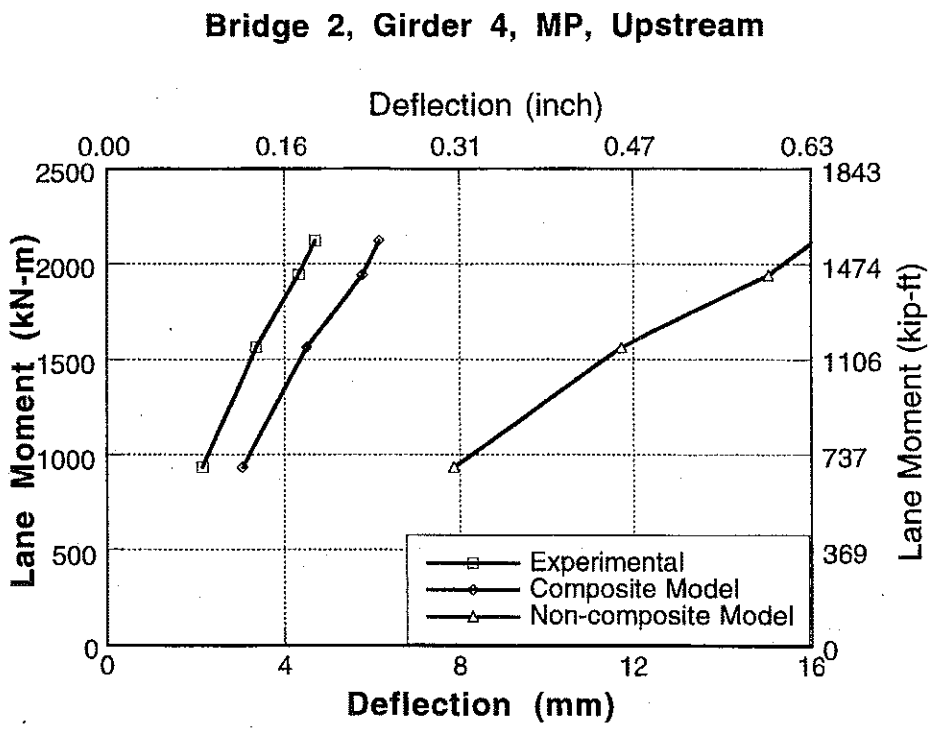


Figure A-28 : Experimental and Analytical Deflections for Bridge No. 2, Girder 2 and 3 for Upstream Loading.



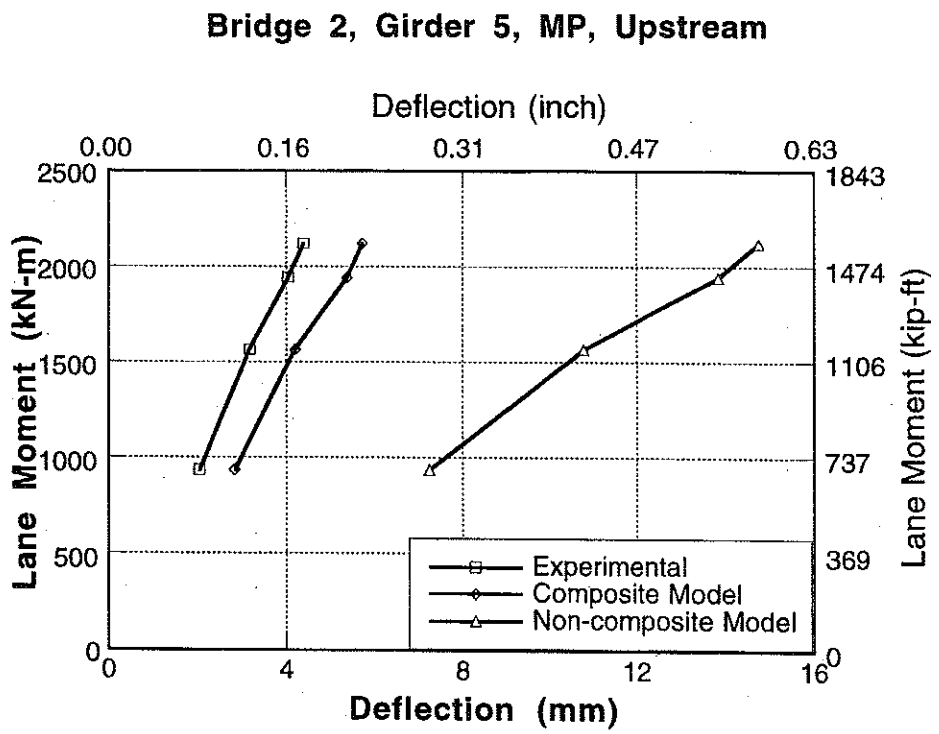
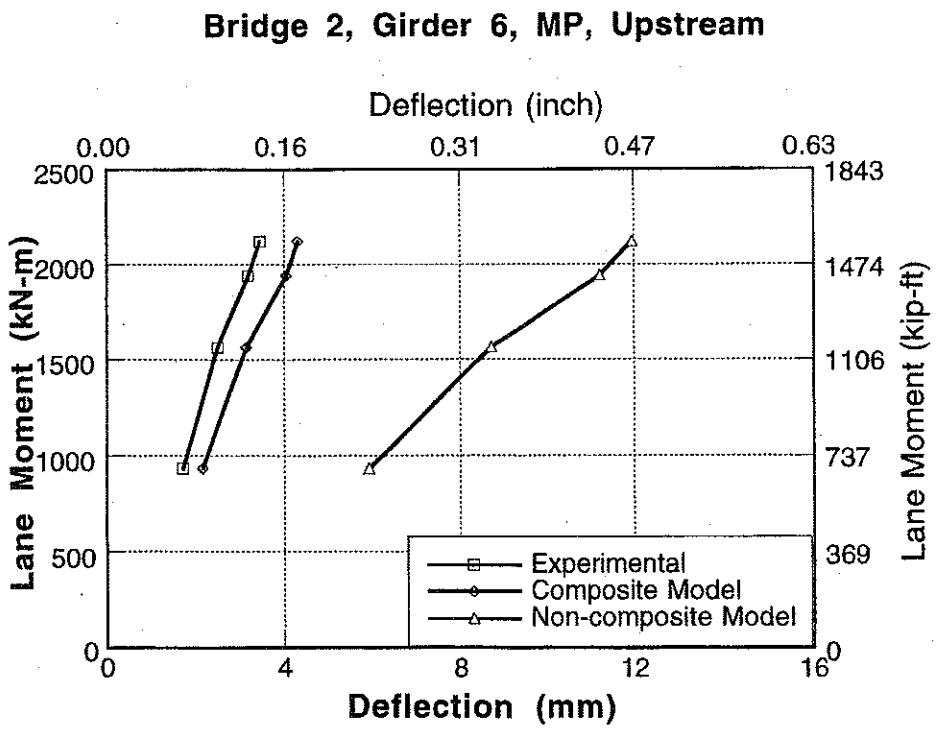


Figure A-29 : Experimental and Analytical Deflections for Bridge No. 2, Girder 4 and 5 for Upstream Loading.



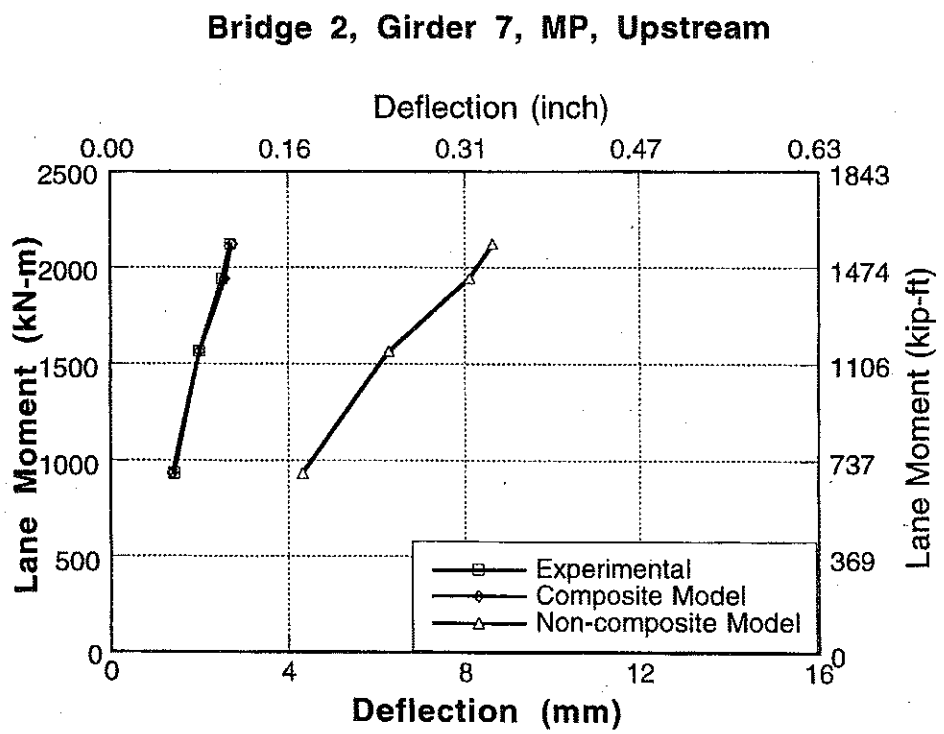
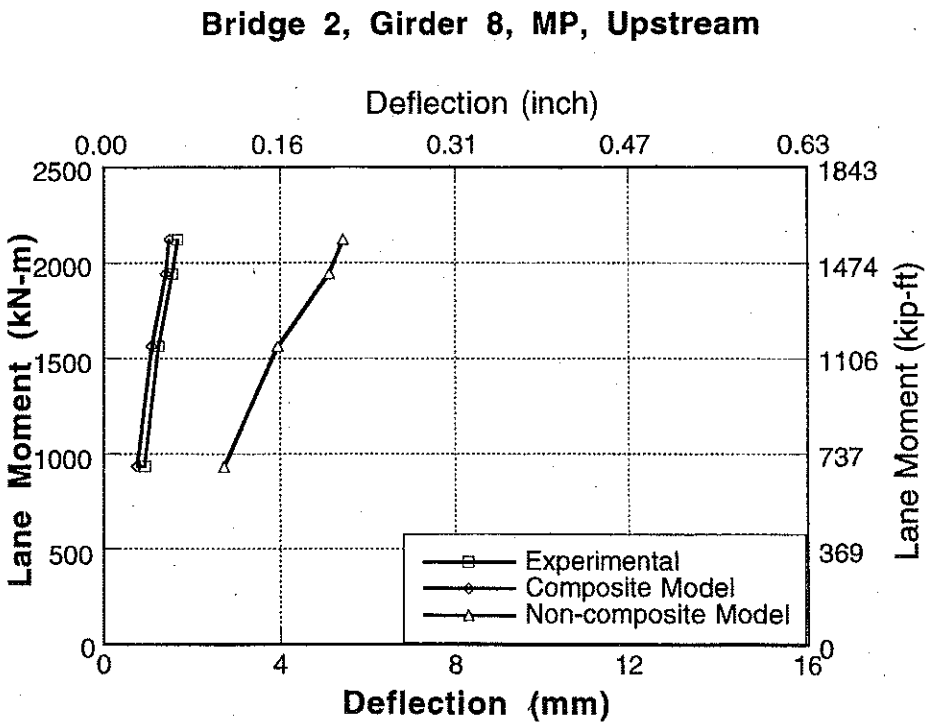


Figure A-30 : Experimental and Analytical Deflections for Bridge No. 2, Girder 6 and 7 for Upstream Loading.



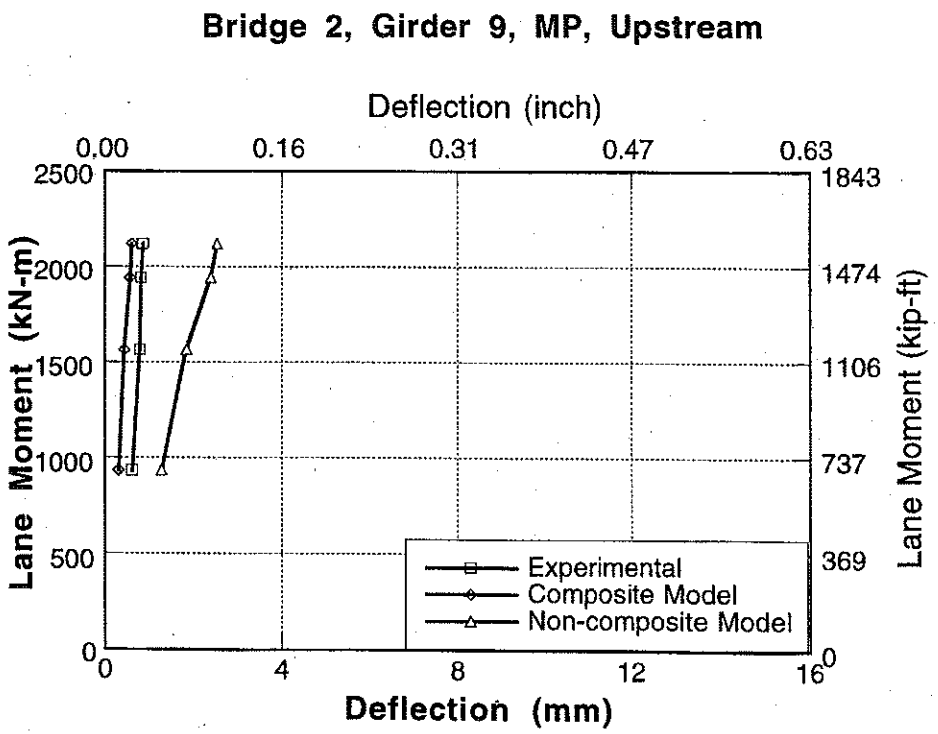


Figure A-31 : Experimental and Analytical Deflections for Bridge No. 2, Girder 8 and 9 for Upstream Loading.

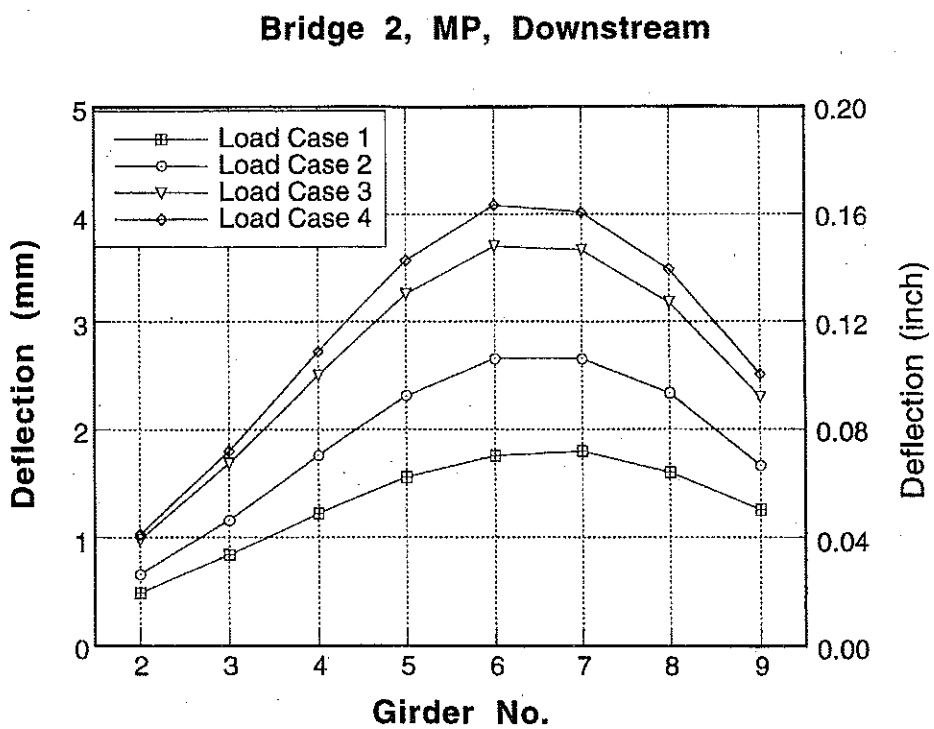


Figure A-32 : Girder Distribution of Deflections for Bridge No. 2 due to Downstream Loading.

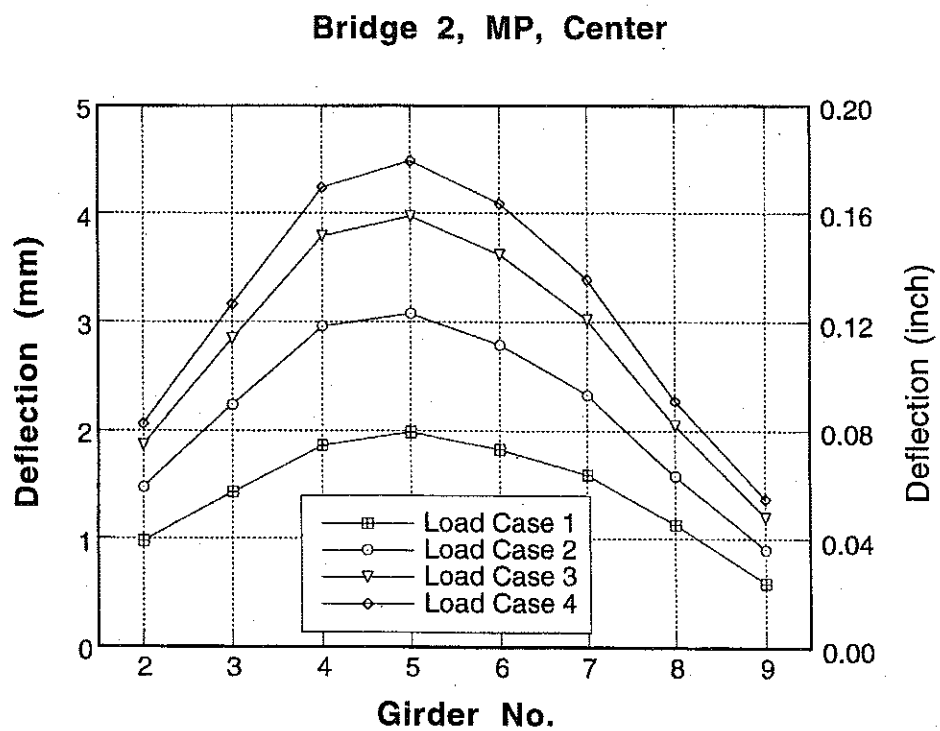


Figure A-33 : Girder Distribution of Deflections for Bridge No. 2 due to Center Loading.

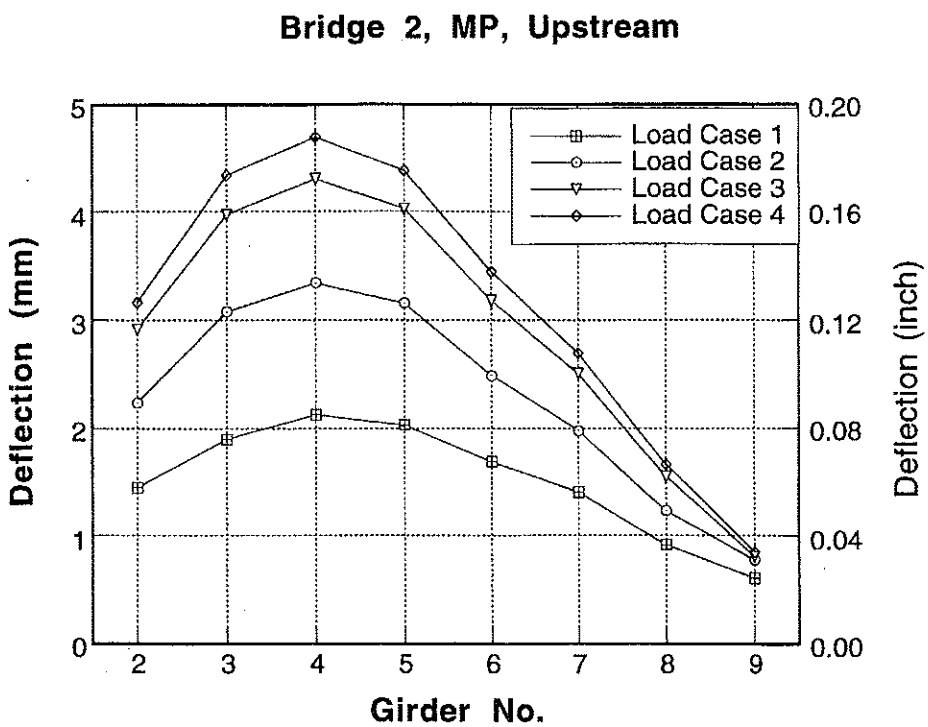


Figure A-34 : Girder Distribution of Deflections for Bridge No. 2 due to Upstream Loading.

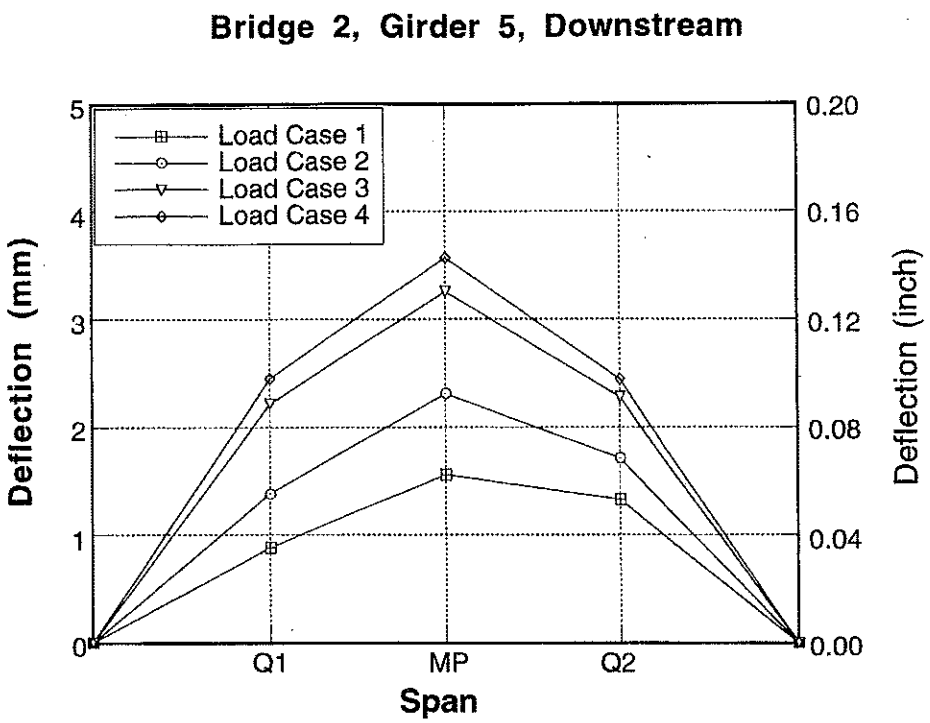


Figure A-35 : Longitudinal Distribution of Deflections for Bridge No. 2, Girder 5 due to Downstream Loading.

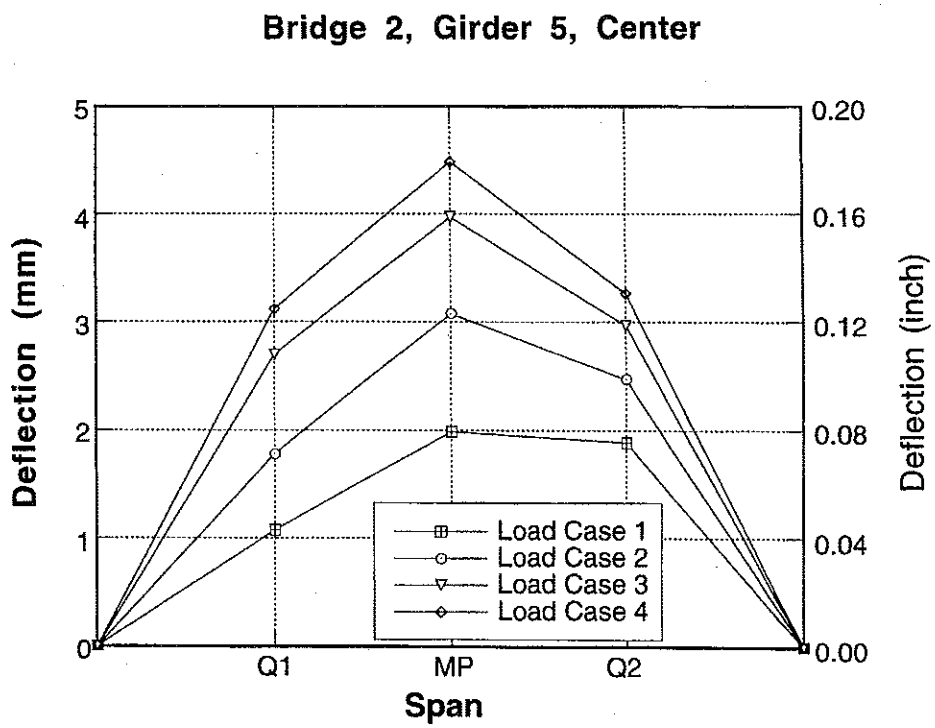


Figure A-36 : Longitudinal Distribution of Deflections for Bridge No. 2, Girder 5 due to Center Loading.

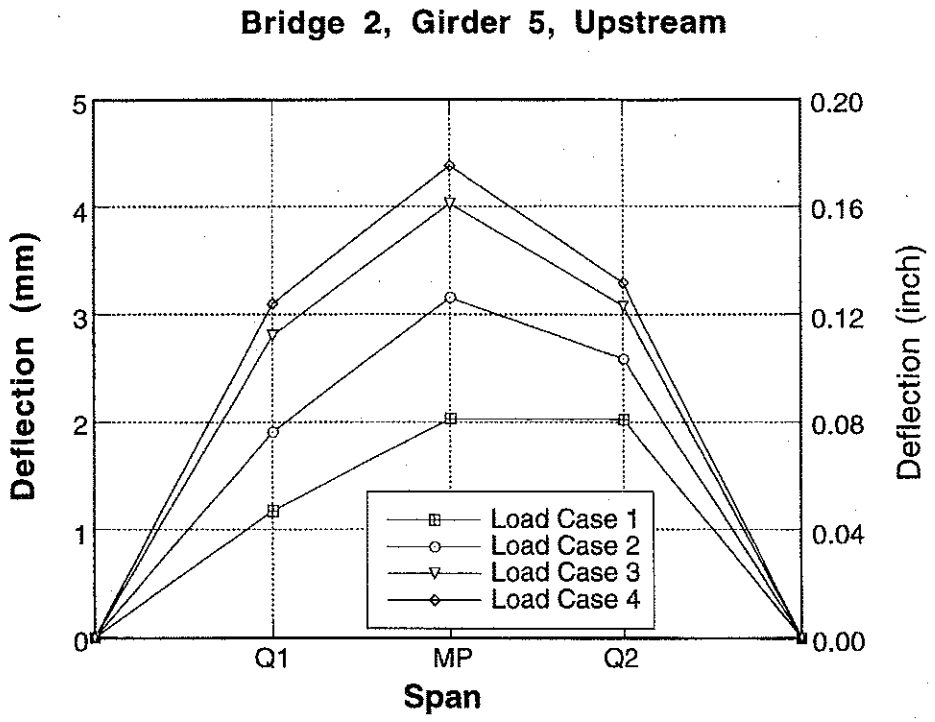
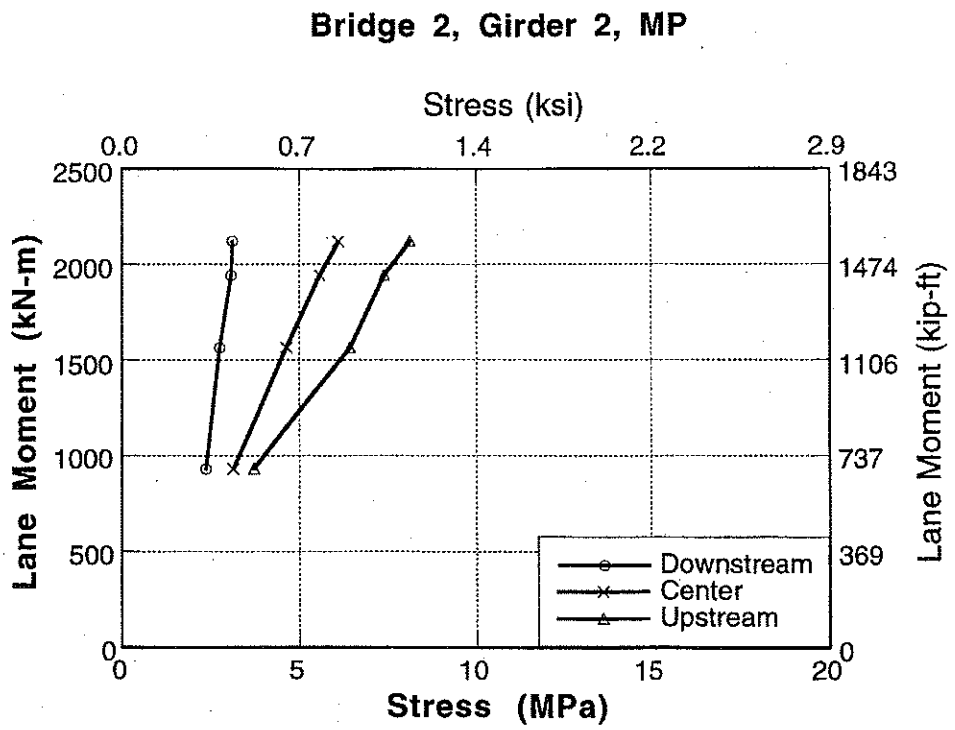


Figure A-37 Longitudinal Distribution of Deflections for Bridge No. 2, Girder 5 due to Upstream Loading.



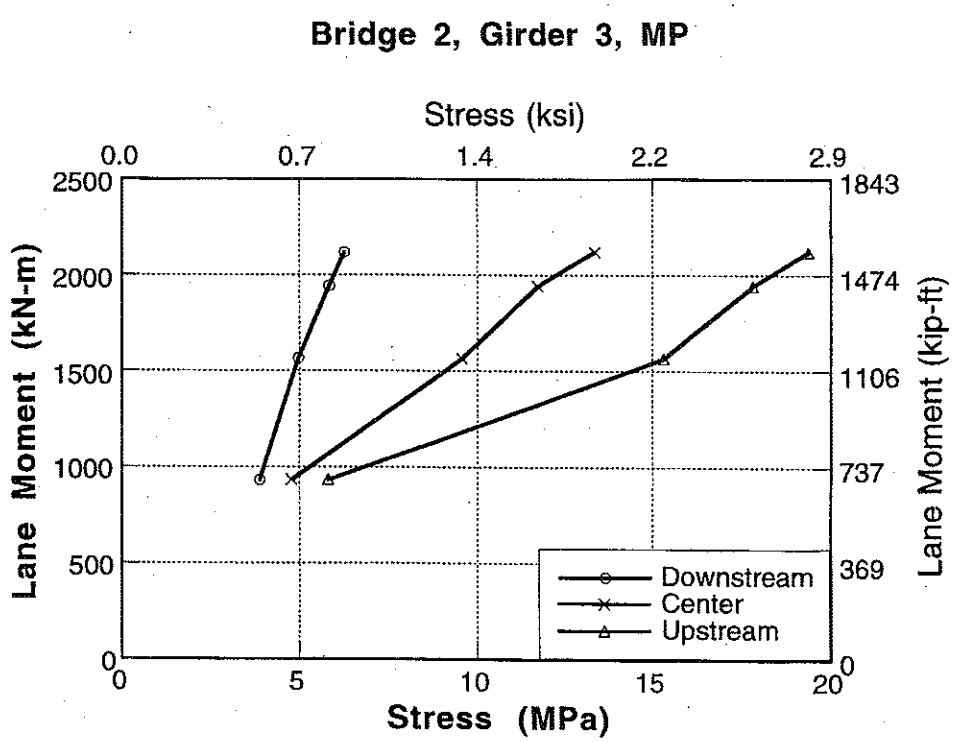
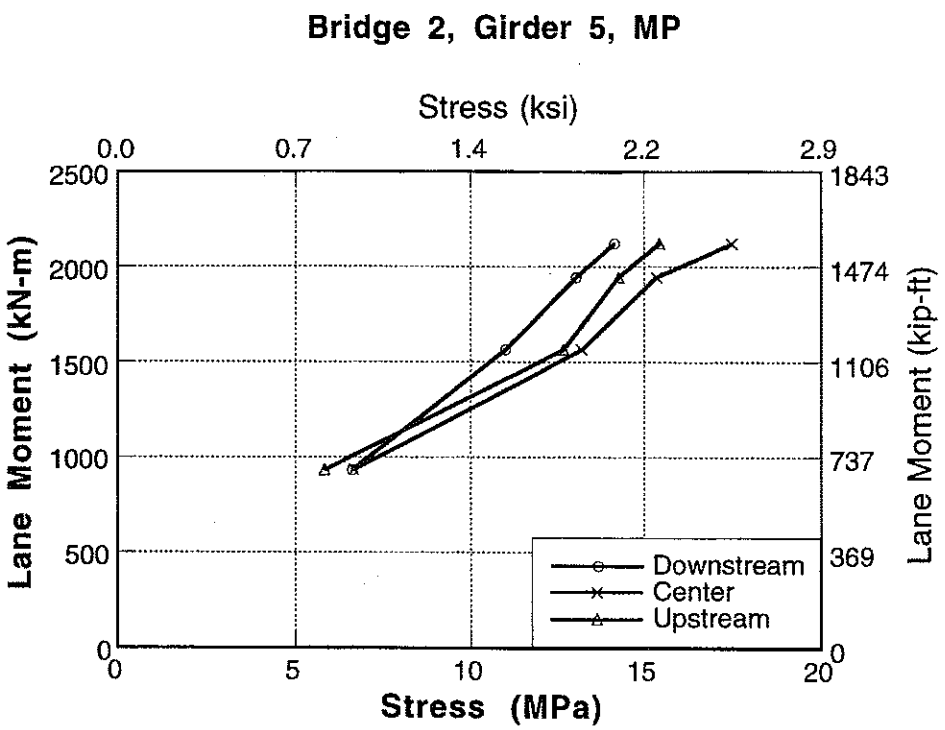


Figure A-38 : Stress vs Lane Moment for Bridge No. 2, Girder 2 and 3 at Mid Point.



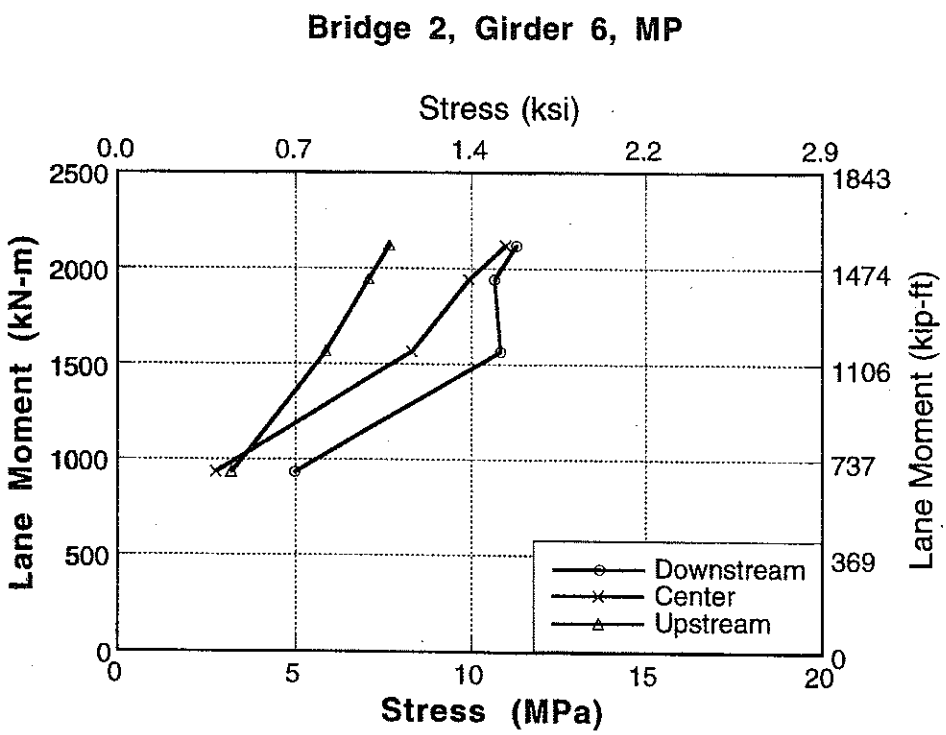
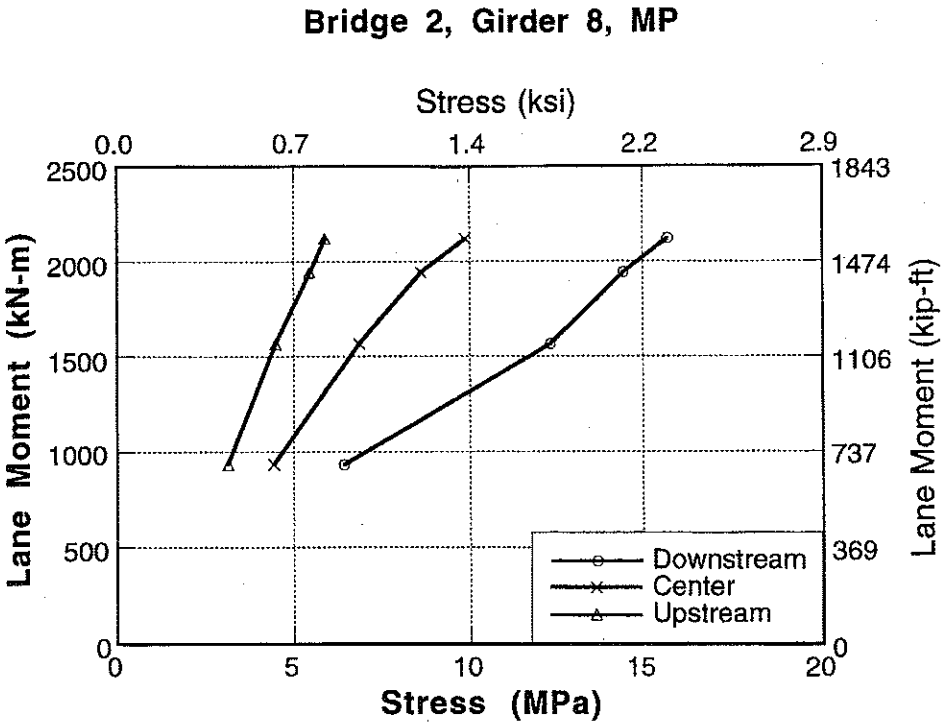


Figure A-39 : Stress vs Lane Moment for Bridge No. 2, Girder 5 and 6 at Mid Point.



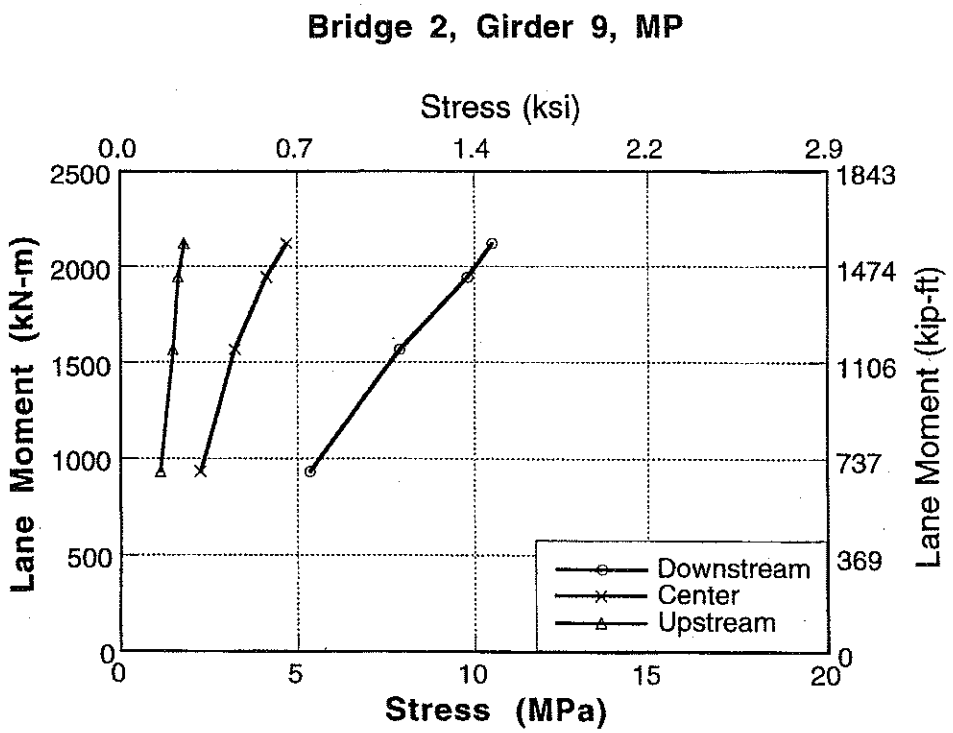
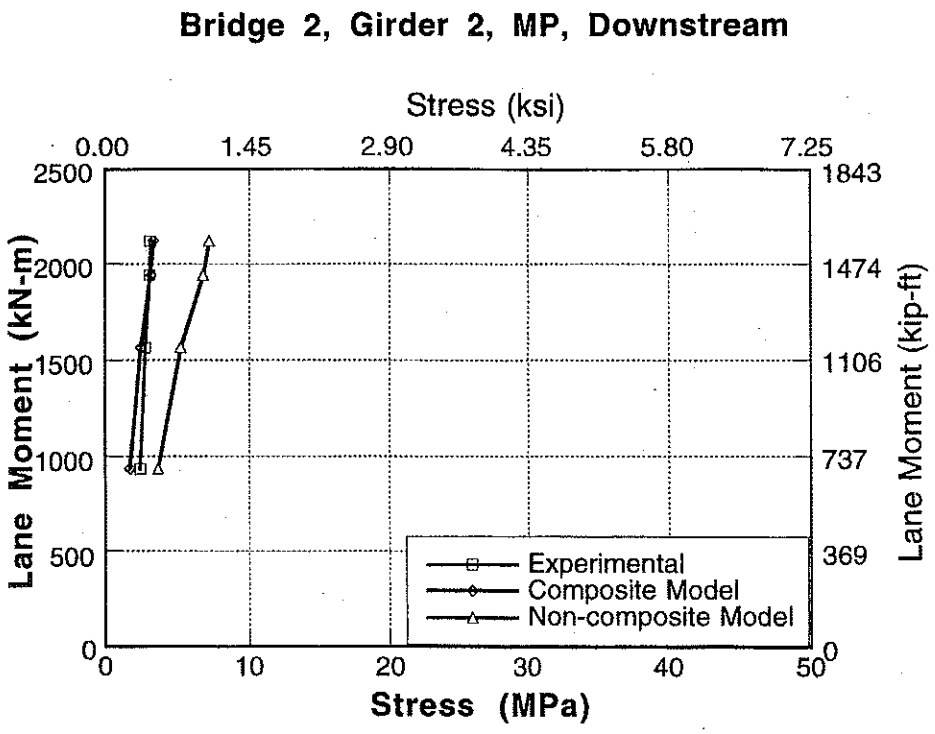


Figure A-40 : Stress vs Lane Moment for Bridge No. 2, Girder 8 and 9 at Mid Point.



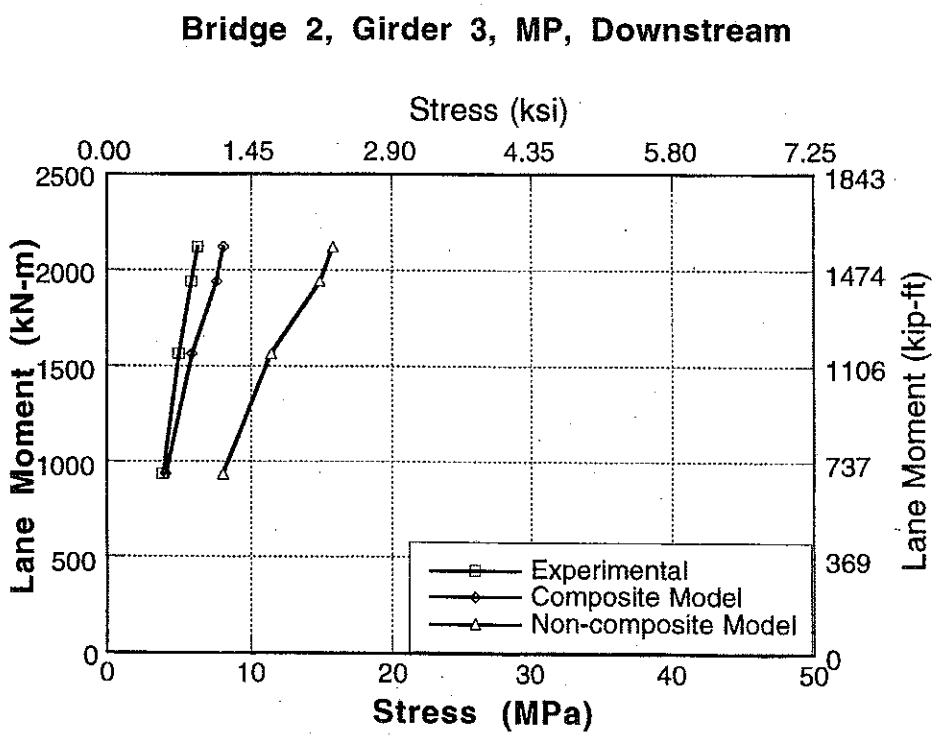
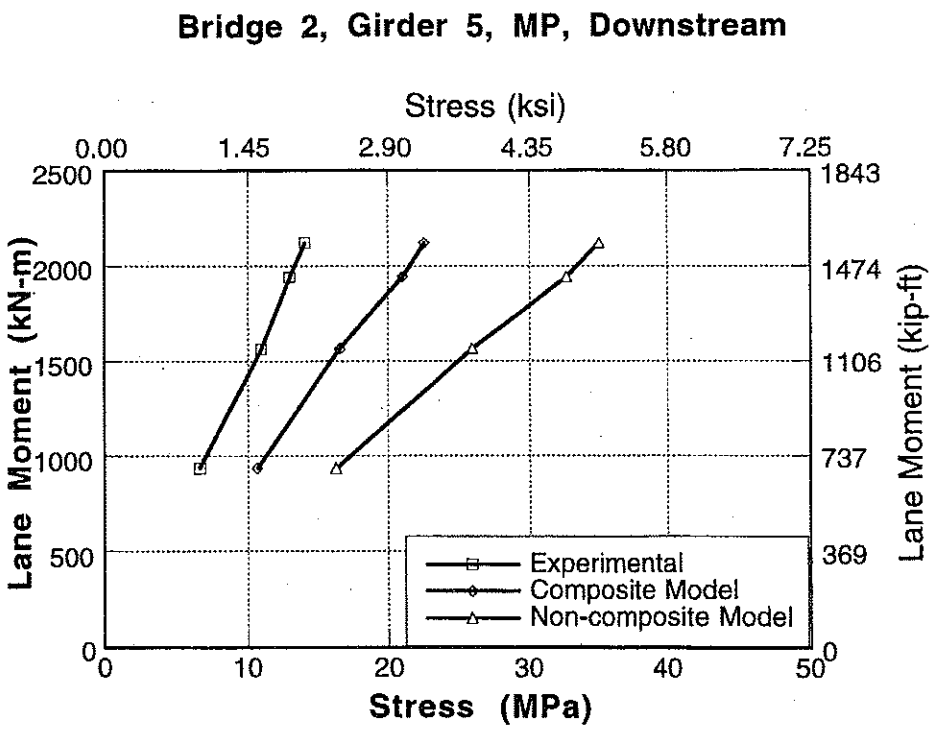


Figure A-41 : Experimental and Analytical Stresses for Bridge No. 2, Girder 2 and 3 for Downstream Loading.



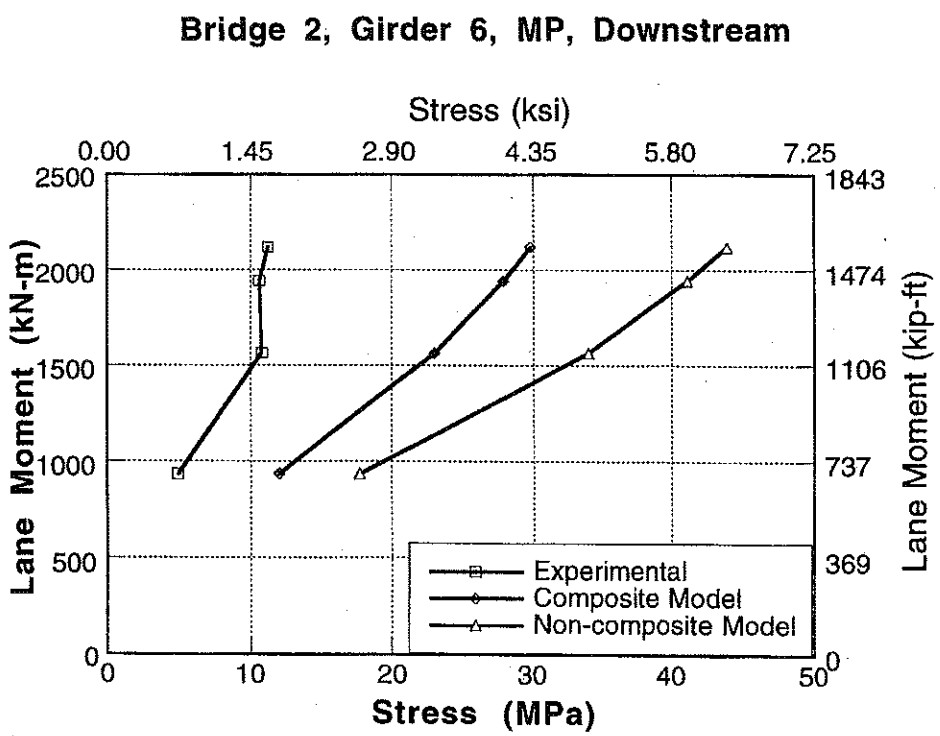
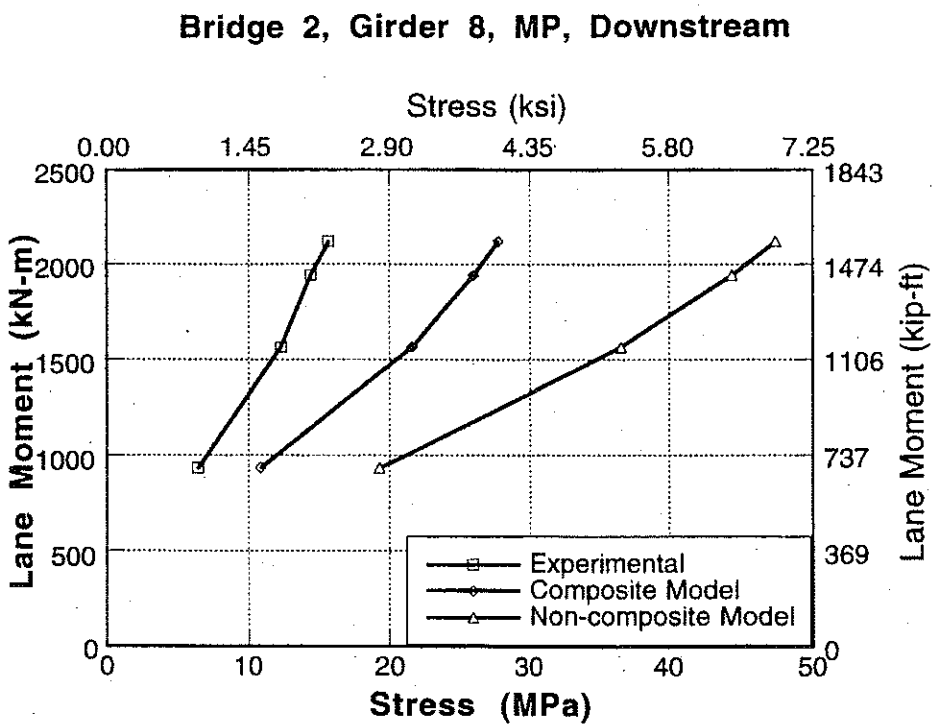


Figure A-42 : Experimental and Analytical Stresses for Bridge No. 2, Girder 5 and 6 for Downstream Loading.



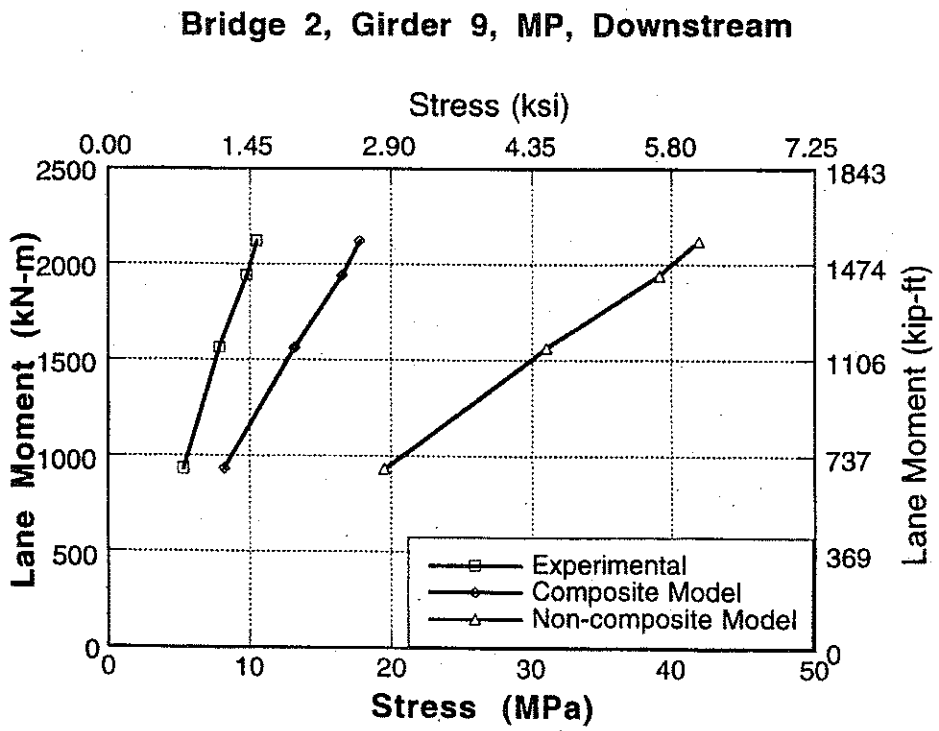
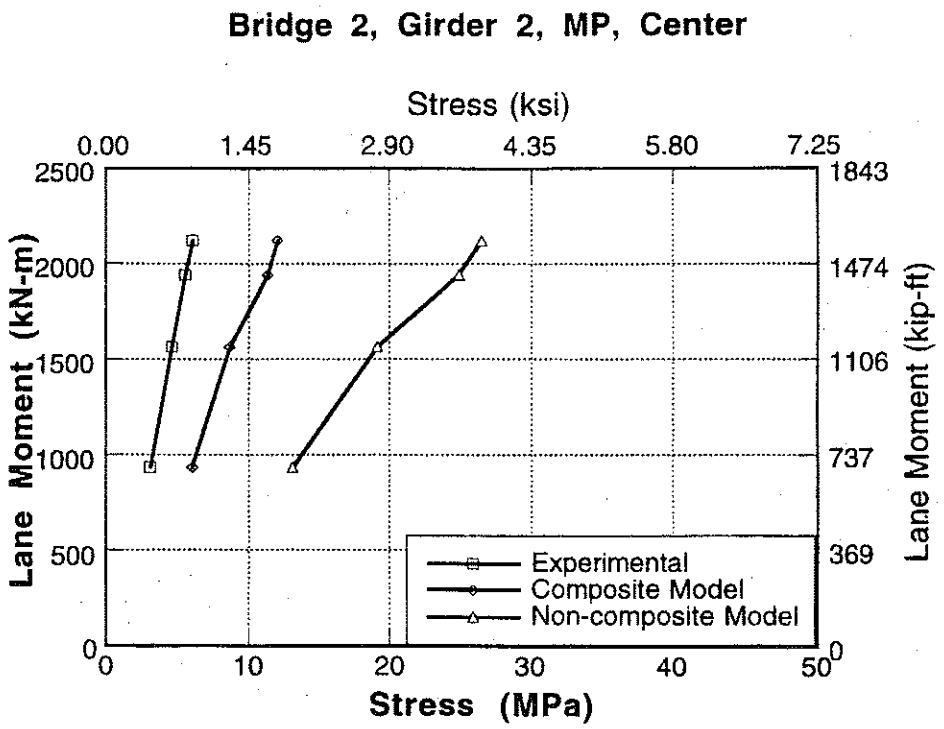


Figure A-43 : Experimental and Analytical Stresses for Bridge No. 2, Girder 8 and 9 for Downstream Loading.



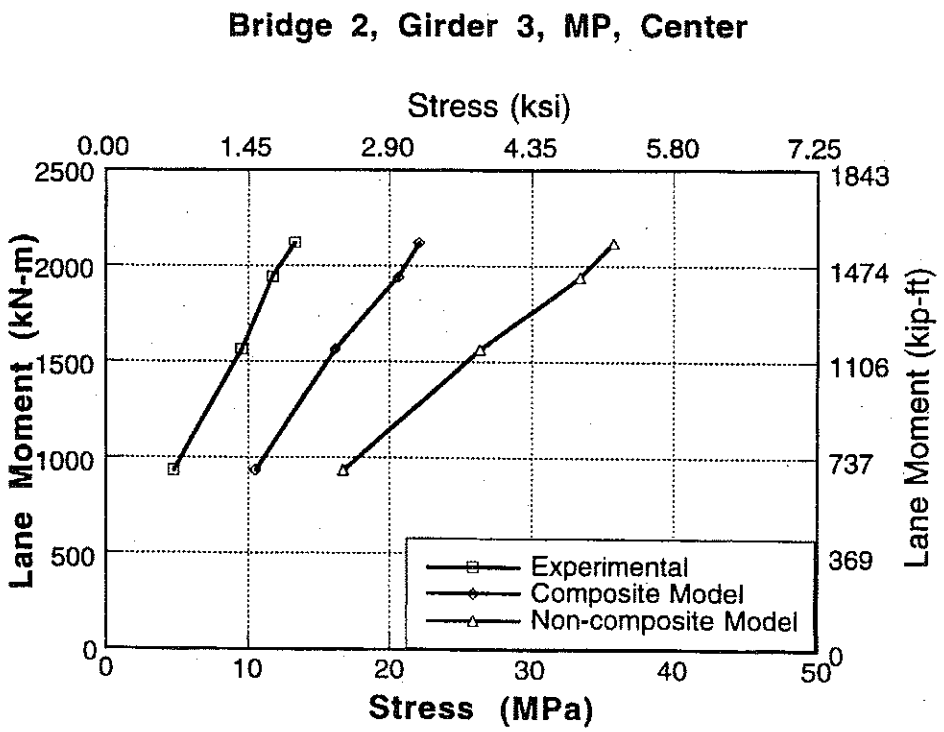
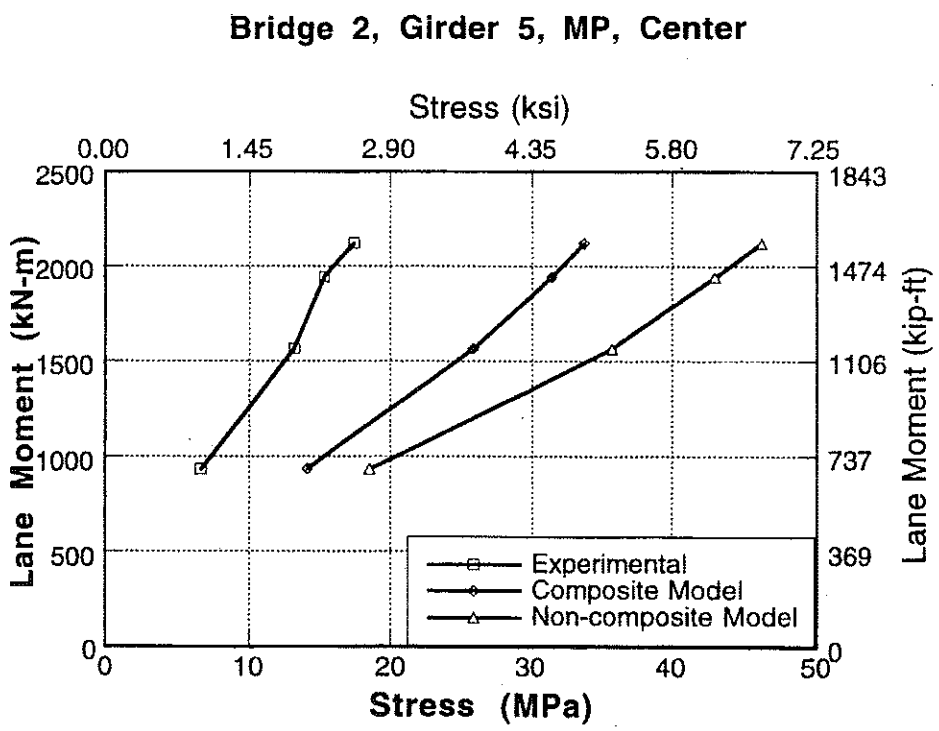


Figure A-44 : Experimental and Analytical Stresses for Bridge No. 2, Girder 2 and 3 for Center Loading.



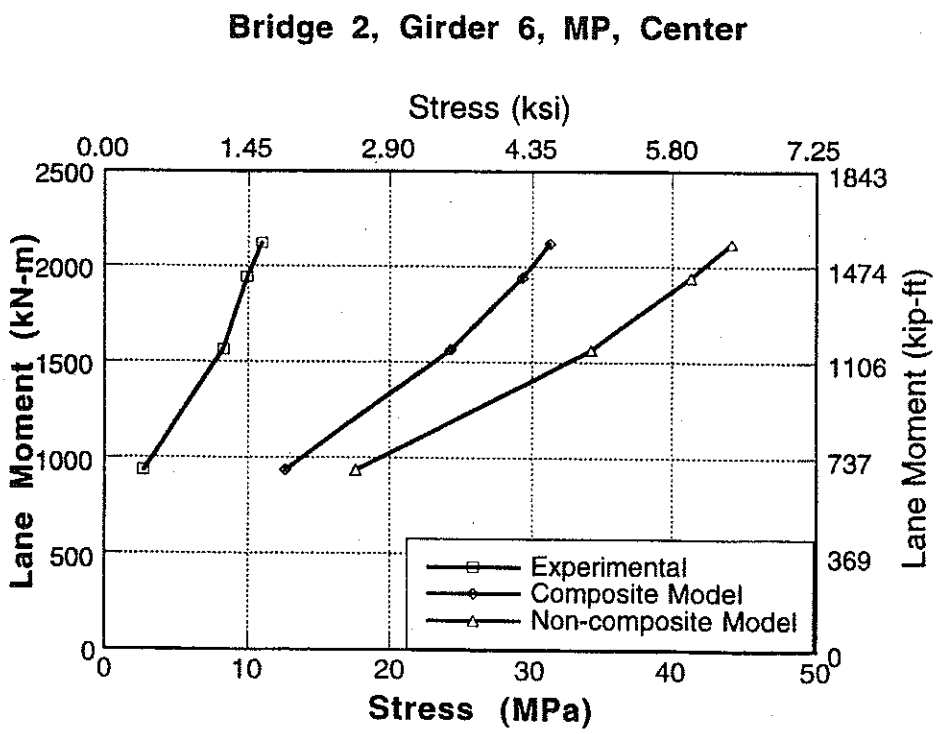
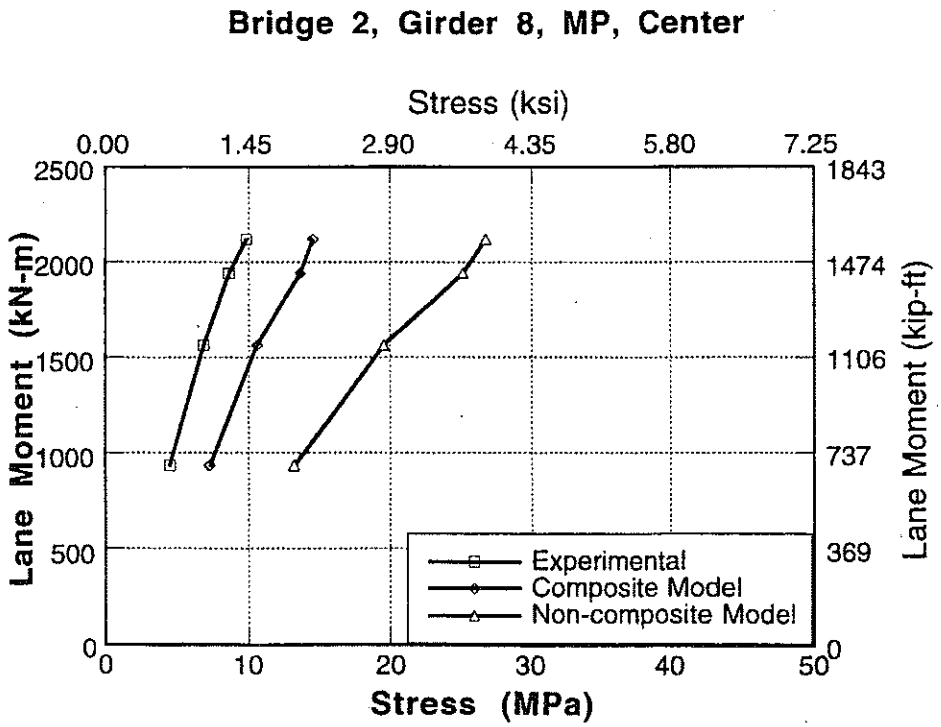


Figure A-45 : Experimental and Analytical Stresses for Bridge No. 2, Girder 5 and 6 for Center Loading.



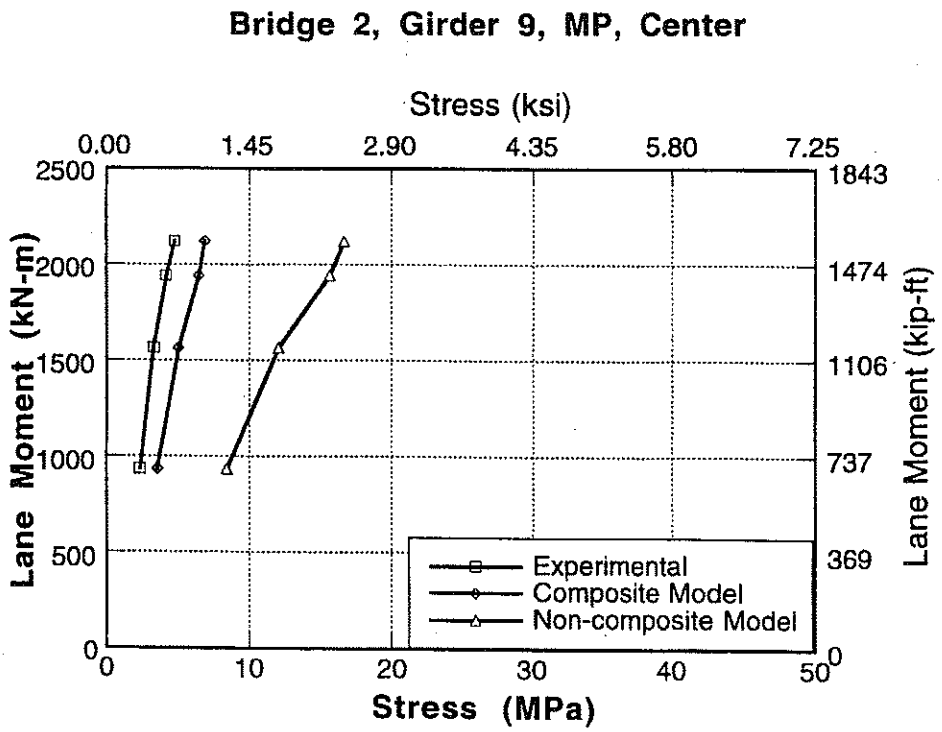
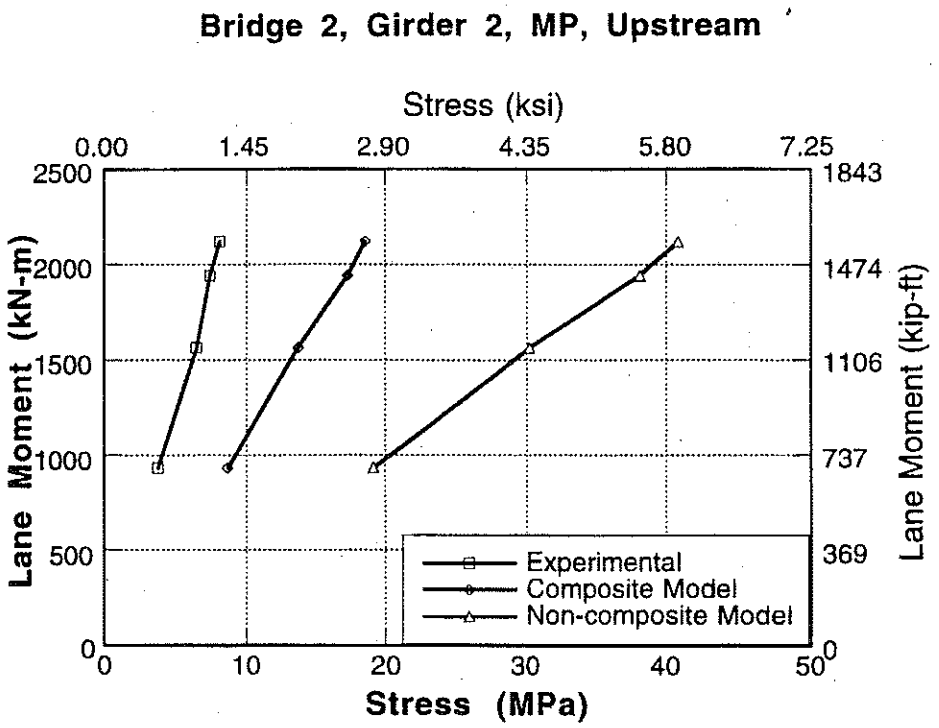


Figure A-46 : Experimental and Analytical Stresses for Bridge No. 2, Girder 8 and 9 for Center Loading.



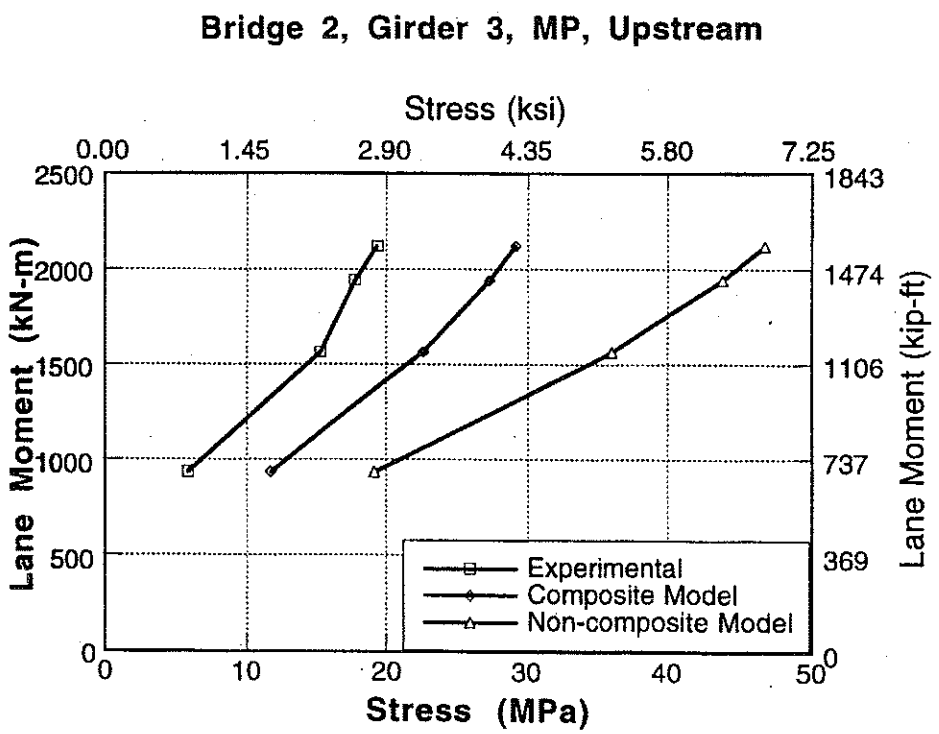
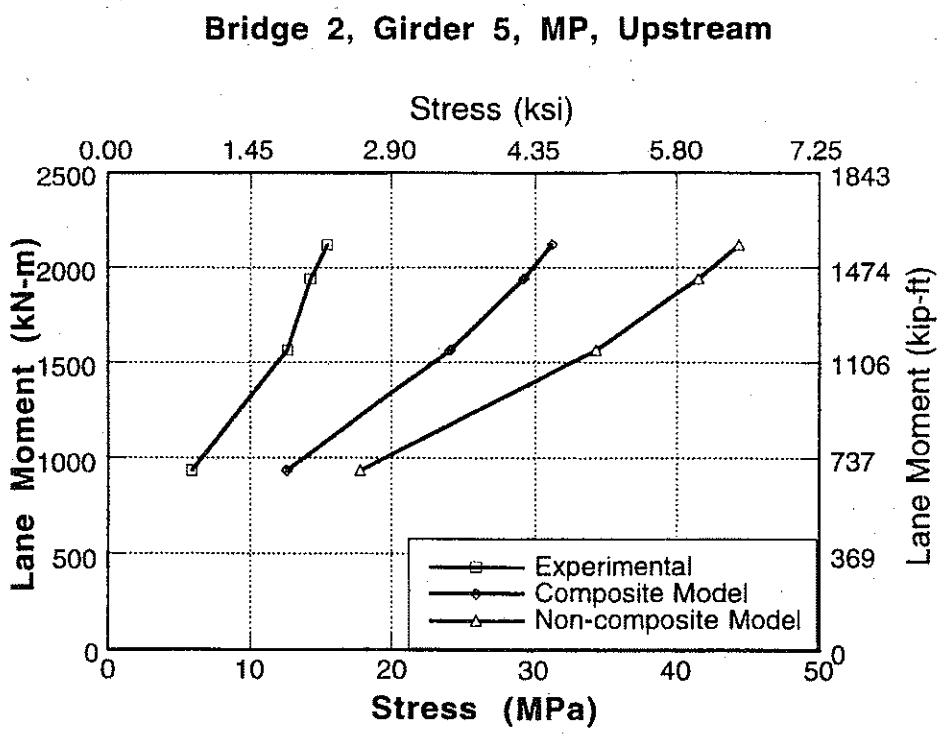


Figure A-47 : Experimental and Analytical Stresses for Bridge No. 2, Girder 2 and 3 for Upstream Loading.



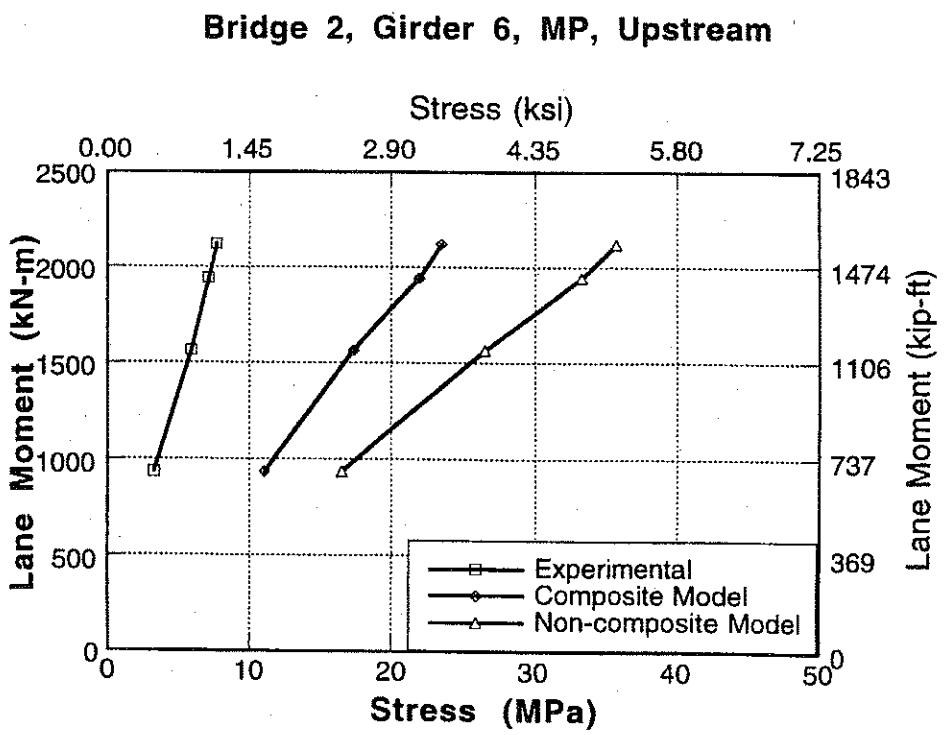
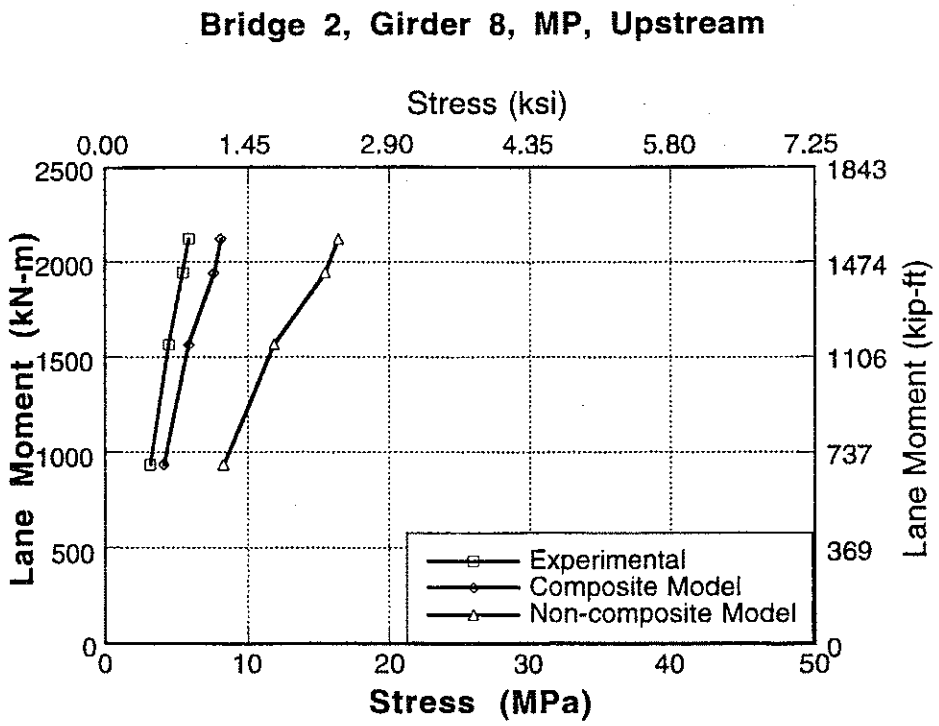


Figure A-48 : Experimental and Analytical Stresses for Bridge No. 2, Girder 5 and 6 for Upstream Loading.



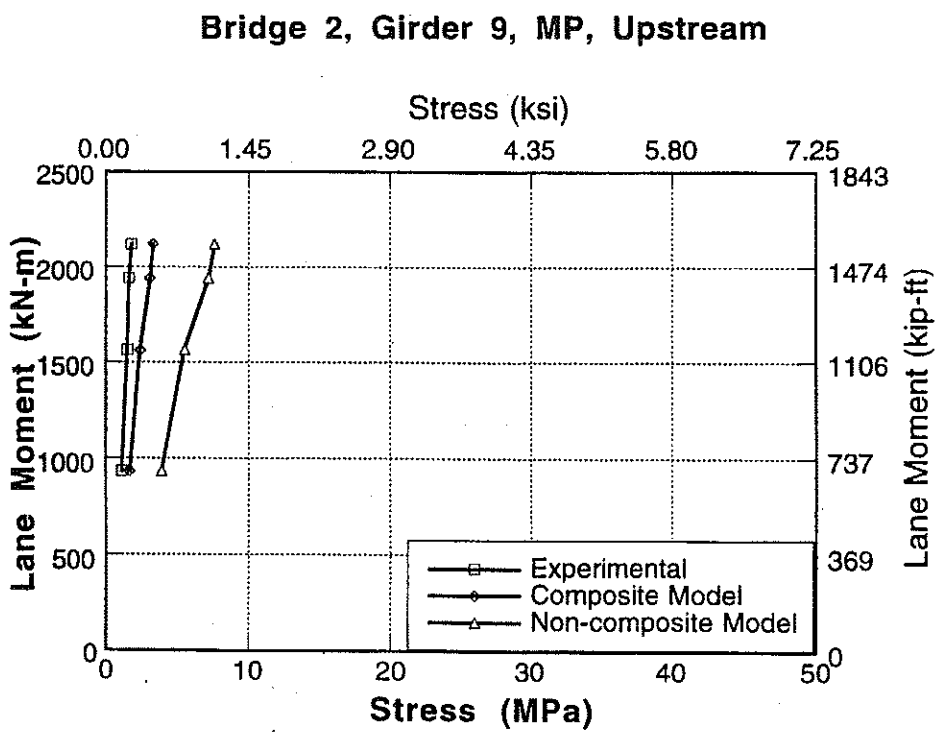


Figure A-49 : Experimental and Analytical Stresses for Bridge No. 2, Girder 8 and 9 for Upstream Loading.

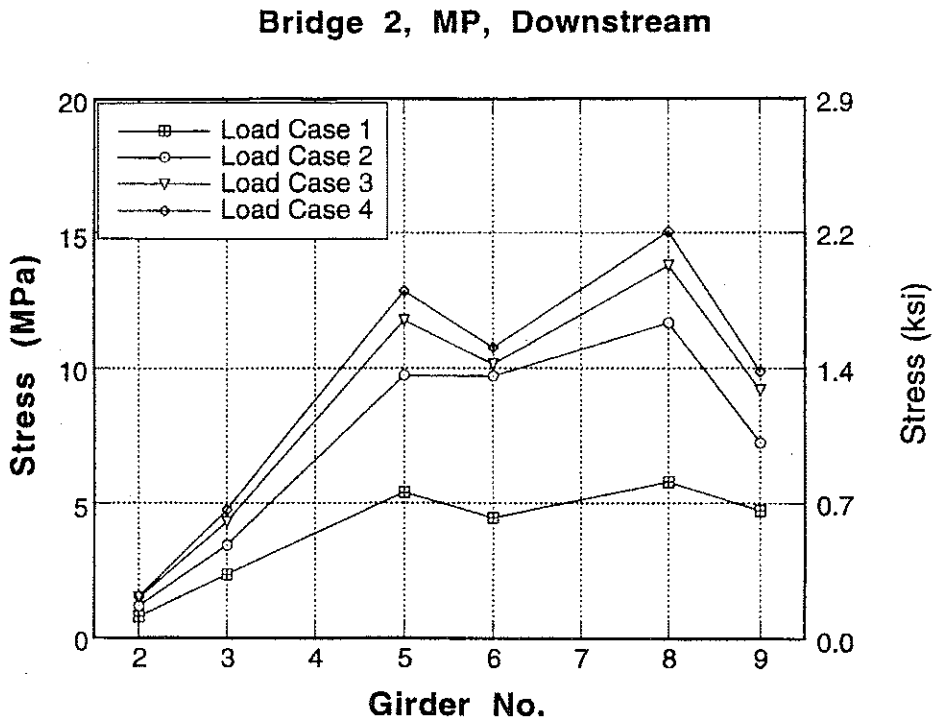


Figure A-50 : Girder Distribution of Stresses at Mid Point for Bridge No. 2 due to Downstream Loading.

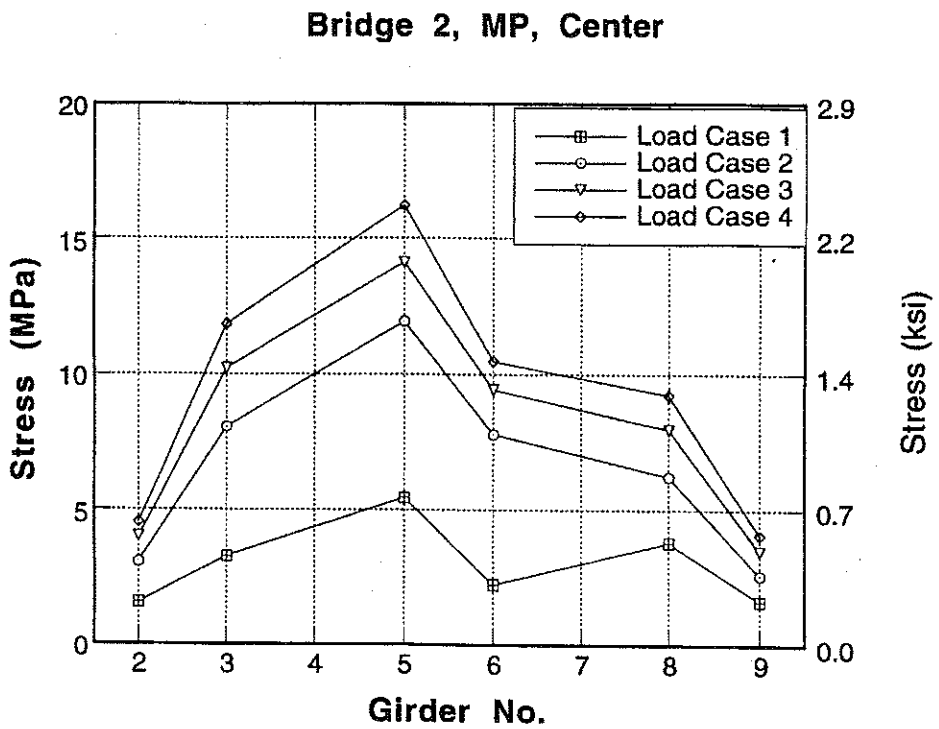


Figure A-51 : Girder Distribution of Stresses at Mid Point for Bridge No. 2 due to Center Loading.

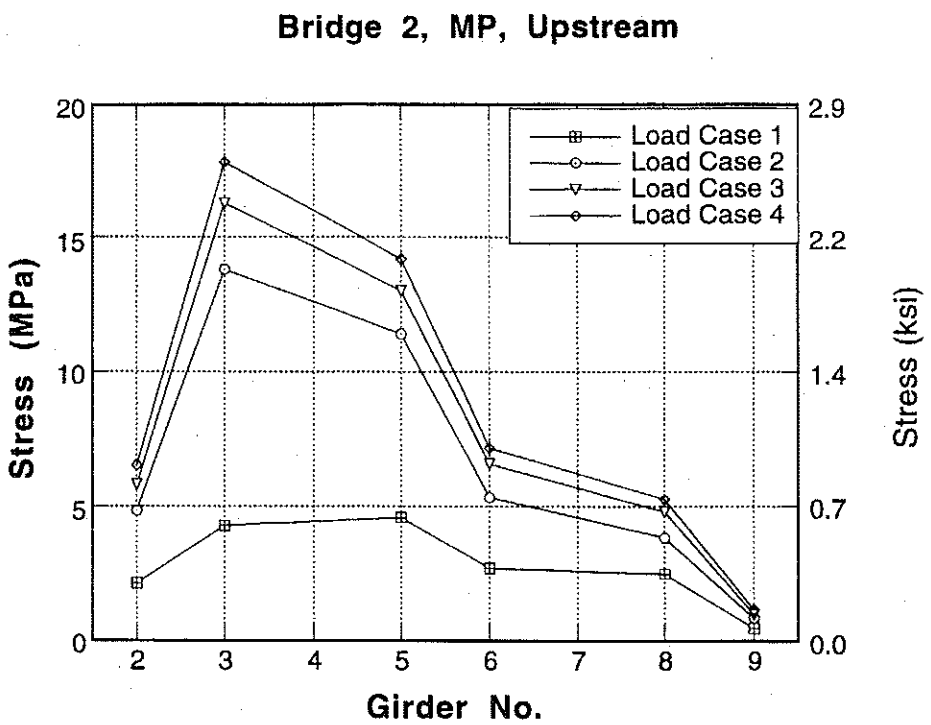


Figure A-52 : Girder Distribution of Stresses at Mid Point for Bridge No. 2 due to Upstream Loading.

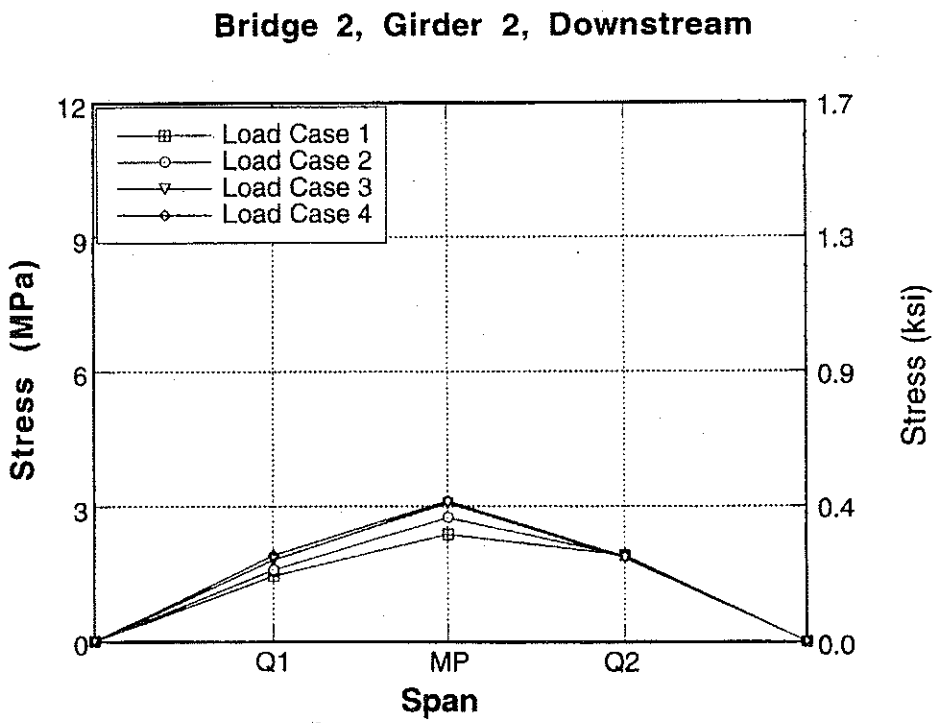


Figure A-53 : Longitudinal Distribution of Stresses for Bridge No. 2, Girder 2 due to Downstream Loading.

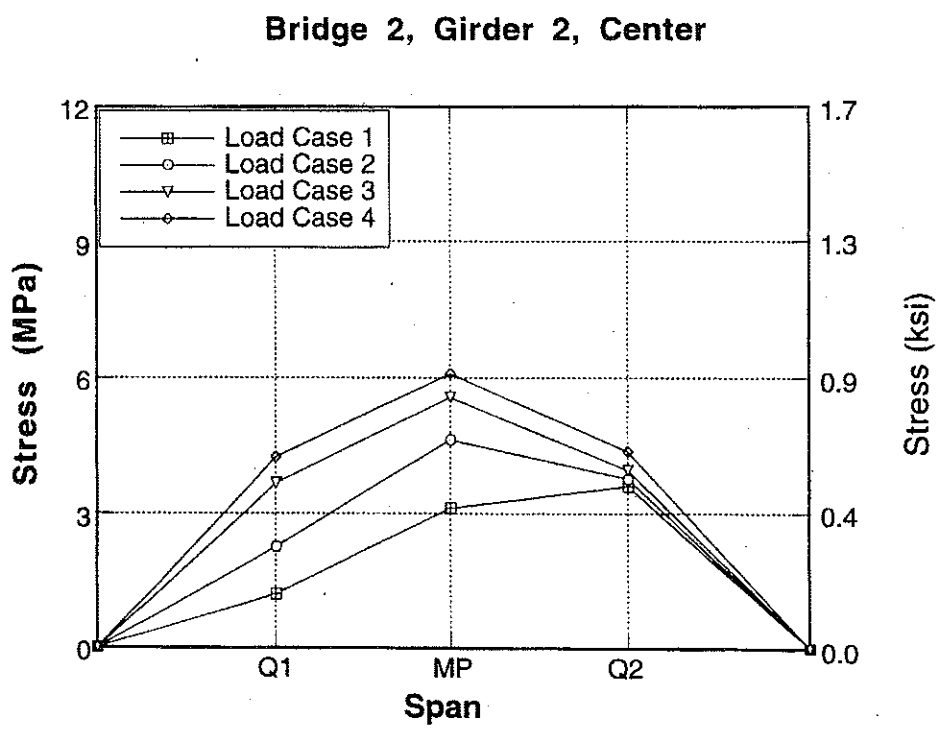


Figure A-54 : Longitudinal Distribution of Stresses for Bridge No. 2, Girder 2 due to Center Loading.

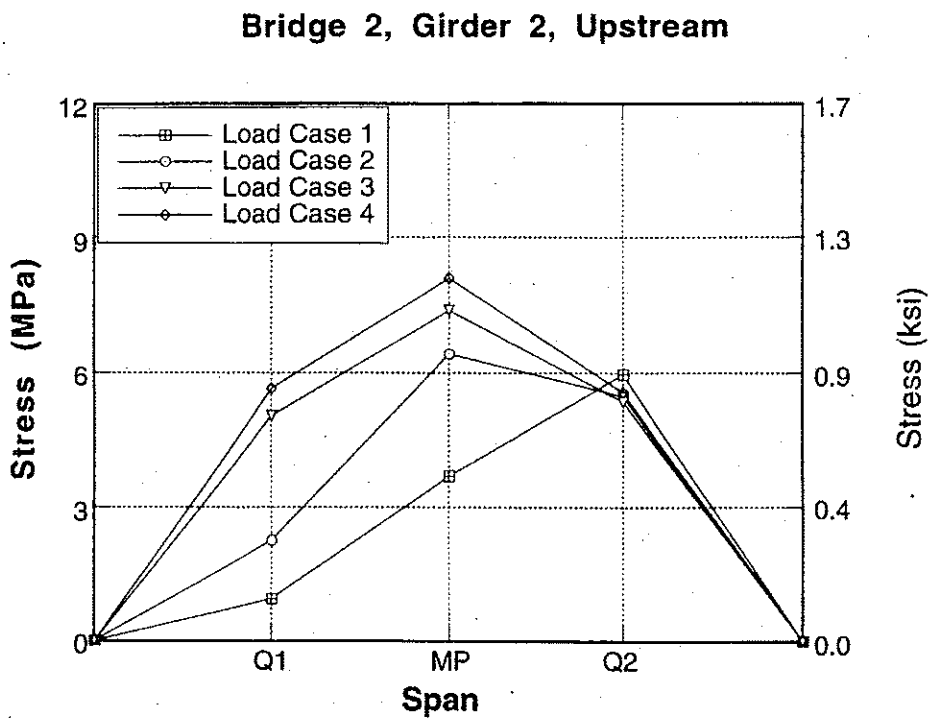


Figure A-55 : Longitudinal Distribution of Stresses for Bridge No. 2, Girder 2 due to Upstream Loading.

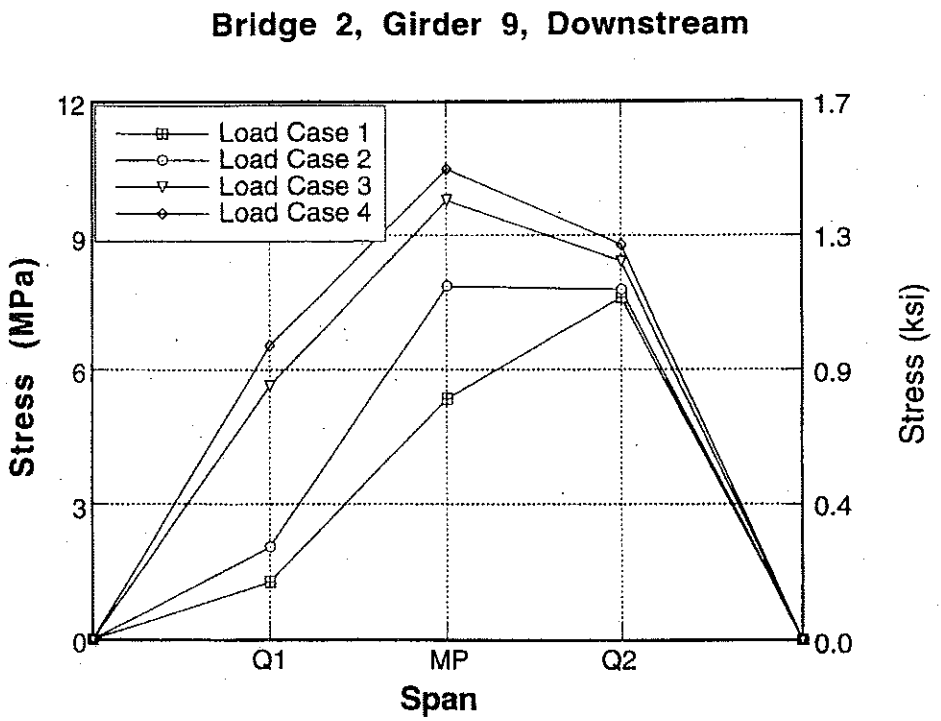


Figure A-56 : Longitudinal Distribution of Stresses for Bridge No. 2, Girder 9 due to Downstream Loading.

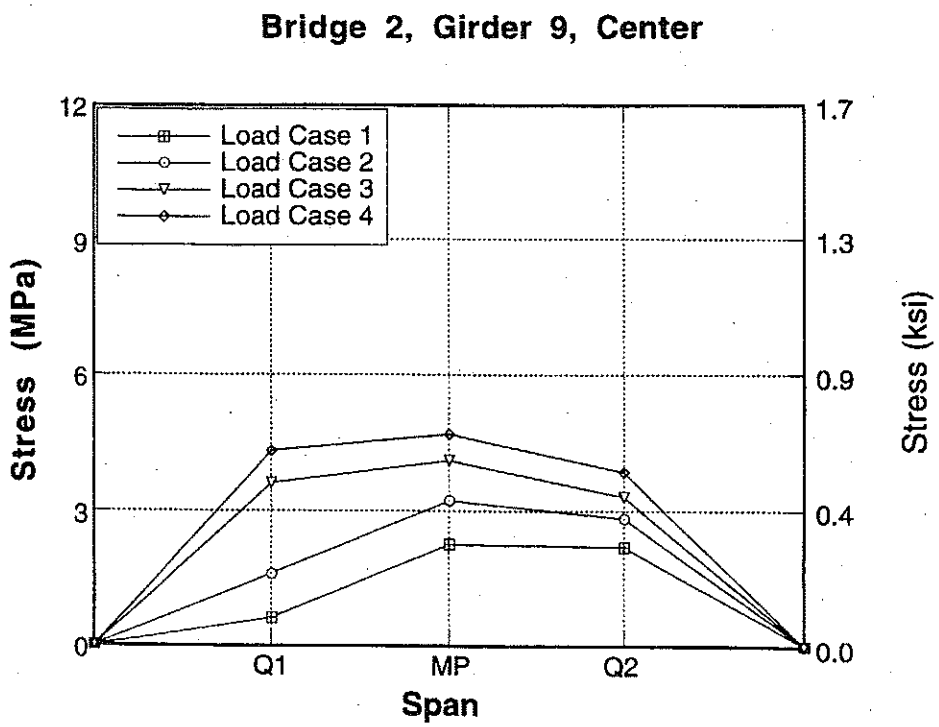


Figure A-57 : Longitudinal Distribution of Stresses for Bridge No. 2, Girder 9 due to Center Loading.

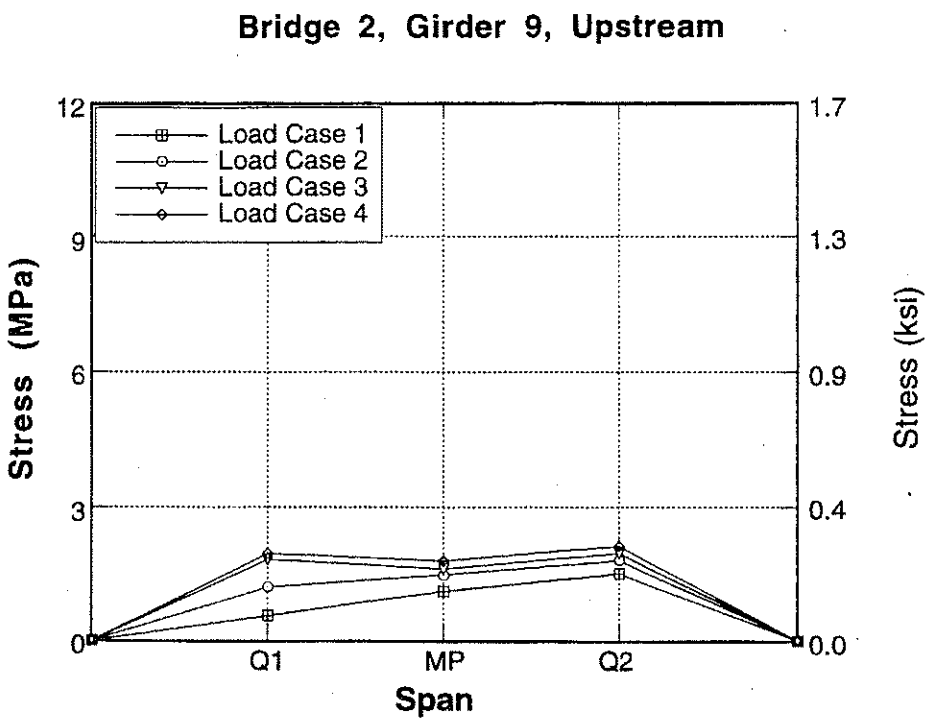


Figure A-58 : Longitudinal Distribution of Stresses for Bridge No. 2, Girder 9 due to Upstream Loading.

Note:

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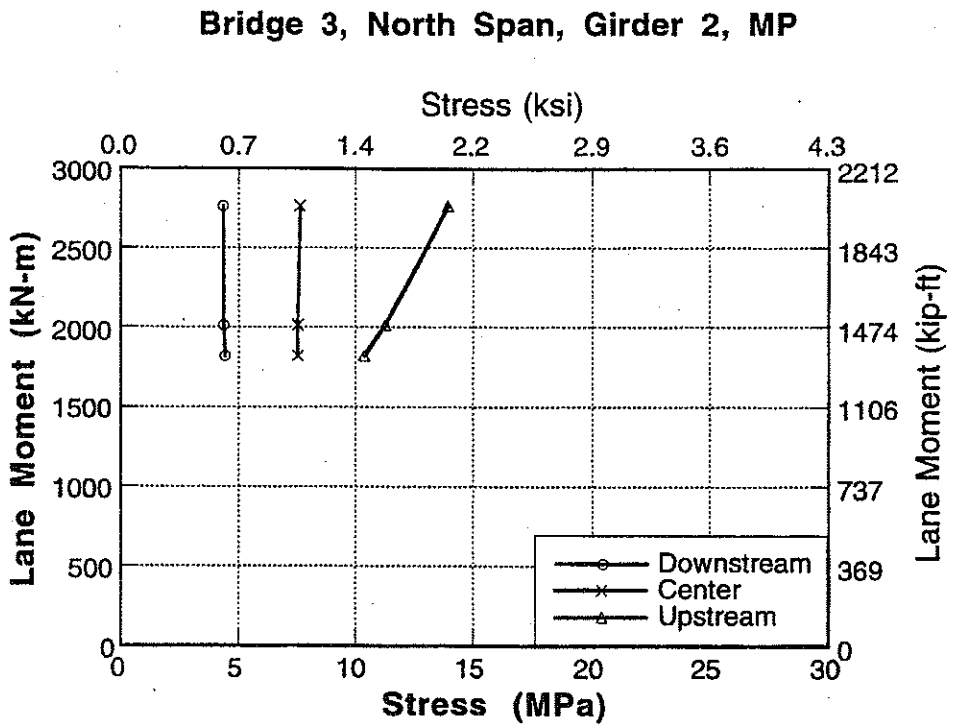
APPENDIX C - RESULTS FOR BRIDGE NO. 3

MDOT ID # B01-78011

M-103 bridge over White Pigeon River located in St. Joseph County, Michigan.
Simply supported steel girder bridge.

Results for north and south spans contain:

- Measured stresses vs calculated lane moment.
- Measured stresses vs analytical stresses.
- Girder distribution of measured stresses.
- Longitudinal distribution of measured stresses.



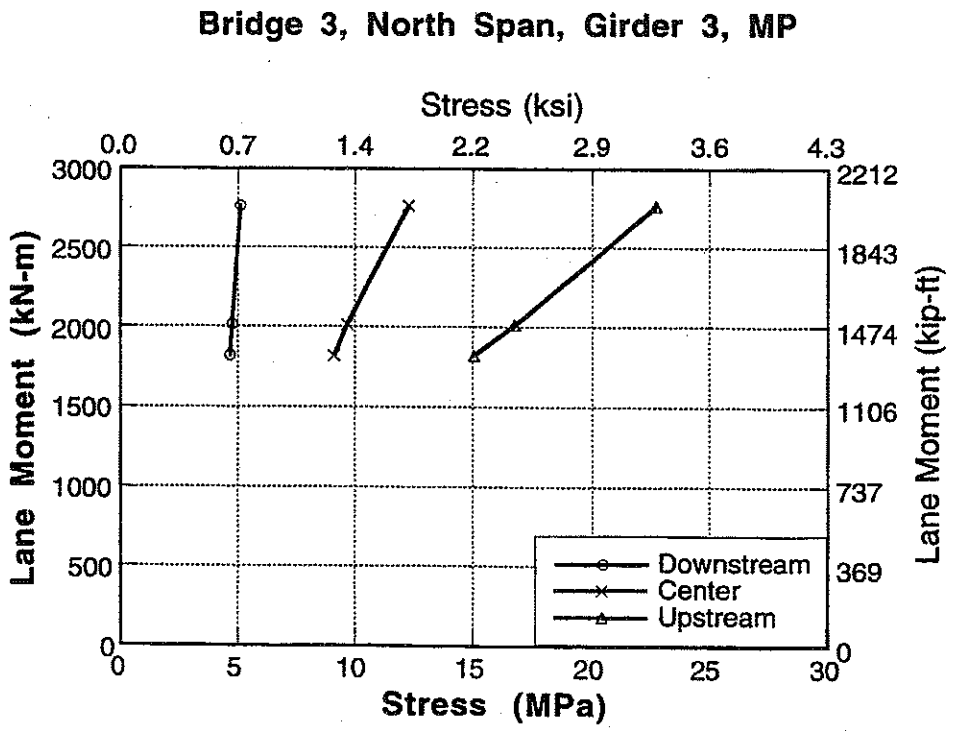
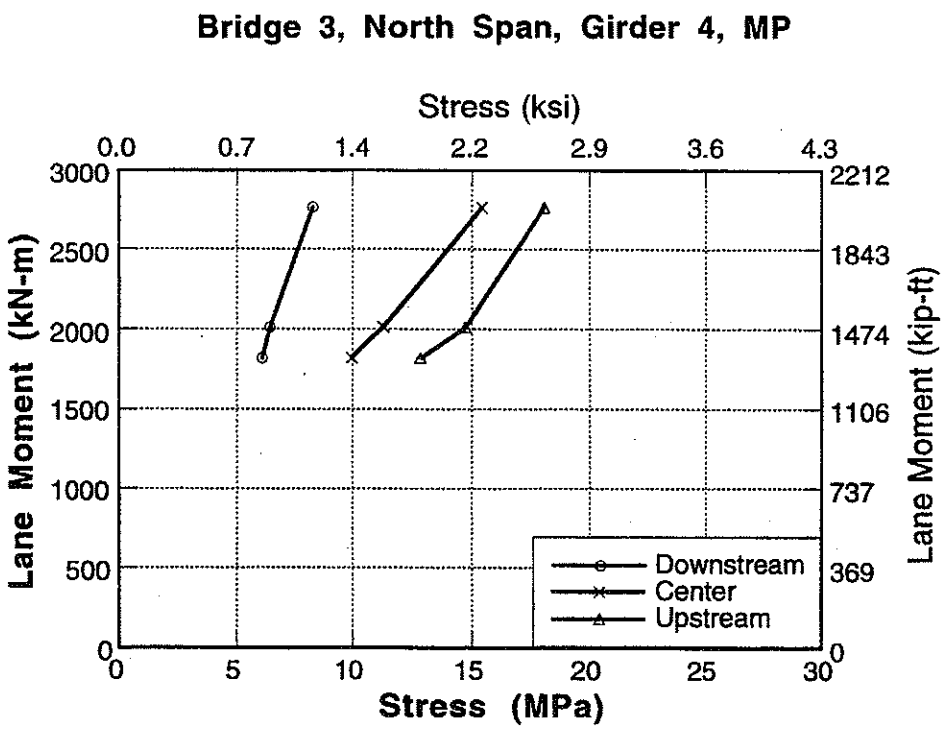


Figure A-59: Stress vs Lane Moment for North Span of Bridge No. 3, Girder 2 and 3 at Mid Point.



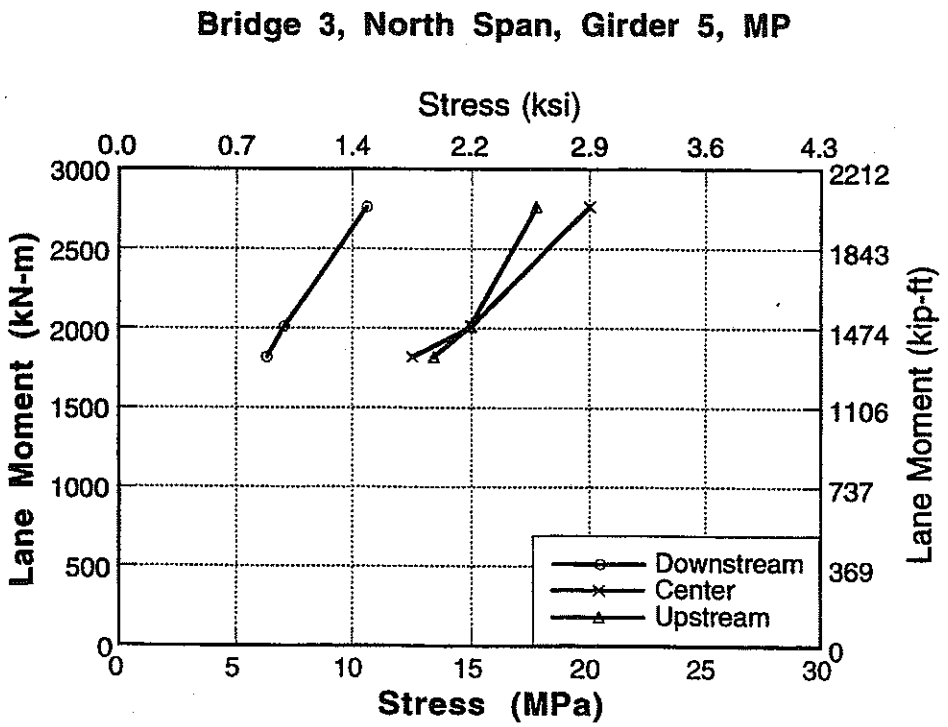
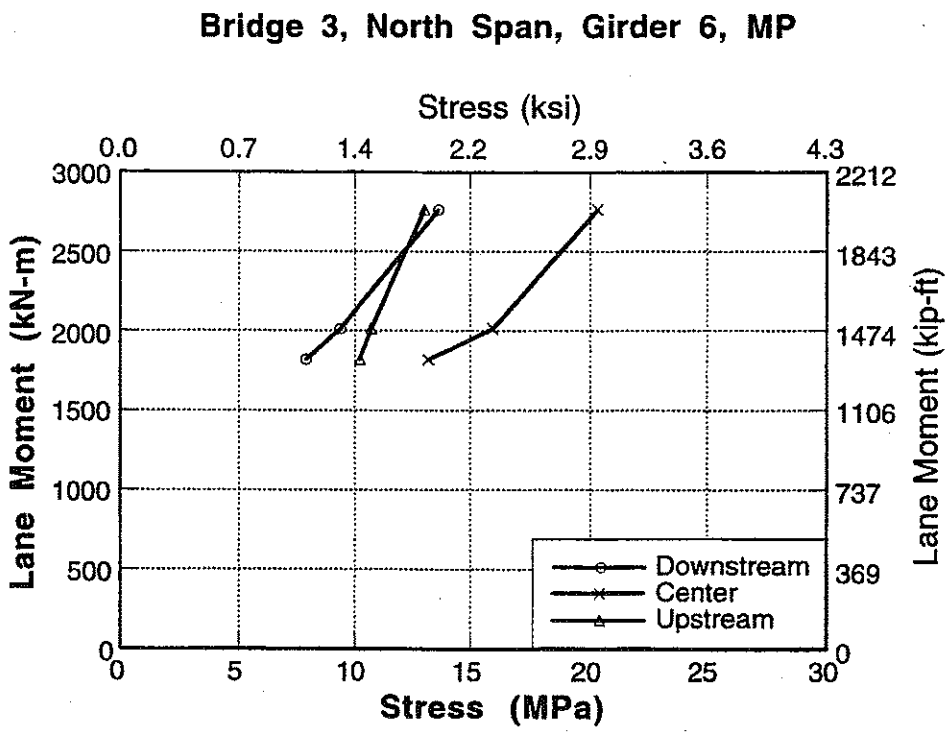


Figure A-60 : Stress vs Lane Moment for North Span of Bridge No. 3, Girder 4 and 5 at Mid Point.



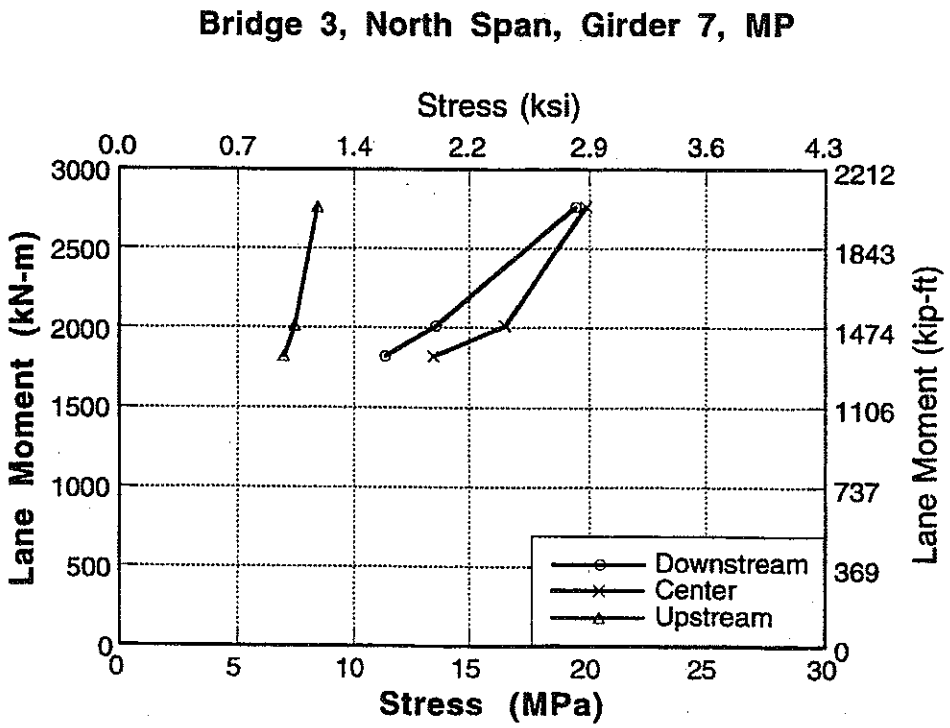
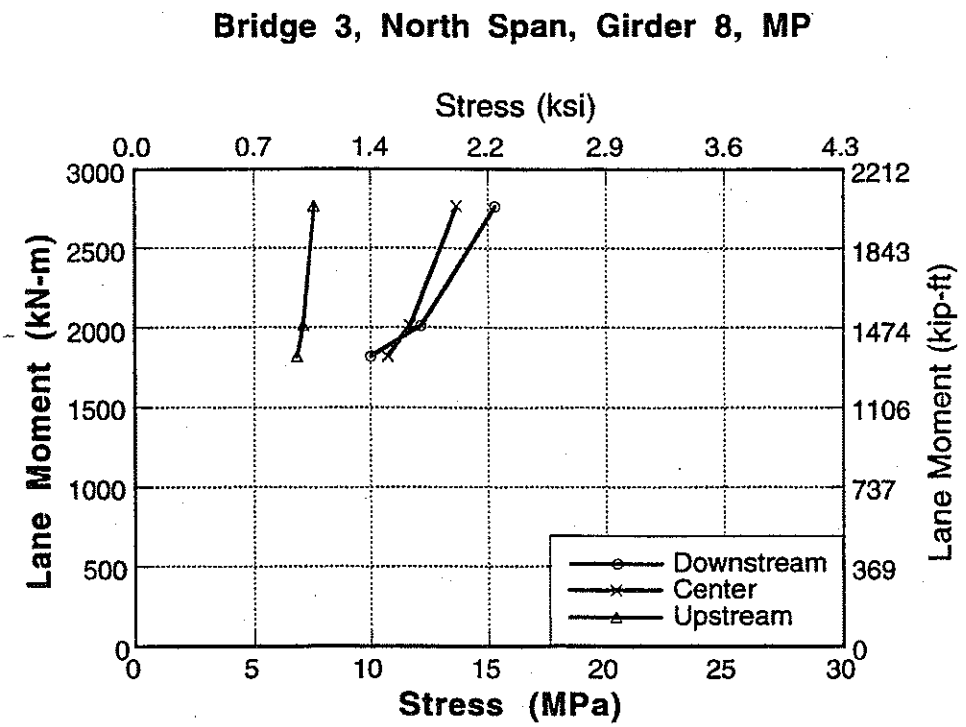


Figure A-61 : Stress vs Lane Moment for North Span of Bridge No. 3, Girder 6 and 7 at Mid Point.



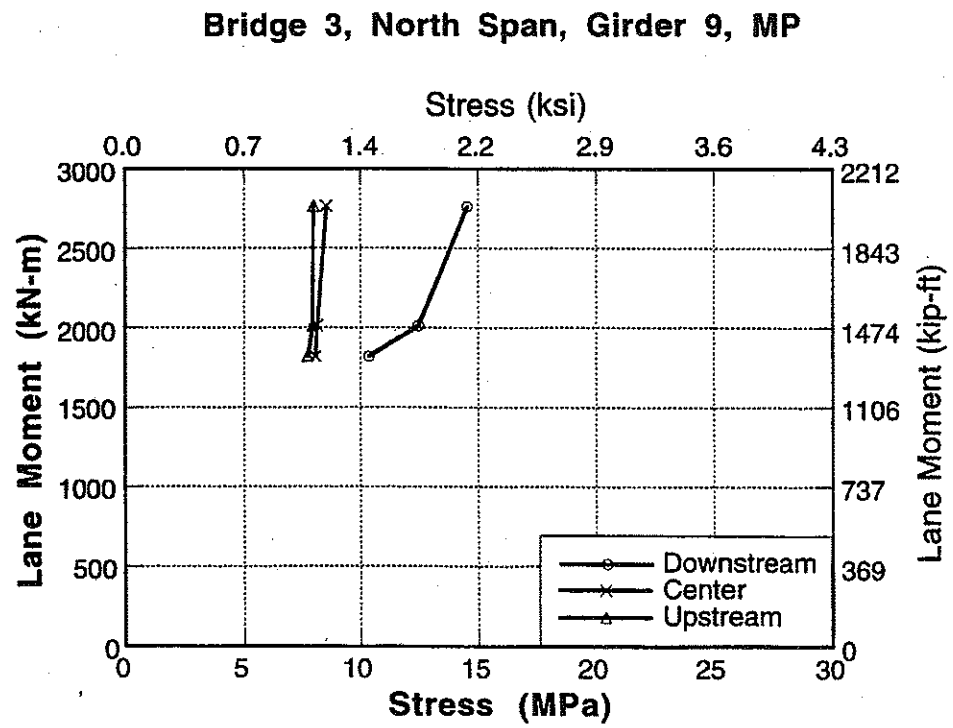
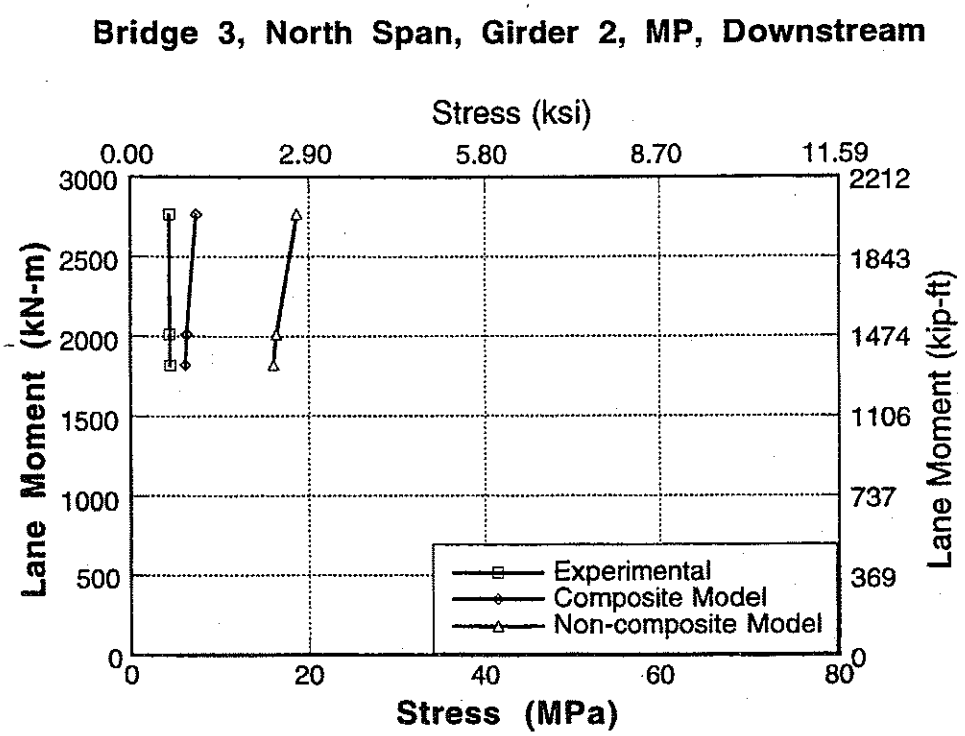


Figure A-62 : Stress vs Lane Moment for North Span of Bridge No. 3, Girder 8 and 9 at Mid Point.



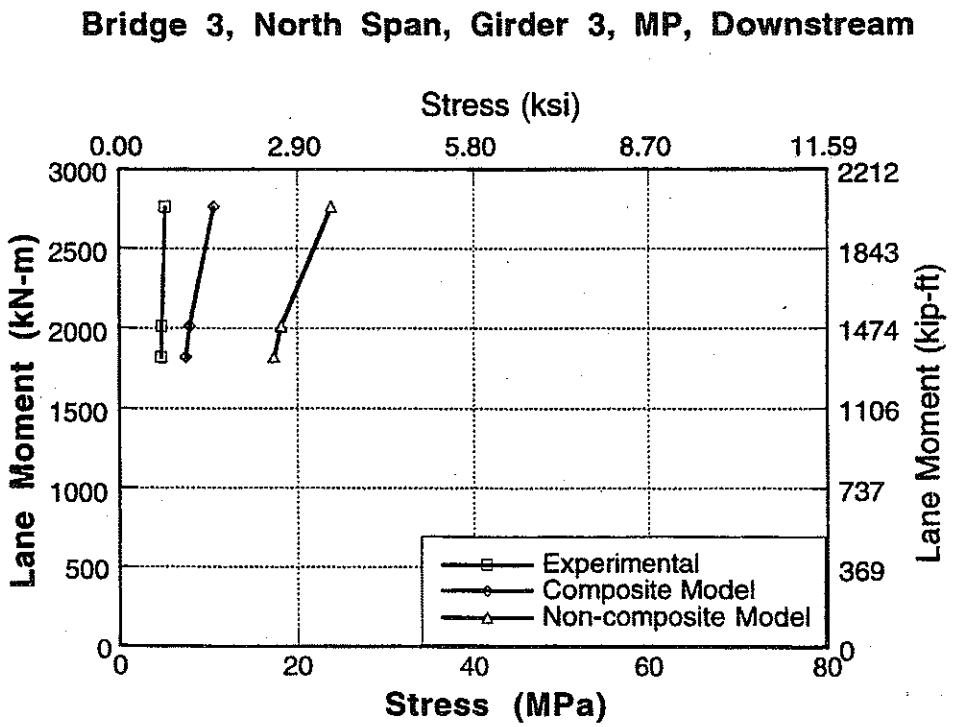
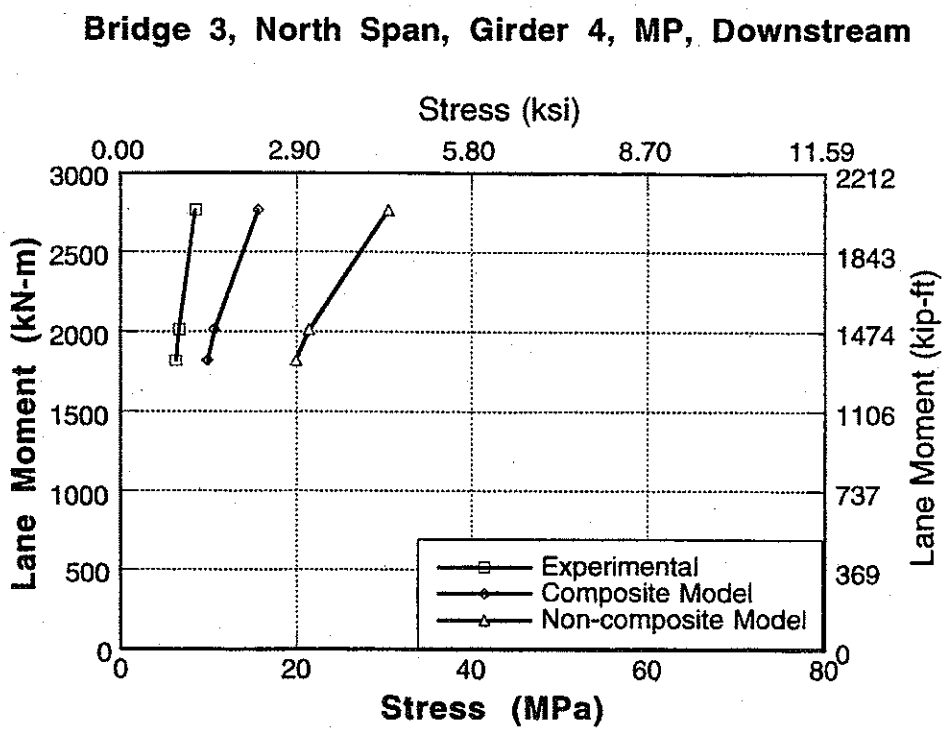


Figure A-63 : Experimental and Analytical Stresses for North Span of Bridge No. 3, Girder 2 and 3 for Downstream Loading.



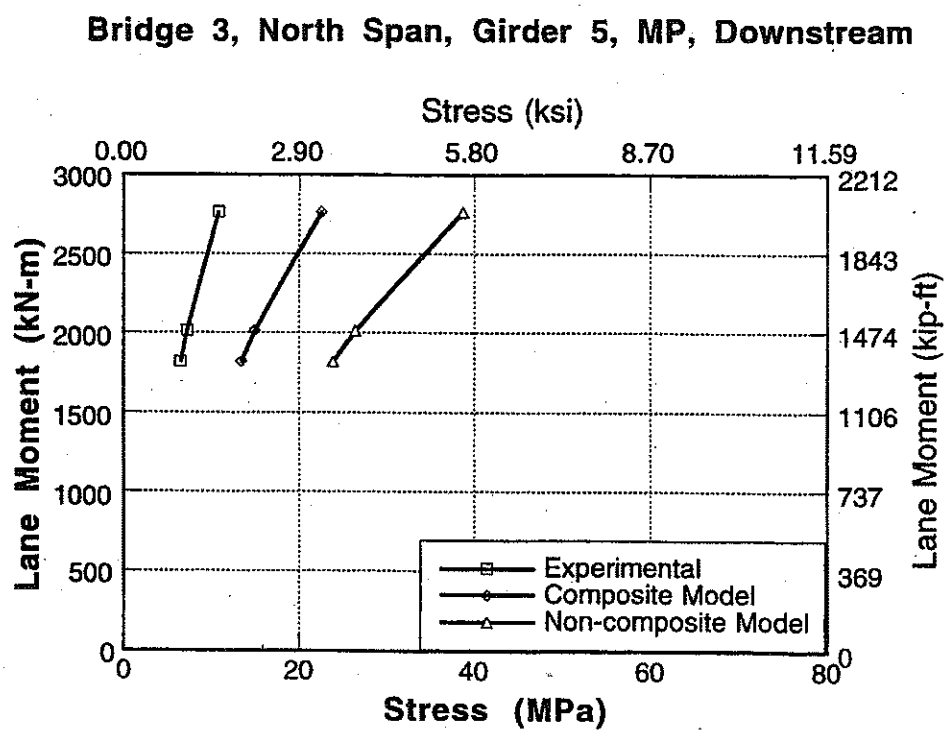
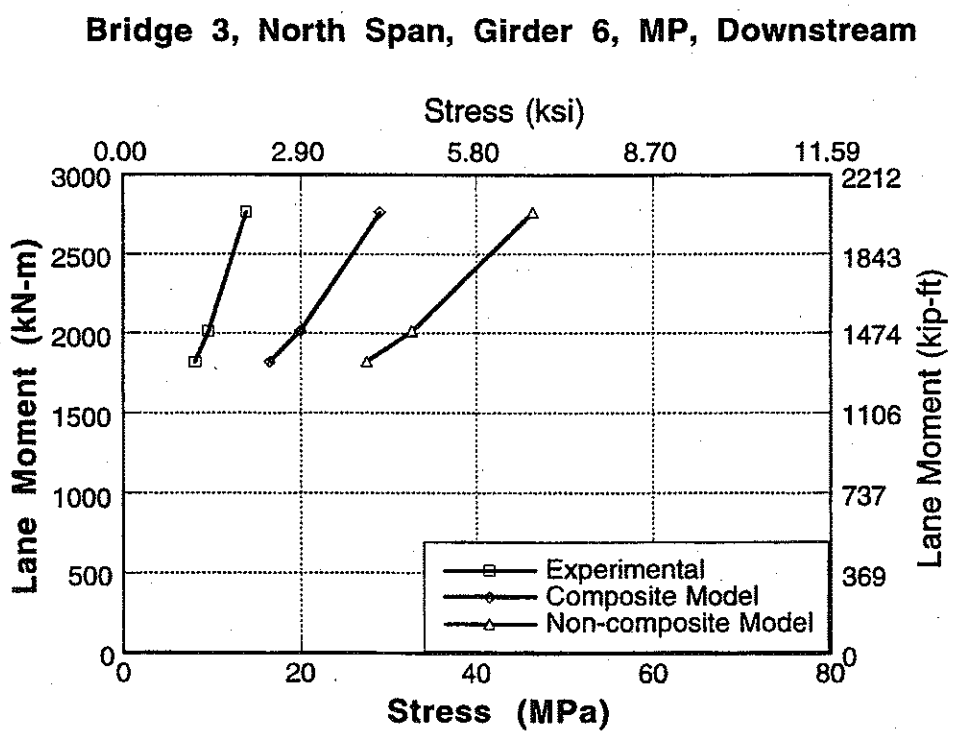


Figure A-64 : Experimental and Analytical Stresses for North Span of Bridge No. 3, Girder 4 and 5 for Downstream Loading.



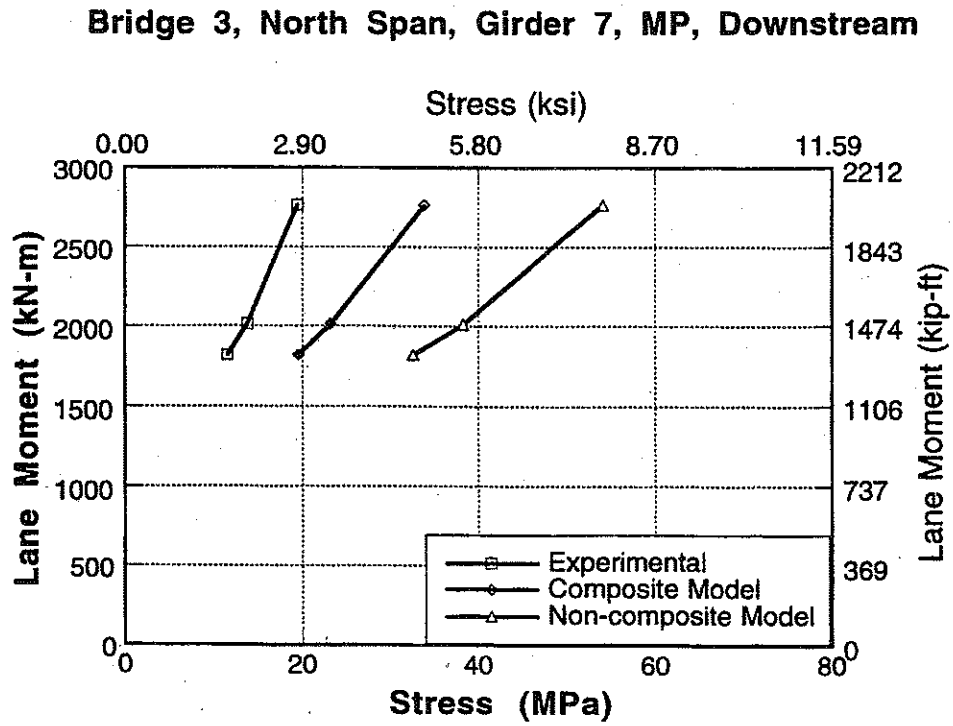
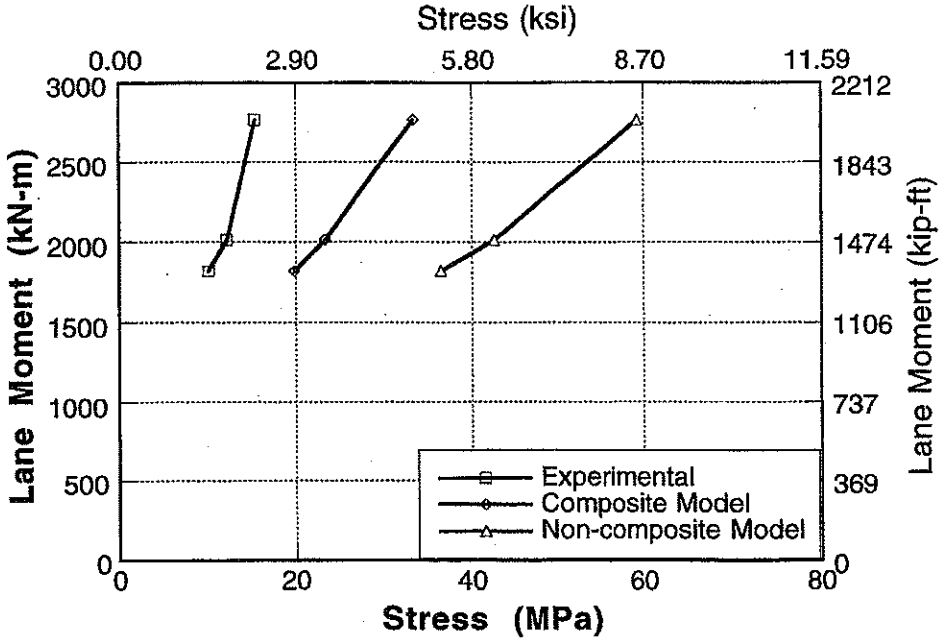


Figure A-65 : Experimental and Analytical Stresses for North Span of Bridge No. 3, Girder 6 and 7 for Downstream Loading.

Bridge 3, North Span, Girder 8, MP, Downstream



Bridge 3, North Span, Girder 9, MP, Downstream

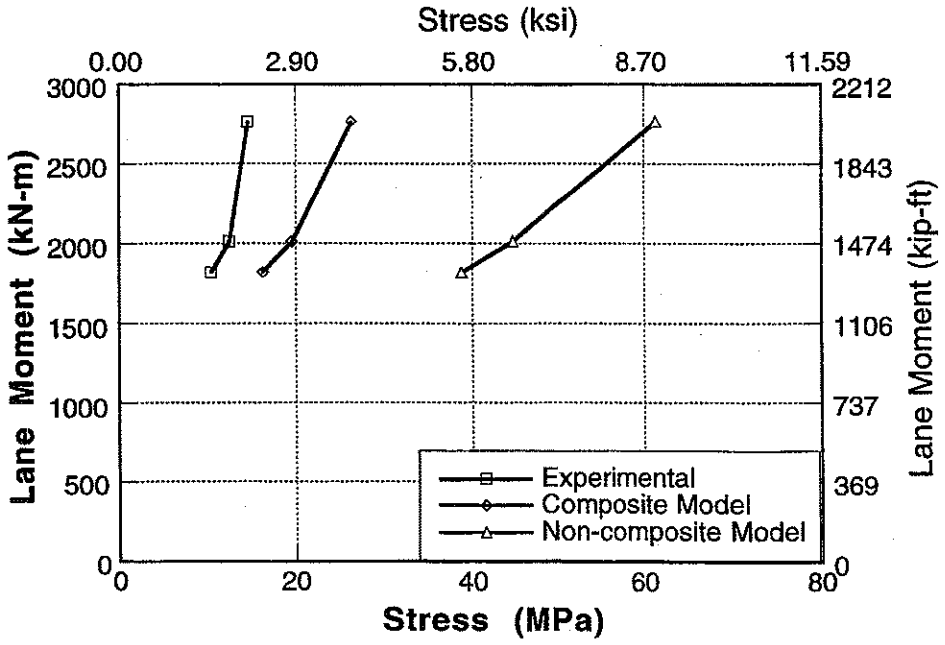
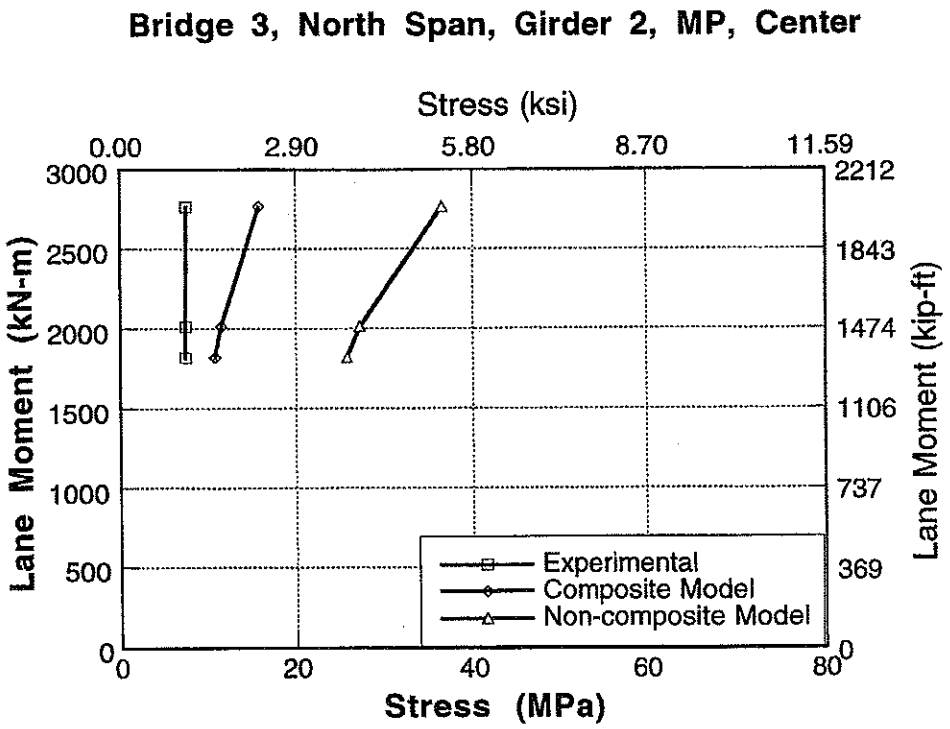


Figure A-66 : Experimental and Analytical Stresses for North Span of Bridge No. 3, Girder 8 and 9 for Downstream Loading.



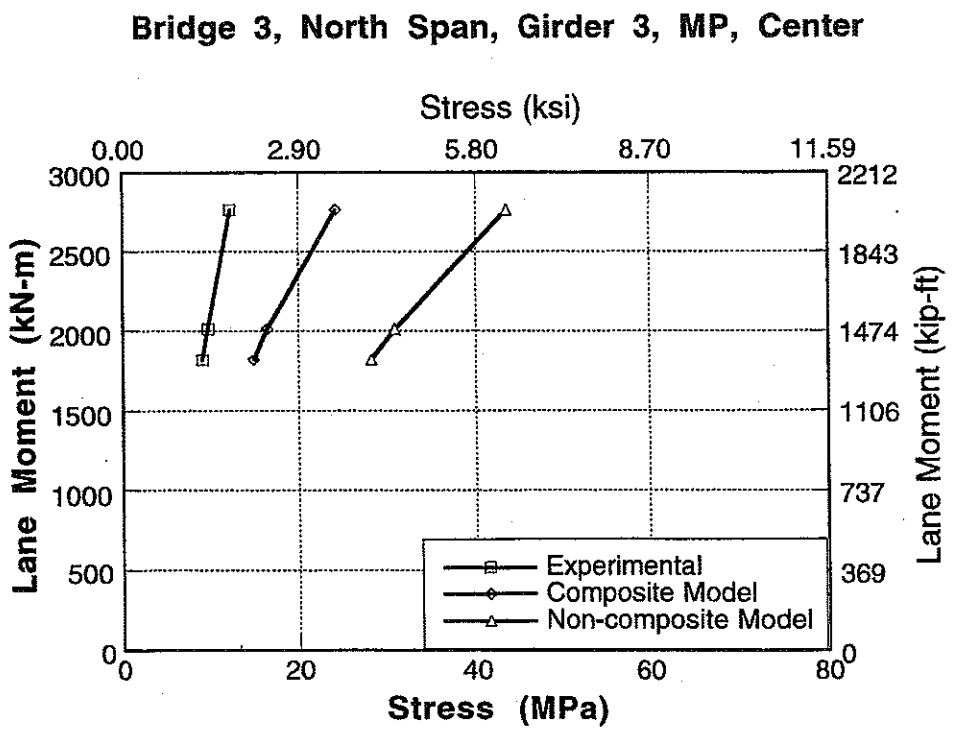
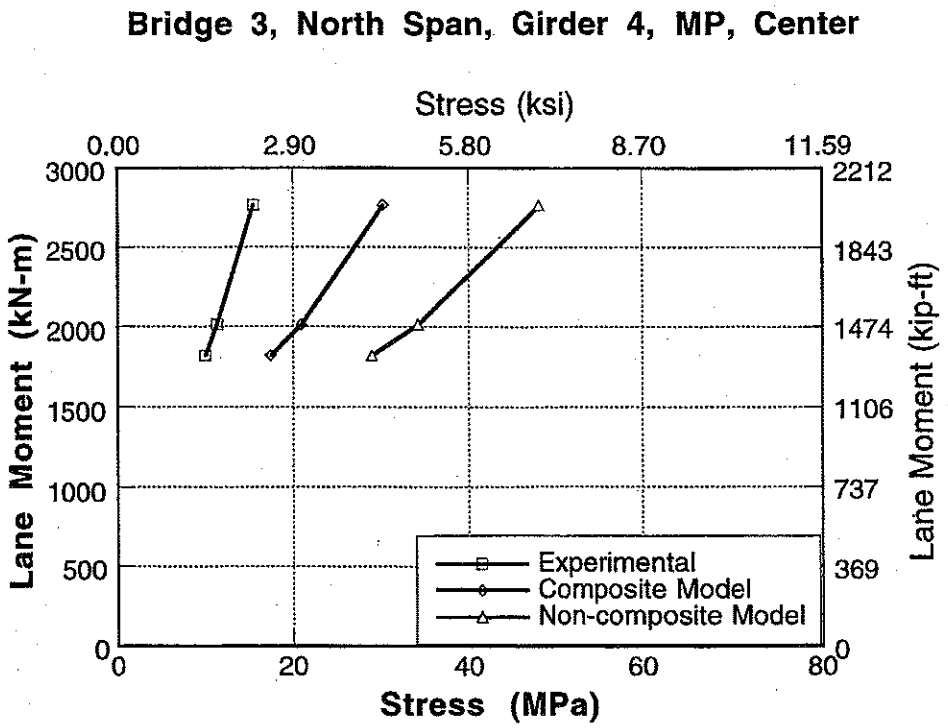


Figure A-67 : Experimental and Analytical Stresses for North Span of Bridge No. 3, Girder 2 and 3 for Center Loading.



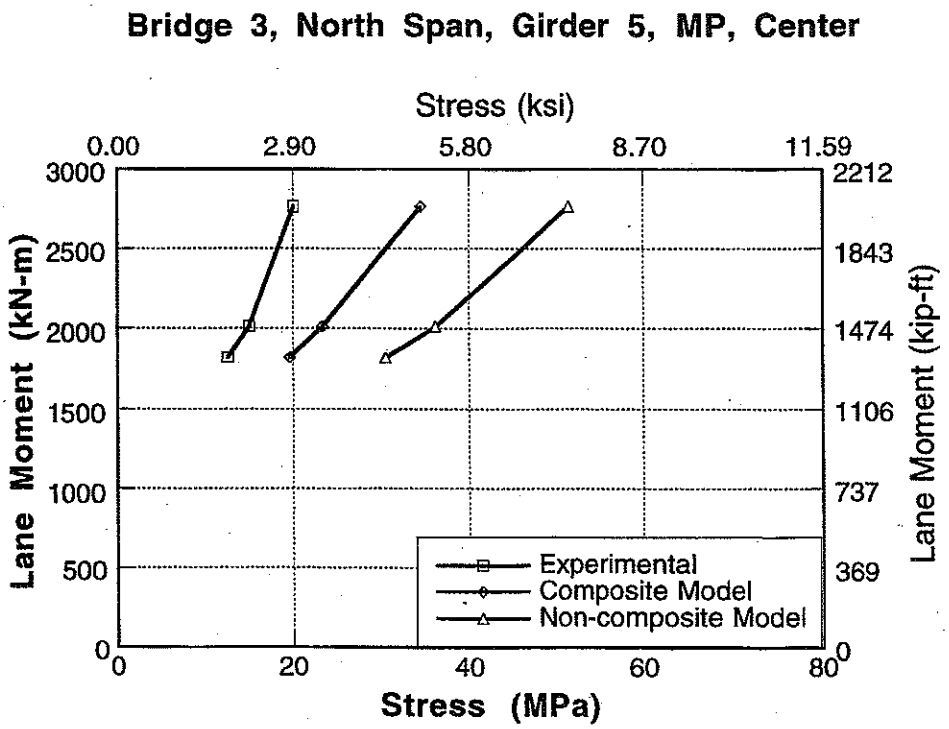
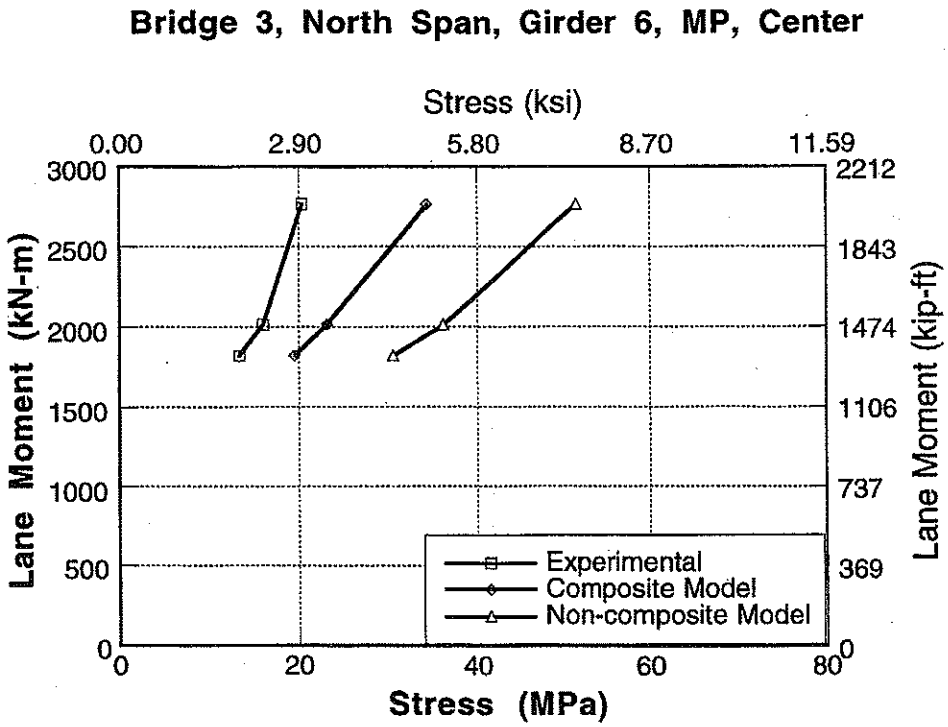


Figure A-68 : Experimental and Analytical Stresses for North Span of Bridge No. 3, Girder 4 and 5 for Center Loading.



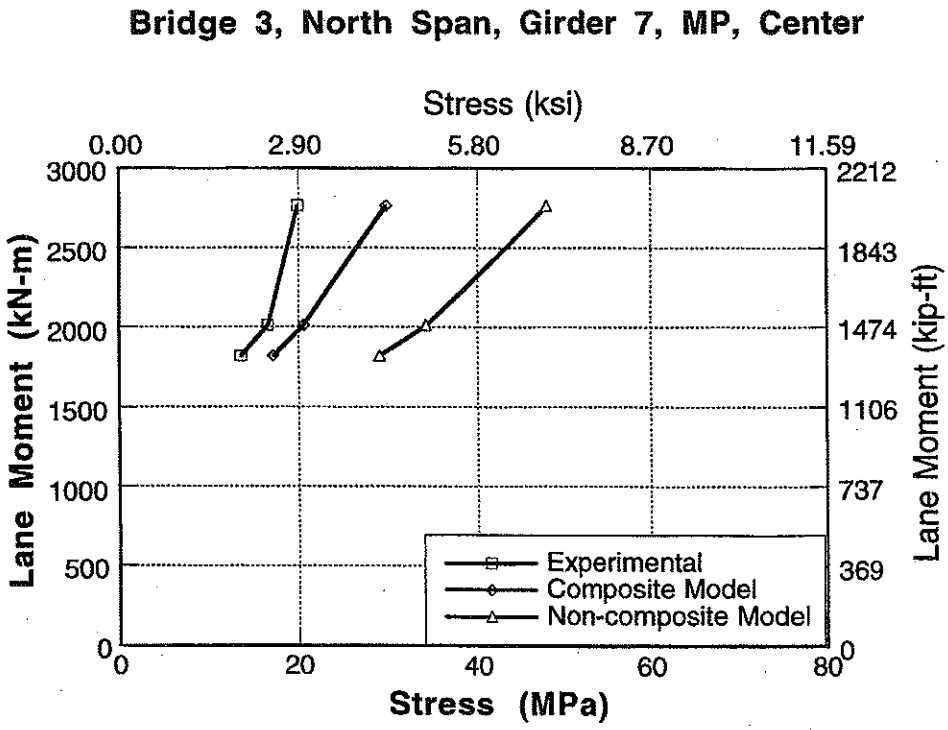
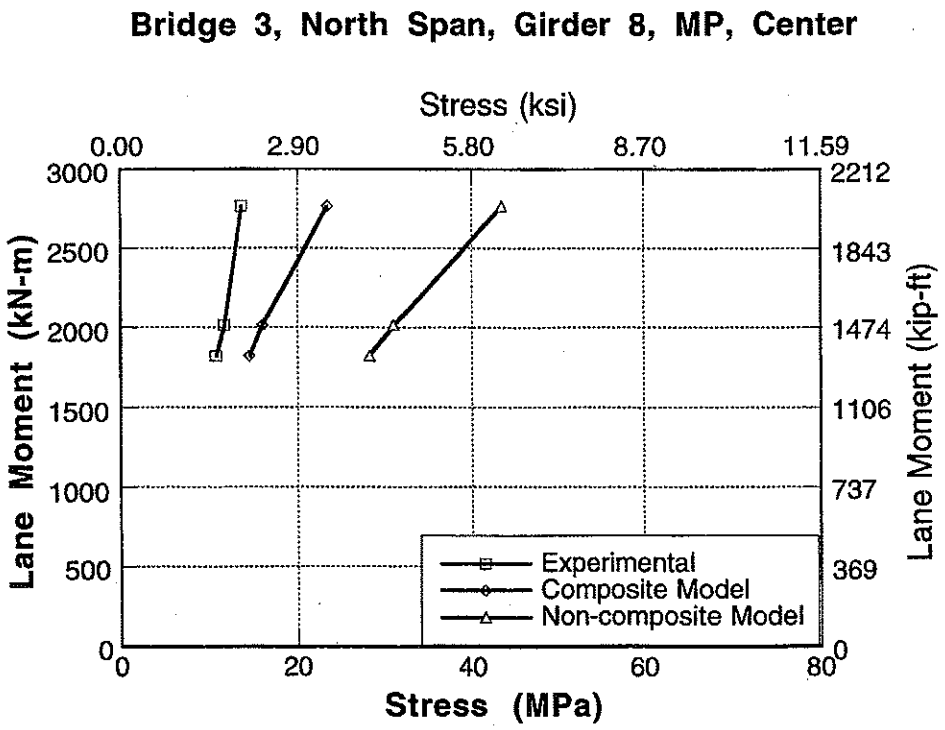


Figure A-69 : Experimental and Analytical Stresses for North Span of Bridge No. 3, Girder 6 and 7 for Center Loading.



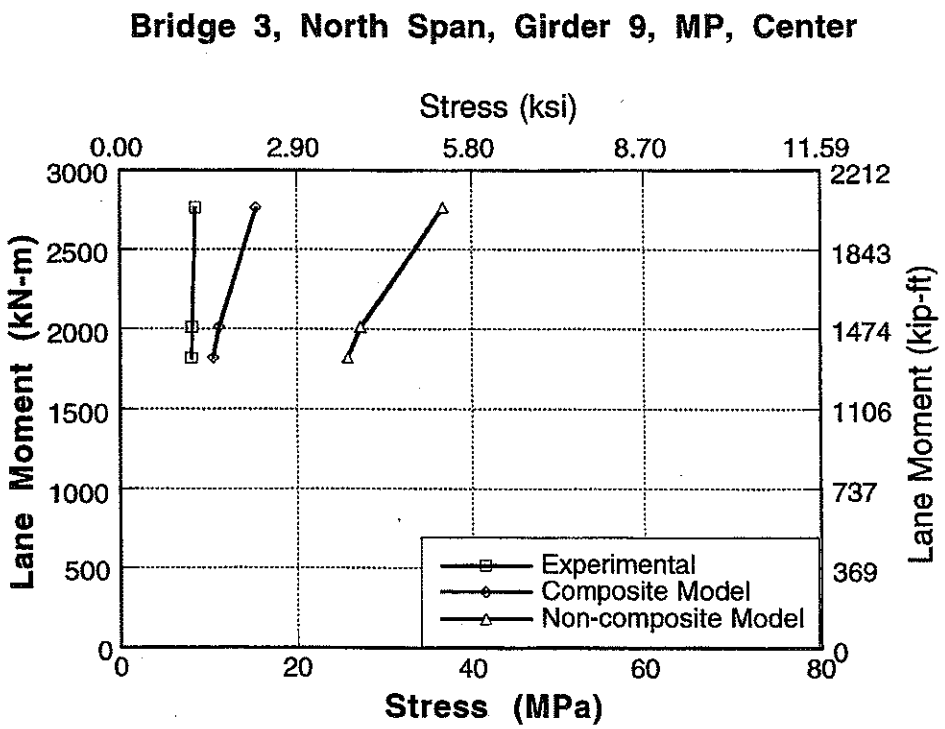
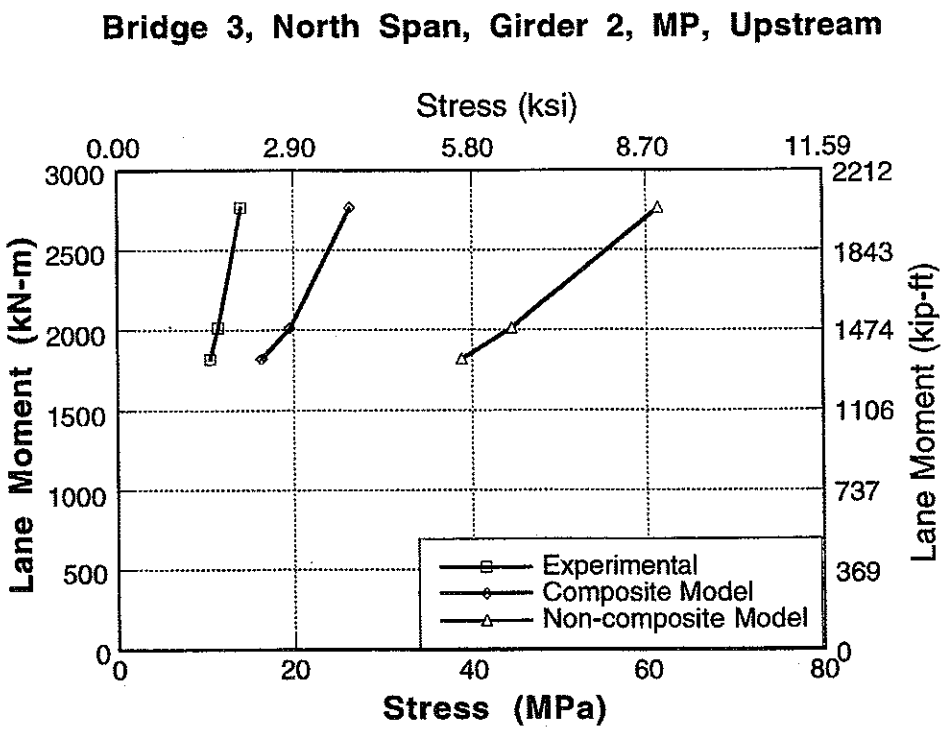


Figure A-70 : Experimental and Analytical Stresses for North Span of Bridge No. 3, Girder 8 and 9 for Center Loading.



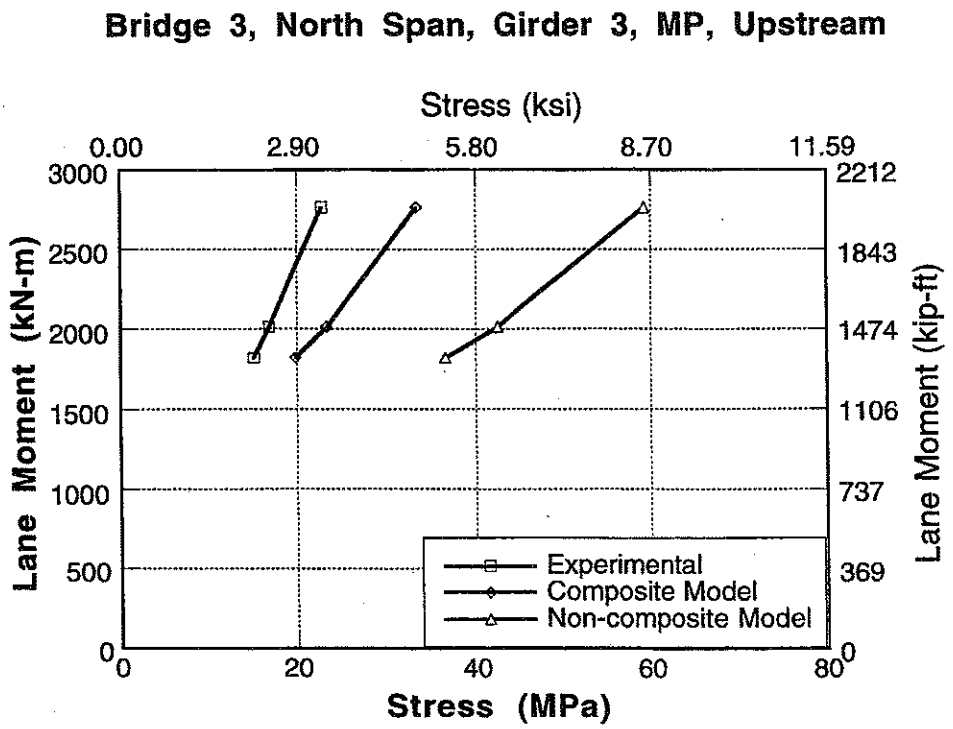
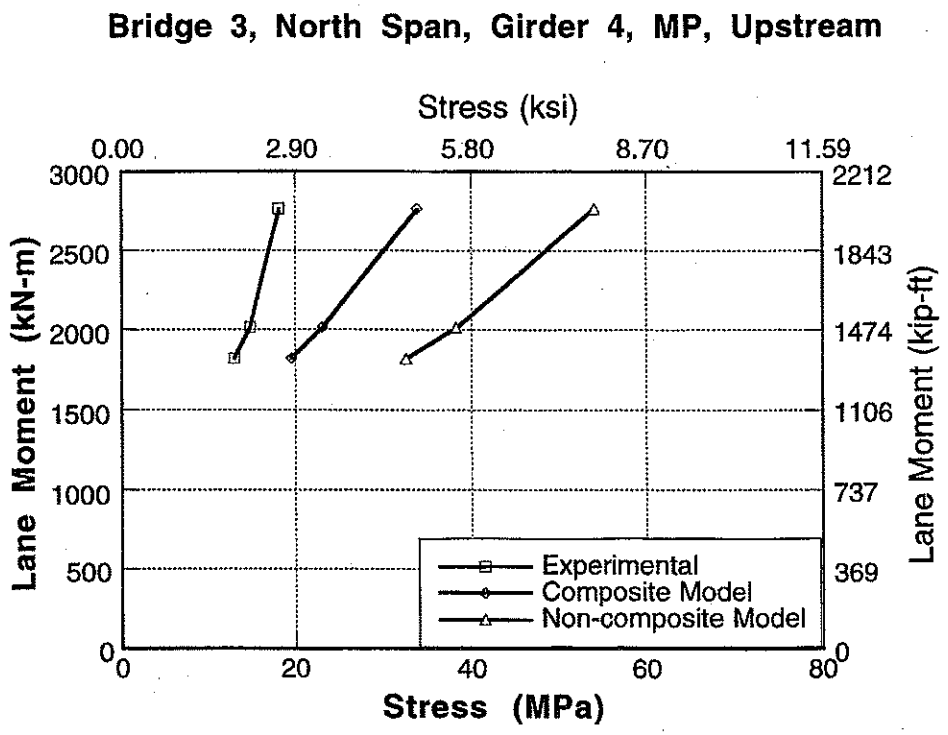


Figure A-71 : Experimental and Analytical Stresses for North Span of Bridge No. 3, Girder 2 and 3 for Upstream Loading.



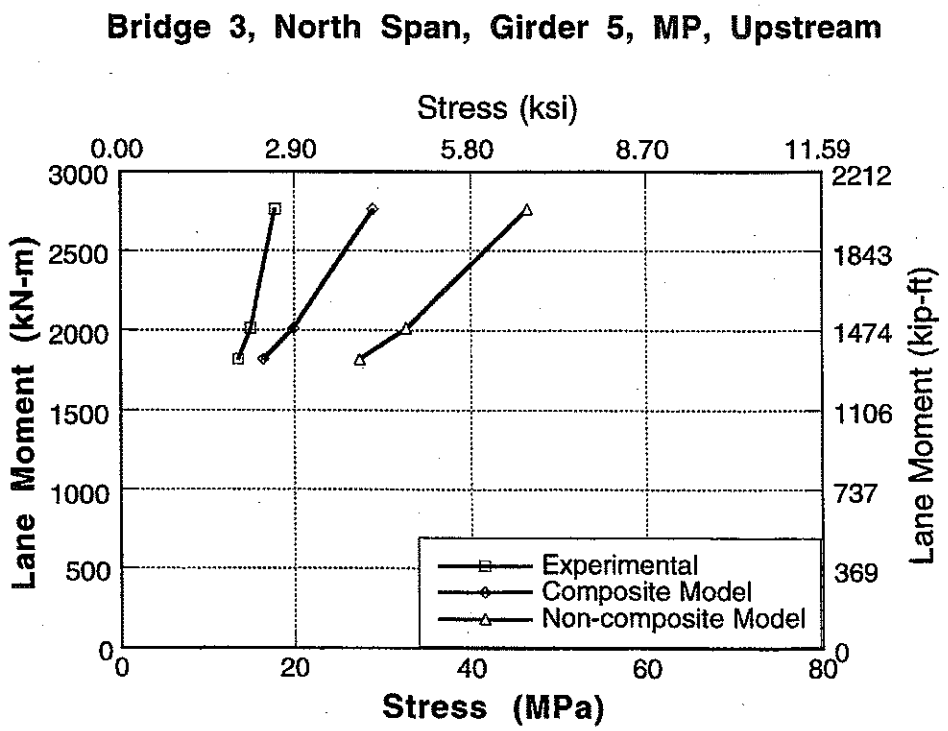
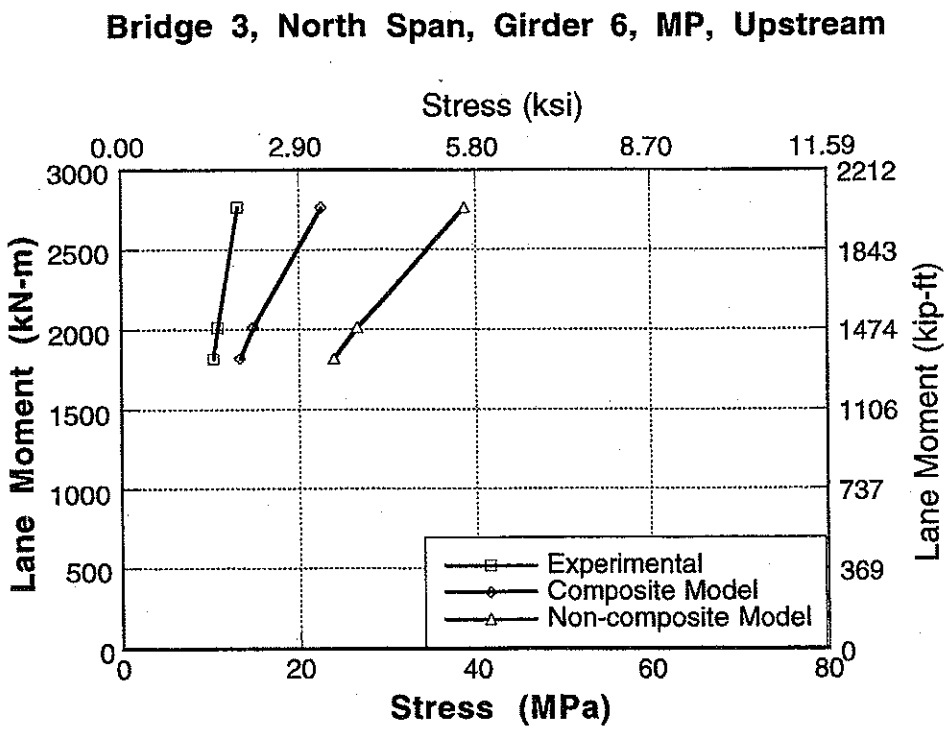


Figure A-72 : Experimental and Analytical Stresses for North Span of Bridge No. 3, Girder 4 and 5 for Upstream Loading.



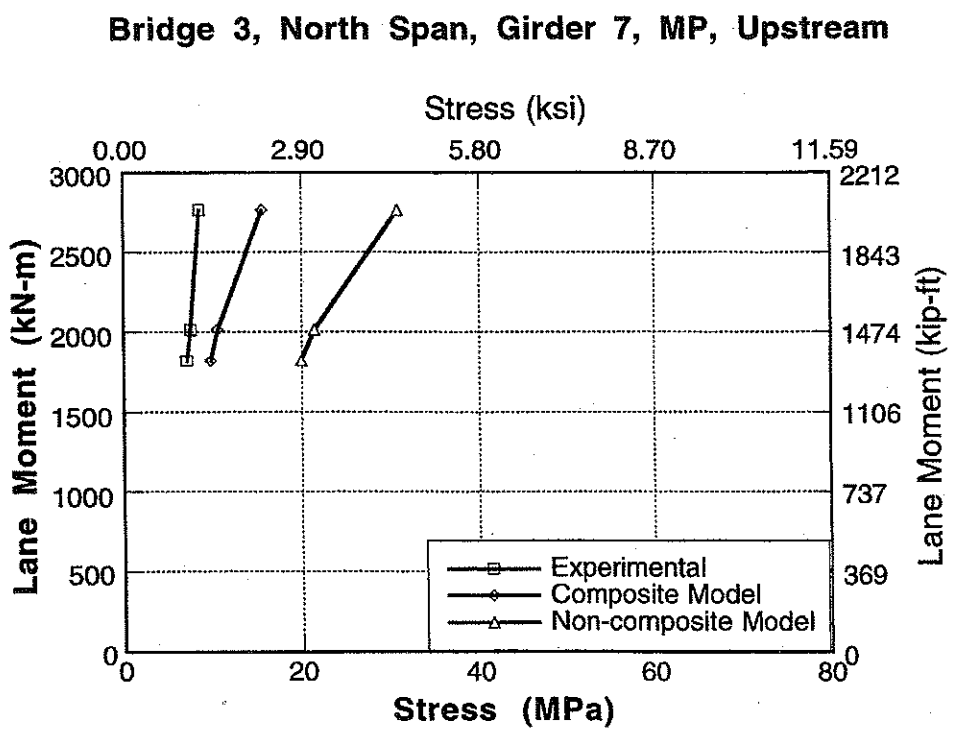
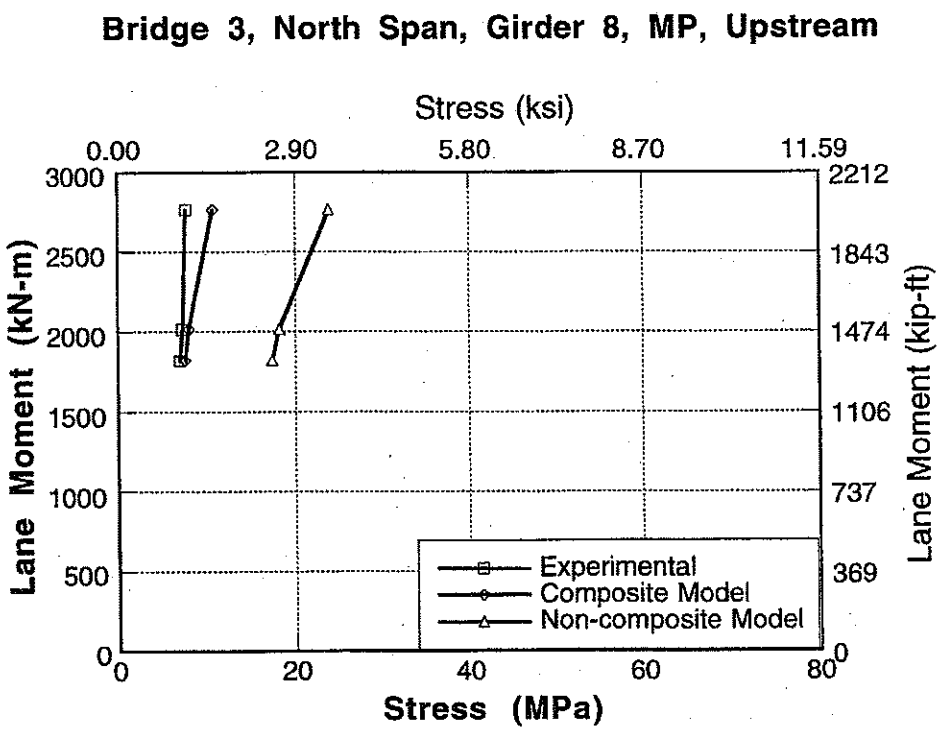


Figure A-73 : Experimental and Analytical Stresses for North Span of Bridge No. 3, Girder 6 and 7 for Upstream Loading.



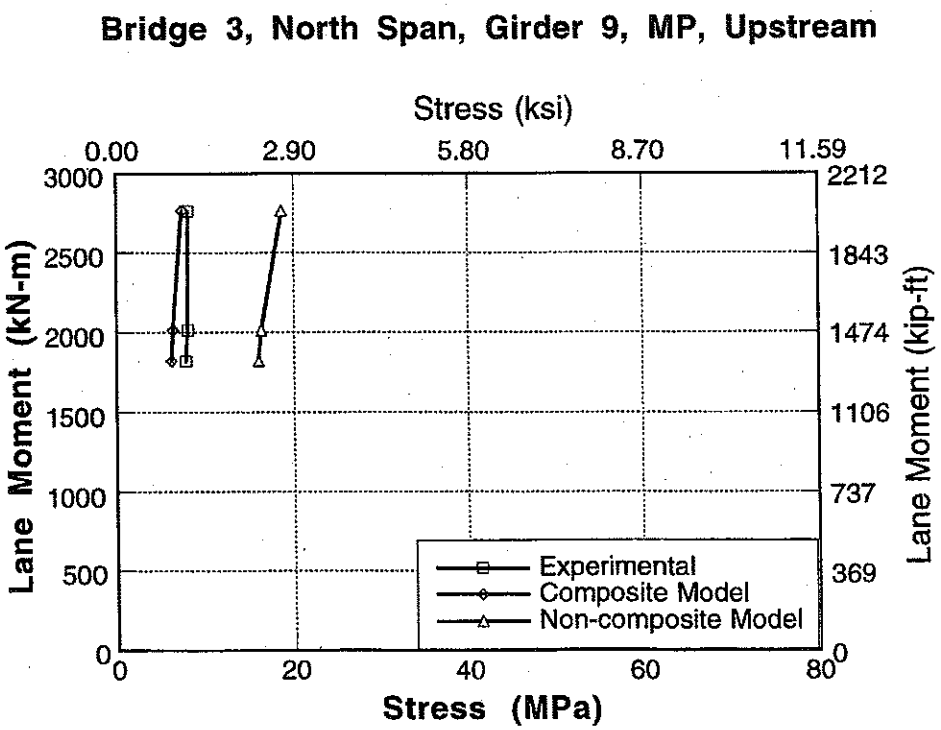


Figure A-74 : Experimental and Analytical Stresses for North Span of Bridge No. 3, Girder 8 and 9 for Upstream Loading.

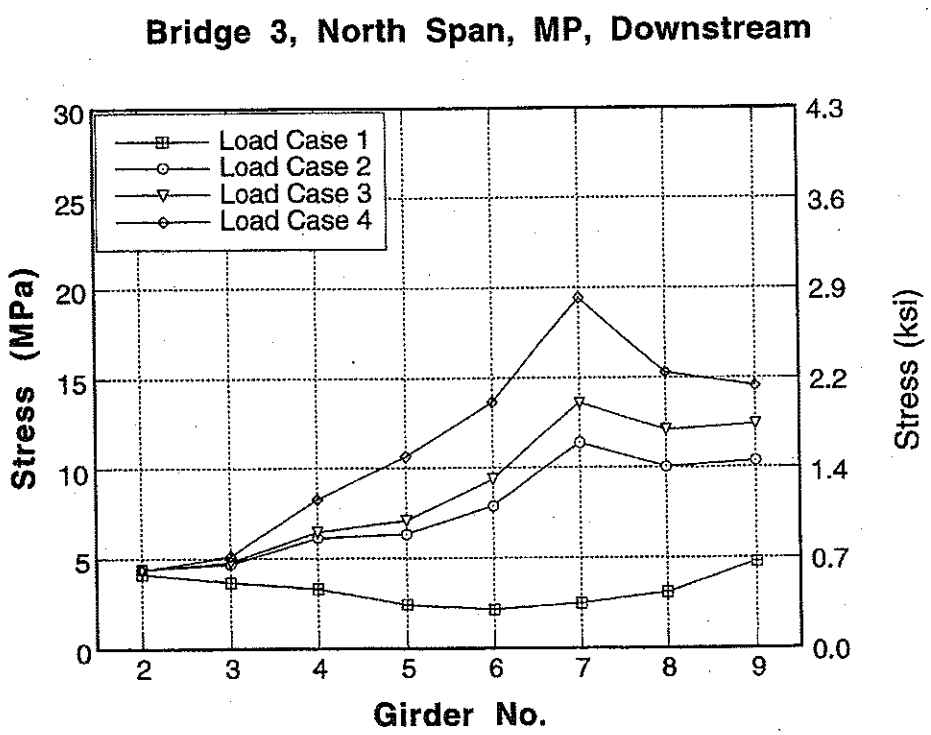


Figure A-75 : Girder Distribution of Stresses at Mid Point for North Span of Bridge No. 3 due to Downstream Loading.

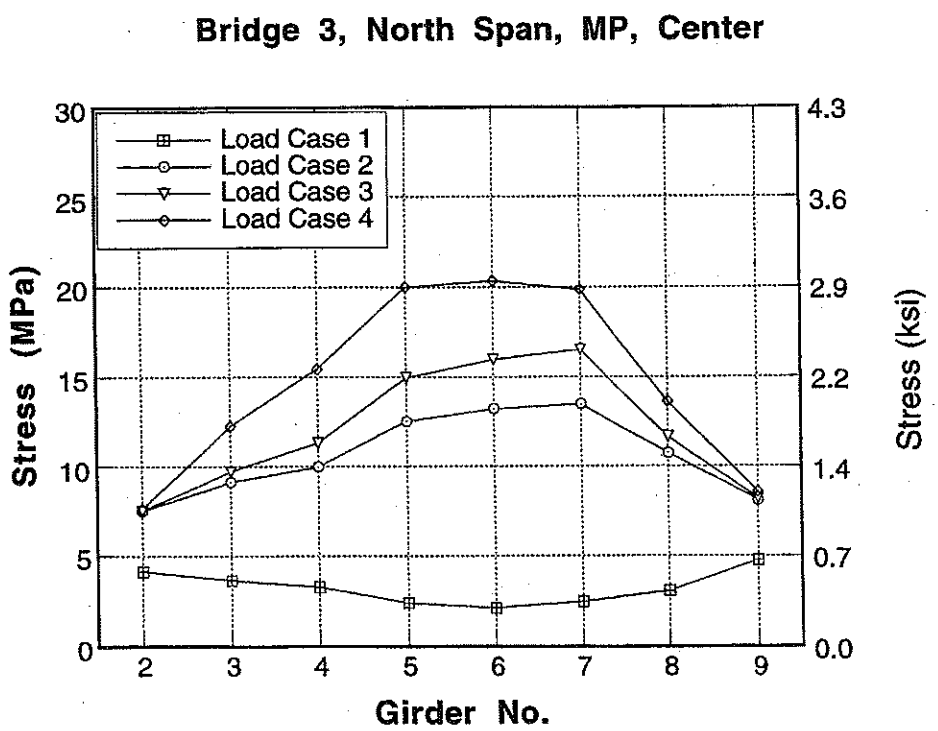


Figure A-76 : Girder Distribution of Stresses at Mid Point for North Span of Bridge No. 3 due to Center Loading.

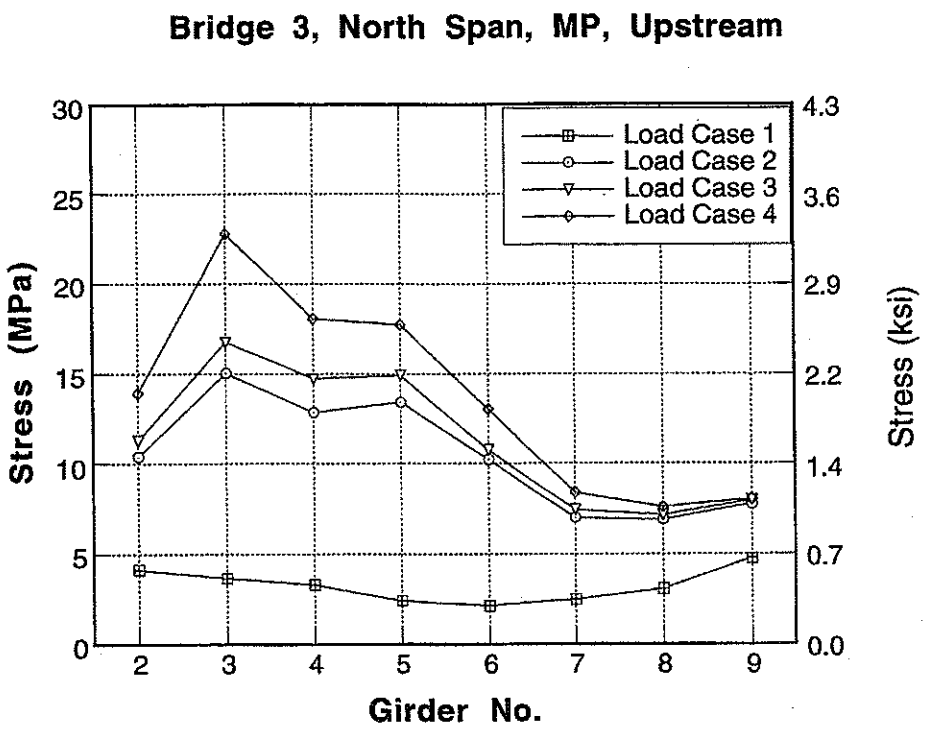


Figure A-77 : Girder Distribution of Stresses at Mid Point for North Span of Bridge No. 3 due to Upstream Loading.

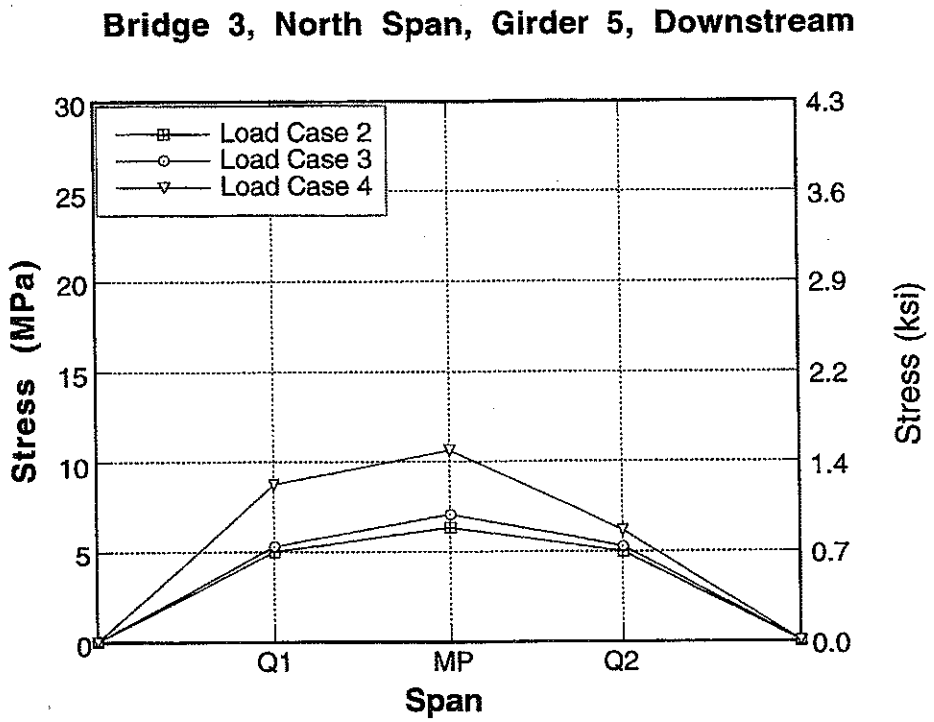


Figure A-78 : Longitudinal Distribution of Stresses for North Span of Bridge No. 3, Girder 5 due to Downstream Loading.

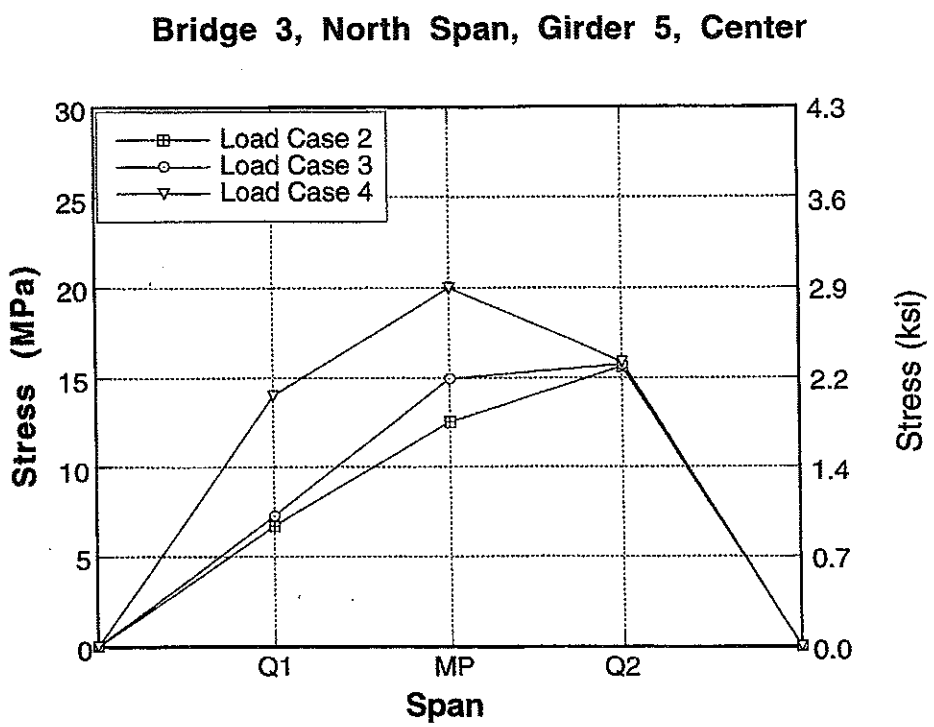


Figure A-79 : Longitudinal Distribution of Stresses for North Span of Bridge No. 3, Girder 5 due to Center Loading.

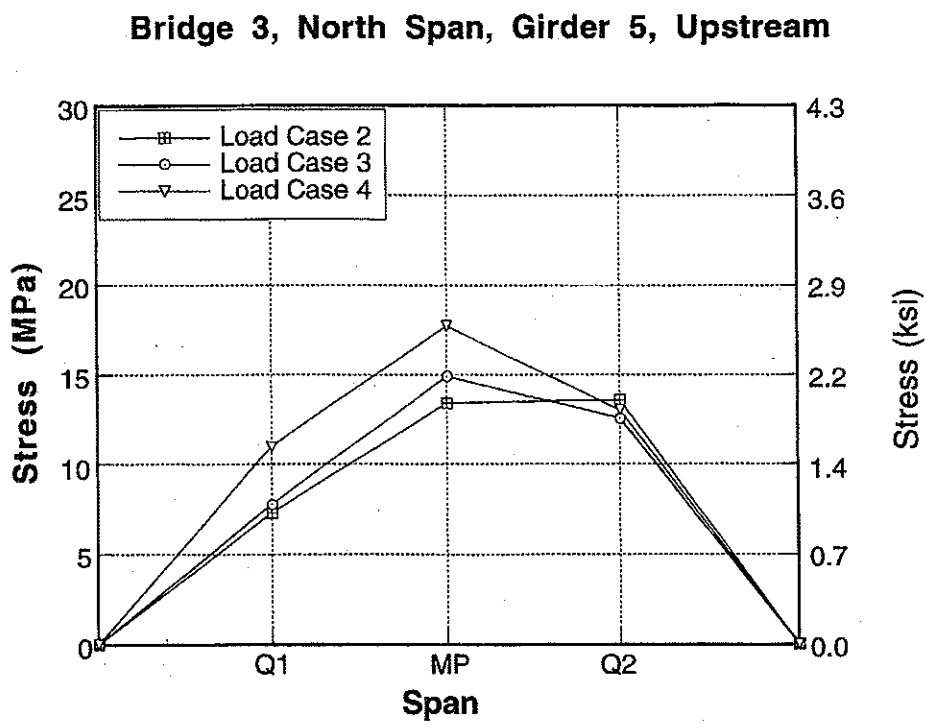


Figure A-80 : Longitudinal Distribution of Stresses for North Span of Bridge No. 3, Girder 5 due to Upstream Loading.

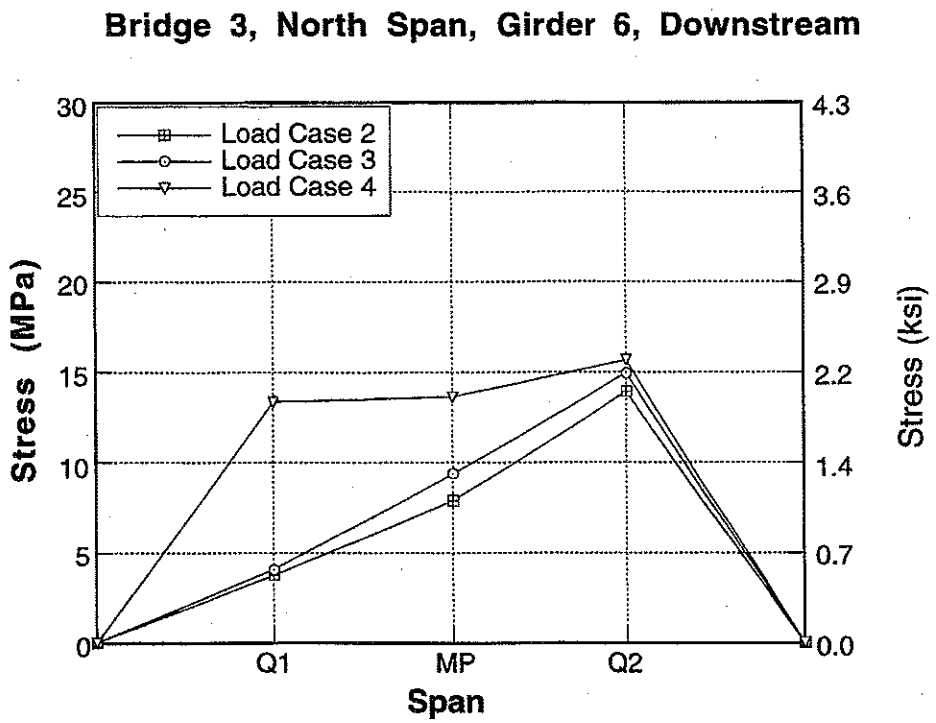


Figure A-81 : Longitudinal Distribution of Stresses for North Span of Bridge No. 3, Girder 6 due to Downstream Loading.

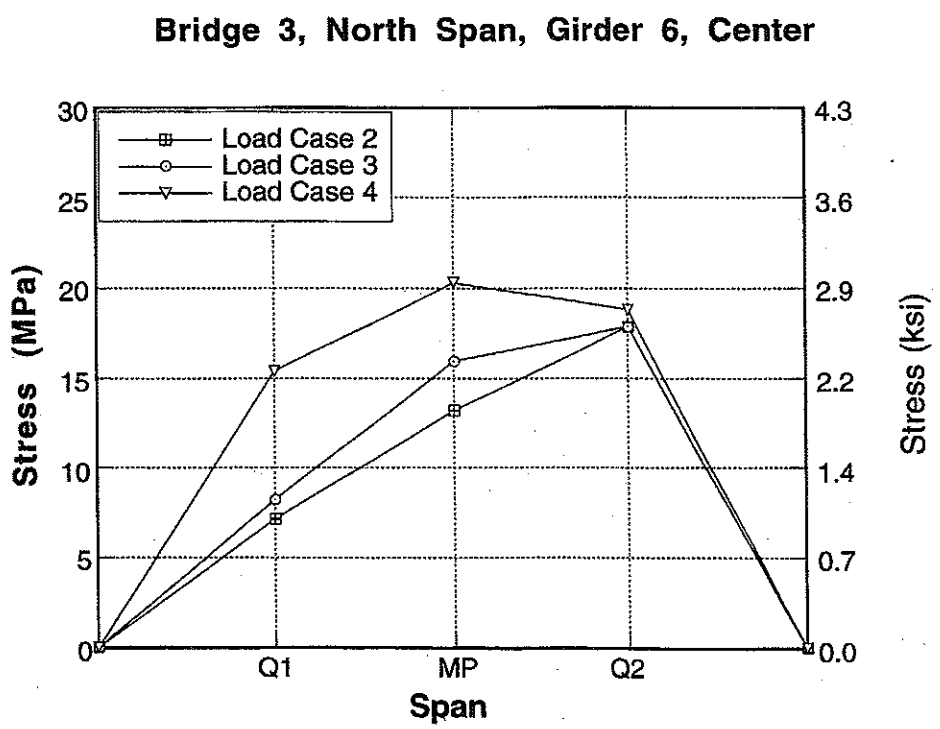


Figure A-82 : Longitudinal Distribution of Stresses for North Span of Bridge No. 3, Girder 6 due to Center Loading.

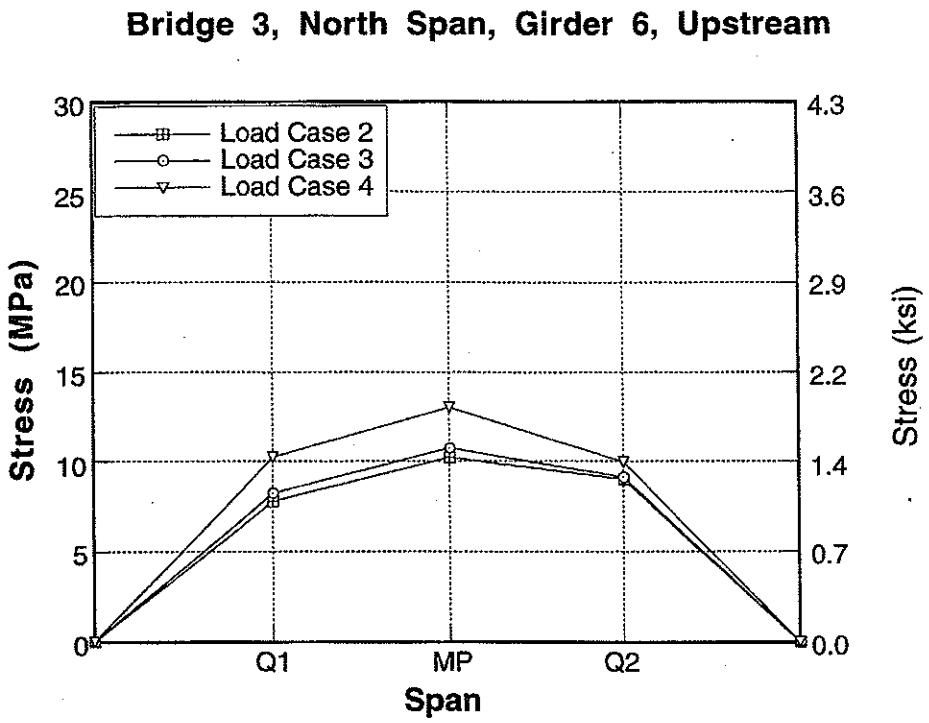
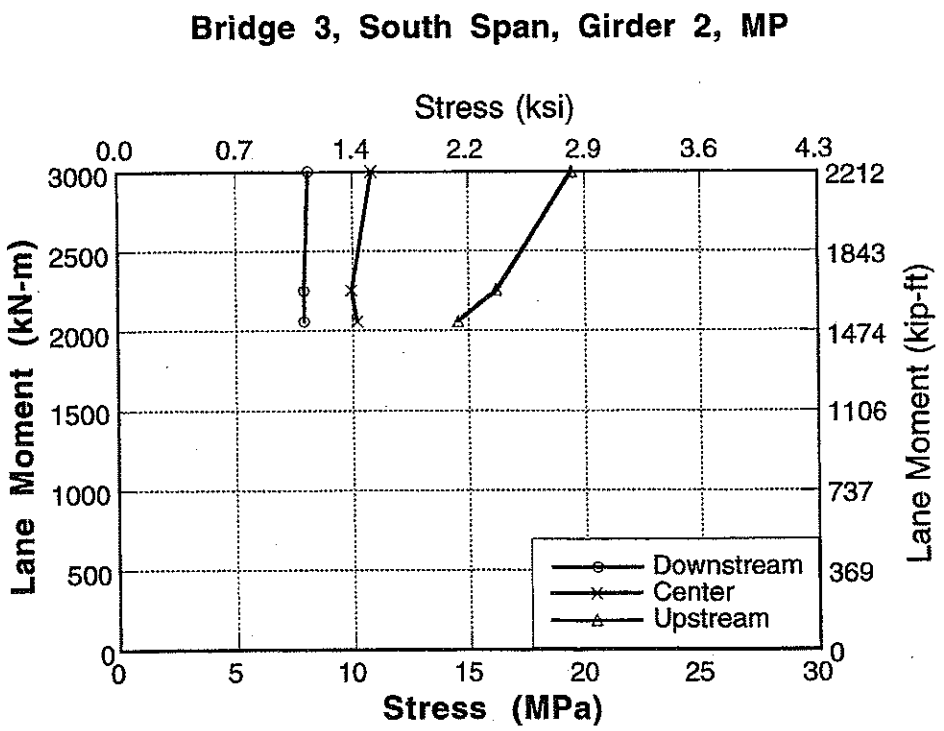


Figure A-83 : Longitudinal Distribution of Stresses for North Span of Bridge No. 3, Girder 6 due to Upstream Loading.



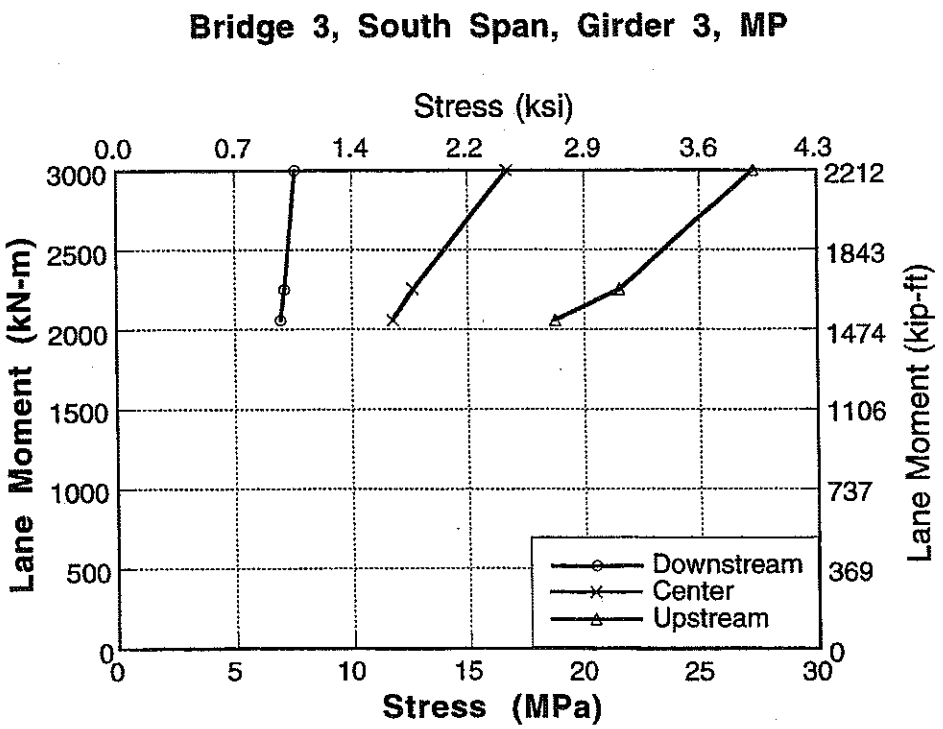
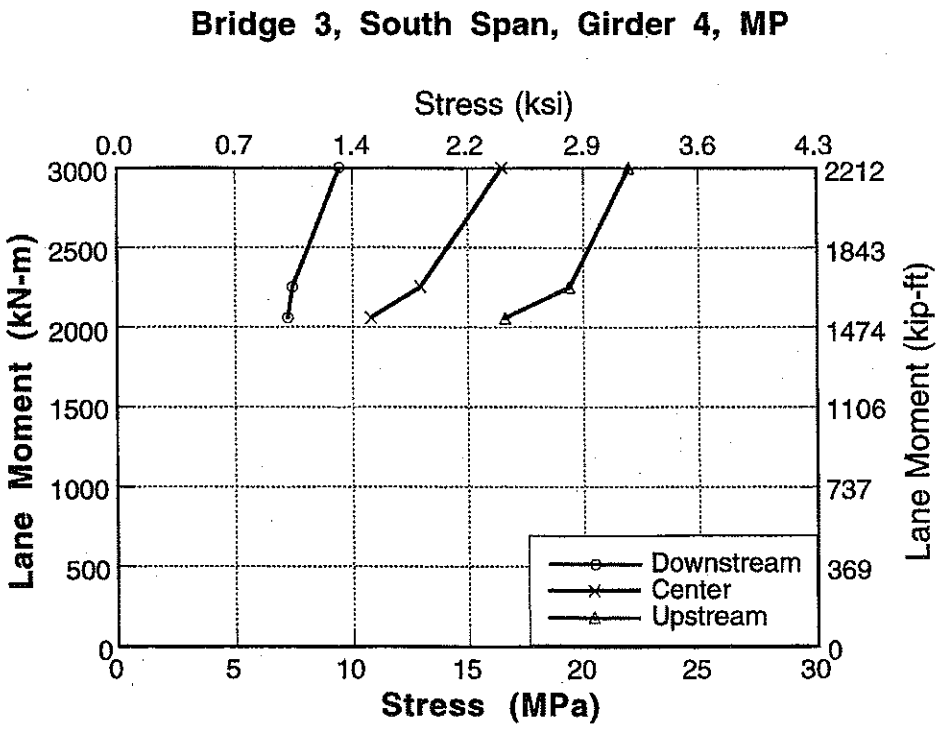


Figure A-84 : Stress vs Lane Moment for South Span of Bridge No. 3, Girder 2 and 3 at Mid Point.



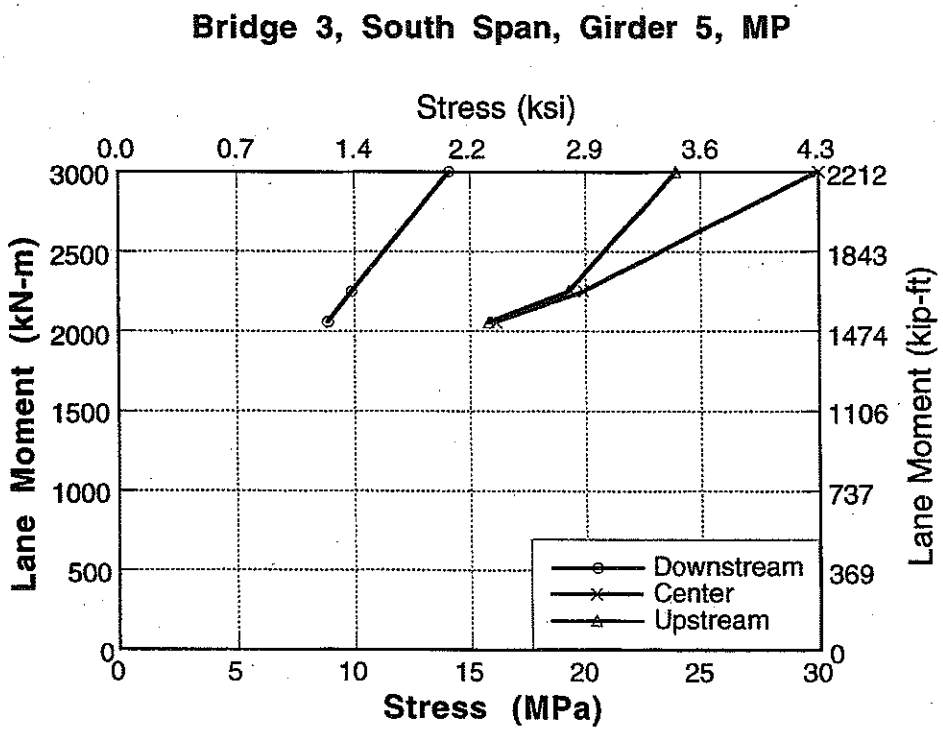
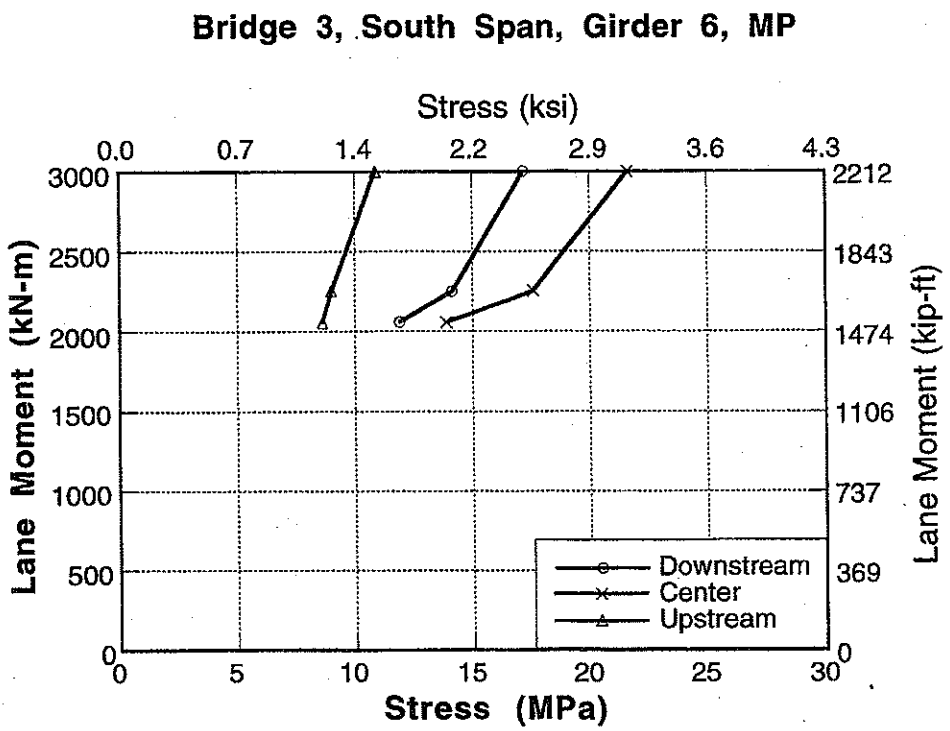


Figure A-85 : Stress vs Lane Moment for South Span of Bridge No. 3, Girder 4 and 5 at Mid Point..



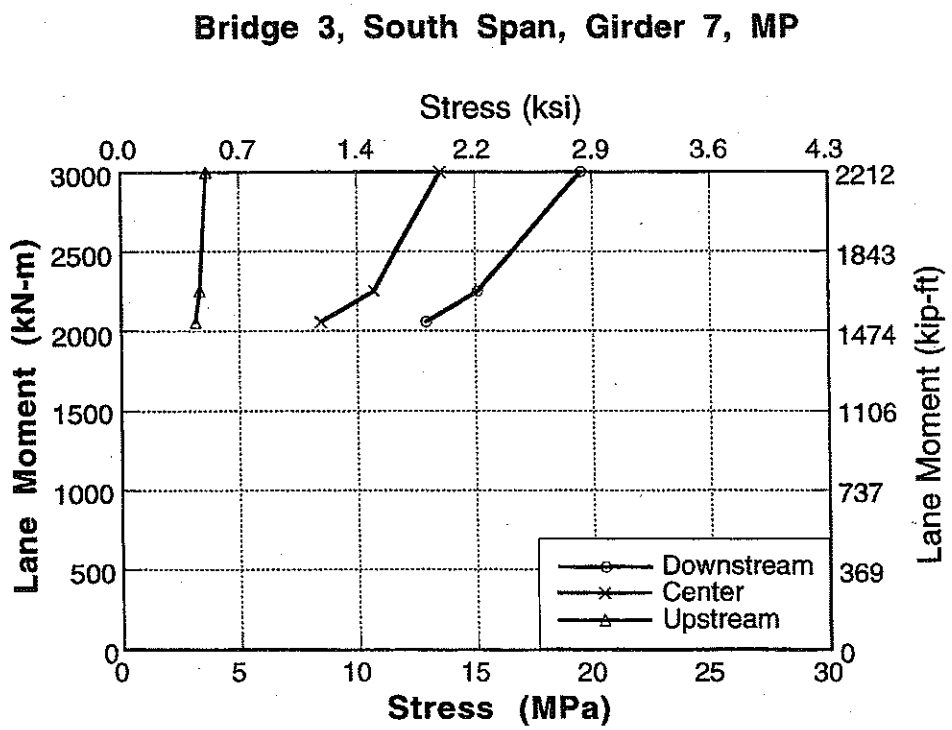
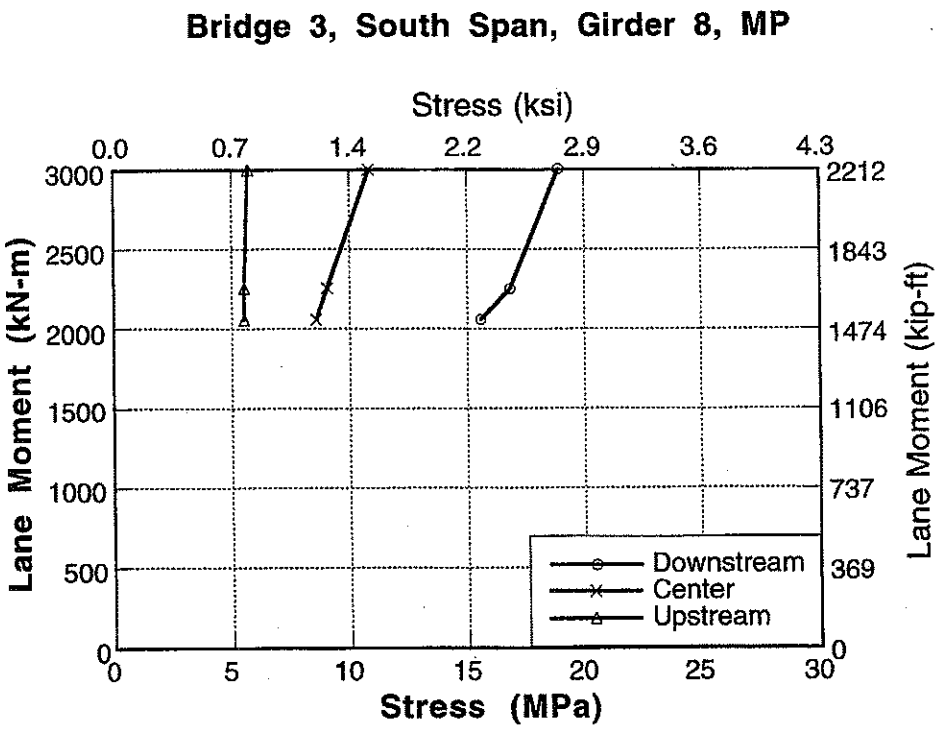


Figure A-86 : Stress vs Lane Moment for South Span of Bridge No. 3, Girder 6 and 7 at Mid Point.



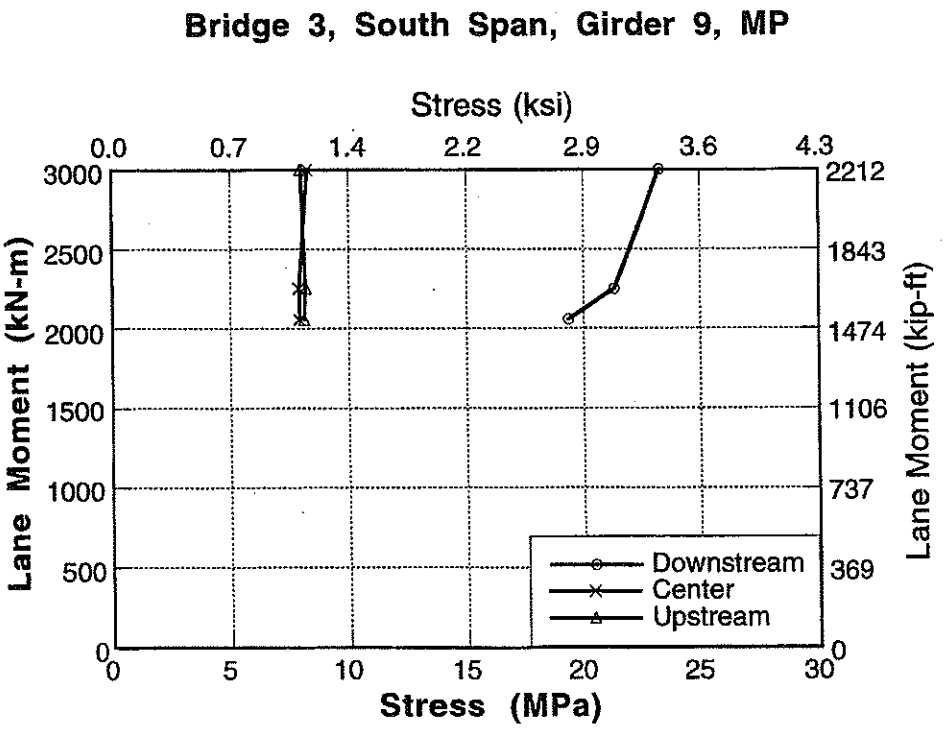
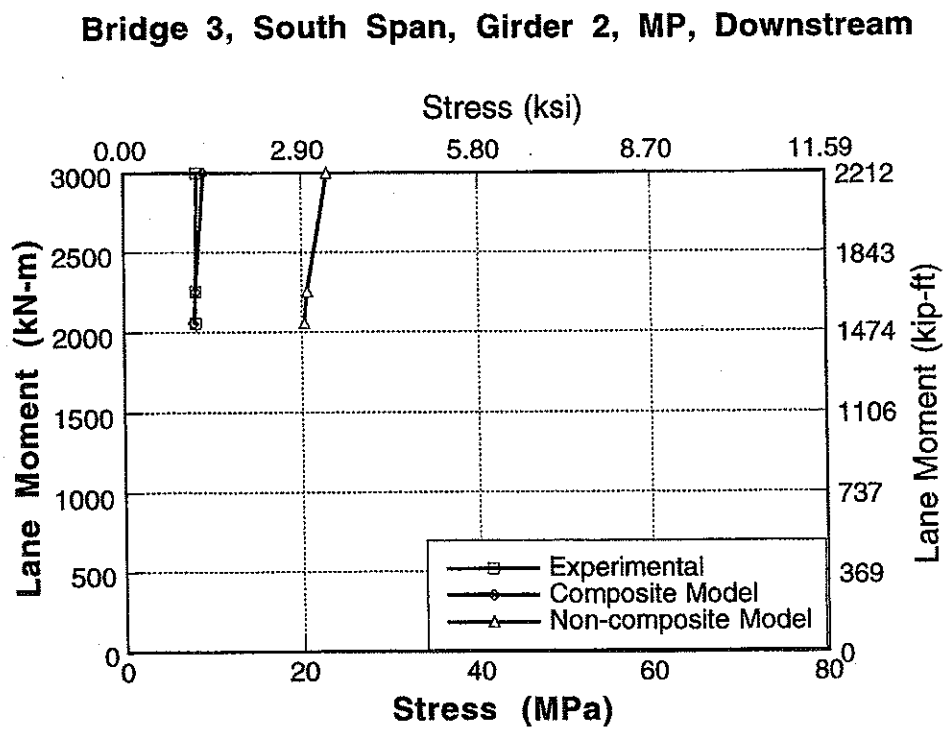


Figure A-87 : Stress vs Lane Moment for South Span of Bridge No. 3, Girder 8 and 9 at Mid Point.



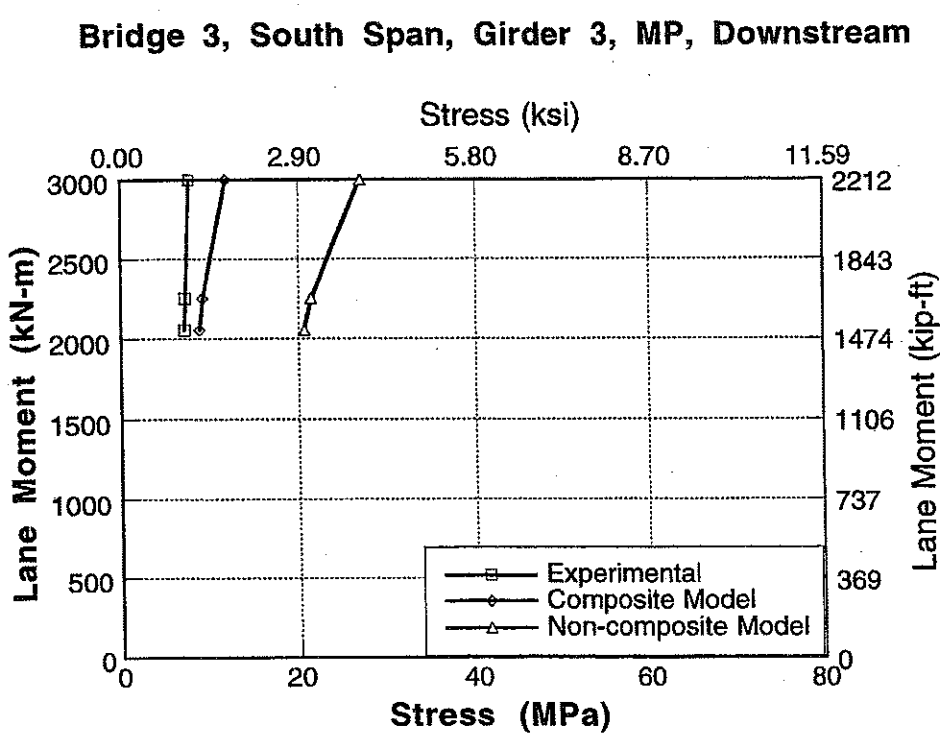
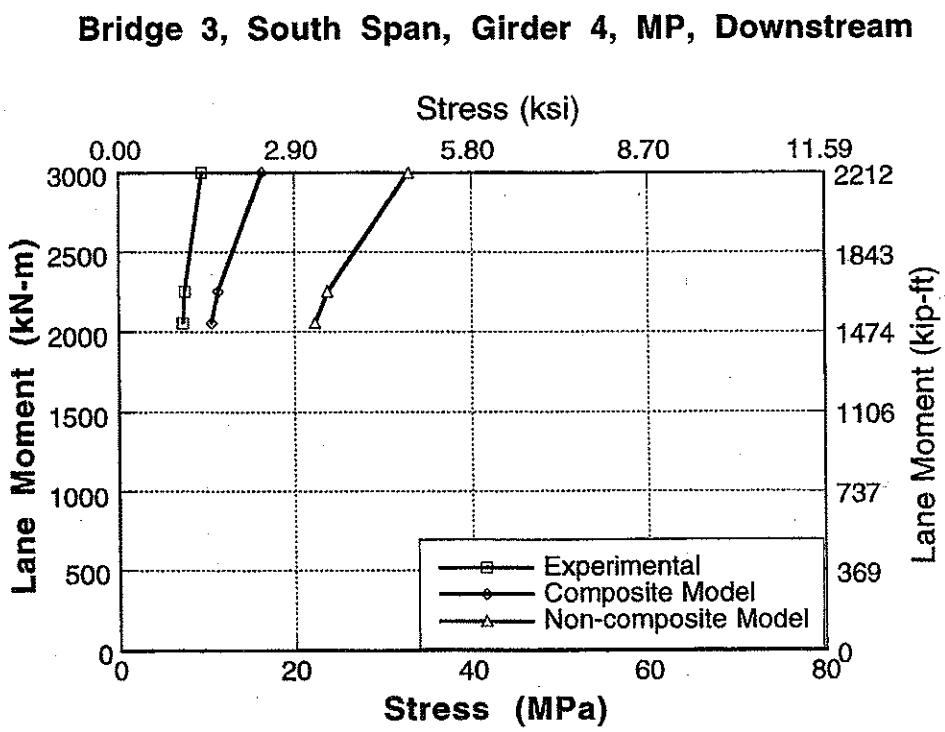


Figure A-88 : Experimental and Analytical Stresses for South Span of Bridge No. 3, Girder 2 and 3 for Downstream Loading.



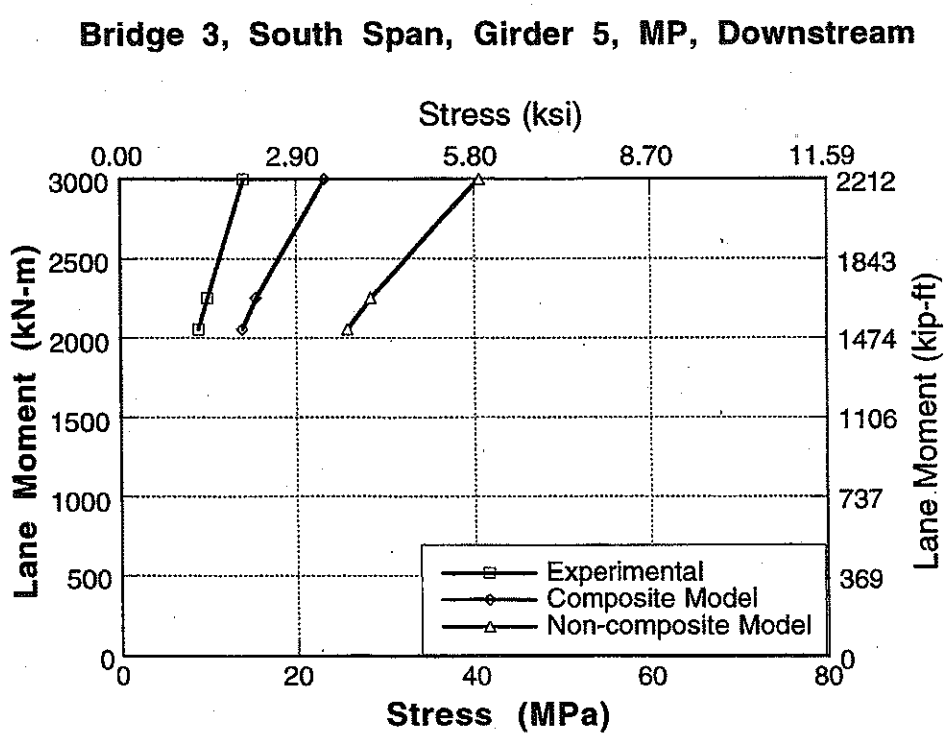
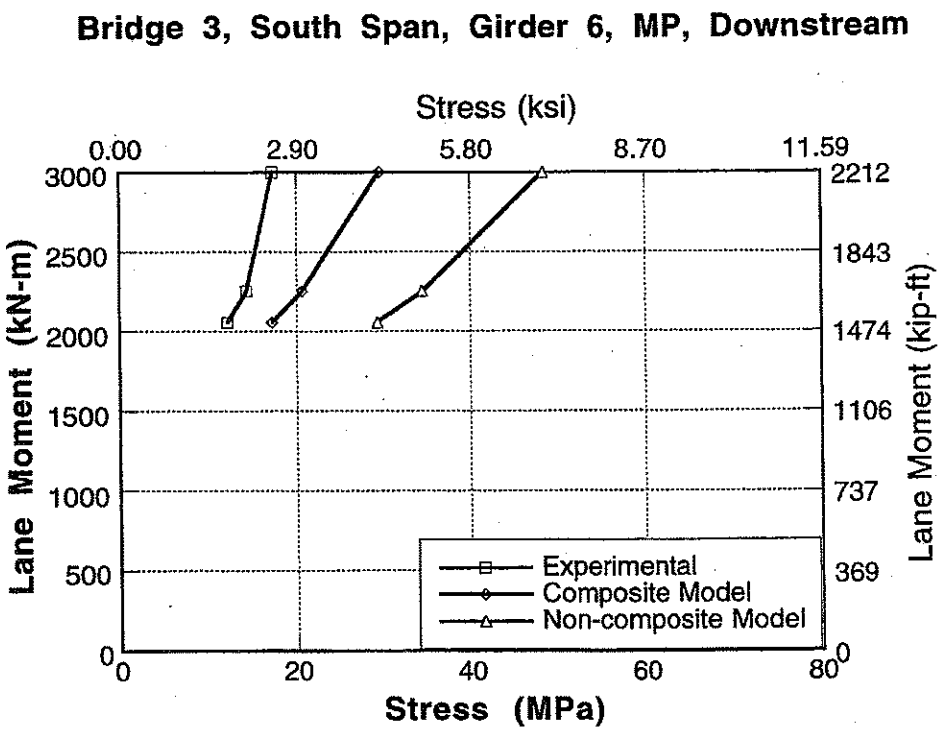


Figure A-89 : Experimental and Analytical Stresses for South Span of Bridge No. 3, Girder 4 and 5 for Downstream Loading.



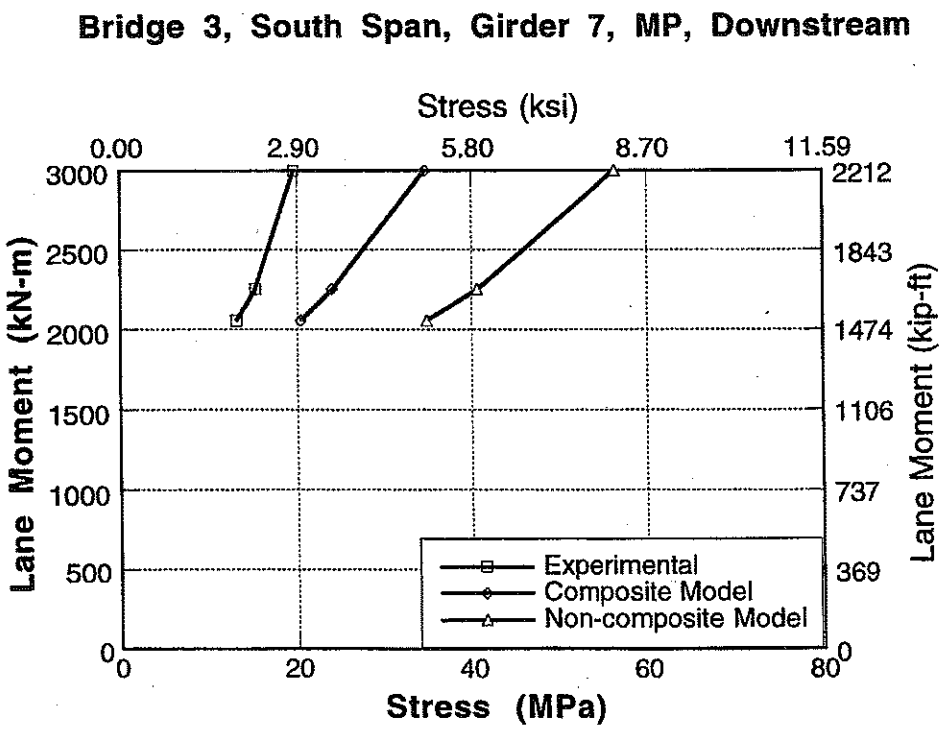
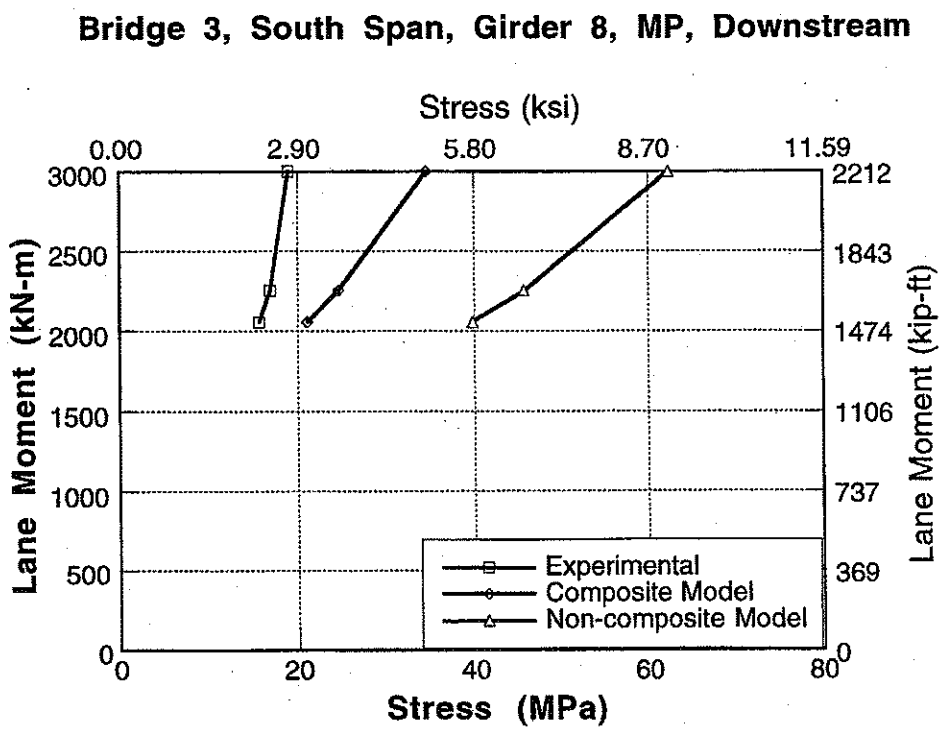


Figure A-90 : Experimental and Analytical Stresses for South Span of Bridge No. 3, Girder 6 and 7 for Downstream Loading.



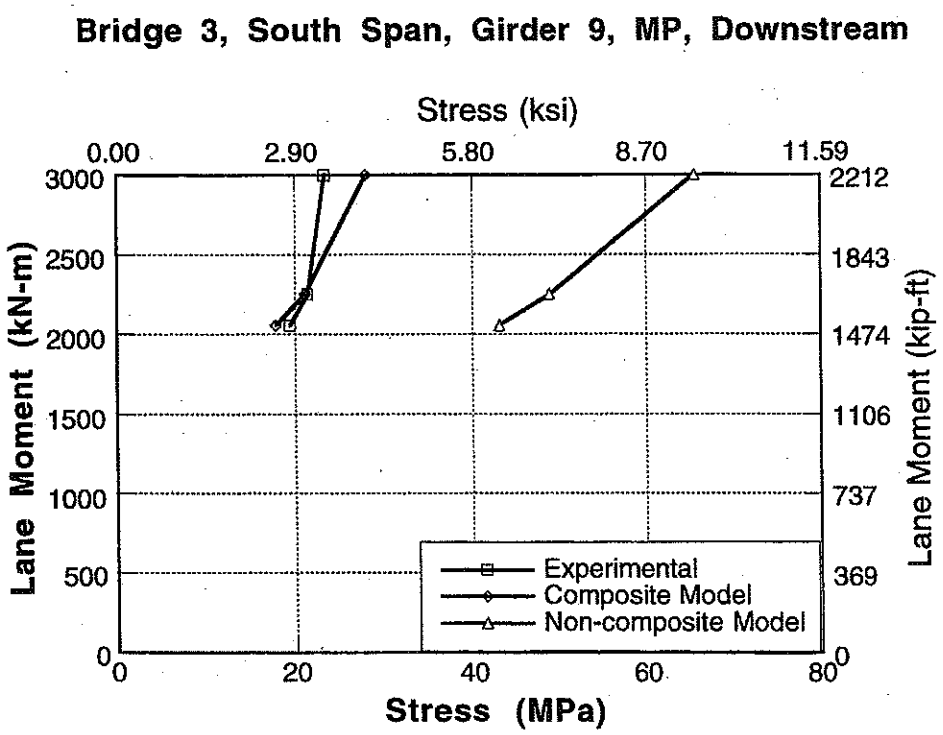
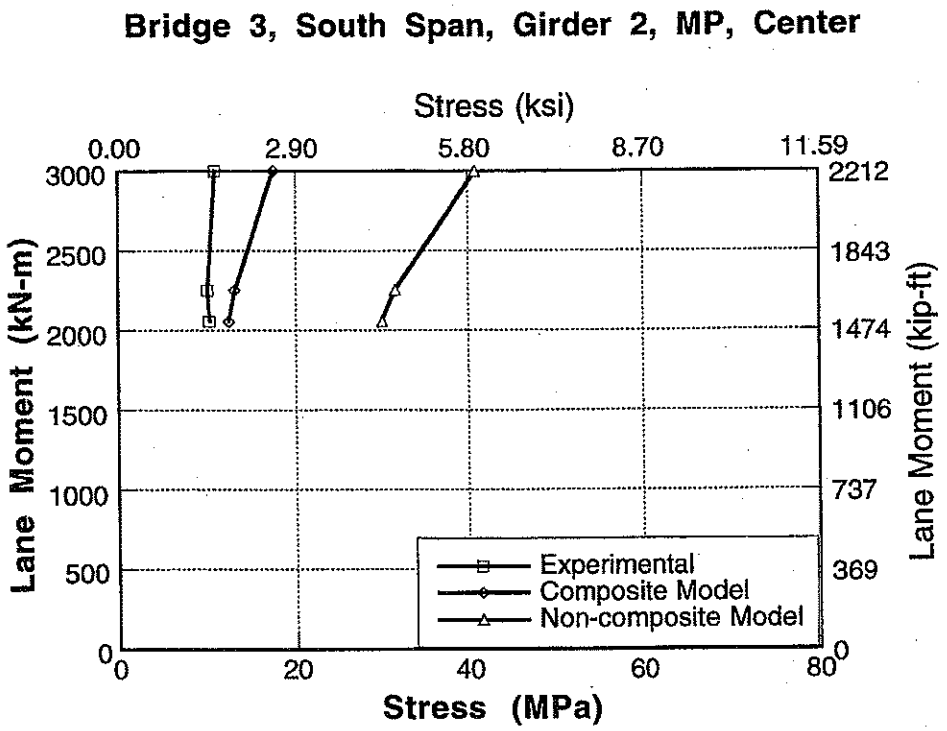


Figure A-91 : Experimental and Analytical Stresses for South Span of Bridge No. 3, Girder 8 and 9 for Downstream Loading.



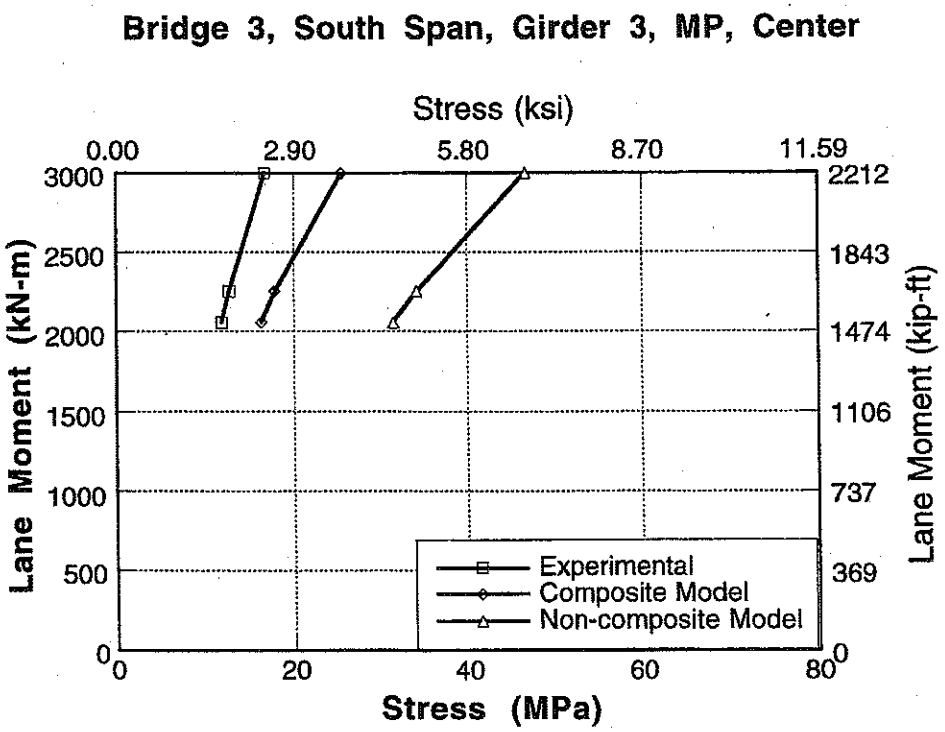
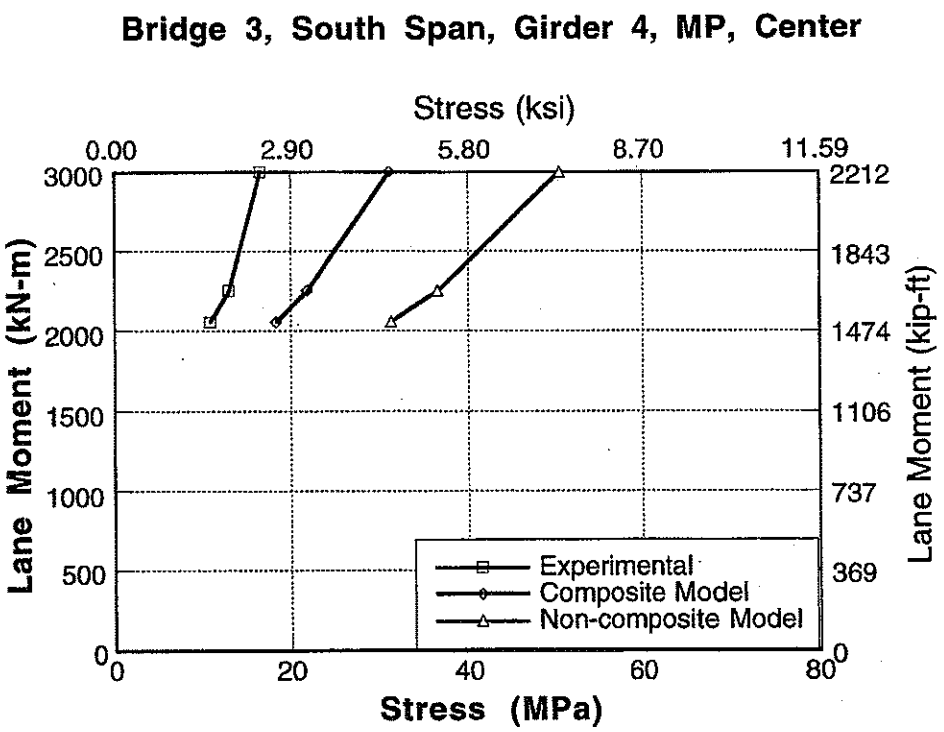


Figure A-92 : Experimental and Analytical Stresses for South Span of Bridge No. 3, Girder 2 and 3 for Center Loading.



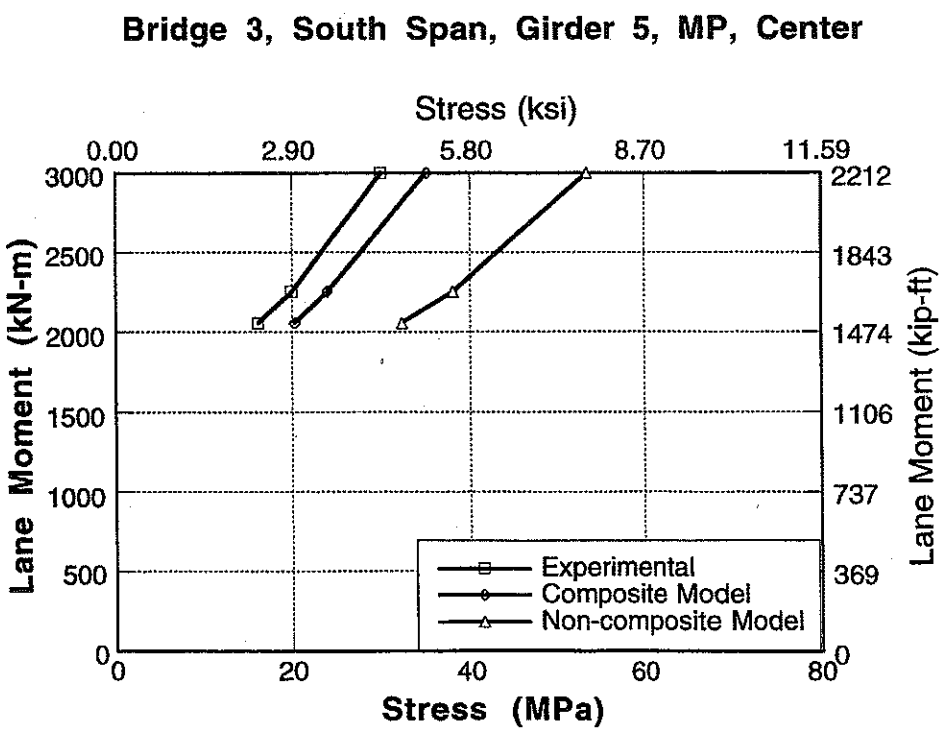
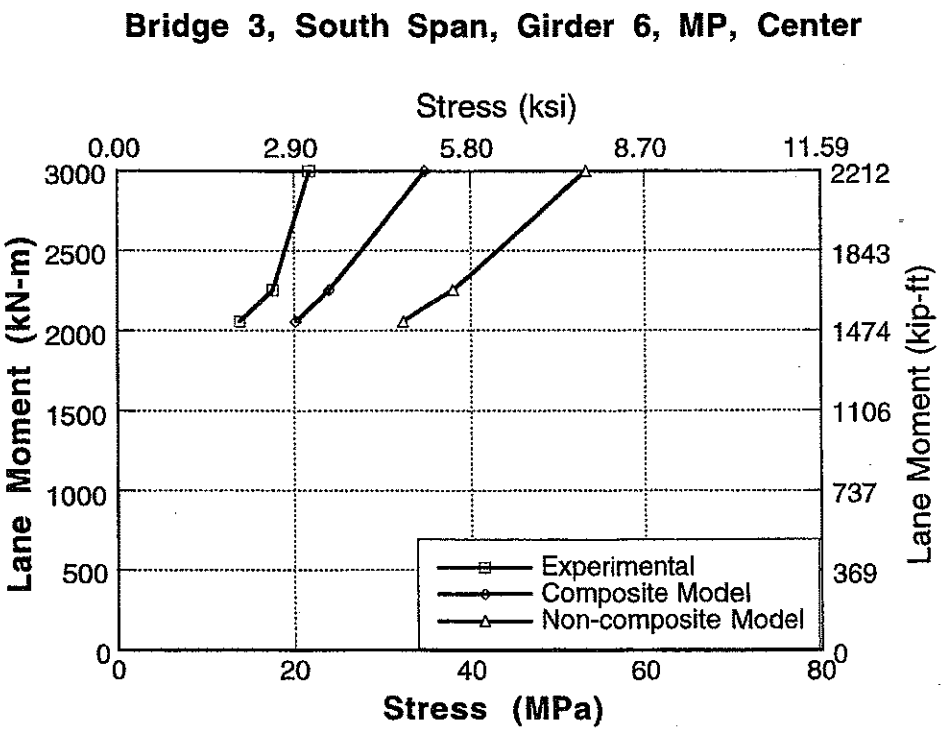


Figure A-93 : Experimental and Analytical Stresses for South Span of Bridge No. 3, Girder 4 and 5 for Center Loading.



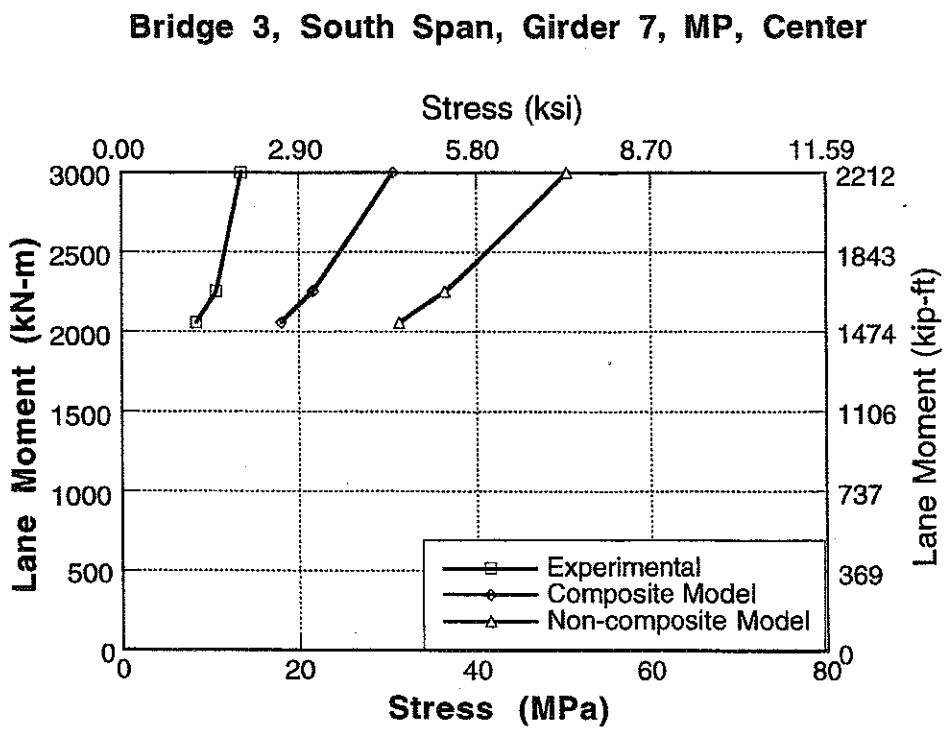
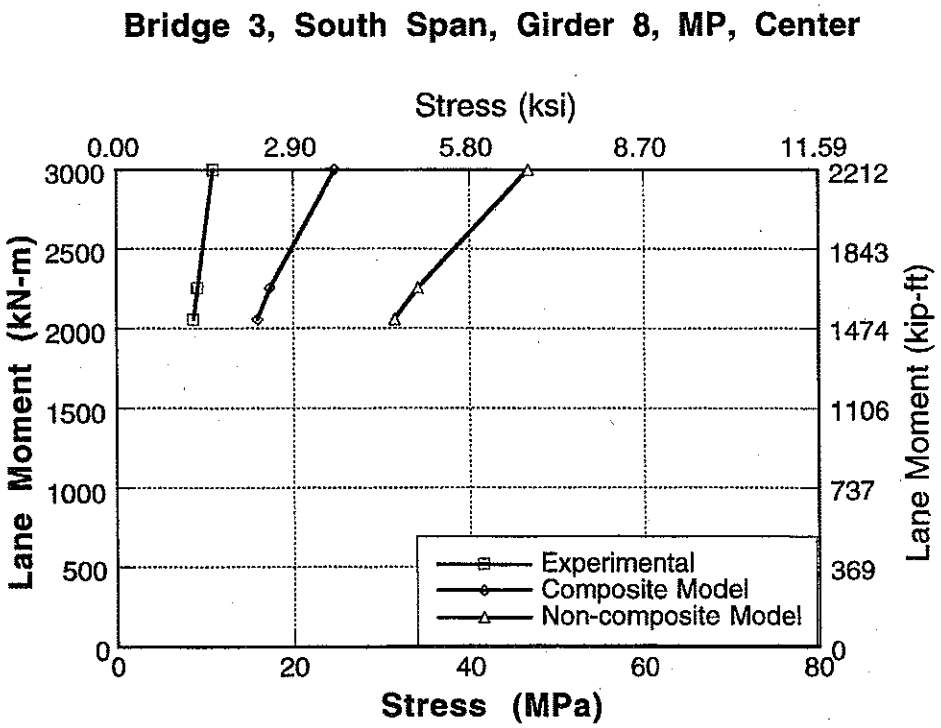


Figure A-94 : Experimental and Analytical Stresses for South Span of Bridge No. 3, Girder 6 and 7 for Center Loading.



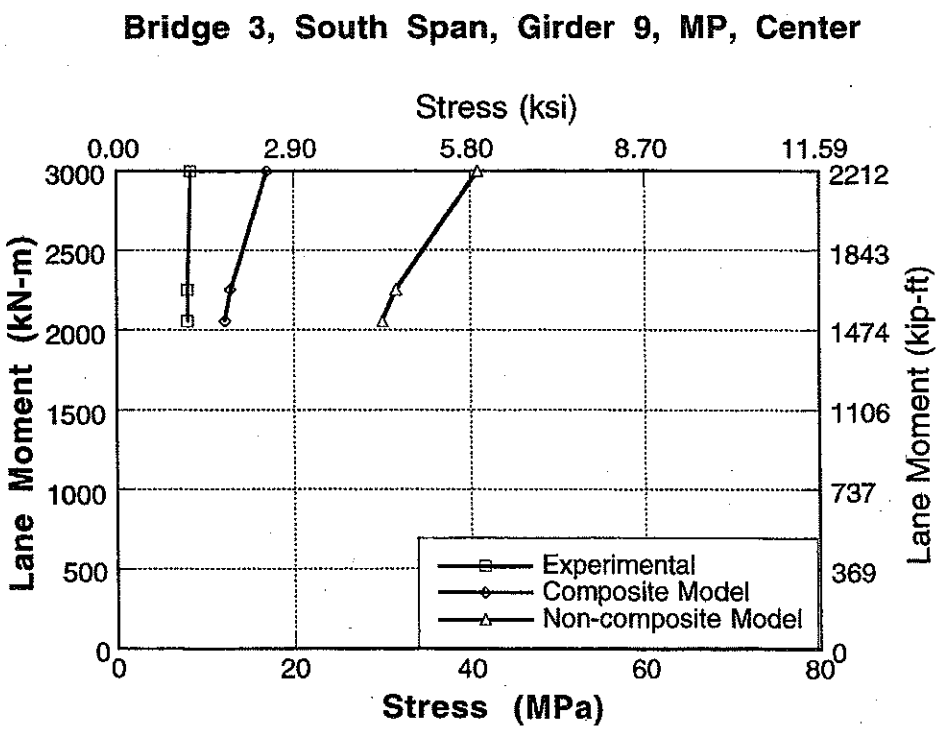
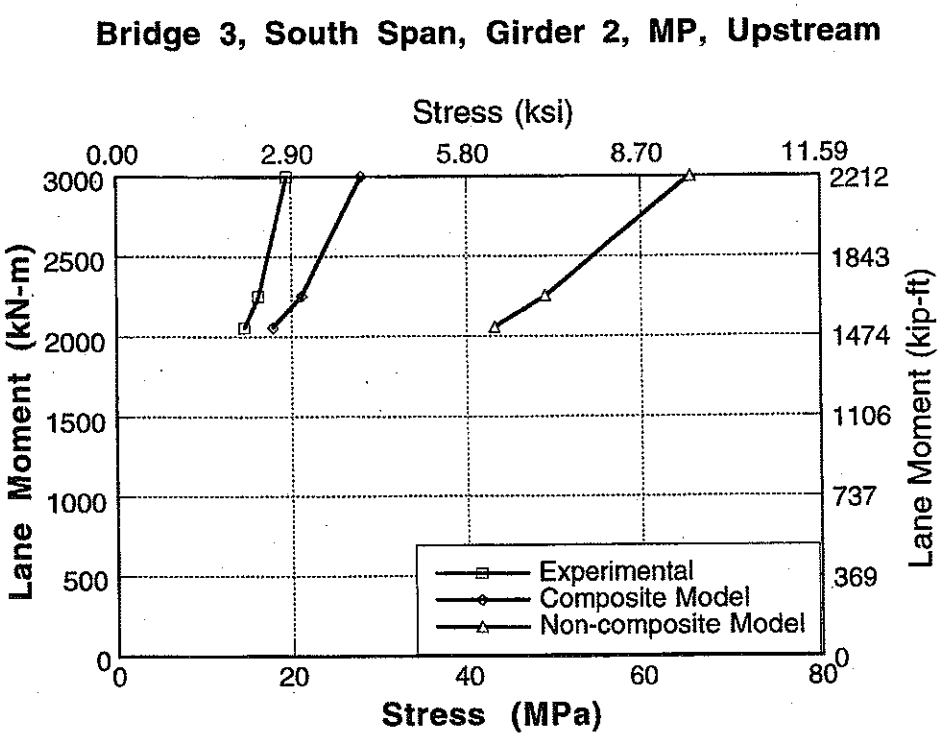


Figure A-95 : Experimental and Analytical Stresses for South Span of Bridge No. 3, Girder 8 and 9 for Center Loading.



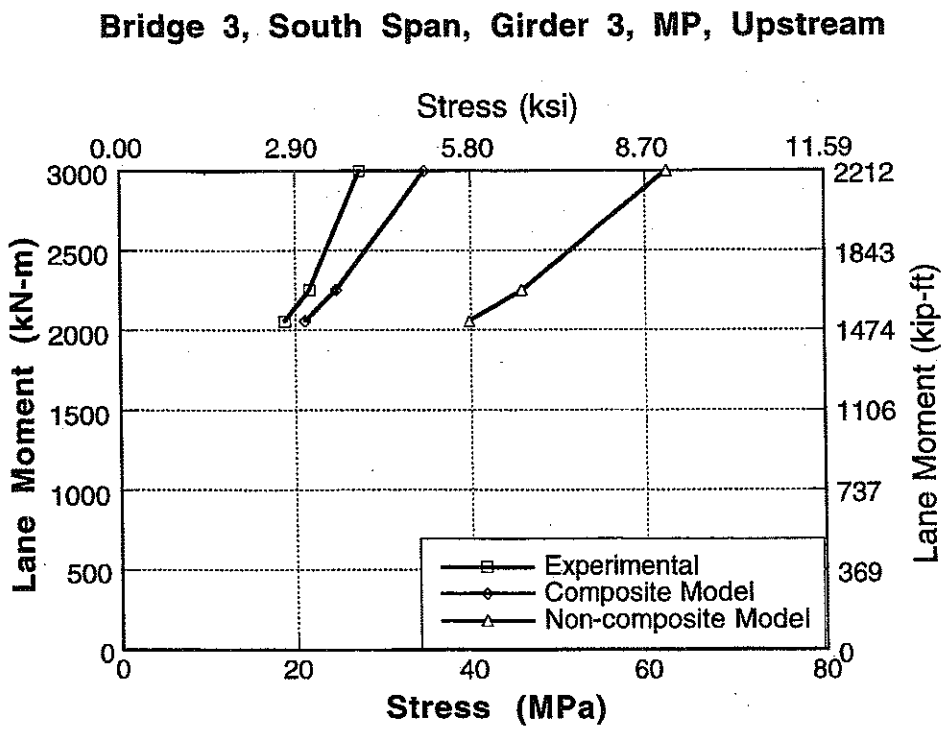
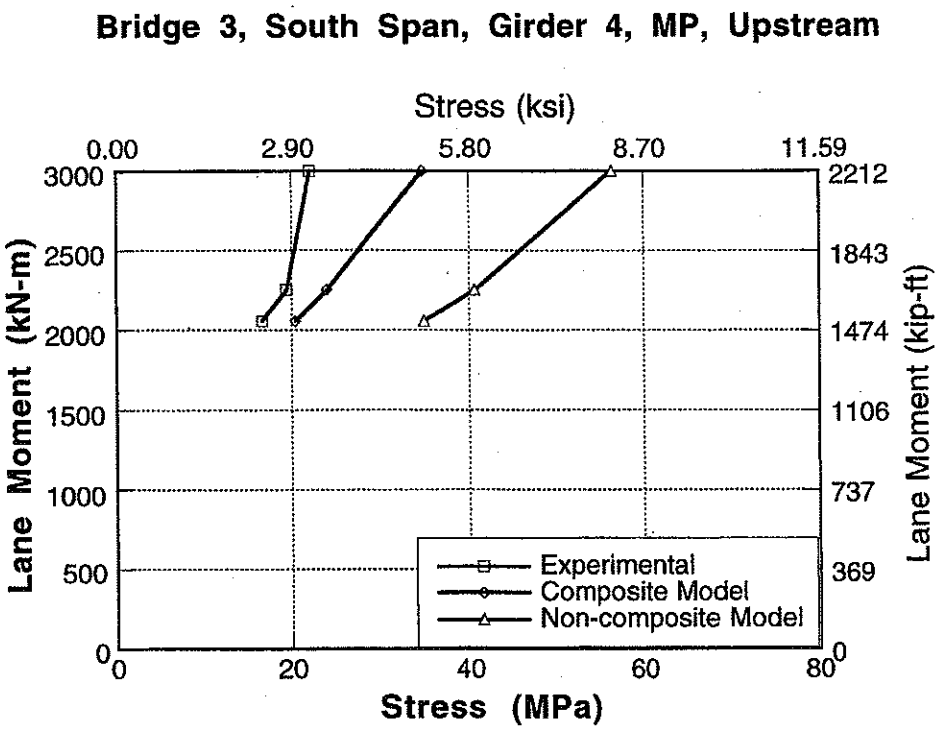


Figure A-96 : Experimental and Analytical Stresses for South Span of Bridge No. 3, Girder 2 and 3 for Upstream Loading.



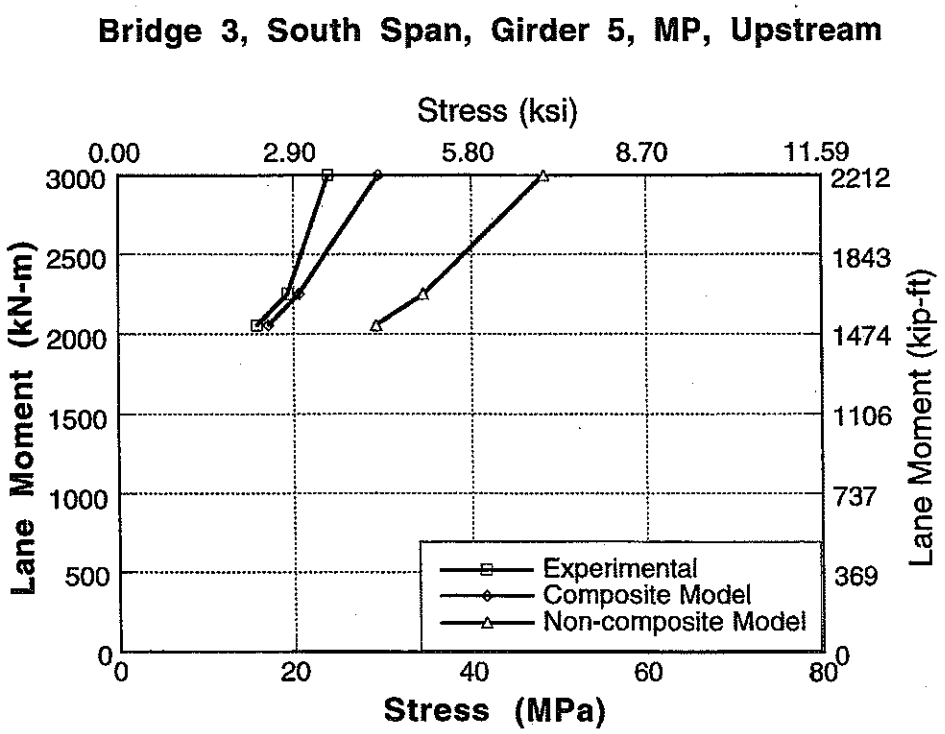
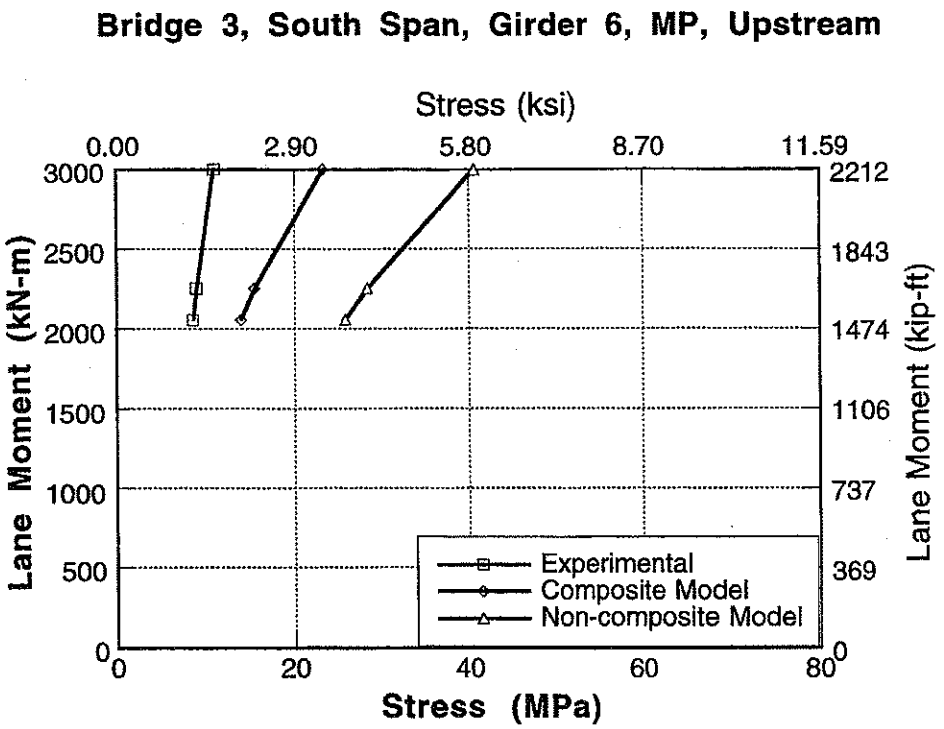


Figure A-97 : Experimental and Analytical Stresses for South Span of Bridge No. 3, Girder 4 and 5 for Upstream Loading.



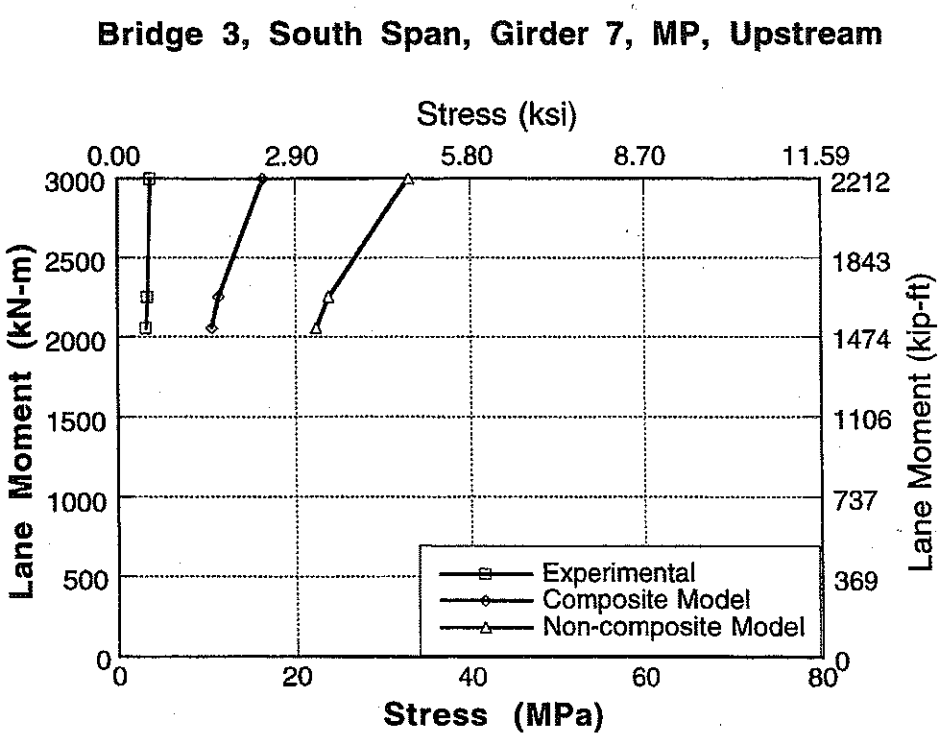
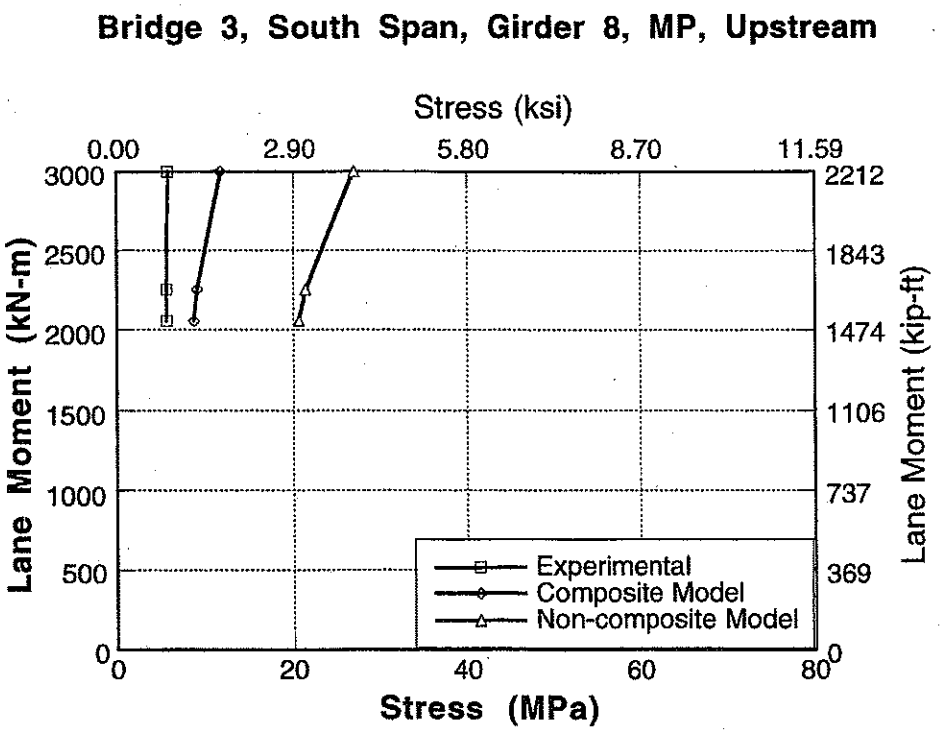


Figure A-98 : Experimental and Analytical Stresses for South Span of Bridge No. 3, Girder 6 and 7 for Upstream Loading.



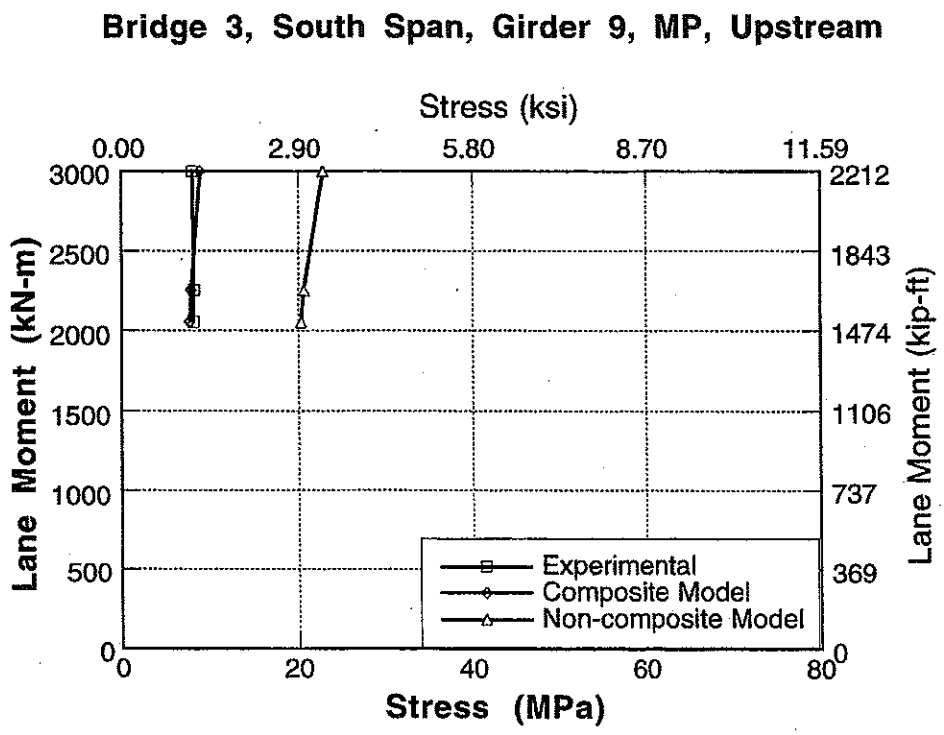


Figure A-99 : Experimental and Analytical Stresses for South Span of Bridge No. 3, Girder 8 and 9 for Upstream Loading.

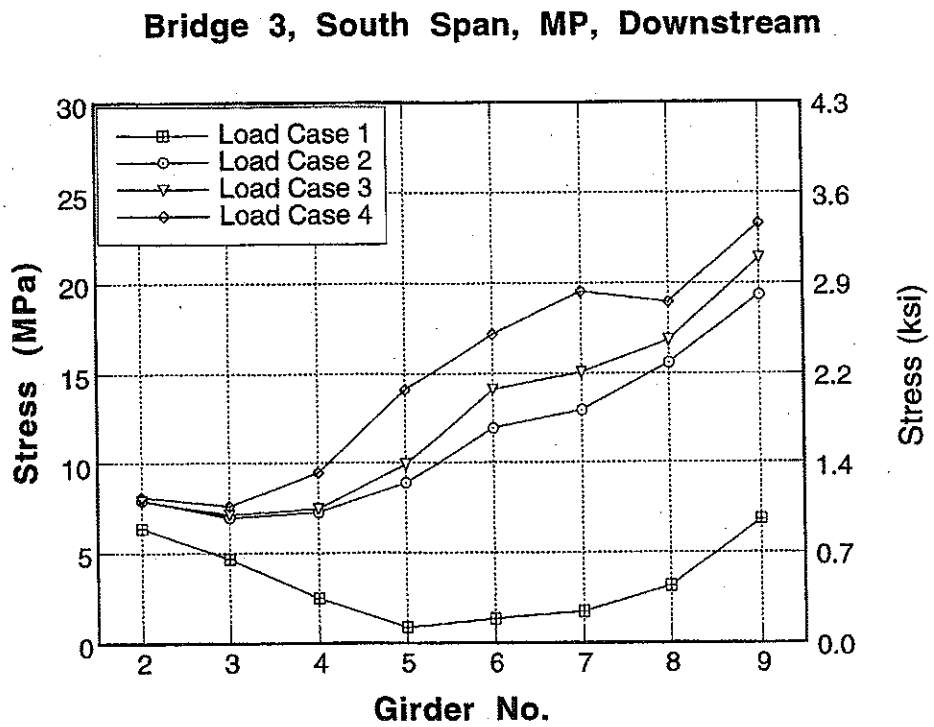


Figure A-100 : Girder Distribution of Stresses at Mid Point for South Span of Bridge No. 3 due to Downstream Loading.

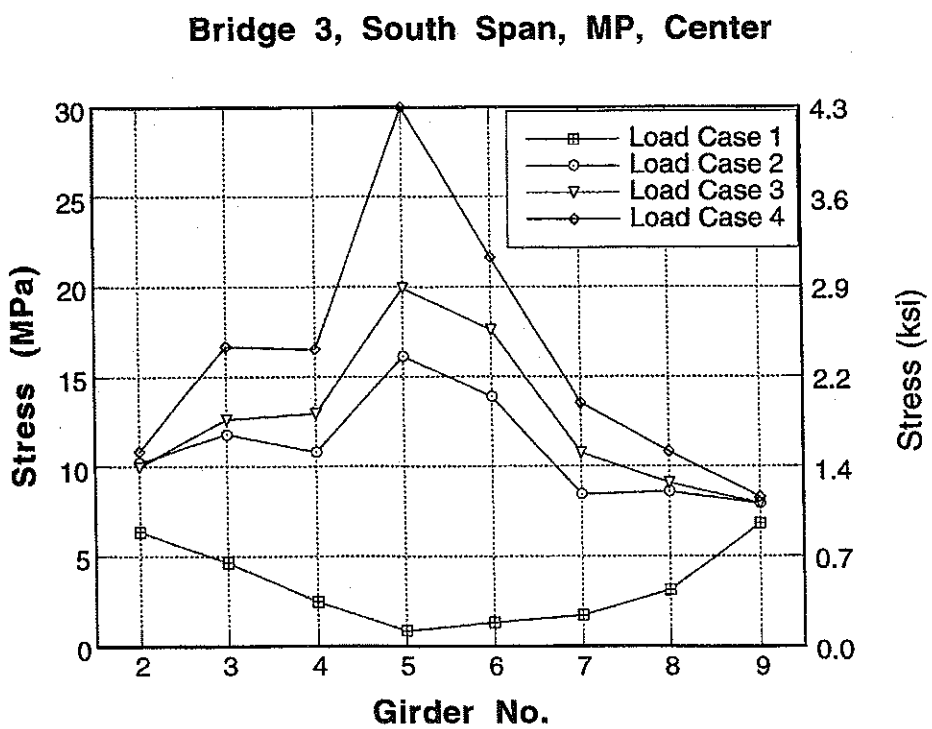


Figure A-101 : Girder Distribution of Stresses at Mid Point for South Span of Bridge No. 3 due to Center Loading.

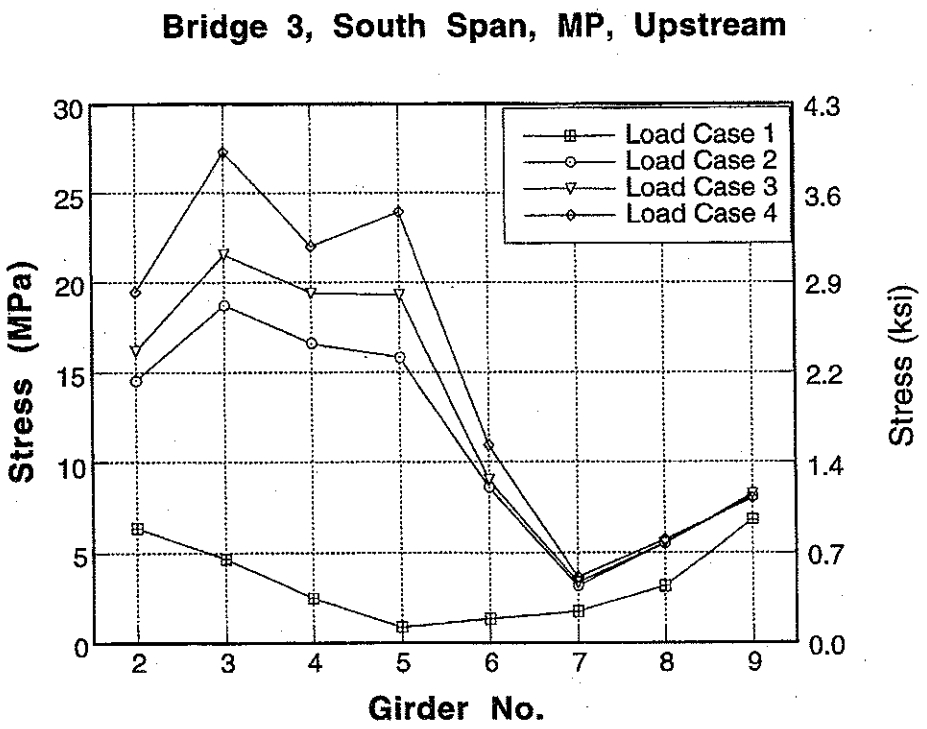


Figure A-102 : Girder Distribution of Stresses at Mid Point for South Span of Bridge No. 3 due to Upstream Loading.

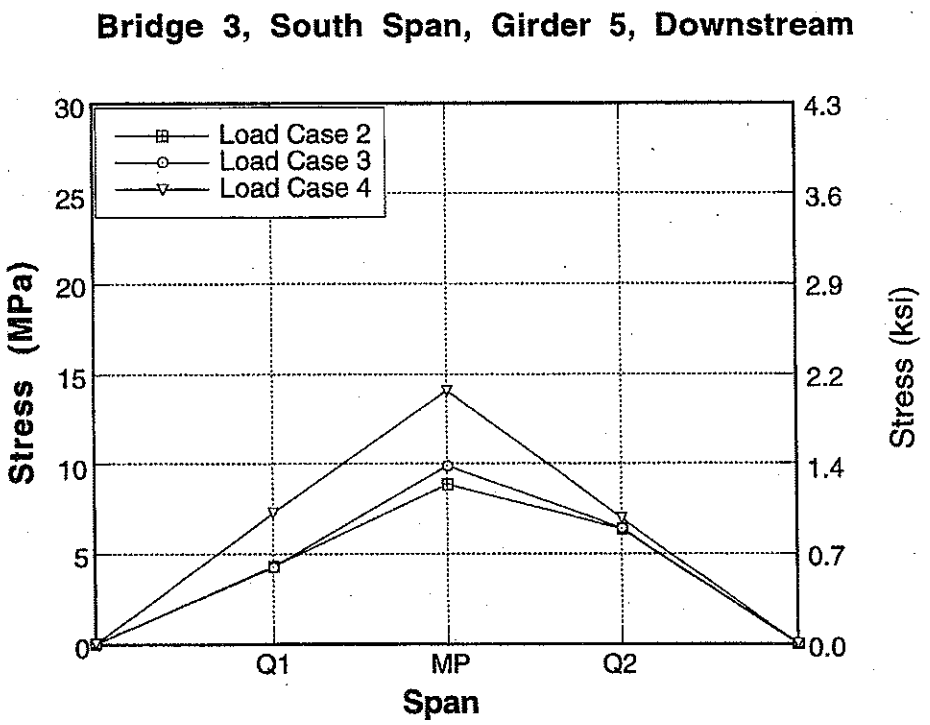


Figure A-103 : Longitudinal Distribution of Stresses for South Span of Bridge No. 3, Girder 5 due to Downstream Loading.

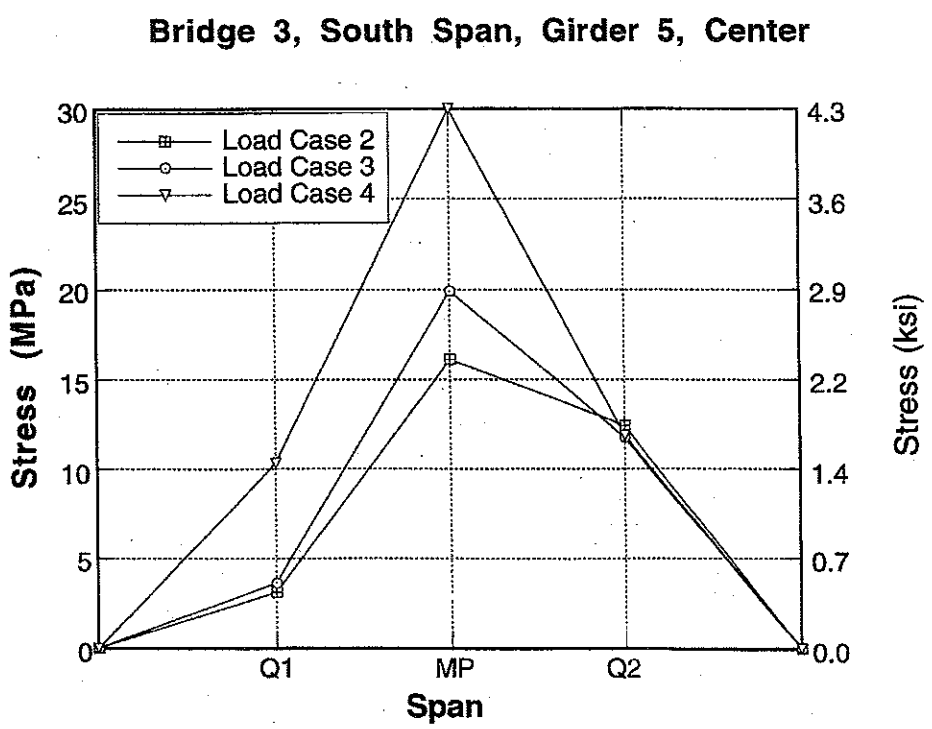


Figure A-104 : Longitudinal Distribution of Stresses for South Span of Bridge No. 3, Girder 5 due to Center Loading.

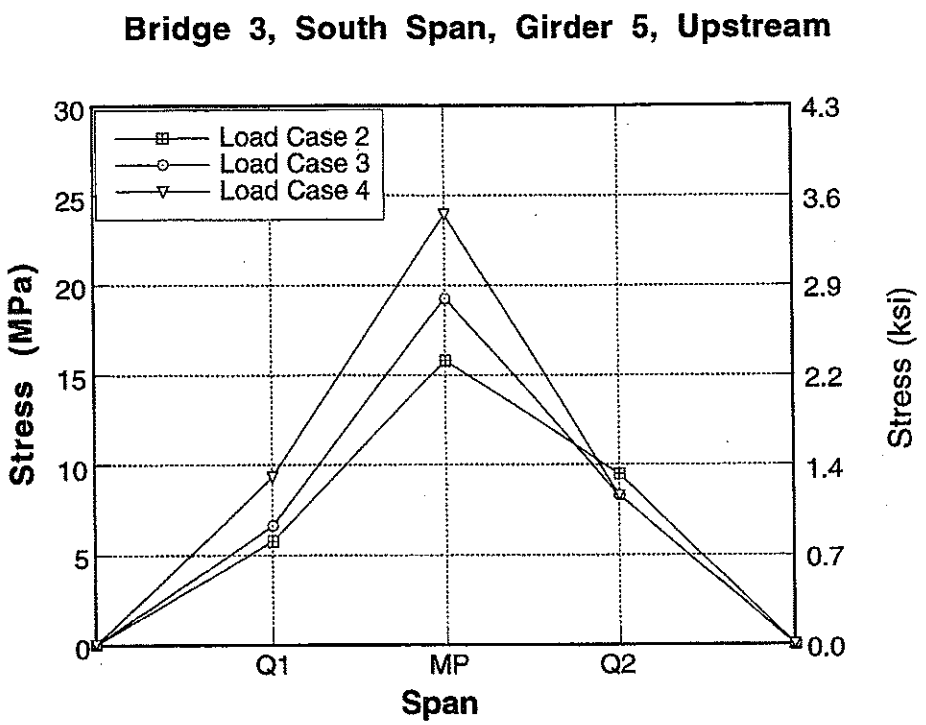


Figure A-105 : Longitudinal Distribution of Stresses for South Span of Bridge No. 3, Girder 5 due to Upstream Loading.

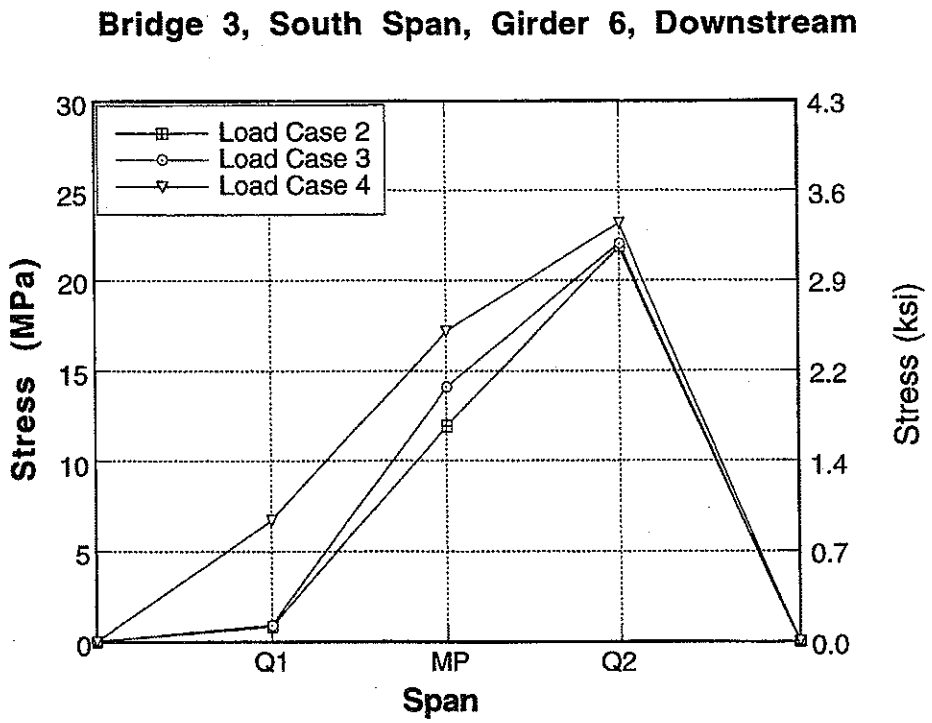


Figure A-106 : Longitudinal Distribution of Stresses for South Span of Bridge No. 3, Girder 6 due to Downstream Loading.

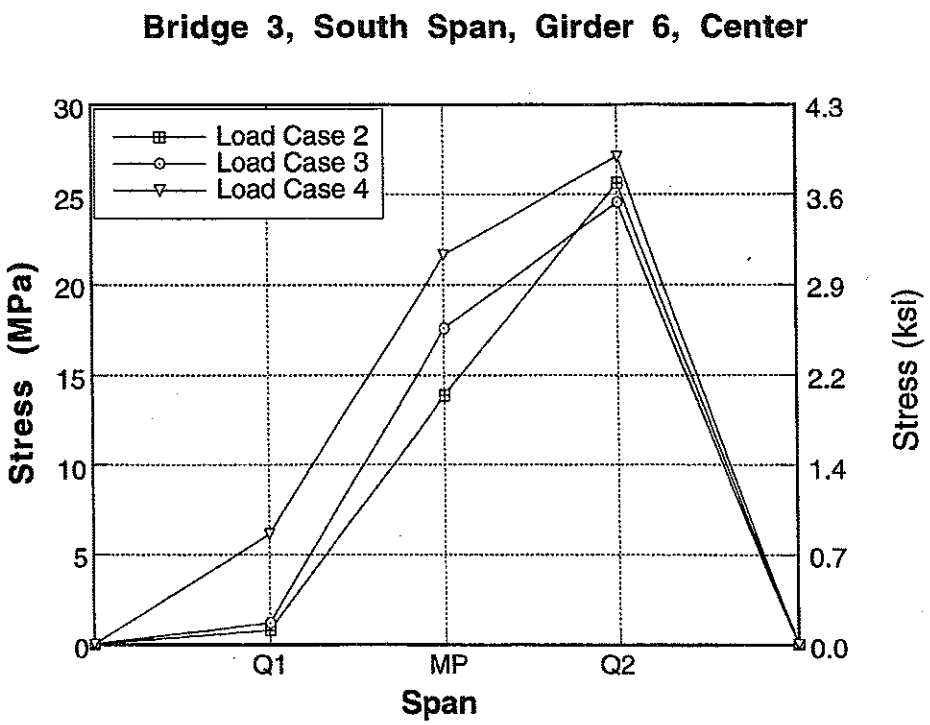


Figure A-107 : Longitudinal Distribution of Stresses for South Span of Bridge No. 3, Girder 6 due to Center Loading.

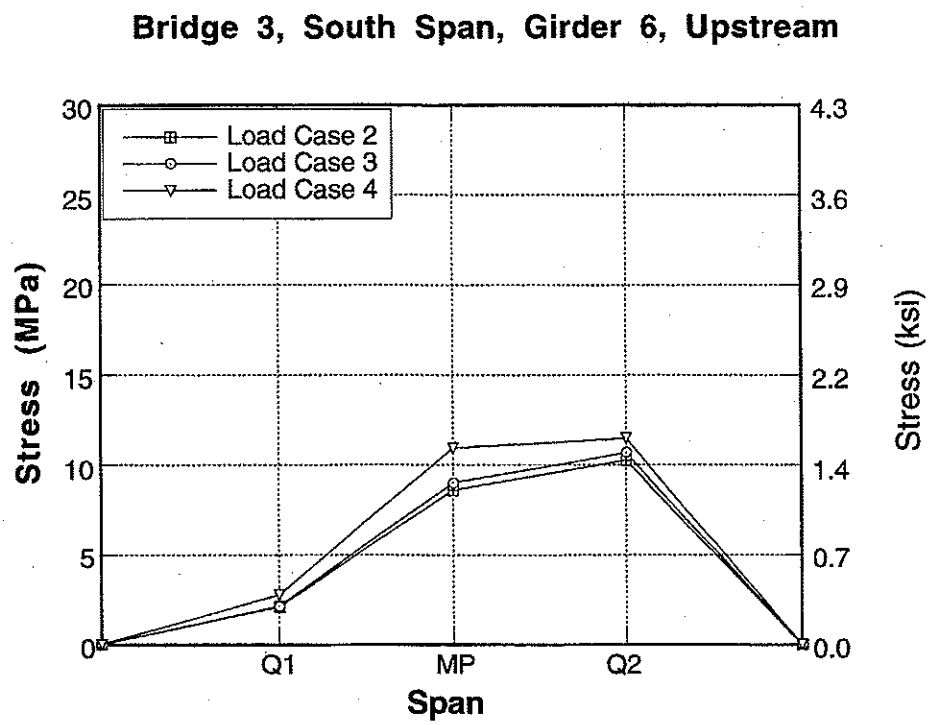


Figure A-108 : Longitudinal Distribution of Stresses for South Span of Bridge No. 3, Girder 6 due to Upstream Loading.

Note:

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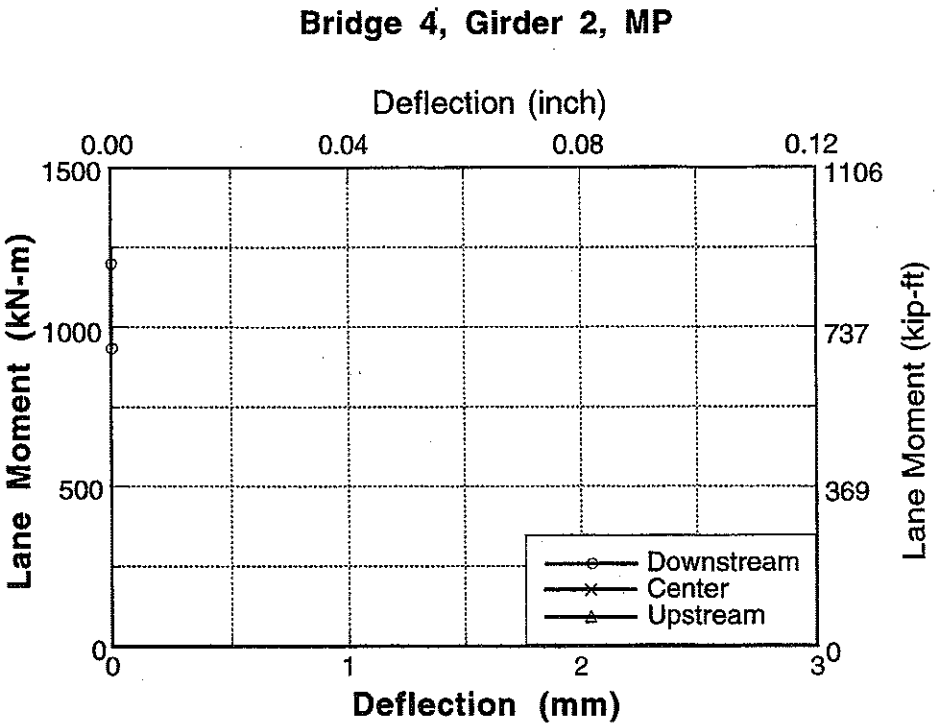
APPENDIX D - RESULTS FOR BRIDGE NO. 4

MDOT ID # B01-19062

M-21 bridge over Little Maple River located in Clinton County, Michigan. Simply supported steel girder bridge.

Results for this bridge contain:

- Measured deflections vs calculated lane moment.
- Measured deflections vs analytical deflections.
- Girder distribution of measured deflections.
- Longitudinal distribution of measured deflections.
- Measured stresses vs calculated lane moment.
- Measured stresses vs analytical stresses.
- Girder distribution of measured stresses.
- Longitudinal distribution of measured stresses.



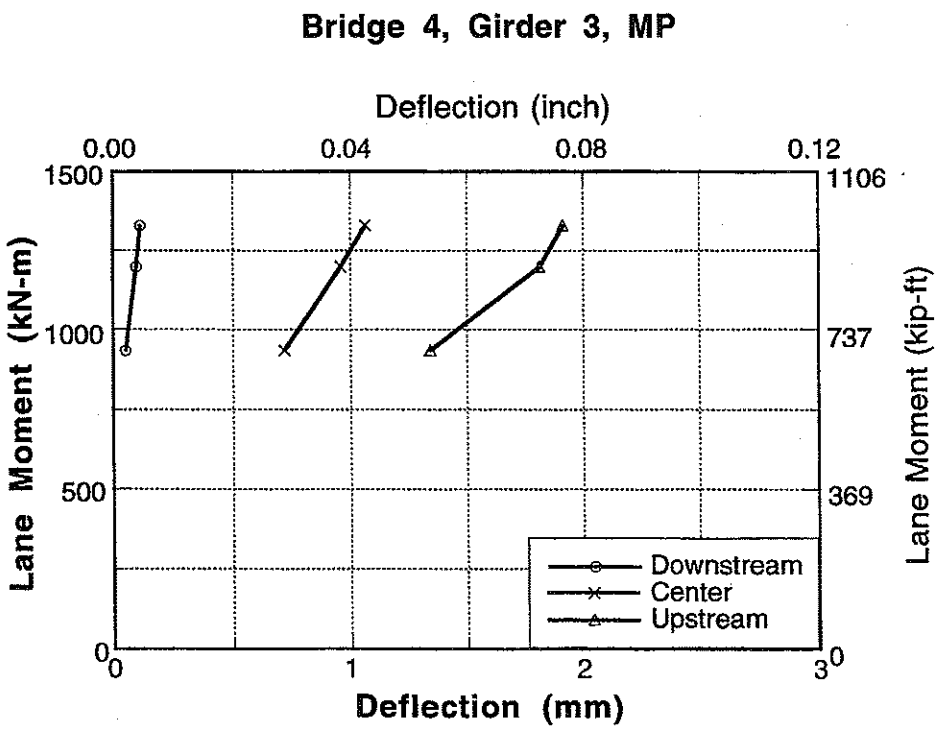
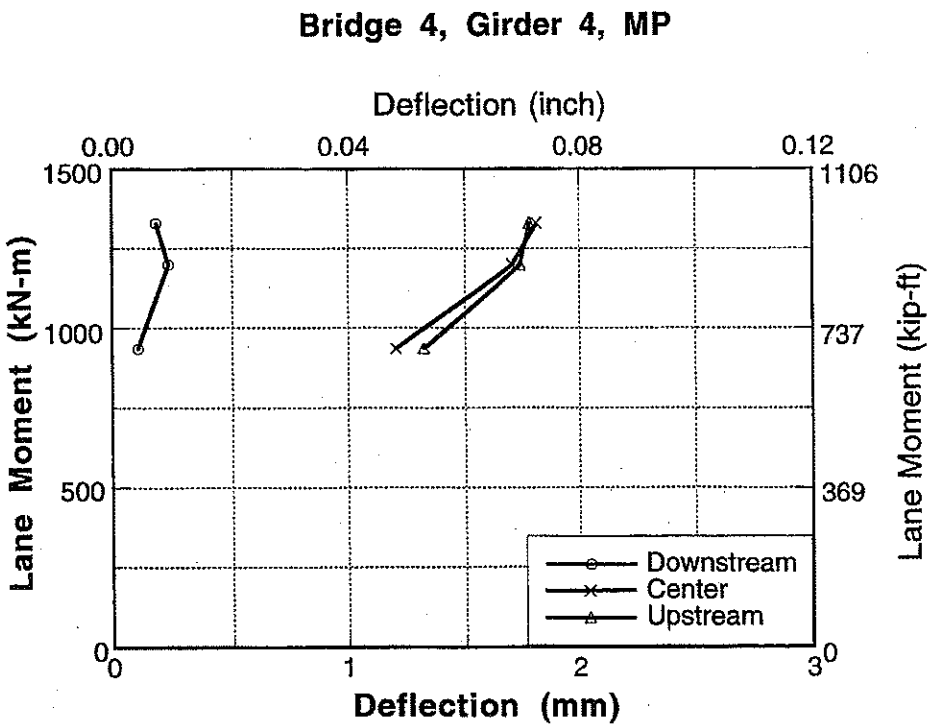


Figure A-109: Deflection vs Lane Moment for Bridge No. 4,Girder 2 and 3.



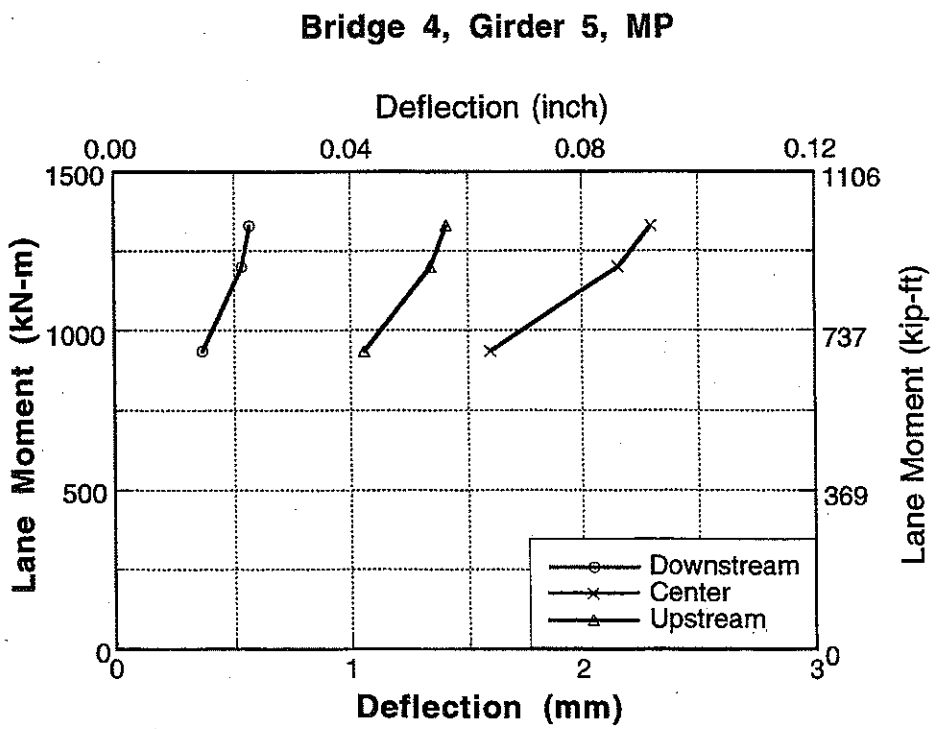
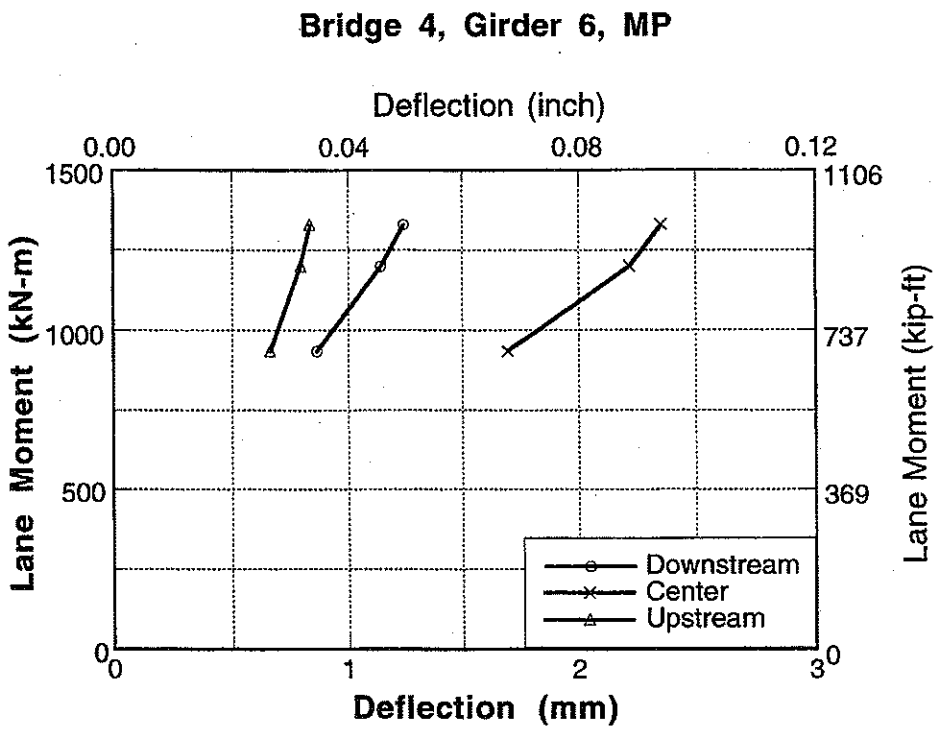


Figure A-110: Deflection vs Lane Moment for Bridge No. 4,Girder 4 and 5.



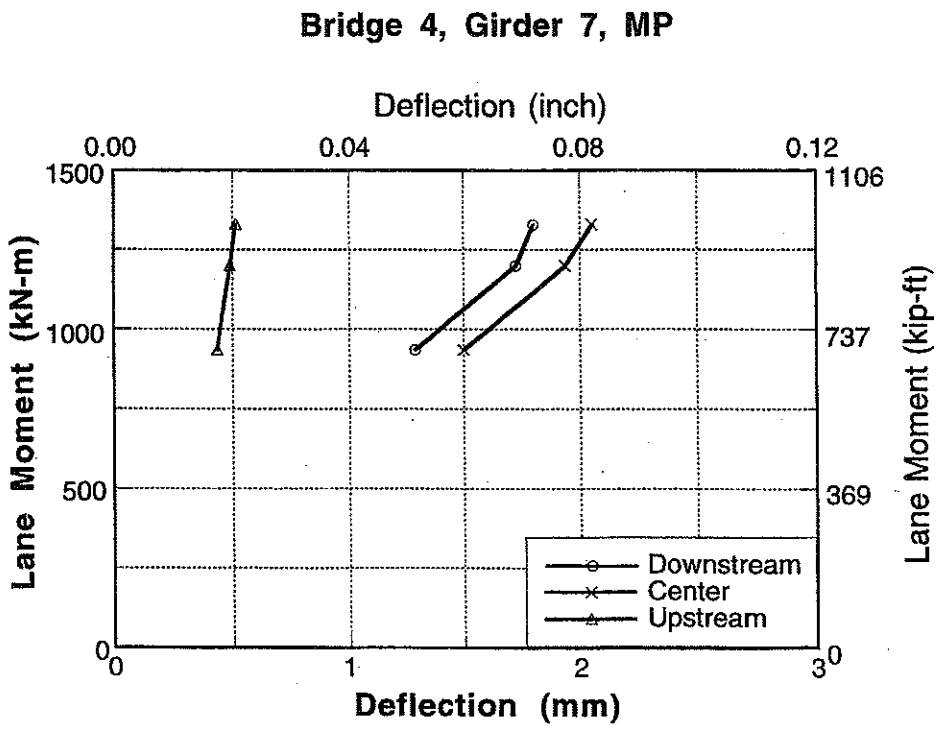
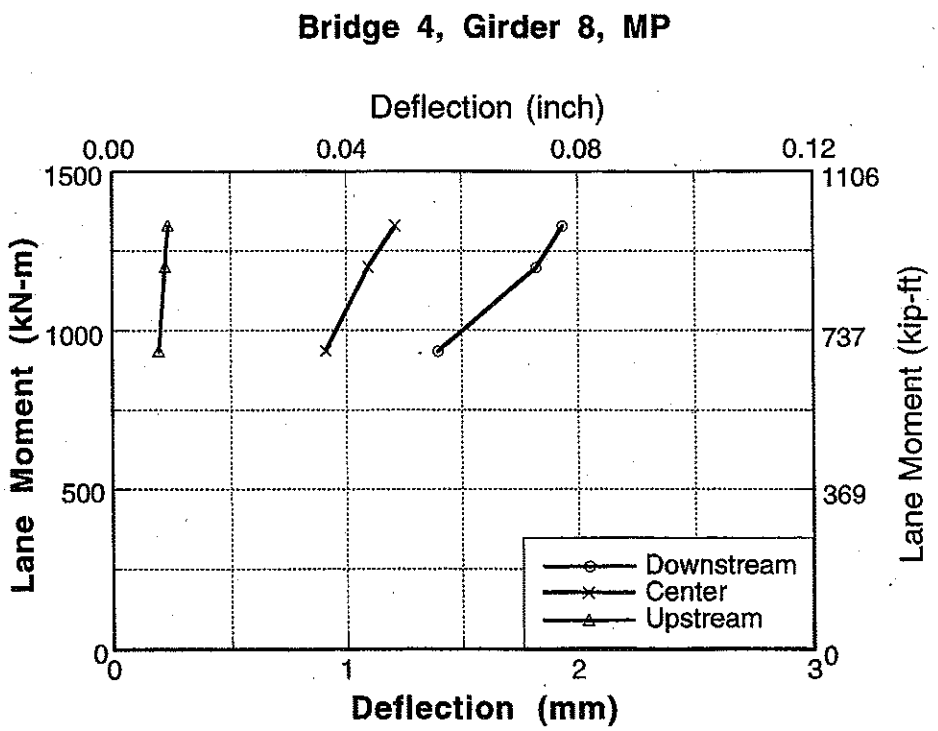


Figure A-111: Deflection vs Lane Moment for Bridge No. 4,Girder 6 and 7.



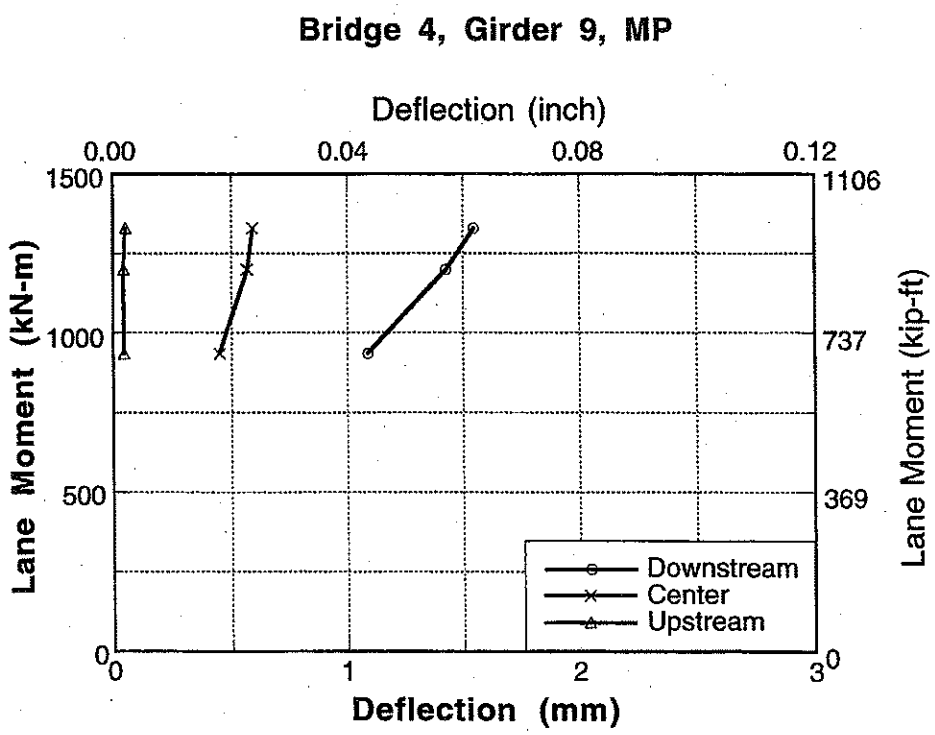
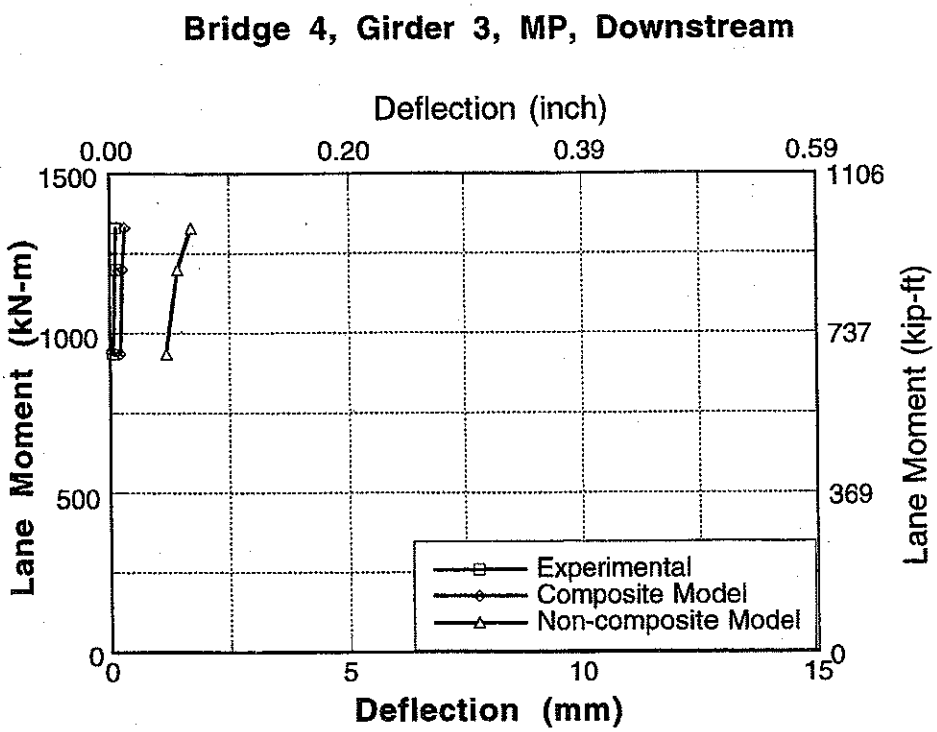


Figure A-112: Deflection vs Lane Moment for Bridge No. 4,Girder 8 and 9.



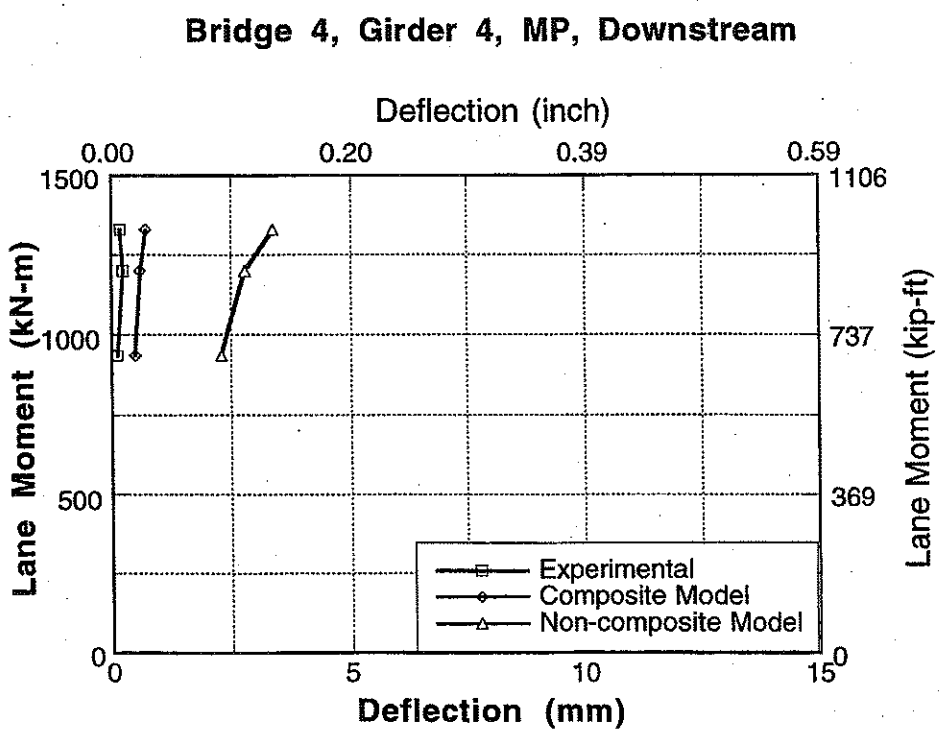
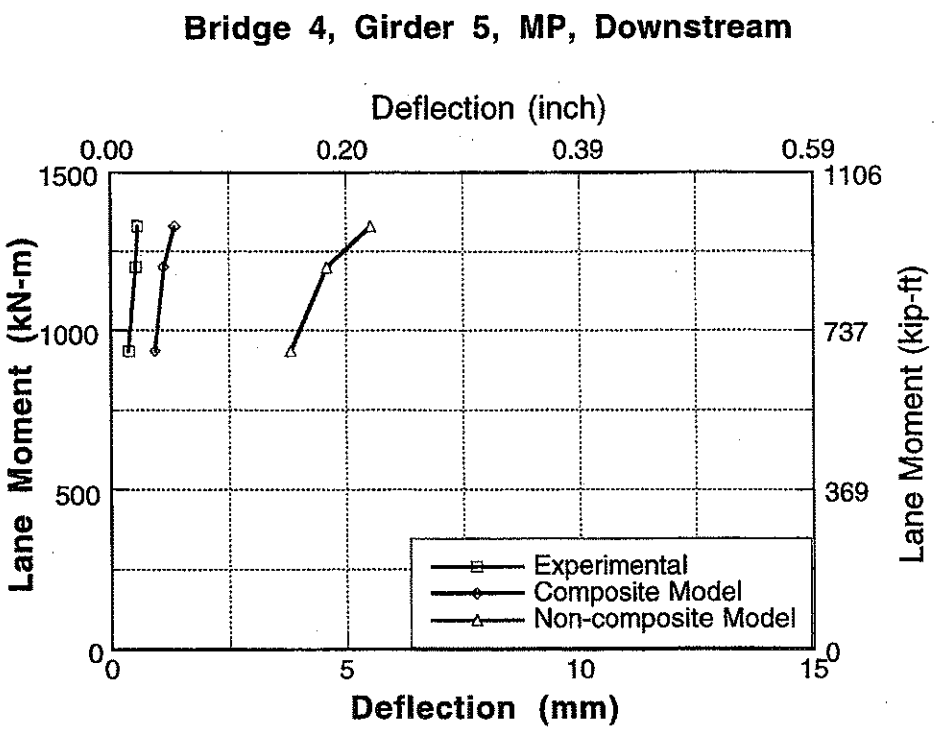


Figure A-113 : Experimental and Analytical Deflections for Bridge No. 4, Girder 3 and 4 for Downstream Loading.



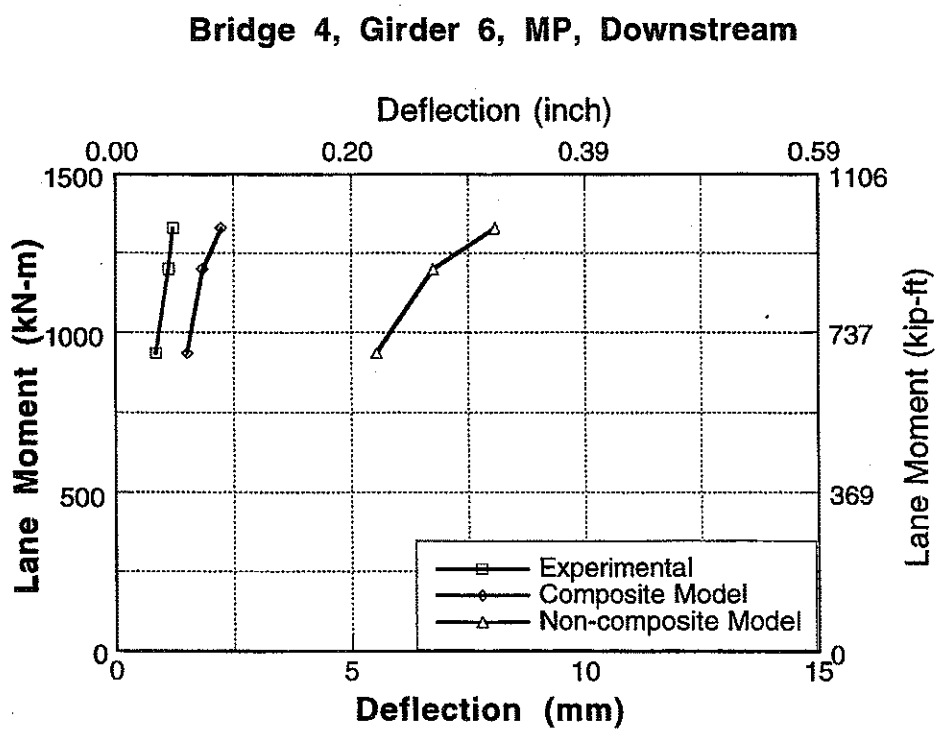
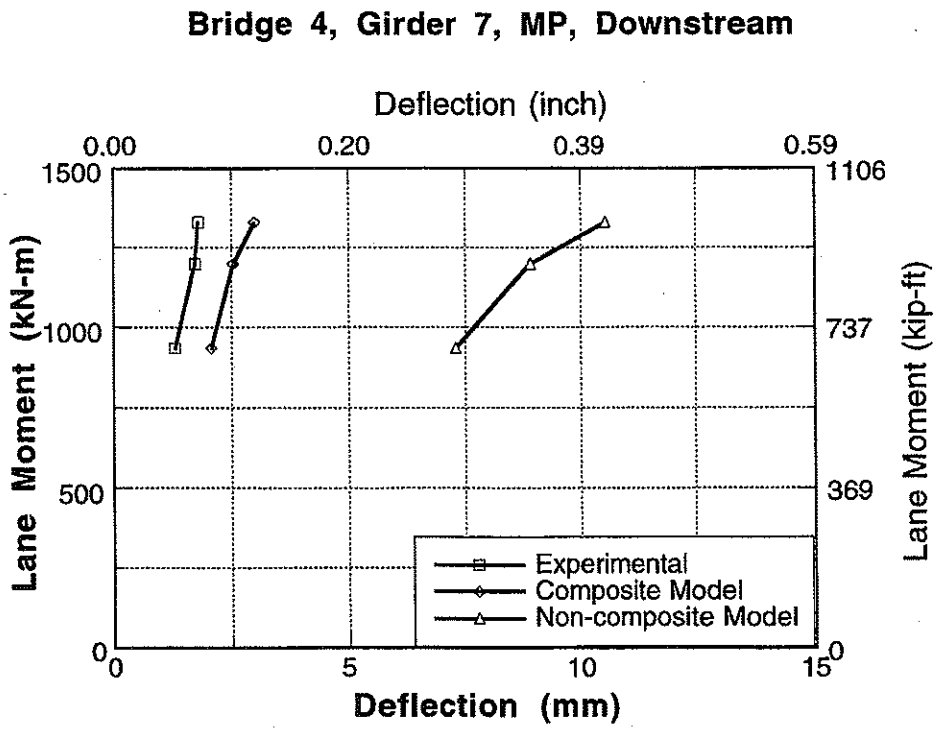


Figure A-114 : Experimental and Analytical Deflections for Bridge No. 4, Girder 5 and 6 for Downstream Loading.



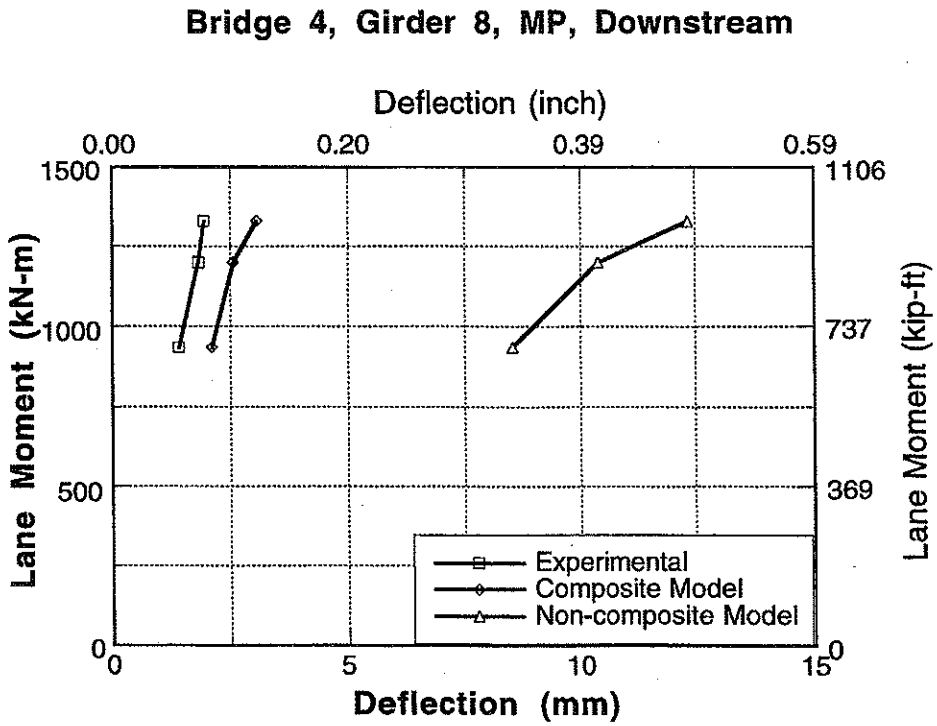


Figure A-115 : Experimental and Analytical Deflections for Bridge No. 4, Girder 7 and 8 for Downstream Loading.

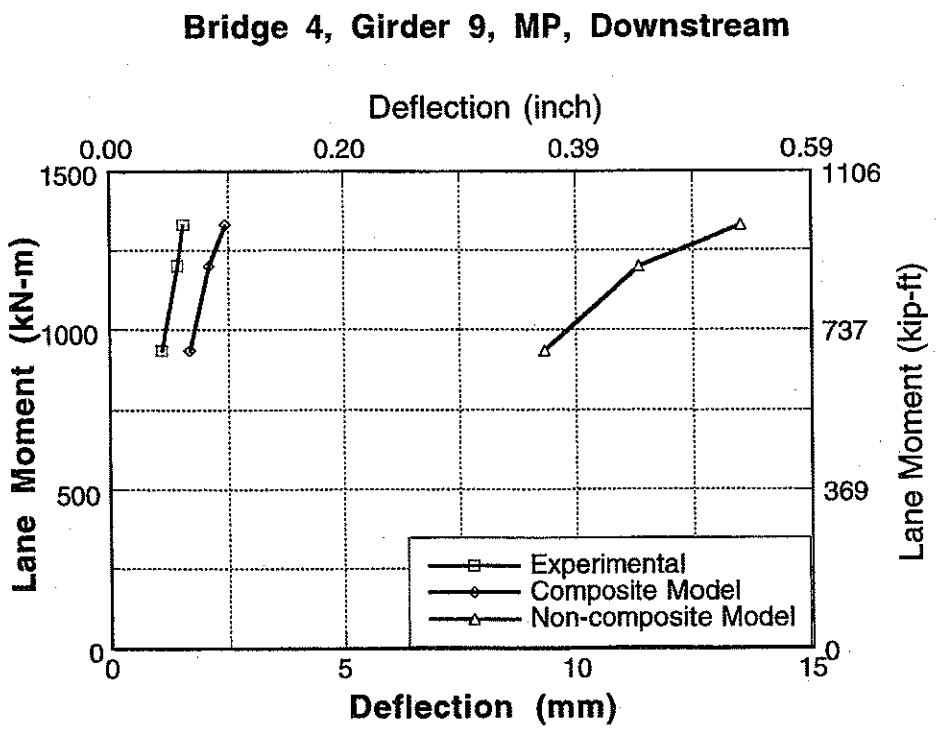
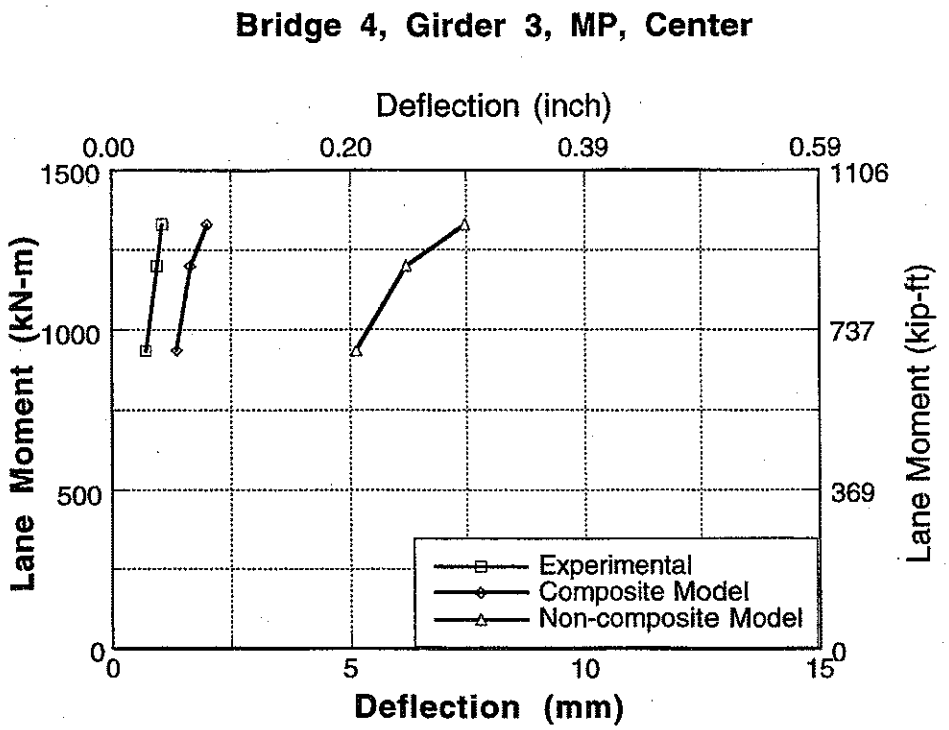


Figure A-116 : Experimental and Analytical Deflections for Bridge No. 4, Girder 9 for Downstream Loading.



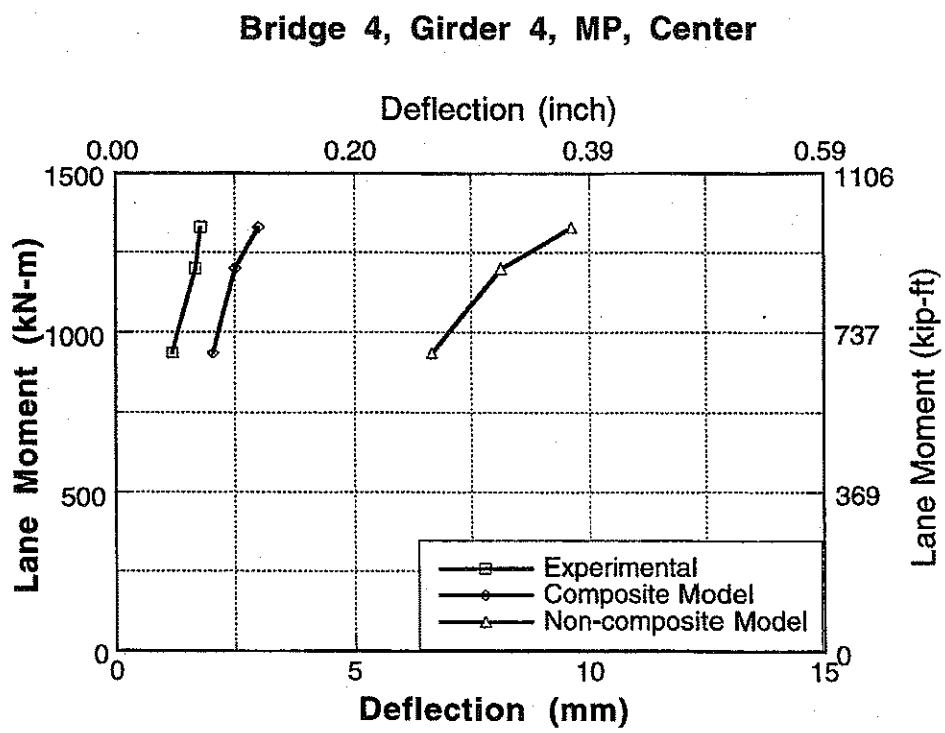
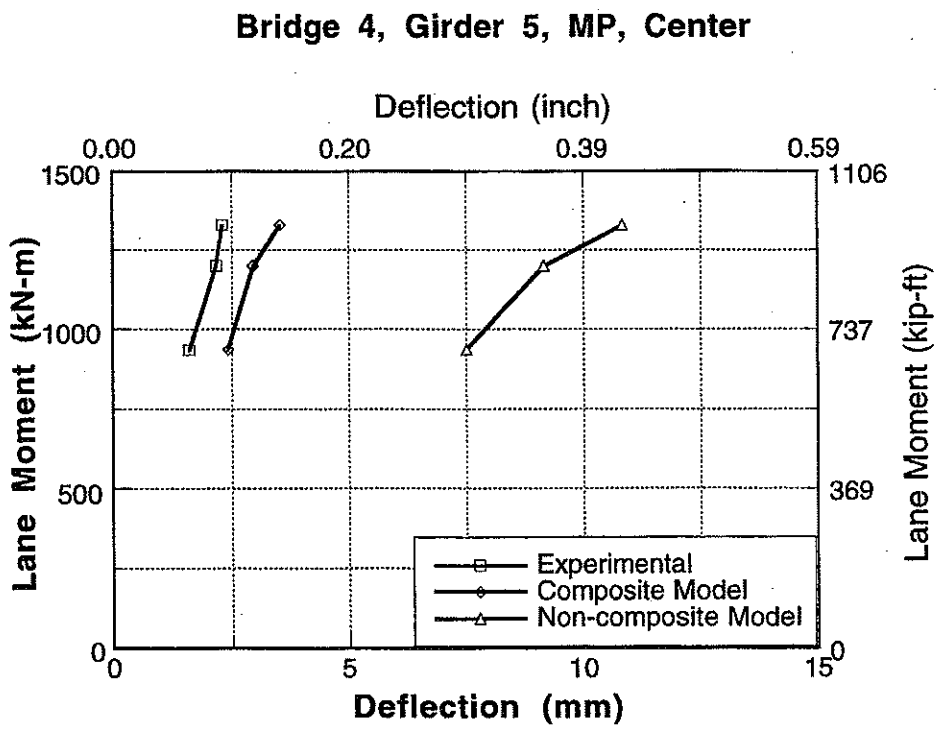


Figure A-117 : Experimental and Analytical Deflections for Bridge No. 4, Girder 3 and 4 for Center Loading.



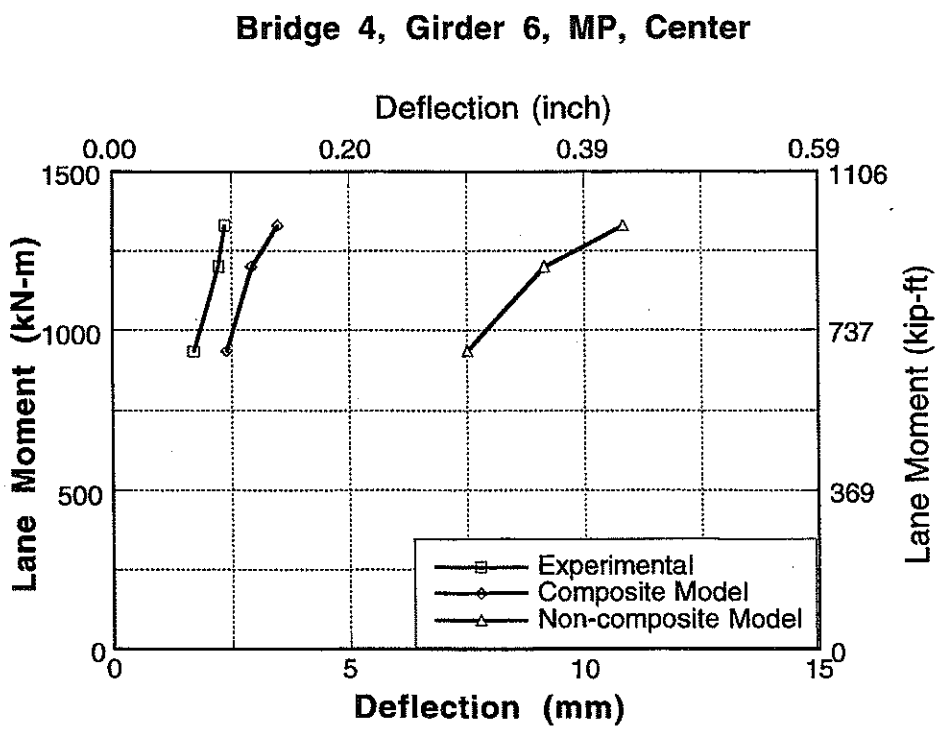
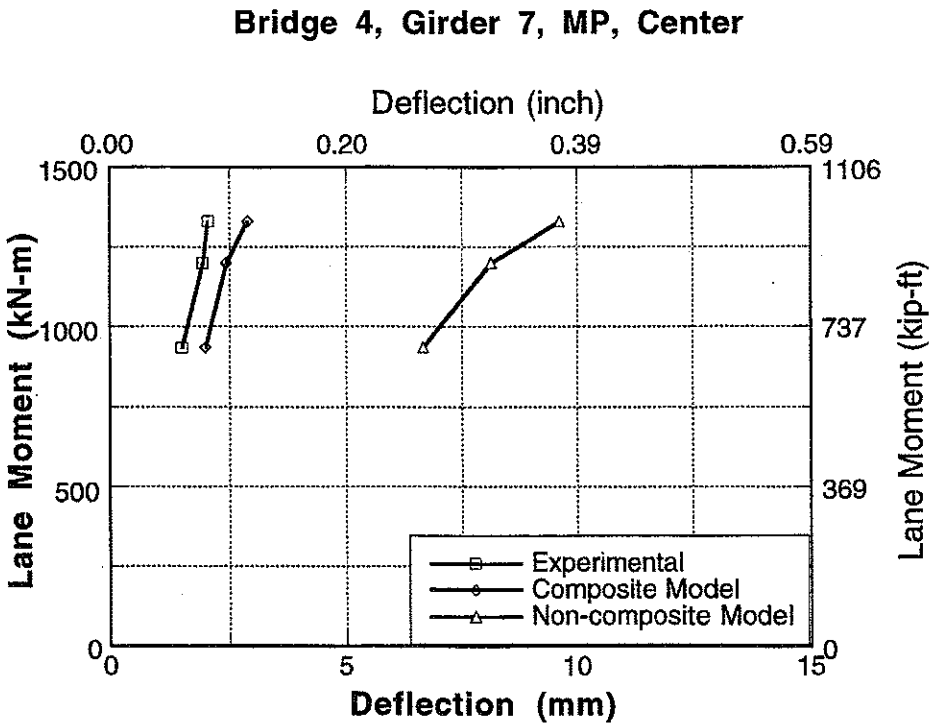


Figure A-118 : Experimental and Analytical Deflections for Bridge No. 4, Girder 5 and 6 for Center Loading.



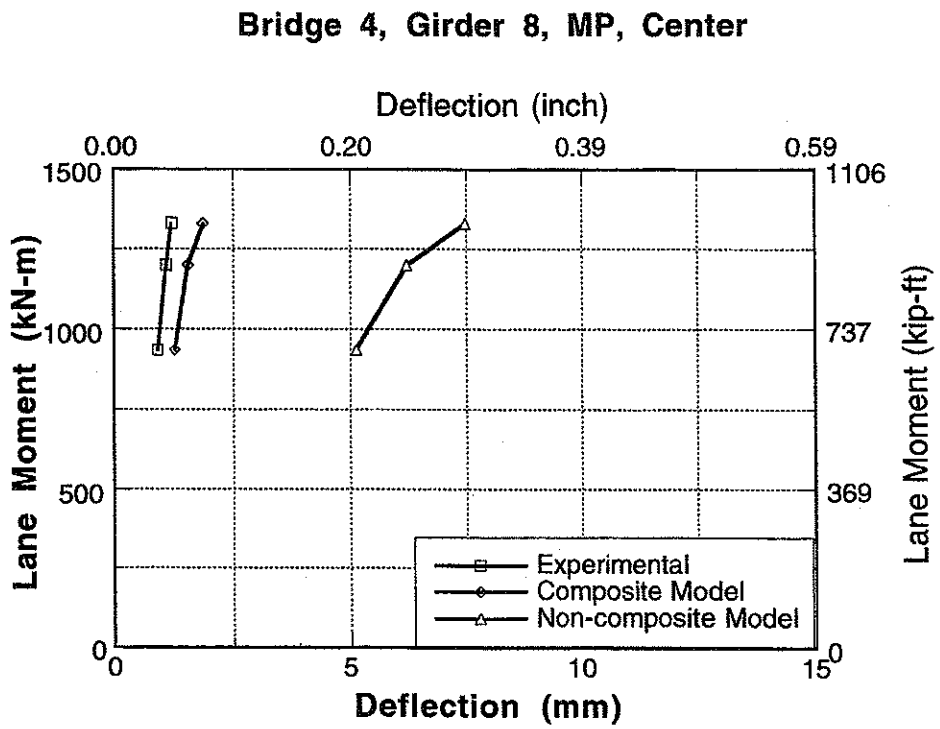


Figure A-119 : Experimental and Analytical Deflections for Bridge No. 4, Girder 7 and 8 for Center Loading.

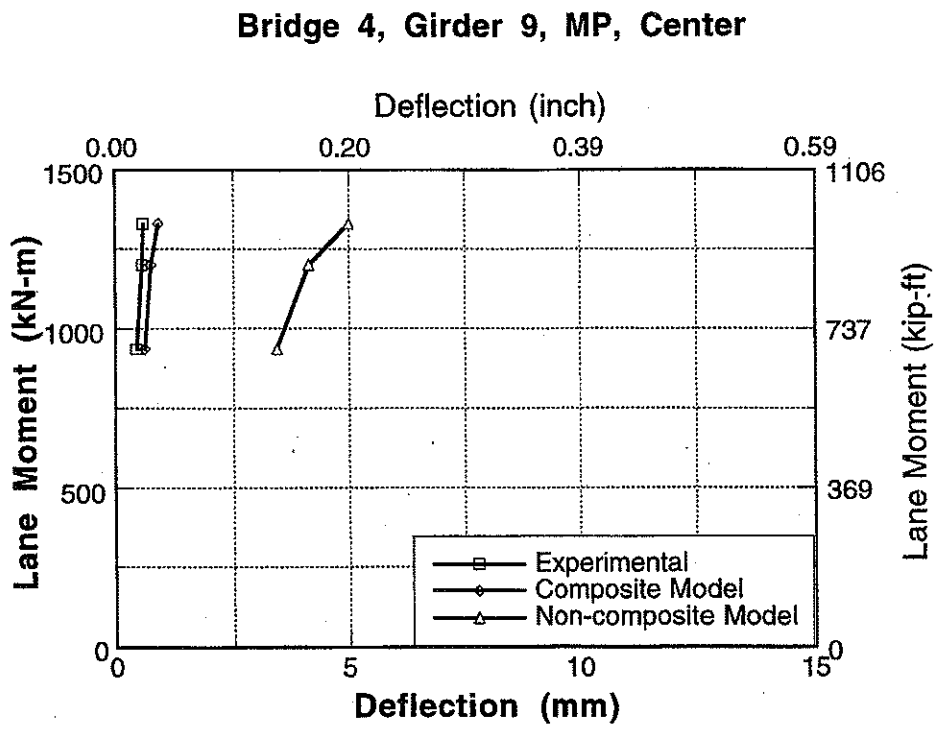
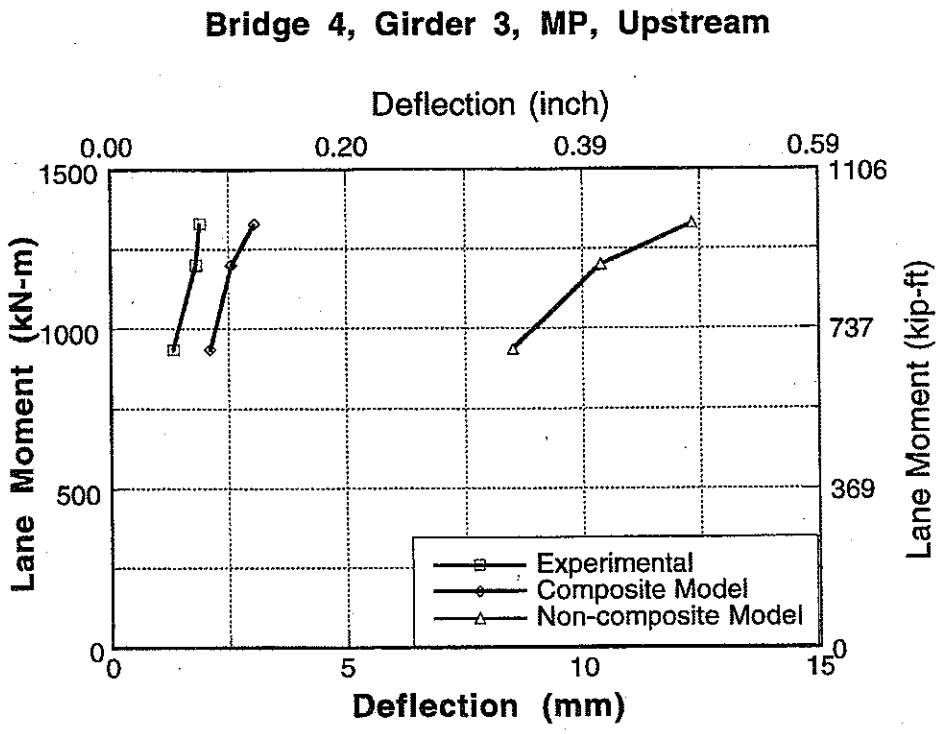


Figure A-120 : Experimental and Analytical Deflections for Bridge No. 4, 9 for Center Loading.



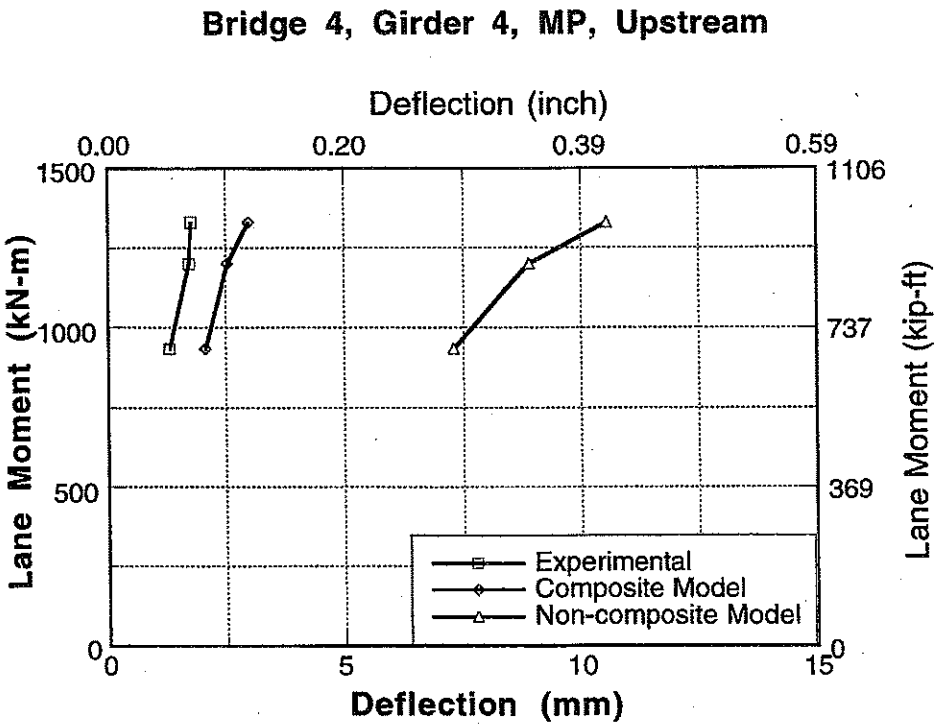
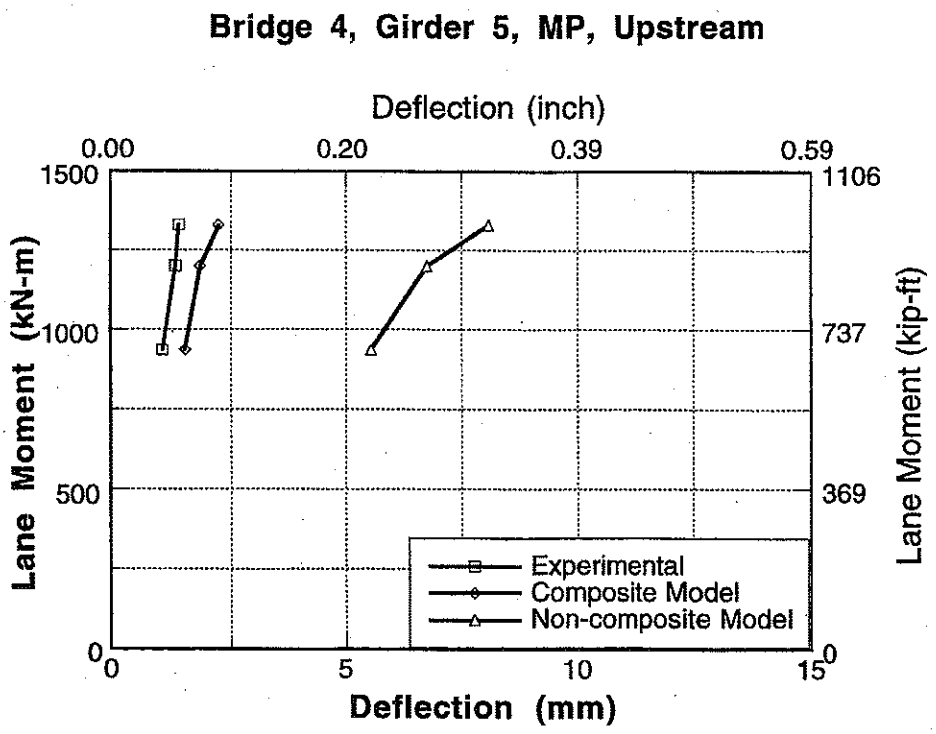


Figure A-121 : Experimental and Analytical Deflections for Bridge No. 4, Girder 3 and 4 for Upstream Loading.



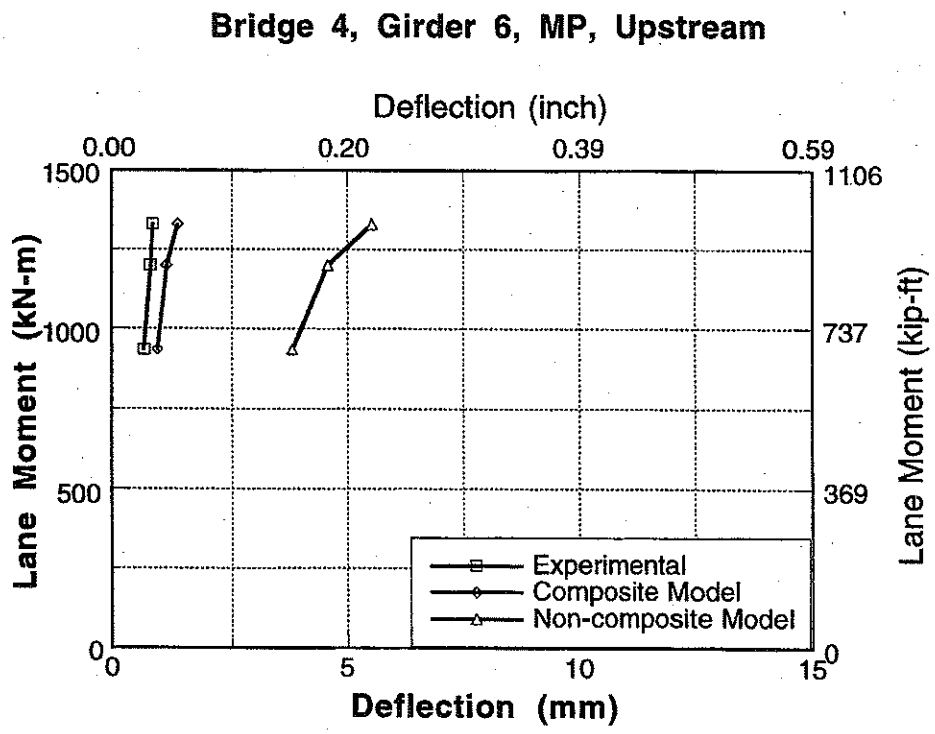
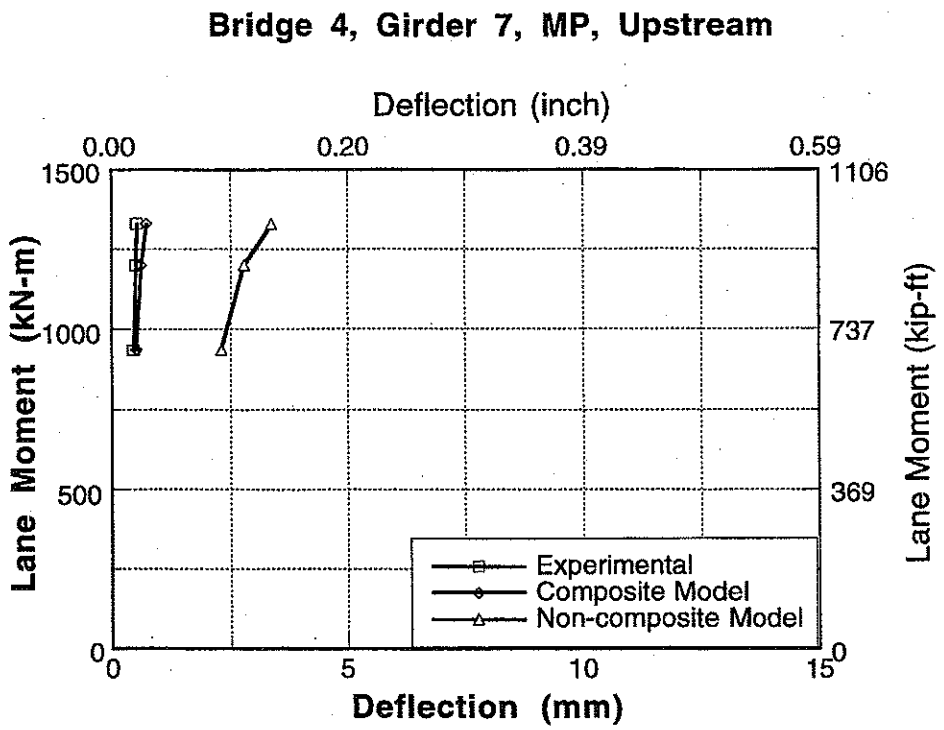


Figure A-122 : Experimental and Analytical Deflections for Bridge No. 4, Girder 5 and 6 for Upstream Loading.



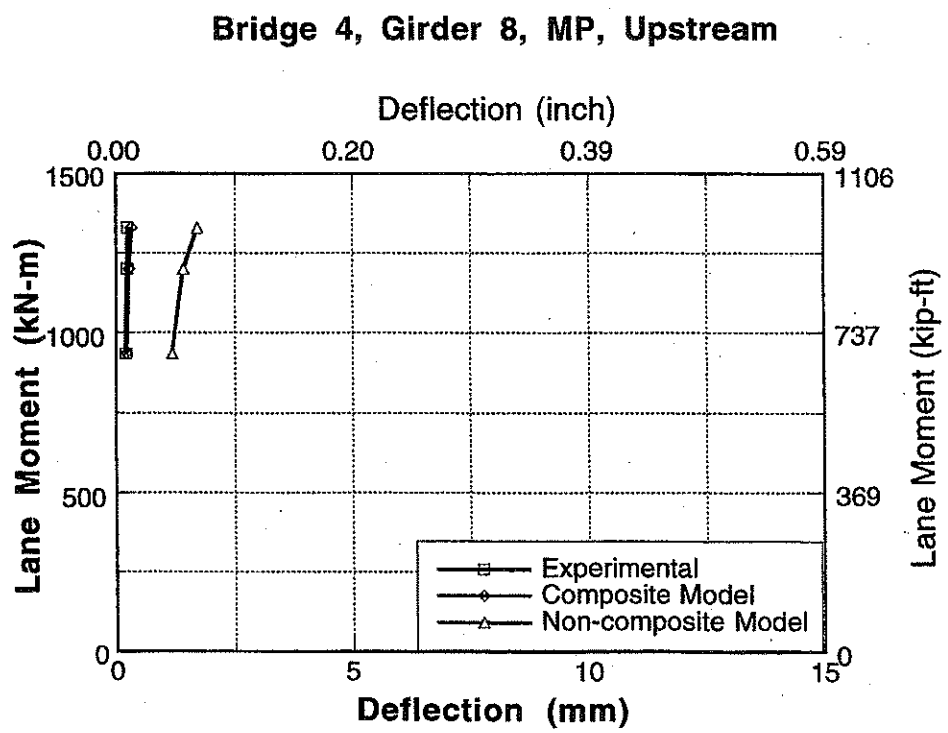


Figure A-123 : Experimental and Analytical Deflections for Bridge No. 4, Girder 7 and 8 for Upstream Loading.

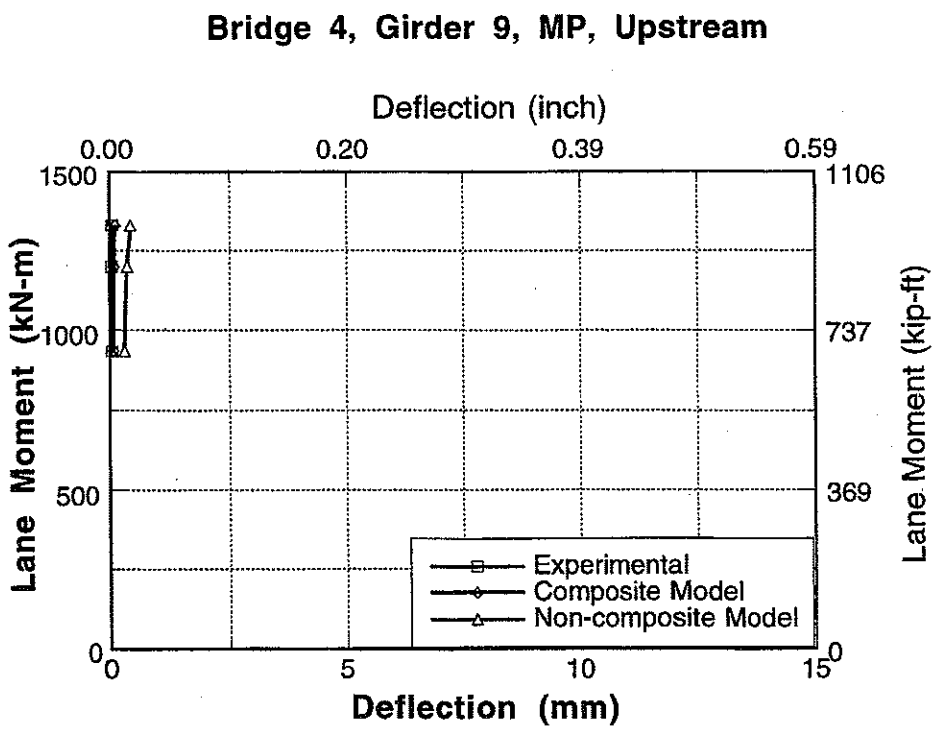


Figure A-124 : Experimental and Analytical Deflections for Bridge No. 4, Girder 8 and 9 for Upstream Loading.

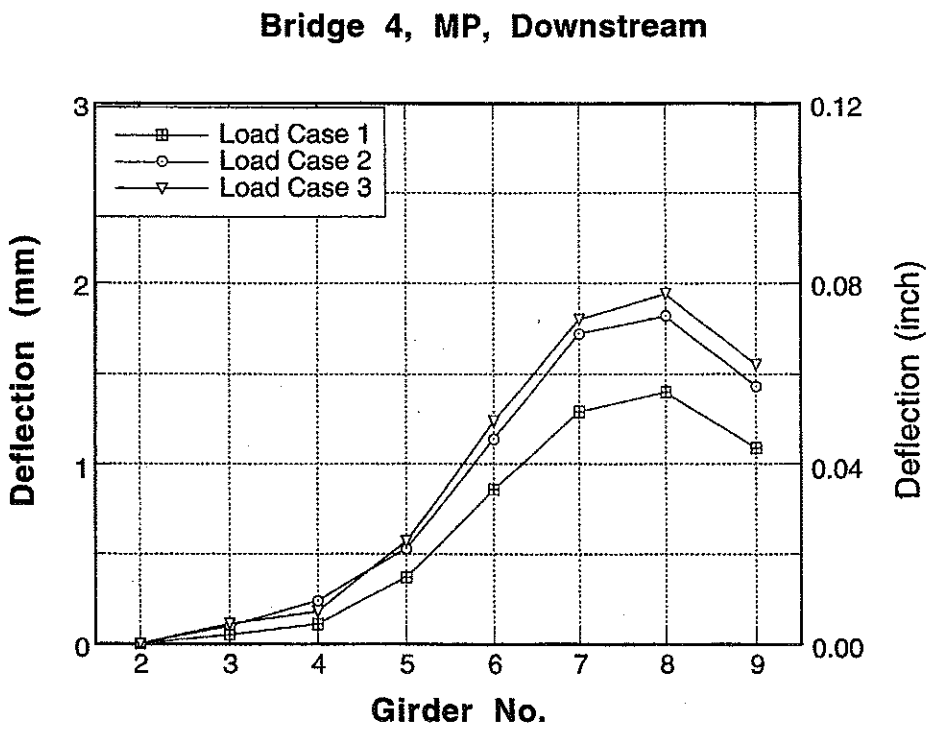


Figure A-125 : Girder Distribution of Deflections for Bridge No. 4 due to Downstream Loading.

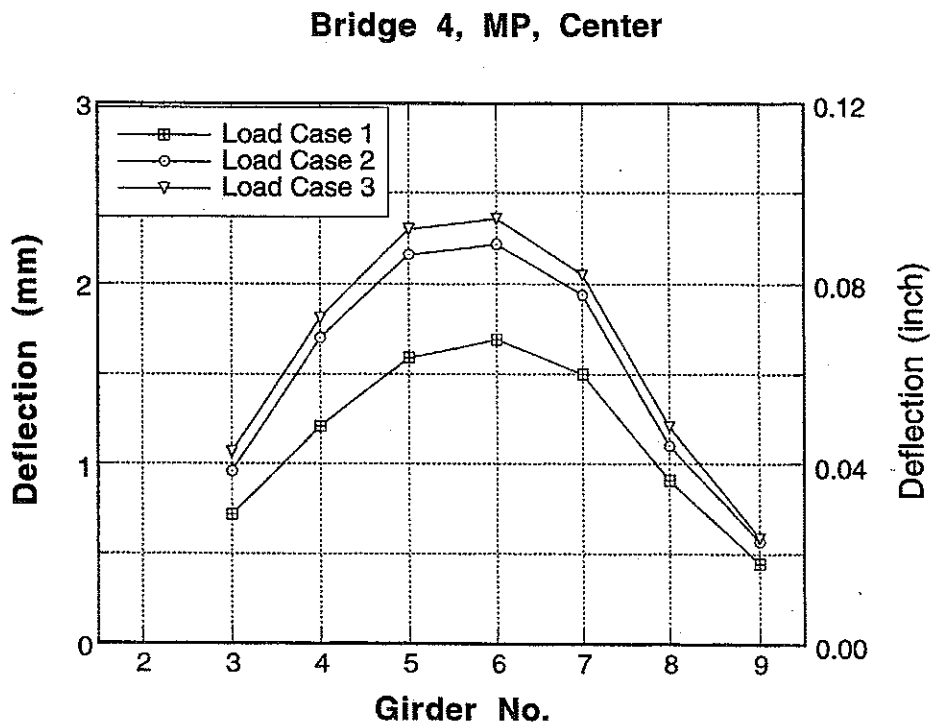


Figure A-126 : Girder Distribution of Deflections for Bridge No. 4 due to Center Loading.

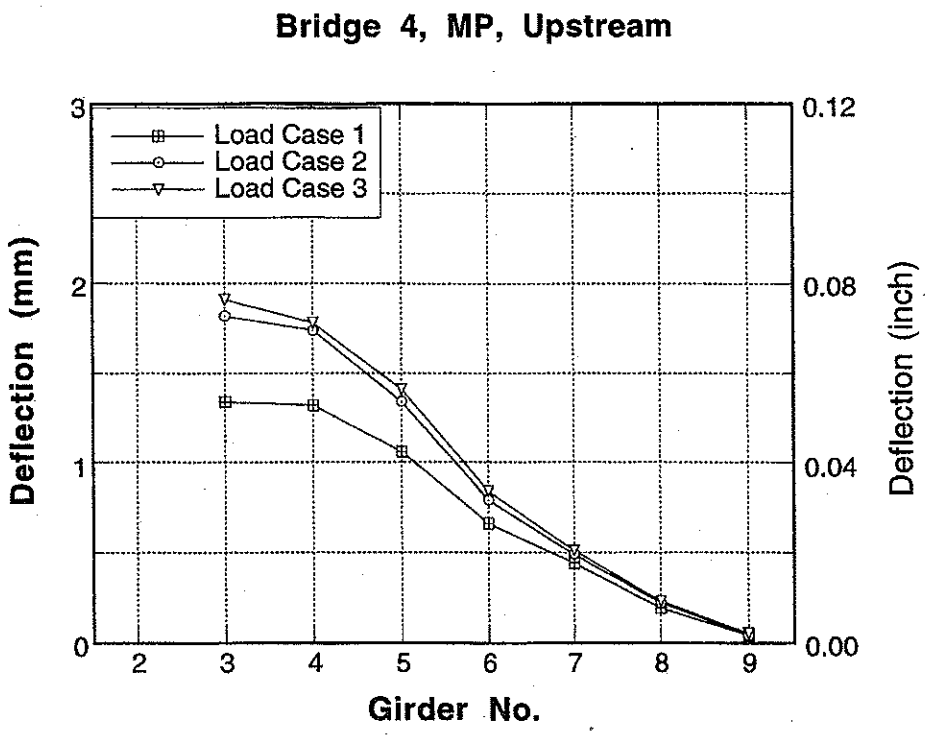


Figure A-127 : Girder Distribution of Deflections for Bridge No. 4 due to Upstream Loading.

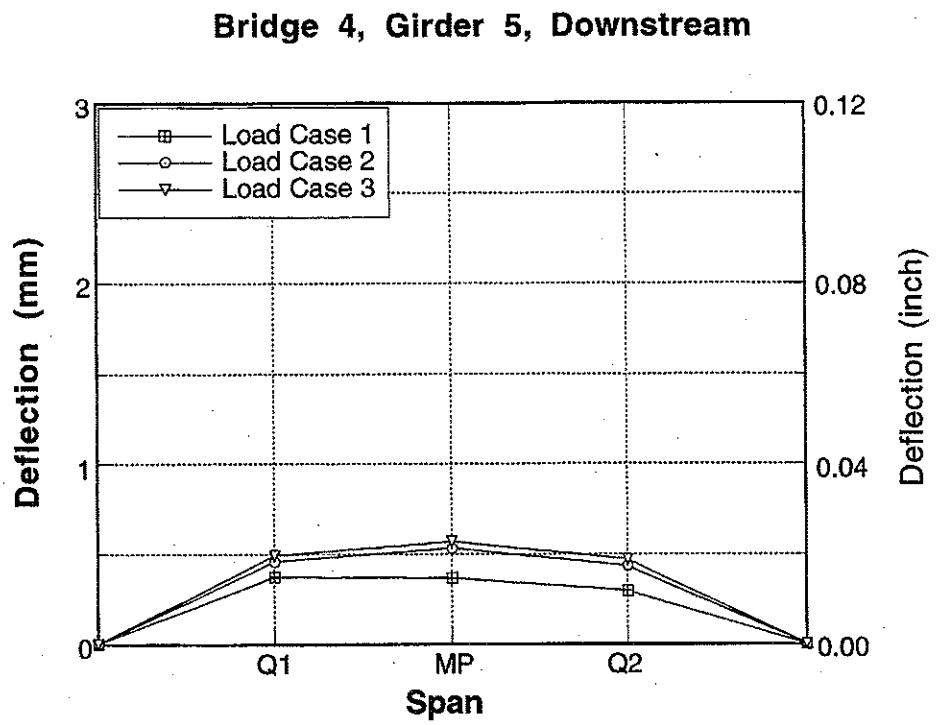


Figure A-128 : Longitudinal Distribution of Deflections for Bridge No. 4, Girder 5 due to Downstream Loading.

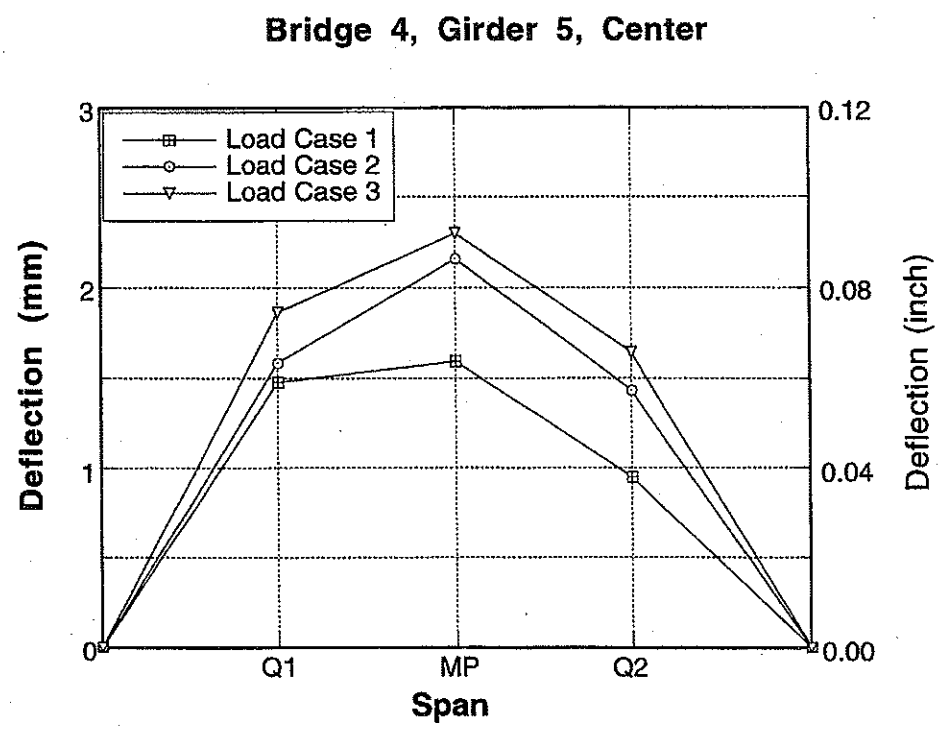


Figure A-129 : Longitudinal Distribution of Deflections for Bridge No. 4, Girder 5 due to Center Loading.

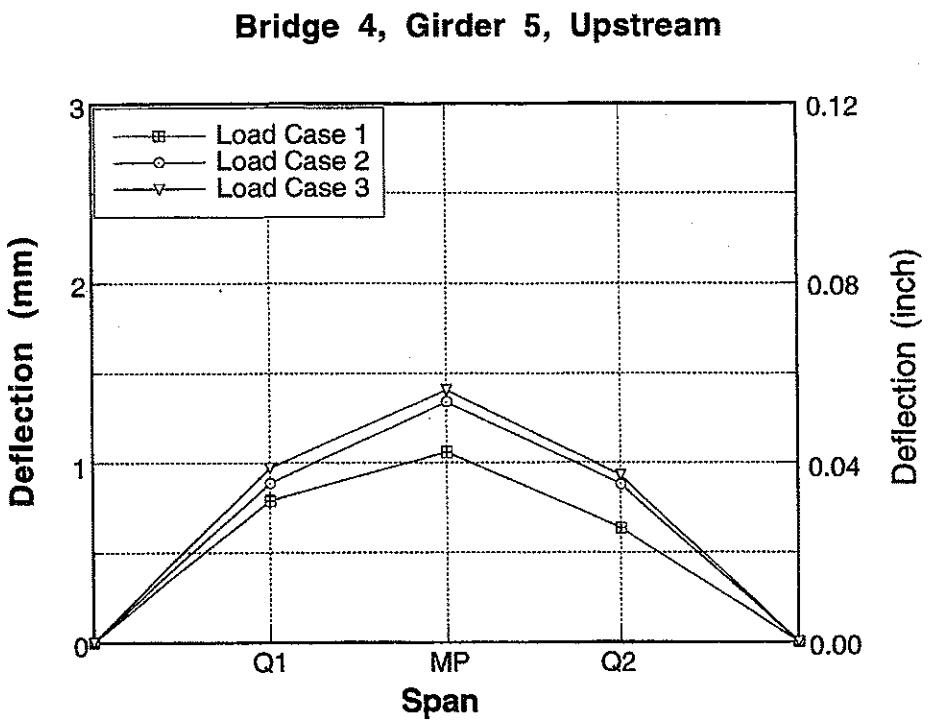
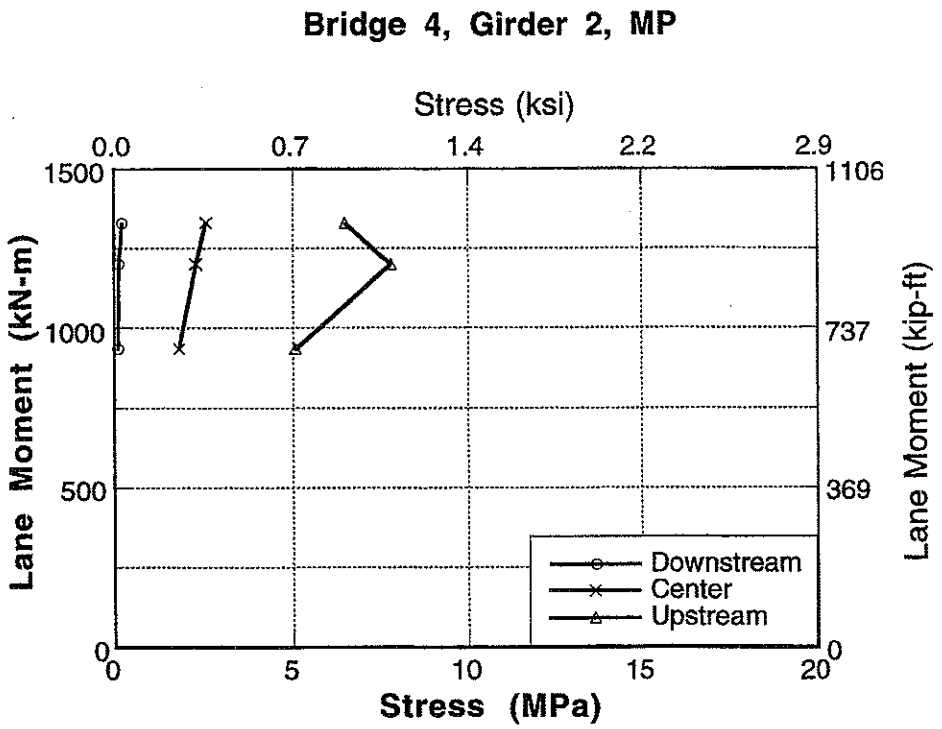


Figure A-130 Longitudinal Distribution of Deflections for Bridge No. 4, Girder 5 due to Upstream Loading.



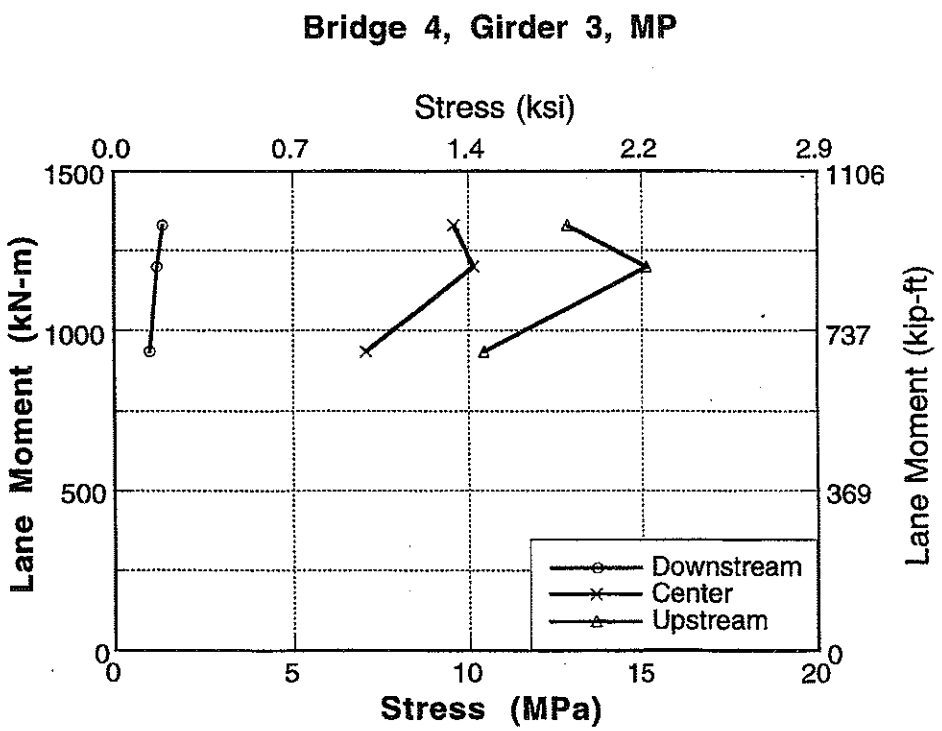
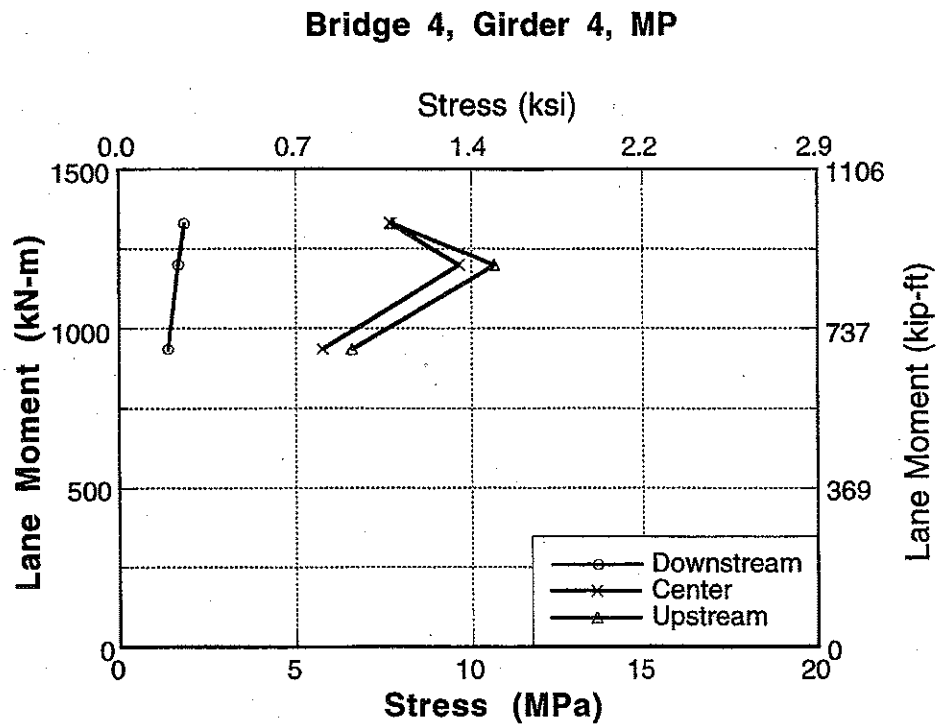


Figure A-131 : Stress vs Lane Moment for Bridge No. 4, Girder 2 and 3 at Mid Point.



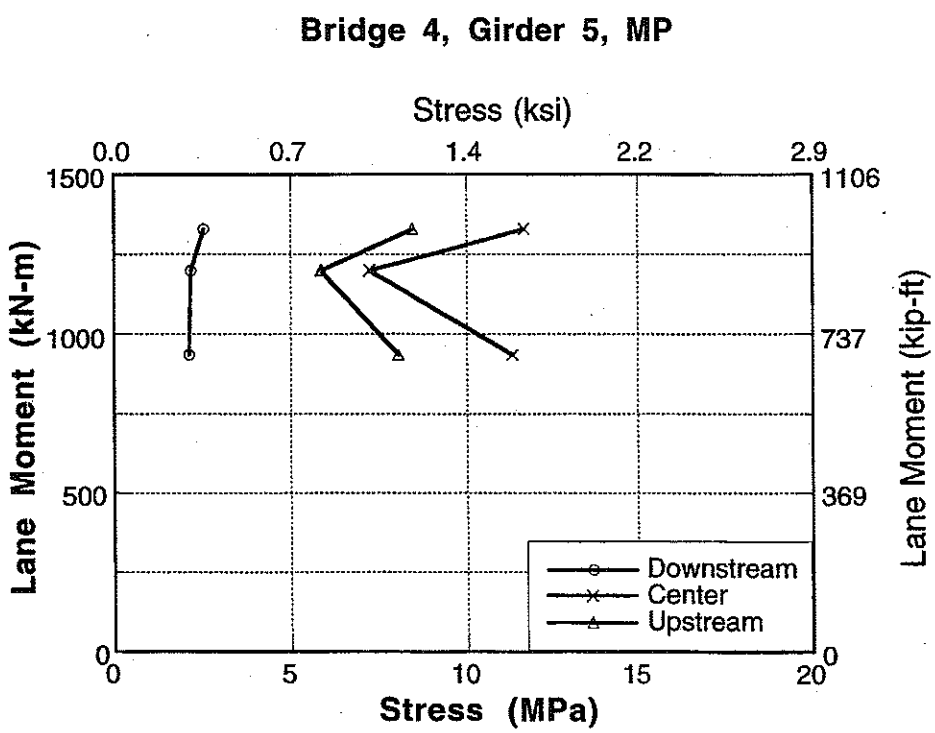
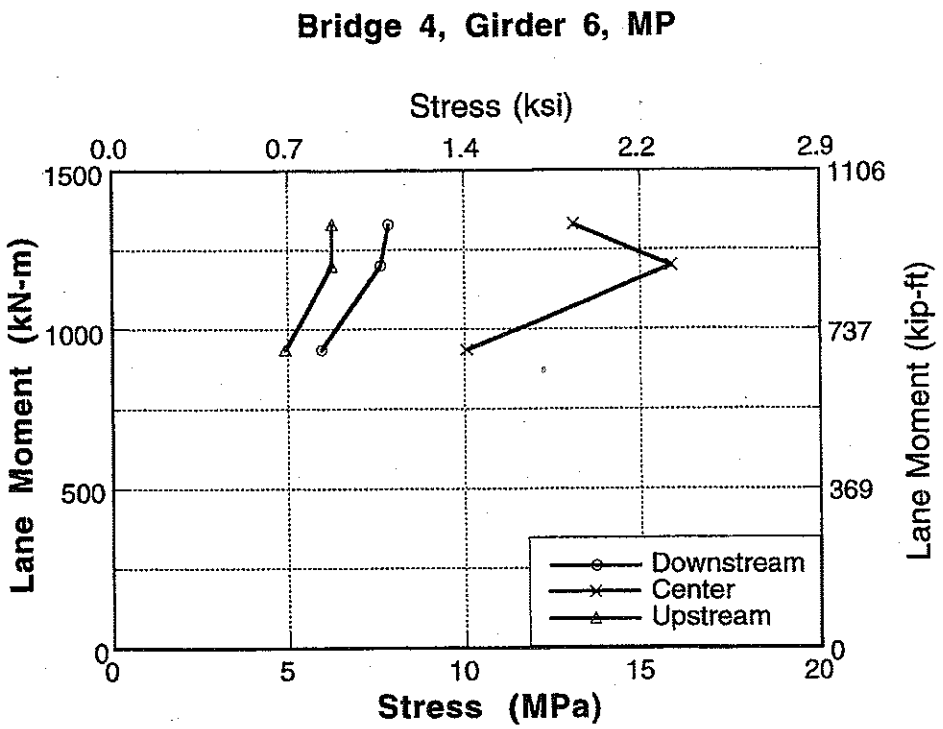


Figure A-132 : Stress vs Lane Moment for Bridge No. 4, Girder 4 and 5 at Mid Point.



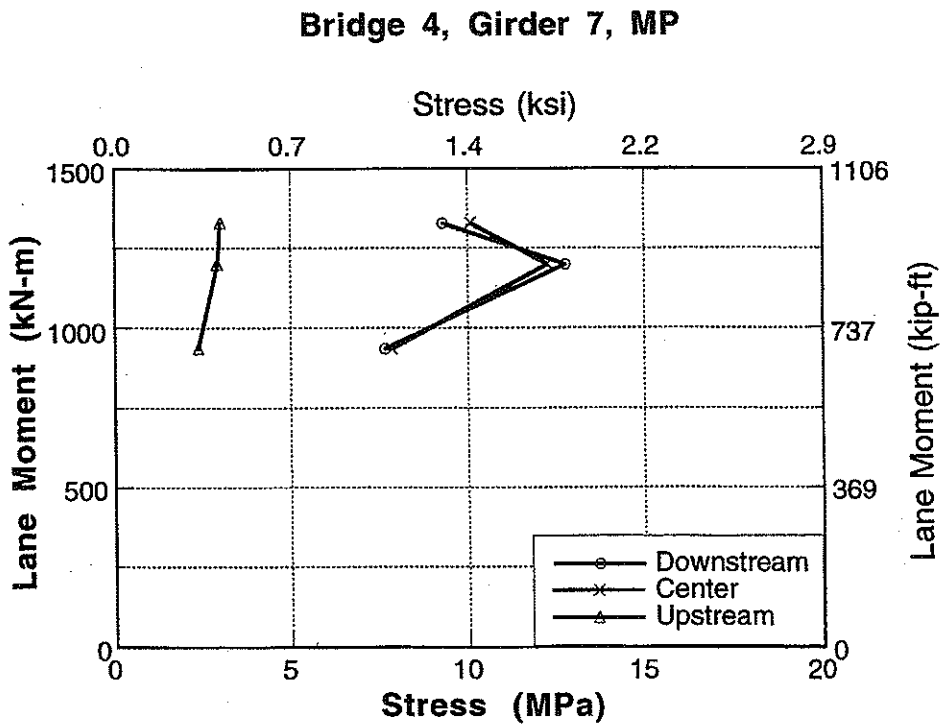
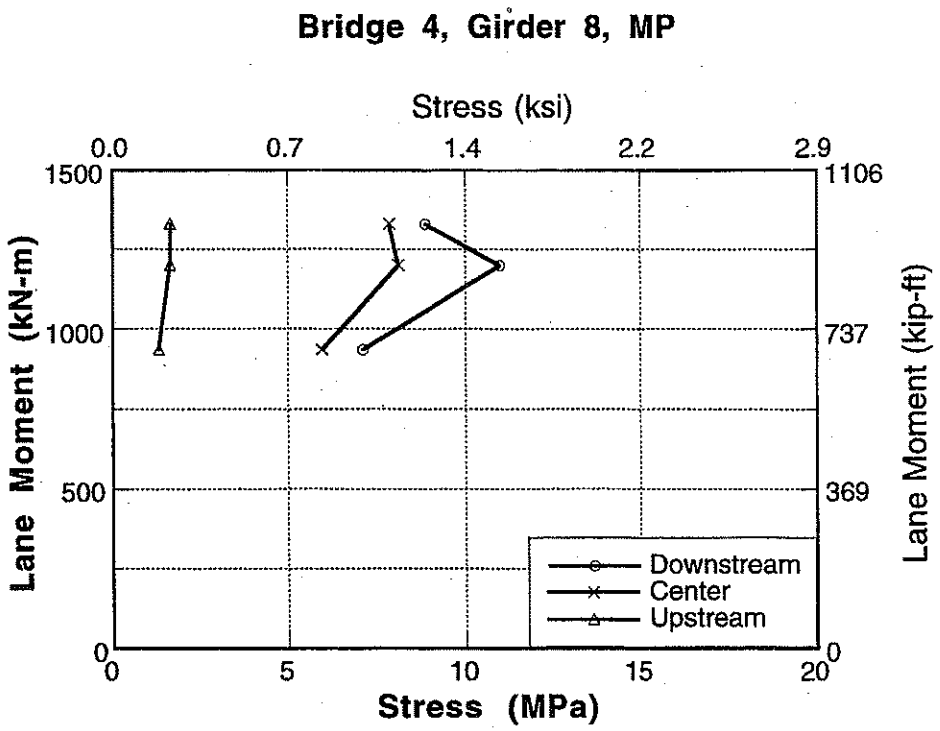


Figure A-133 : Stress vs Lane Moment for Bridge No. 4, Girder 6 and 7 at Mid Point.



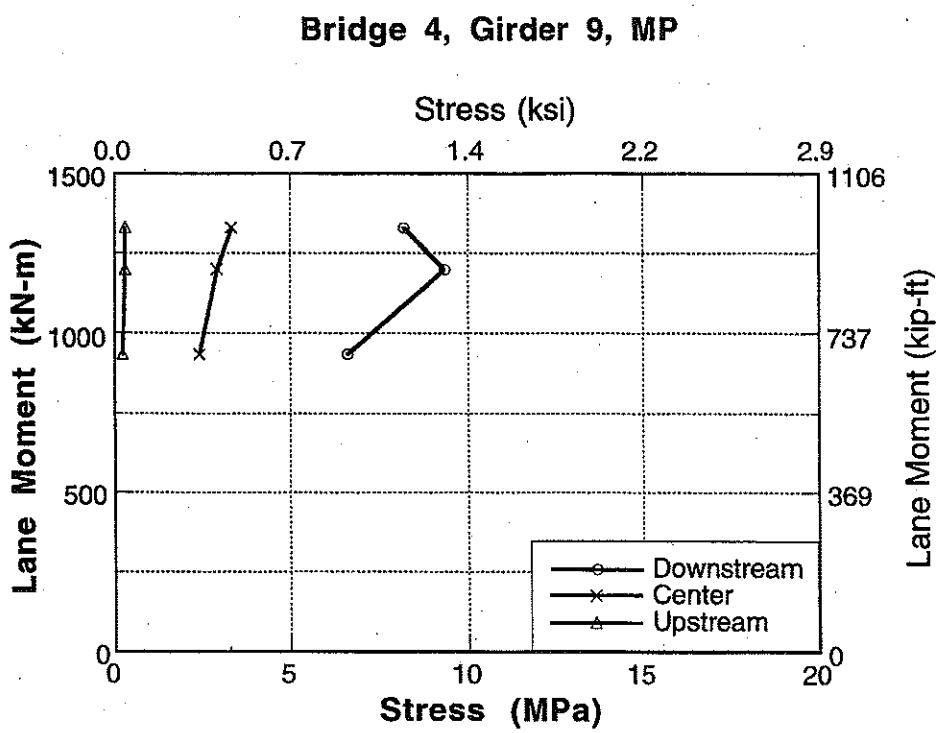
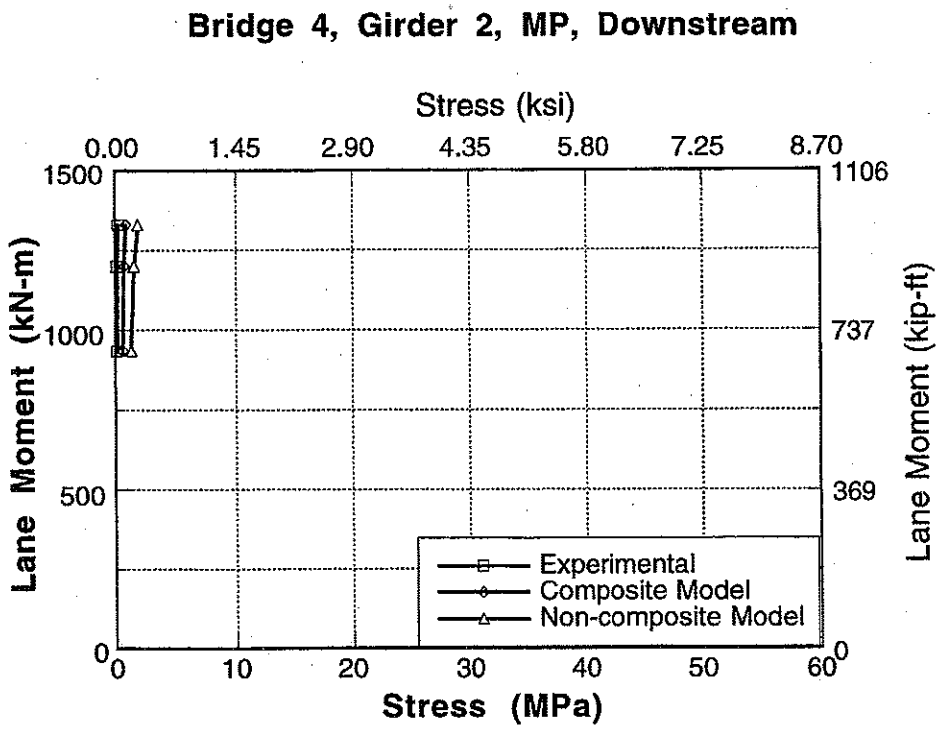


Figure A-134 : Stress vs Lane Moment for Bridge No. 4, Girder 8 and 9 at Mid Point.



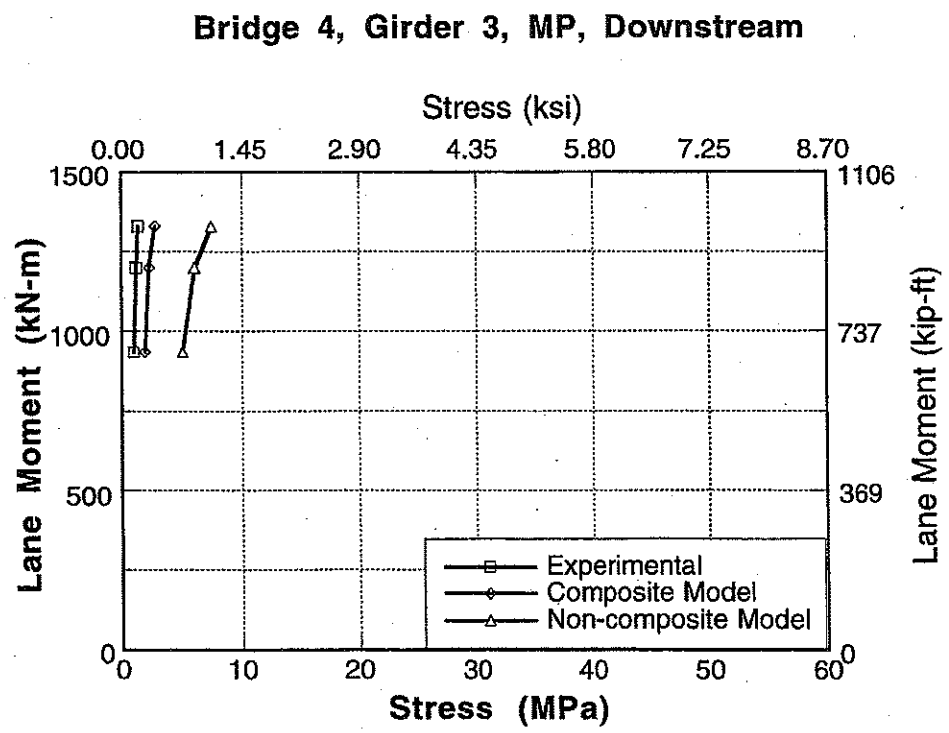
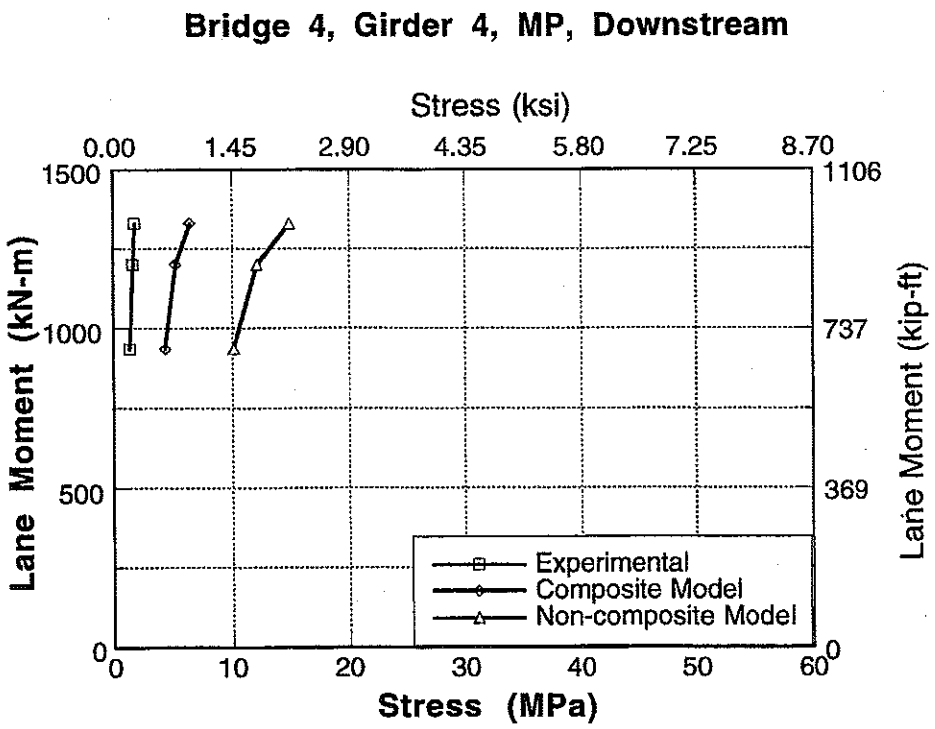


Figure A-41 : Experimental and Analytical Stresses for Bridge No. 4, Girder 2 and 3 for Downstream Loading.



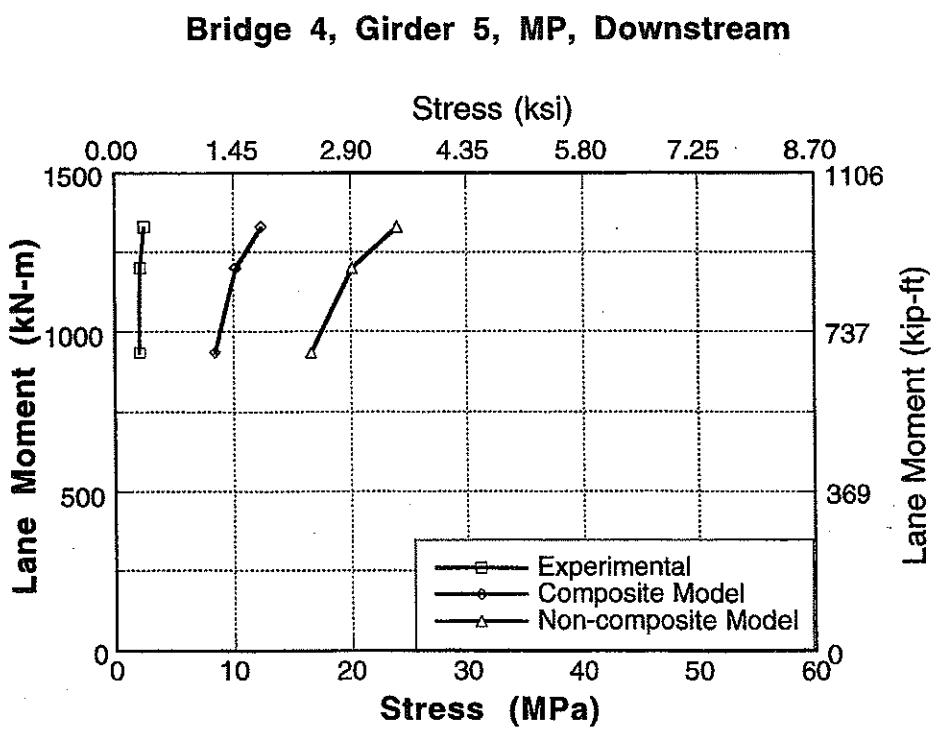
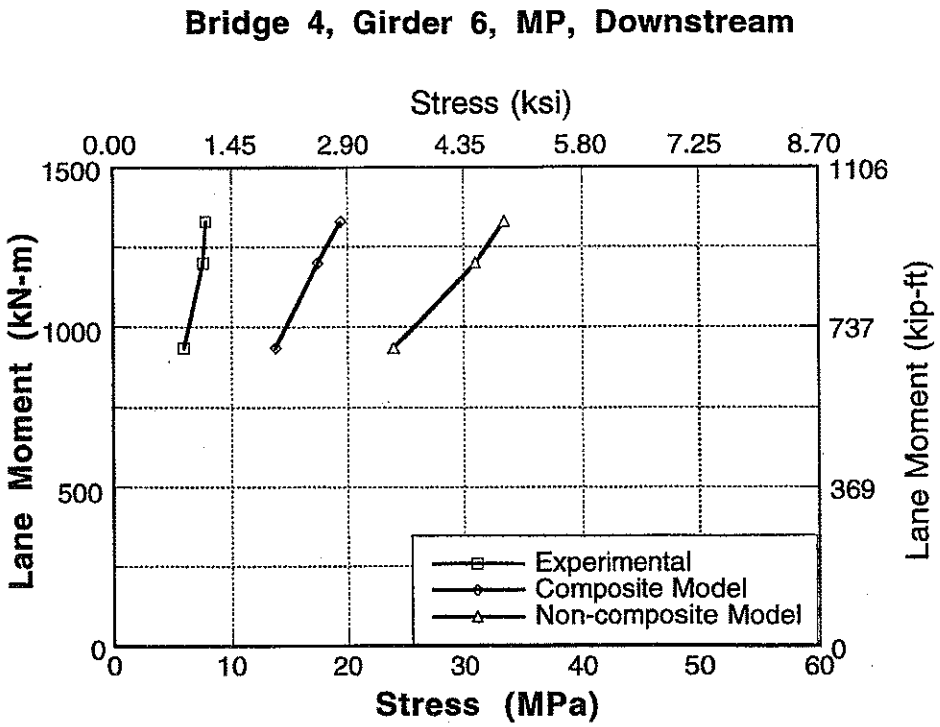


Figure A-135 : Experimental and Analytical Stresses for Bridge No. 4, Girder 4 and 5 for Downstream Loading.



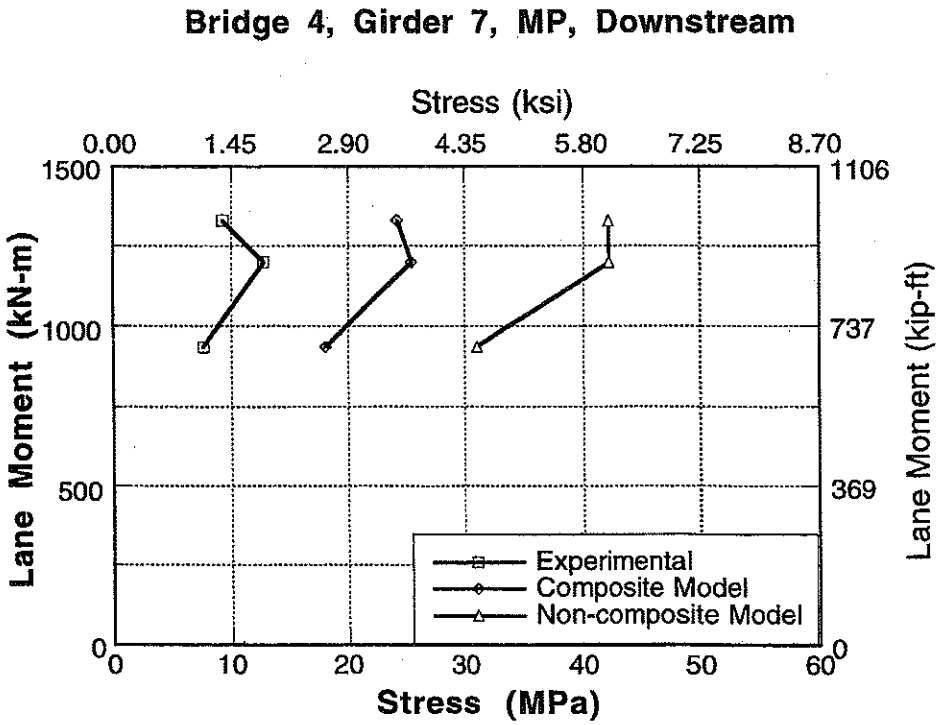
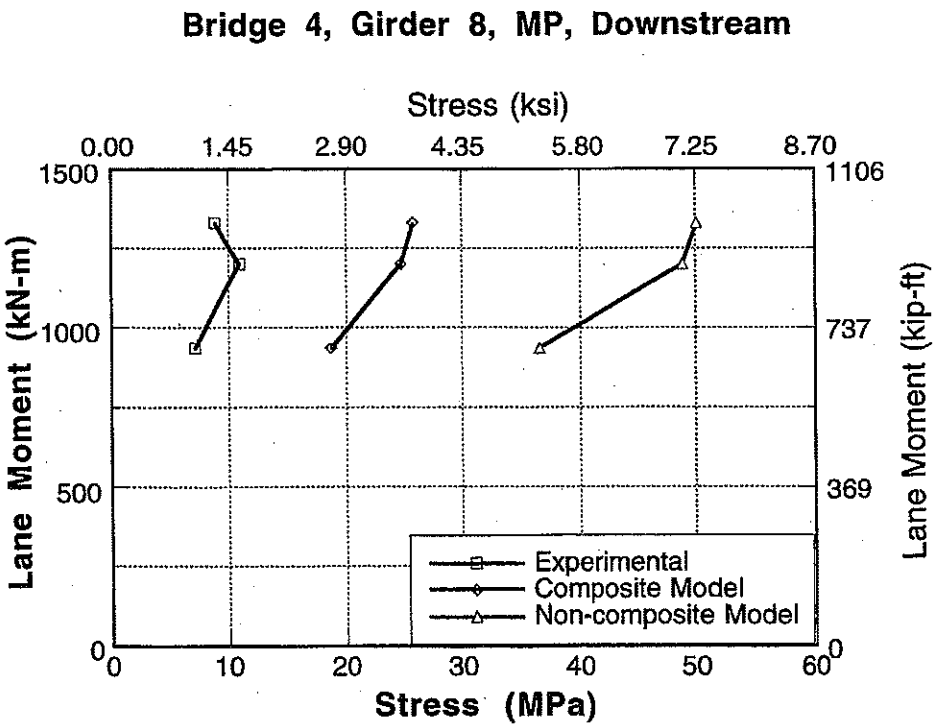


Figure A-136 : Experimental and Analytical Stresses for Bridge No. 4, Girder 6 and 7 for Downstream Loading.



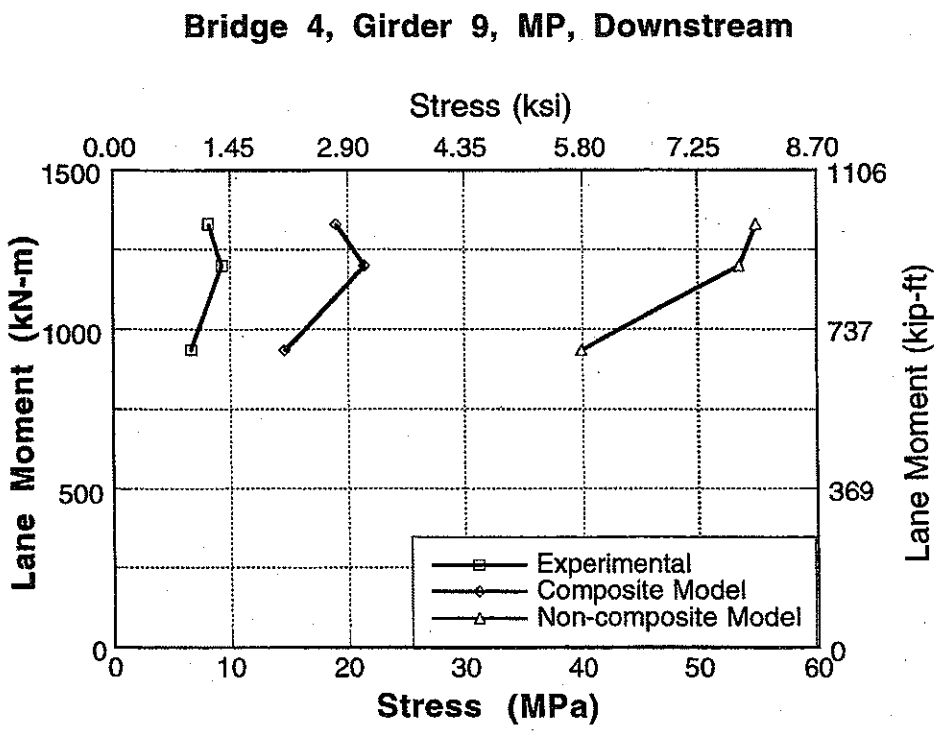
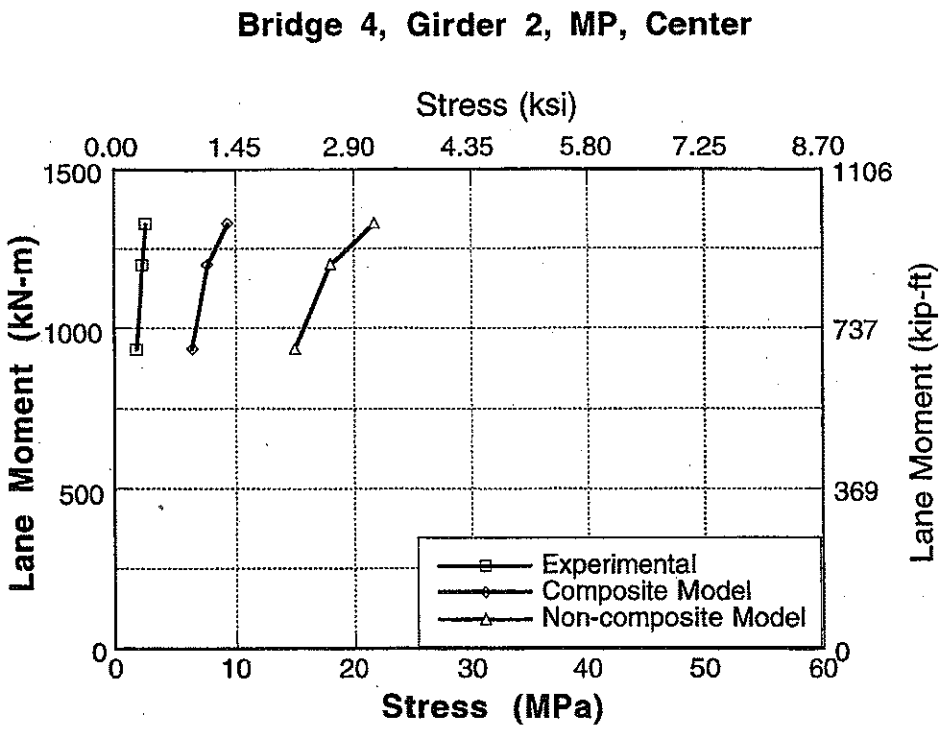


Figure A-137 : Experimental and Analytical Stresses for Bridge No. 4, Girder 8 and 9 for Downstream Loading.



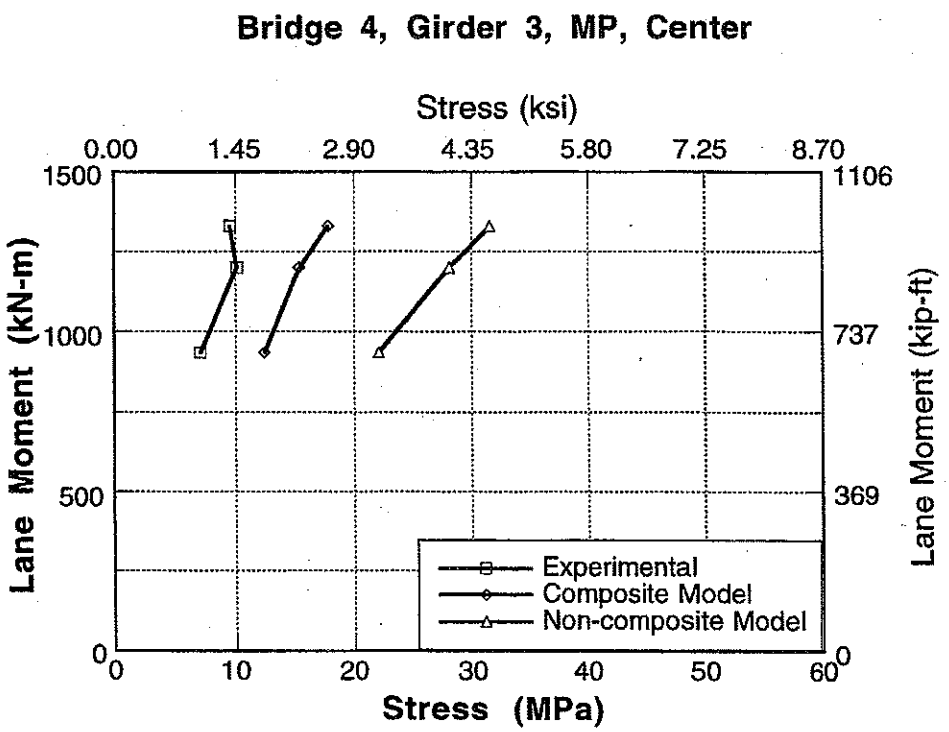
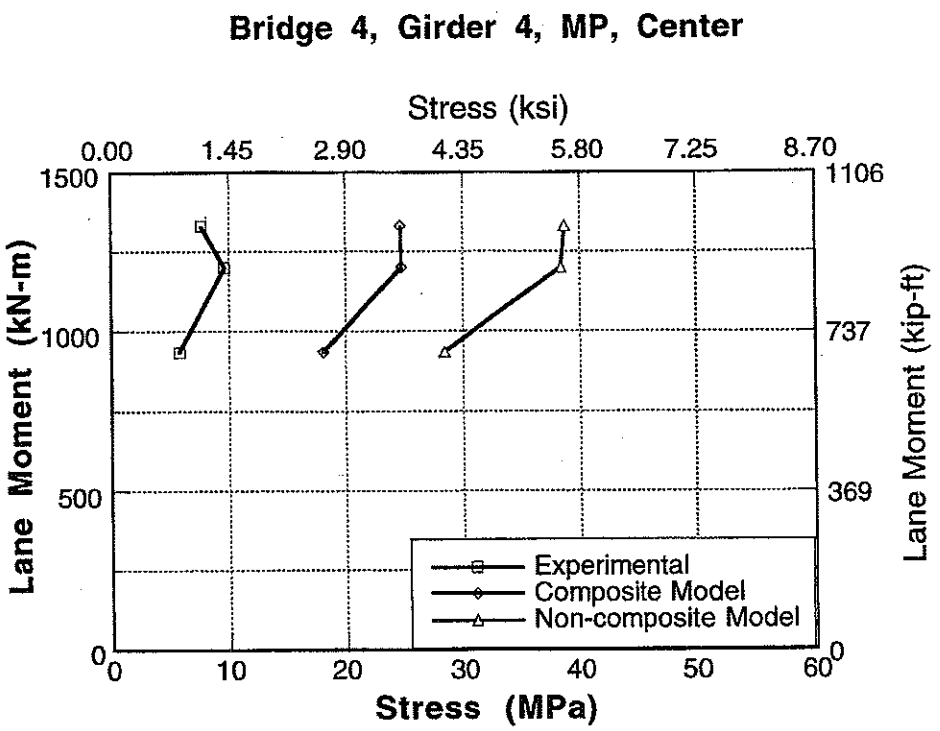


Figure A-138 : Experimental and Analytical Stresses for Bridge No. 4, Girder 2 and 3 for Center Loading.



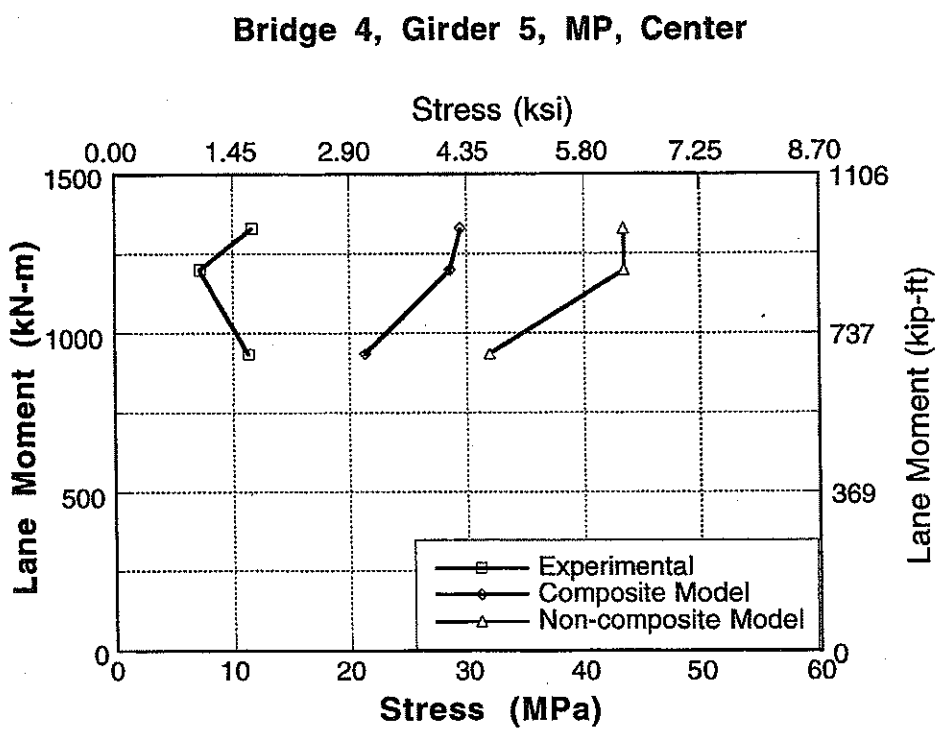
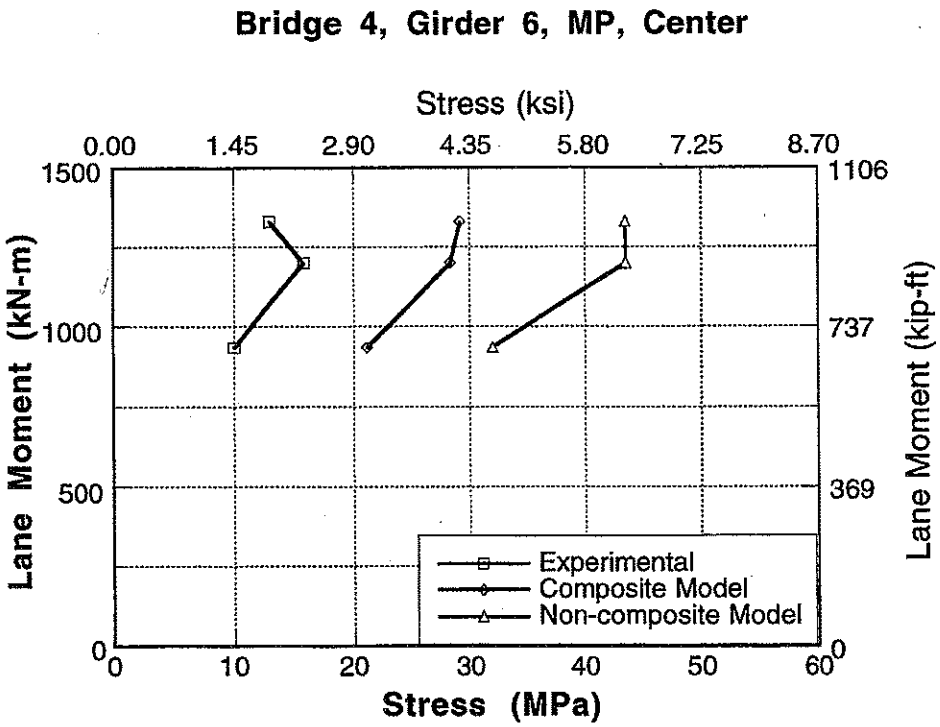


Figure A-139 : Experimental and Analytical Stresses for Bridge No. 4, Girder 4 and 5 for Center Loading.



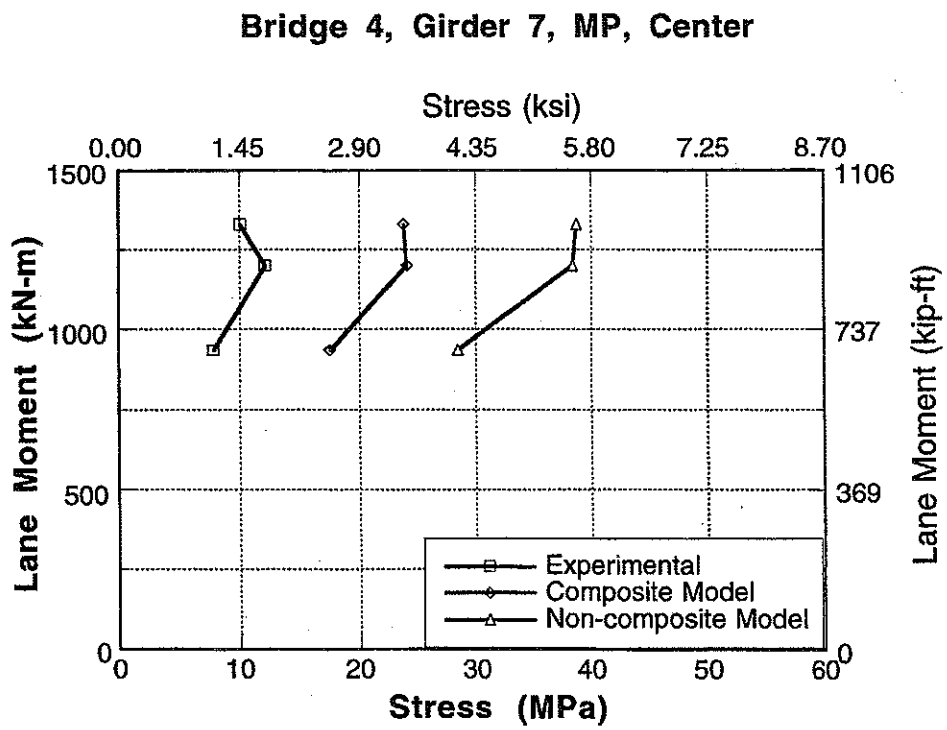
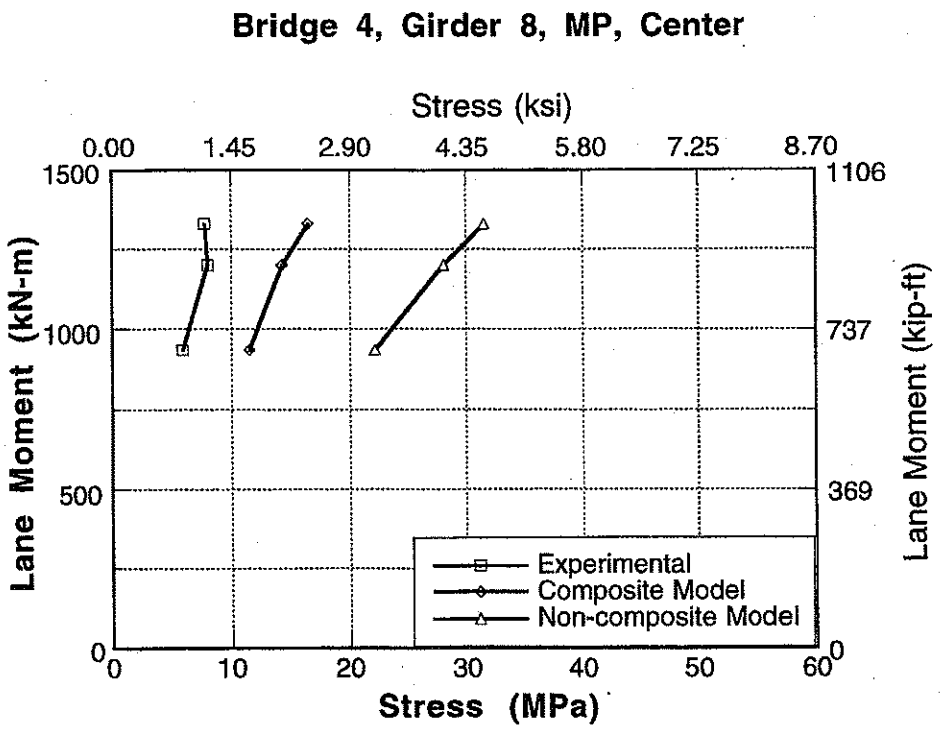


Figure A-140 : Experimental and Analytical Stresses for Bridge No. 4, Girder 6 and 7 for Center Loading.



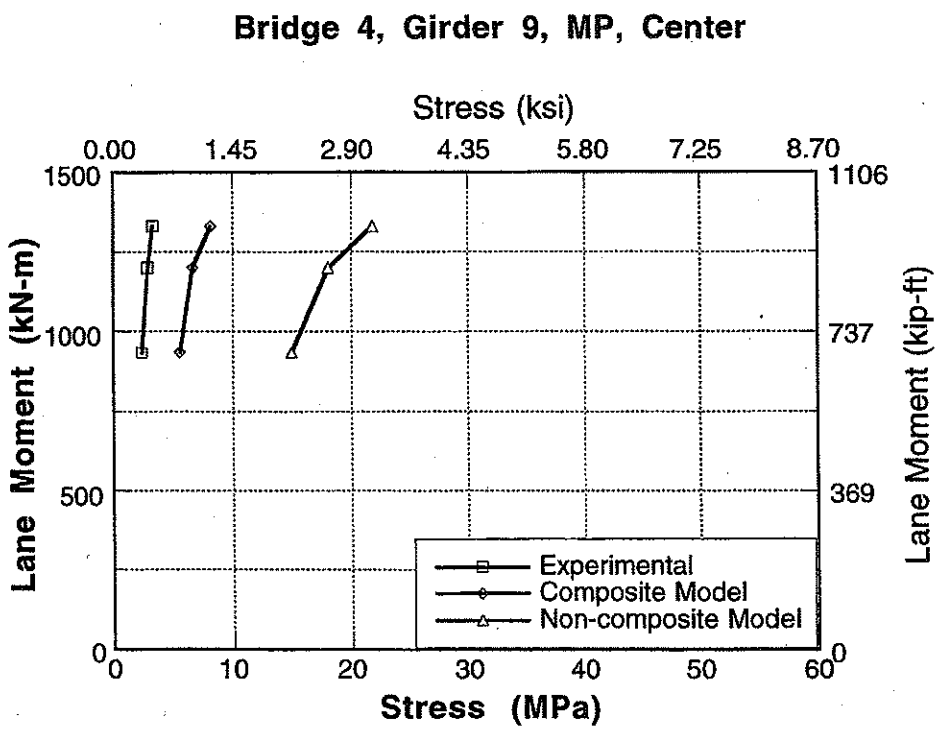
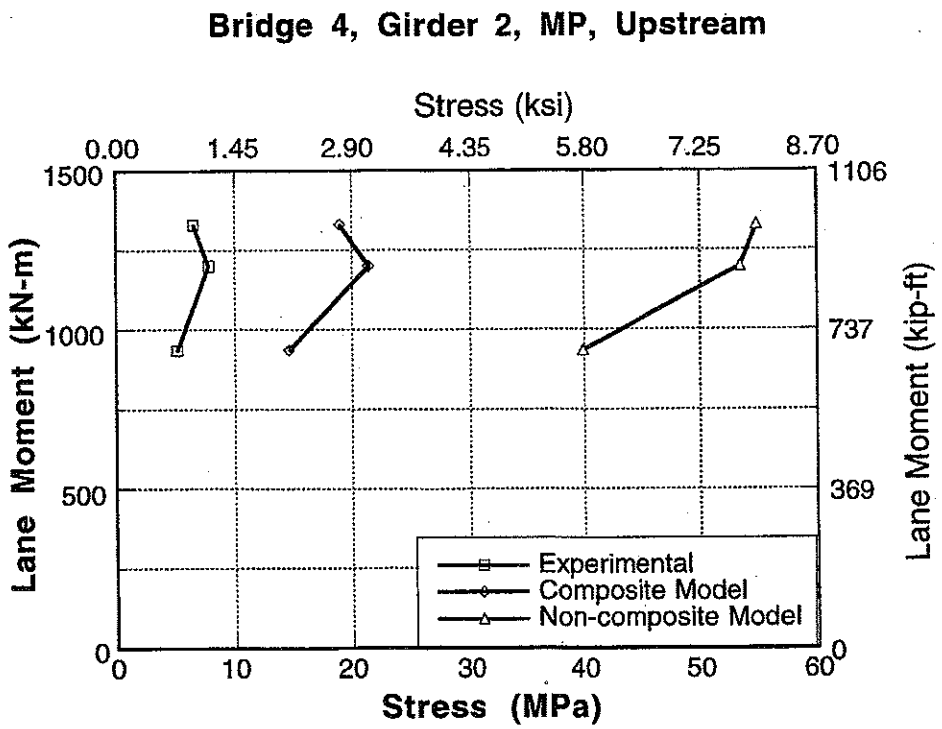


Figure A-141 : Experimental and Analytical Stresses for Bridge No. 4, Girder 8 and 9 for Center Loading.



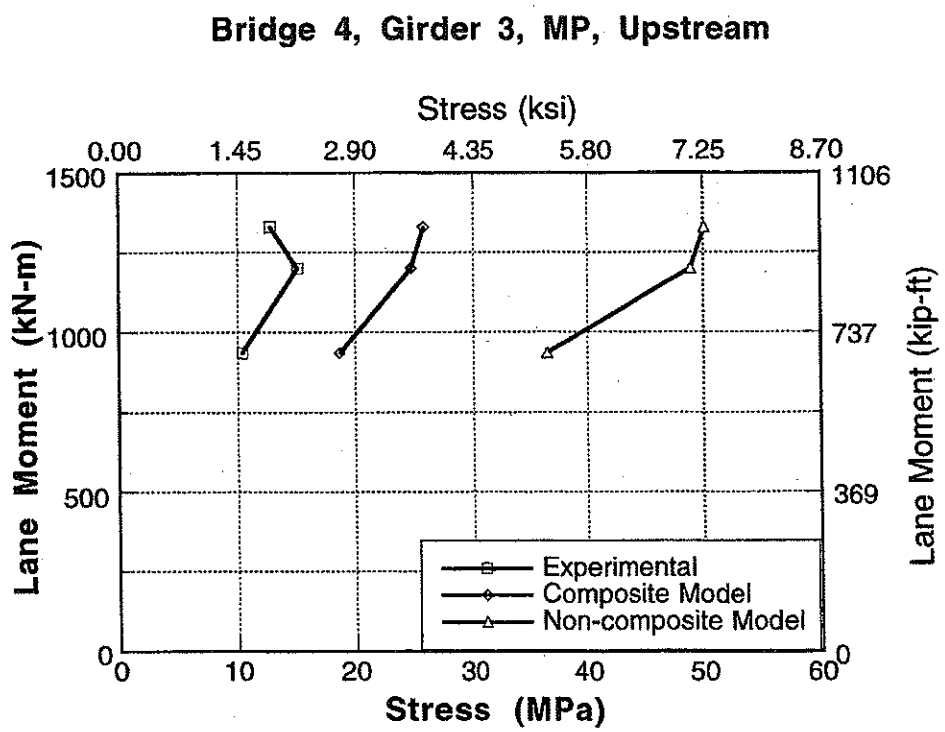
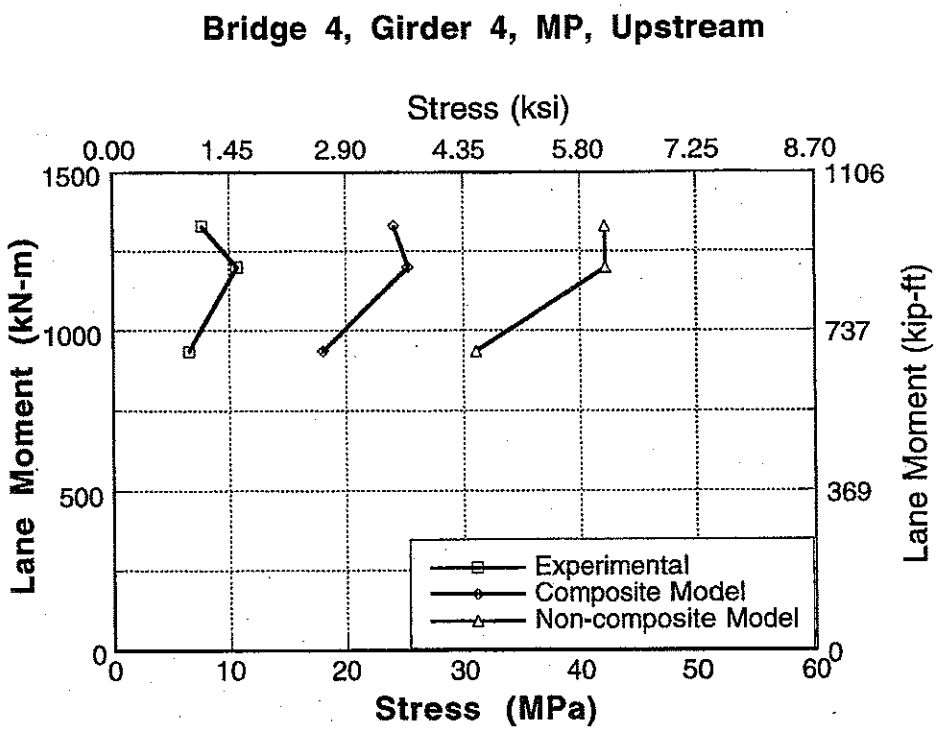


Figure A-142 : Experimental and Analytical Stresses for Bridge No. 4, Girder 2 and 3 for Upstream Loading.



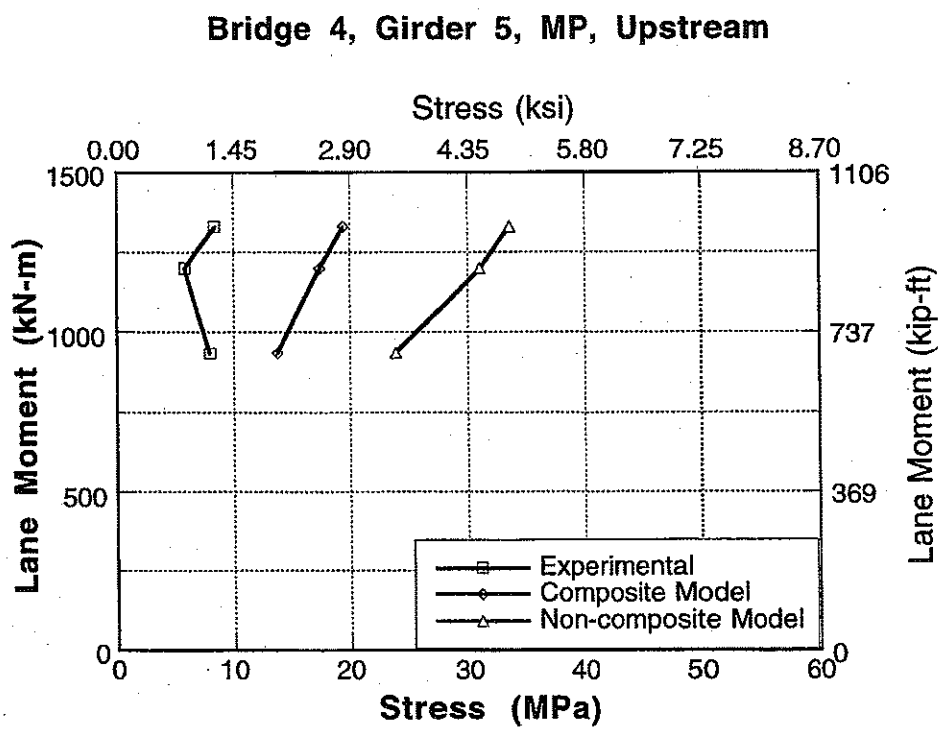
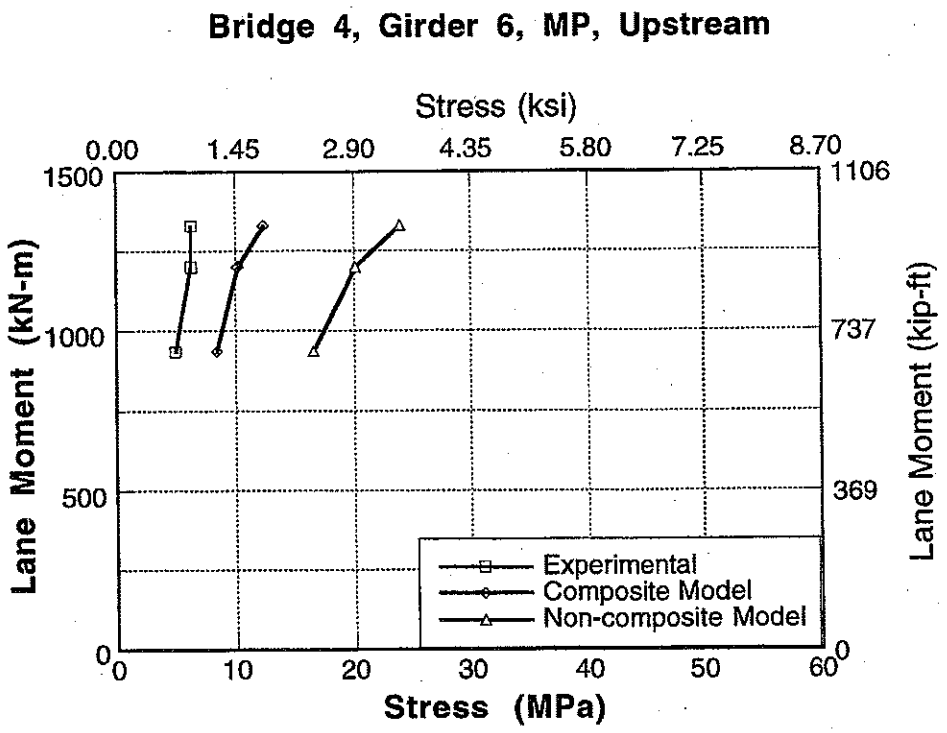


Figure A-143 : Experimental and Analytical Stresses for Bridge No. 4, Girder 4 and 5 for Upstream Loading.



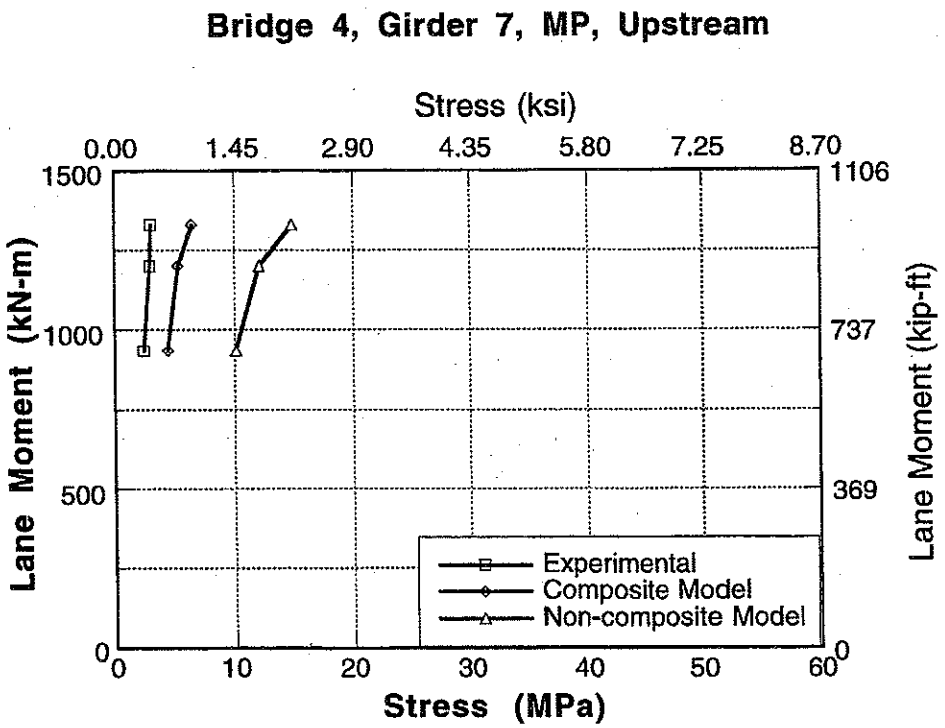
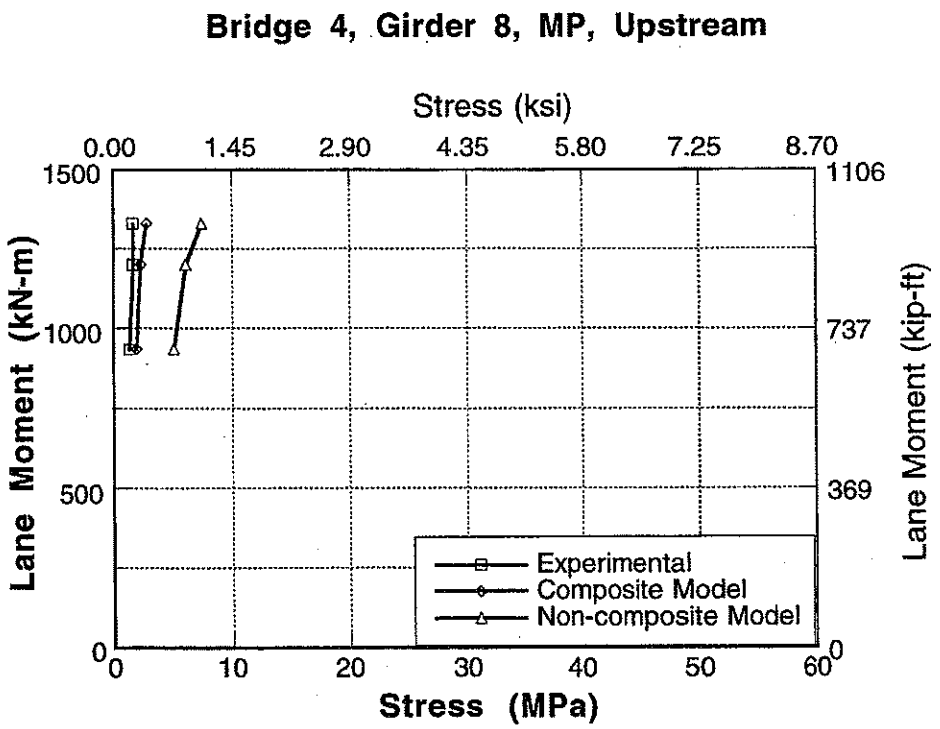


Figure A-144 : Experimental and Analytical Stresses for Bridge No. 4, Girder 6 and 7 for Upstream Loading.



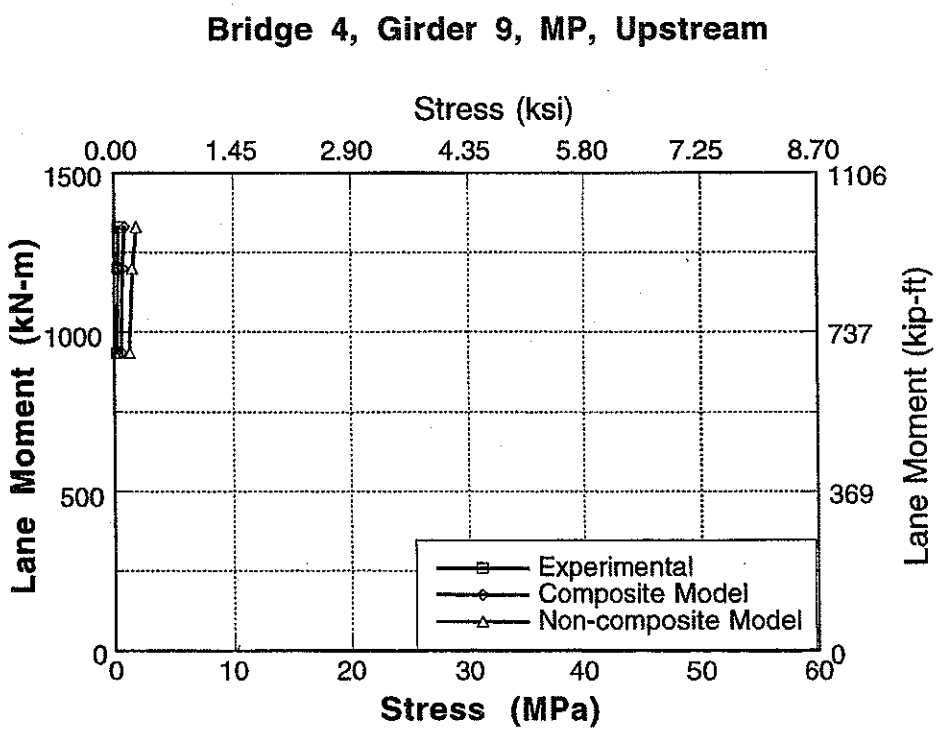


Figure A-145 : Experimental and Analytical Stresses for Bridge No. 4, Girder 8 and 9 for Upstream Loading.

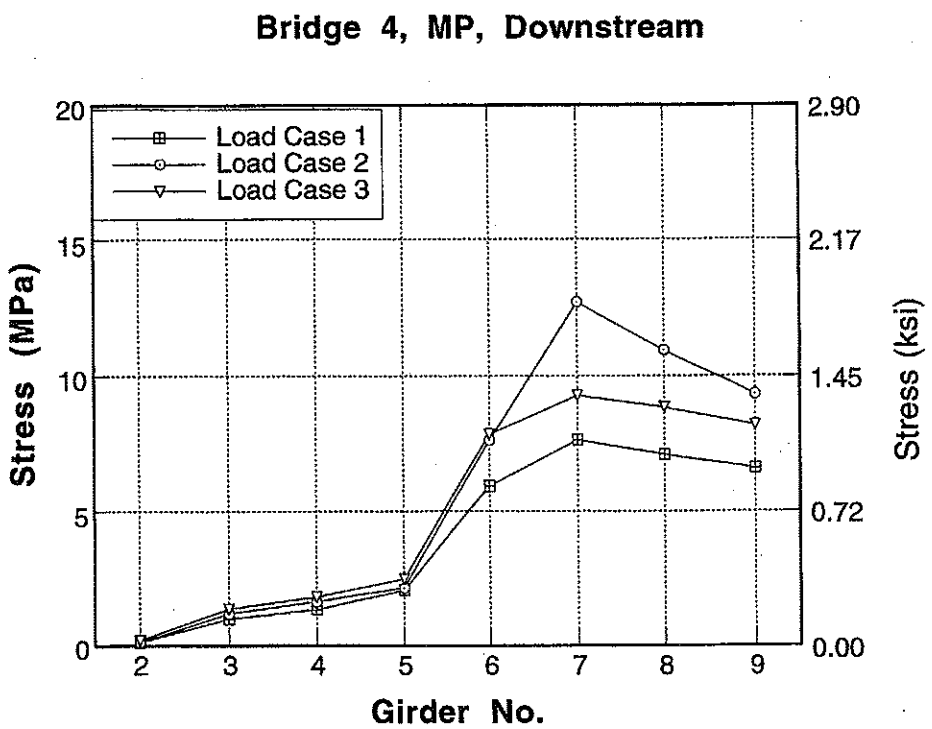


Figure A-146 : Girder Distribution of Stresses at Mid Point for Bridge No. 4 due to Downstream Loading.

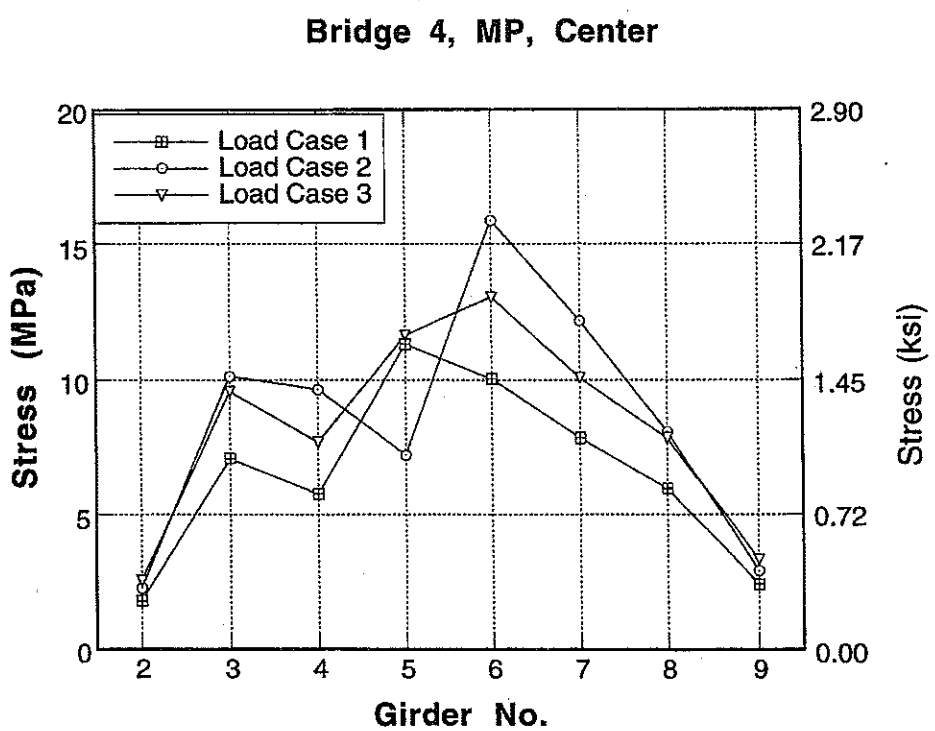


Figure A-147 : Girder Distribution of Stresses at Mid Point for Bridge No. 4 due to Center Loading.

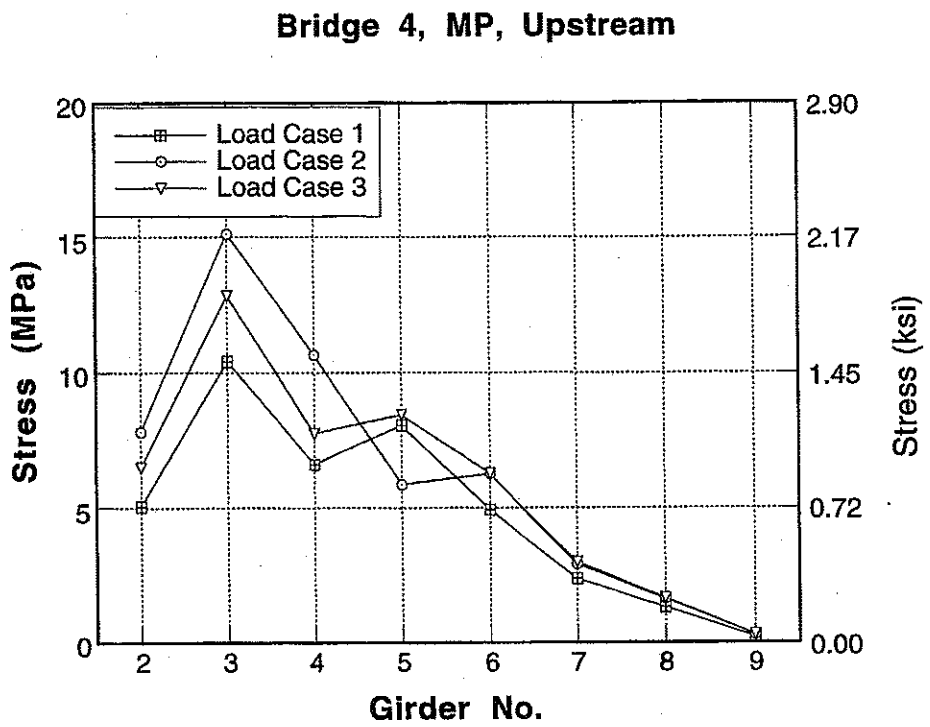


Figure A-148 : Girder Distribution of Stresses at Mid Point for Bridge No. 4 due to Upstream Loading.

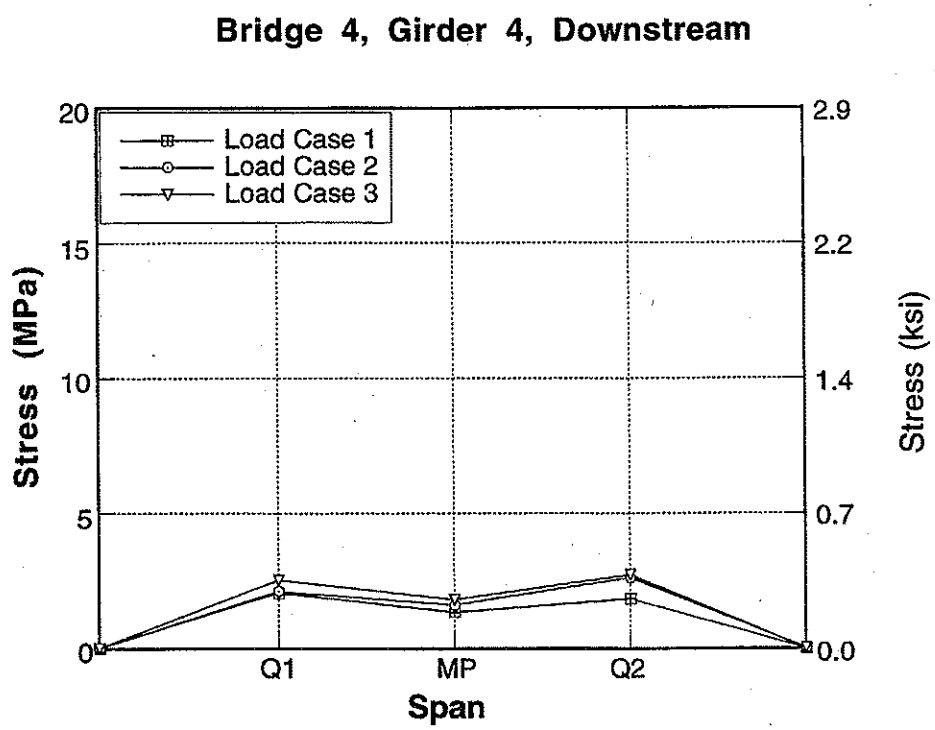


Figure A-149 : Longitudinal Distribution of Stresses for Bridge No. 4, Girder 4 due to Downstream Loading.

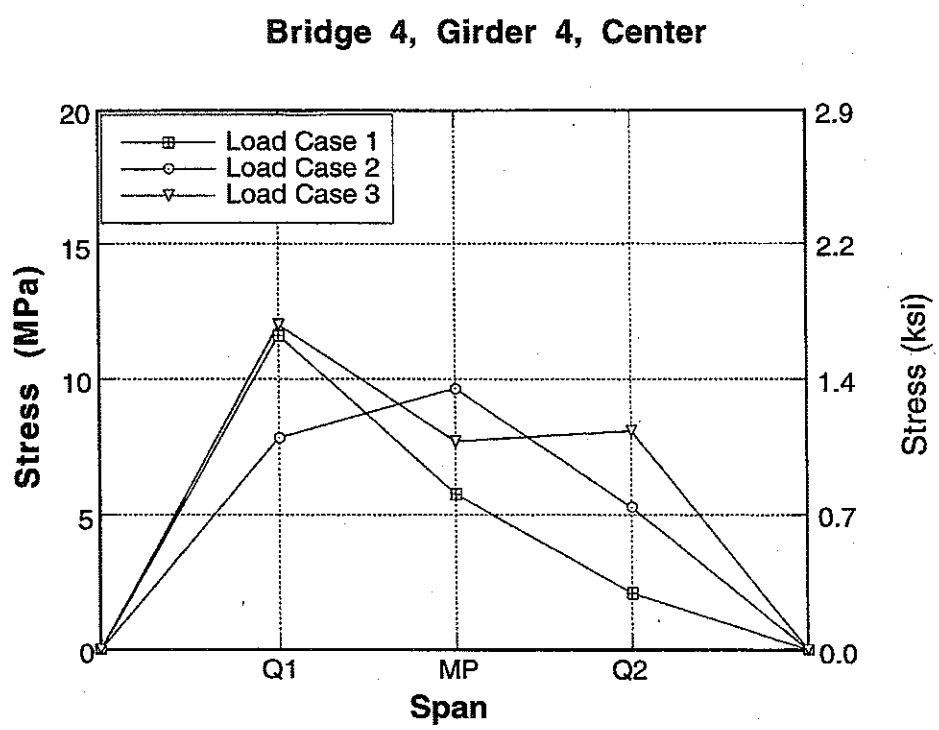


Figure A-150 : Longitudinal Distribution of Stresses for Bridge No. 4, Girder 4 due to Center Loading.

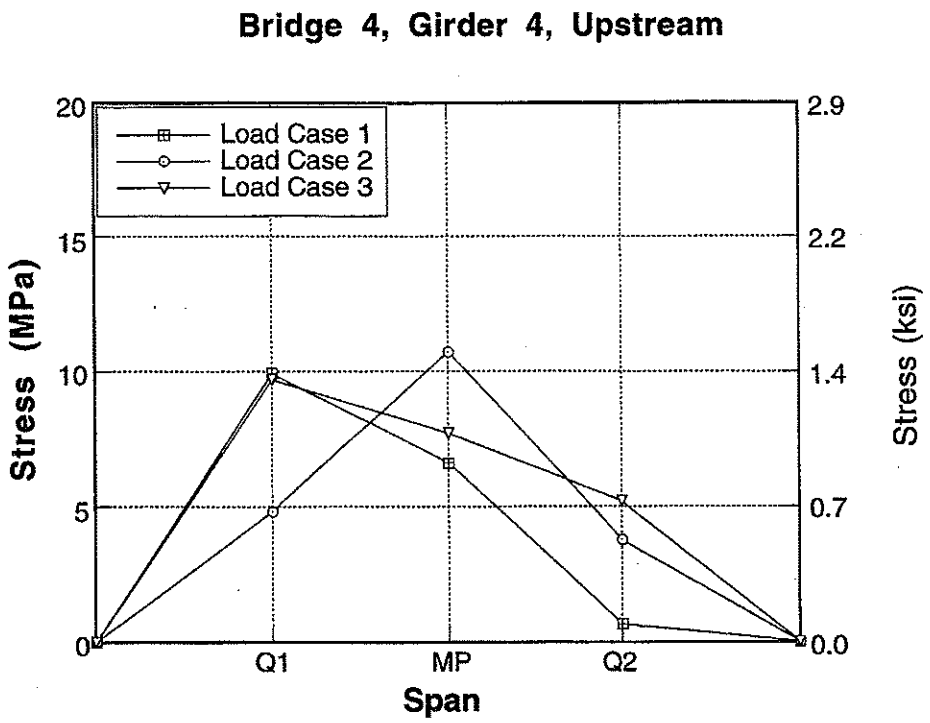


Figure A-151 : Longitudinal Distribution of Stresses for Bridge No. 4, Girder 4 due to Upstream Loading.

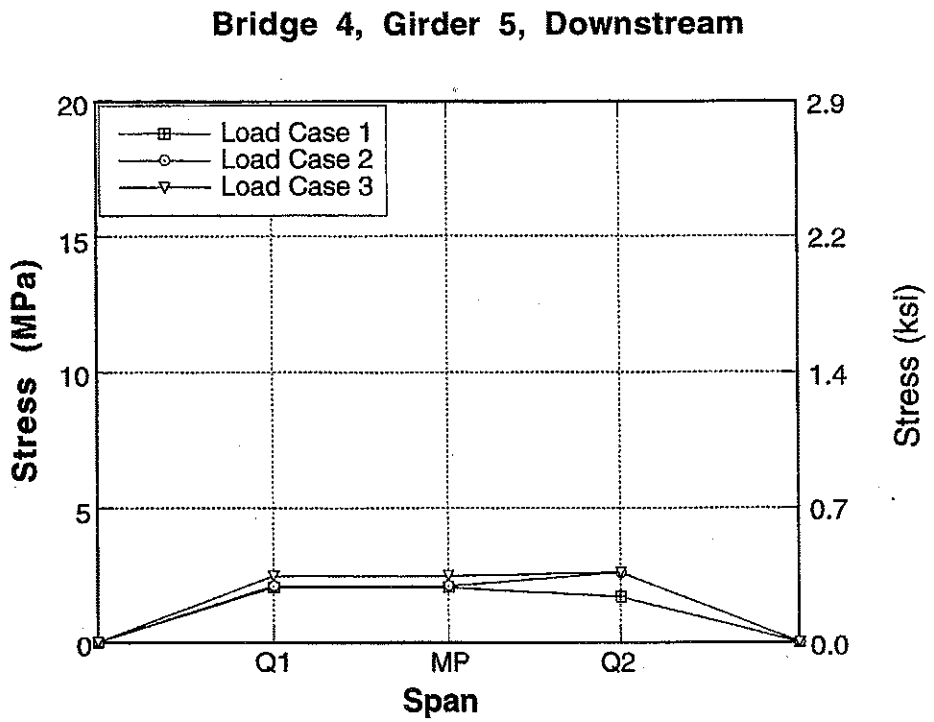


Figure A-152 : Longitudinal Distribution of Stresses for Bridge No. 4, Girder 5 due to Downstream Loading.

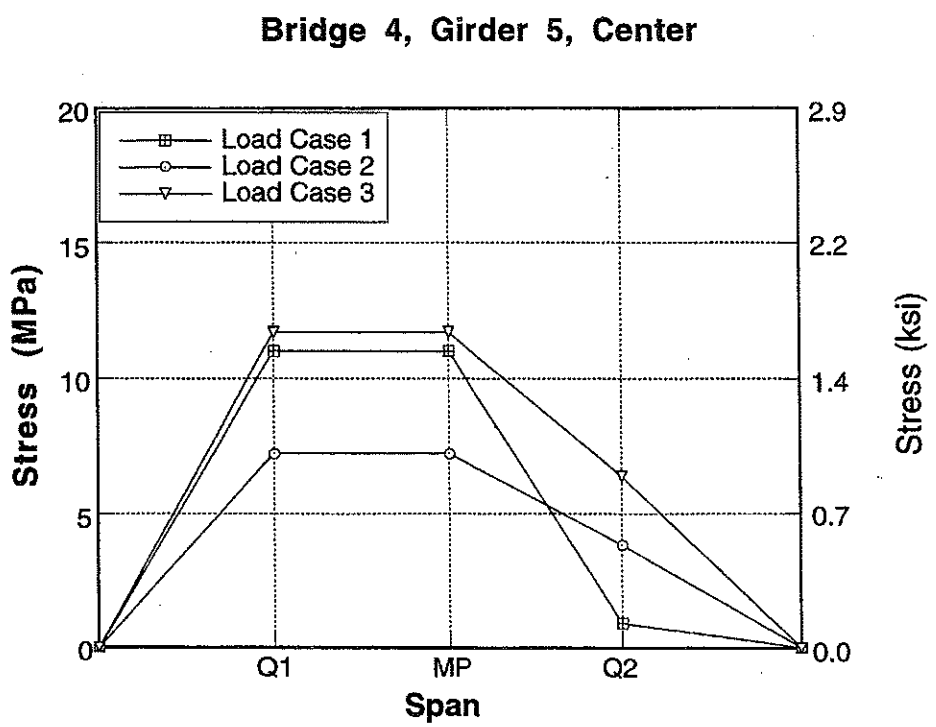


Figure A-153 : Longitudinal Distribution of Stresses for Bridge No. 4, Girder 5 due to Center Loading.

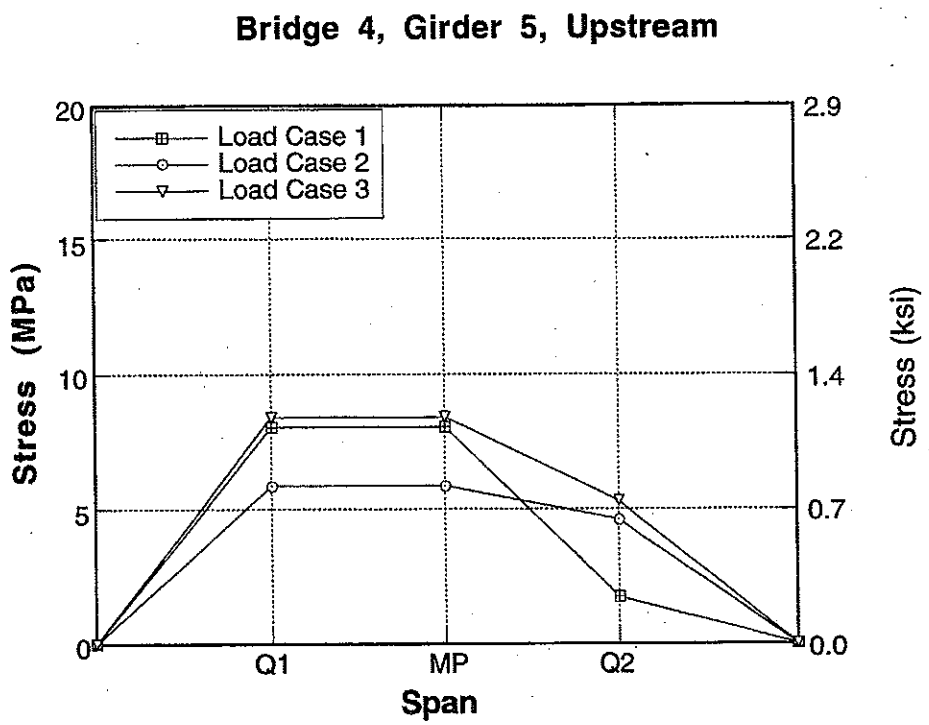


Figure A-154 : Longitudinal Distribution of Stresses for Bridge No. 4, Girder 5 due to Upstream Loading.

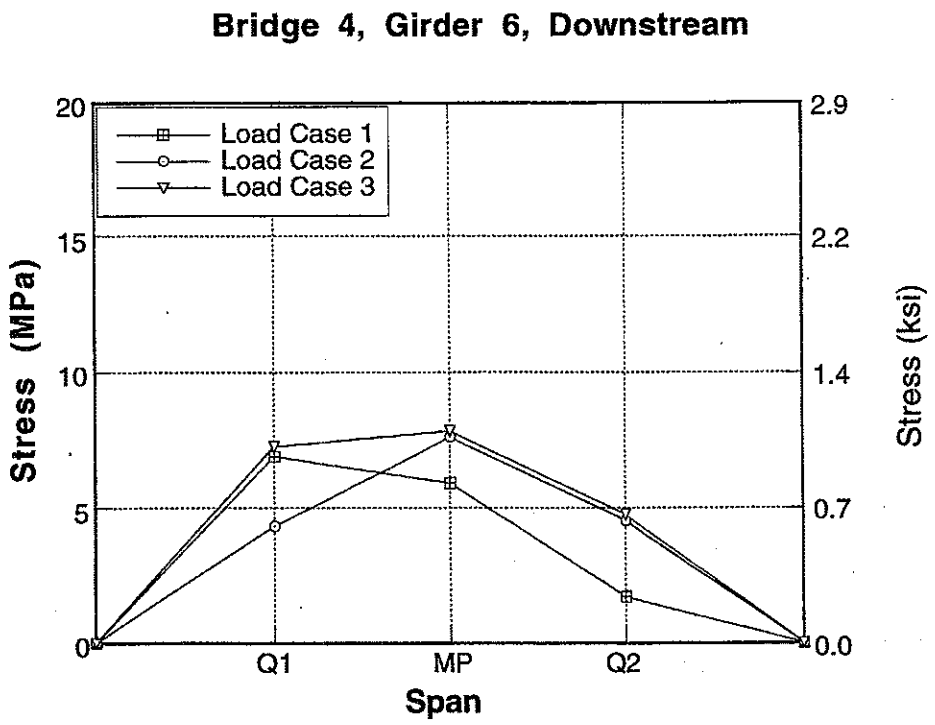


Figure A-155 : Longitudinal Distribution of Stresses for Bridge No. 4, Girder 6 due to Downstream Loading.

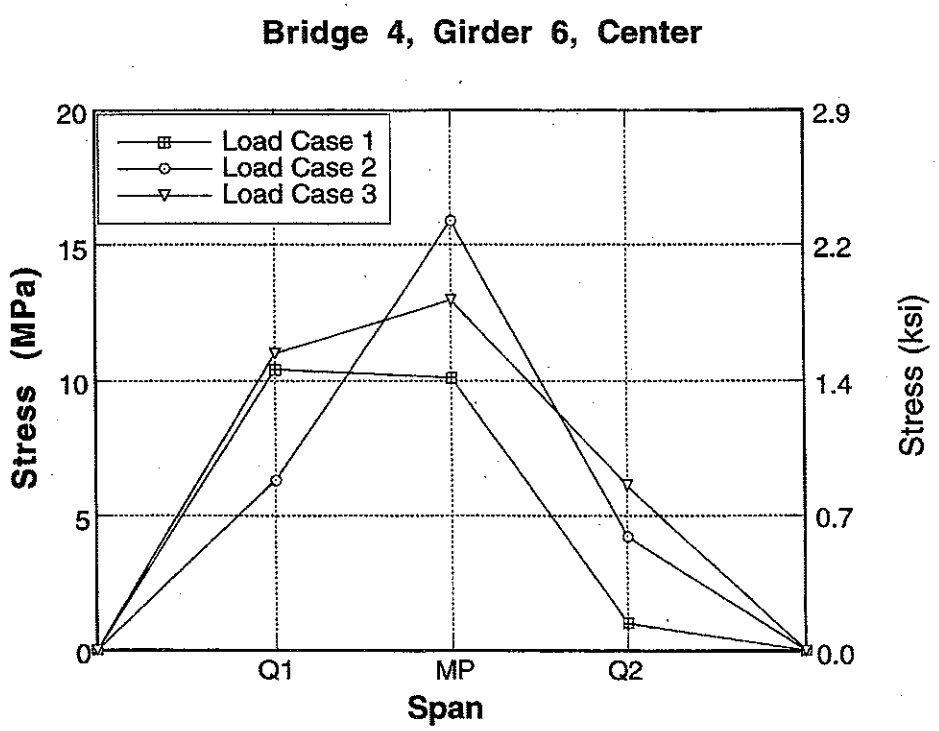


Figure A-156 : Longitudinal Distribution of Stresses for Bridge No. 4, Girder 6 due to Center Loading.

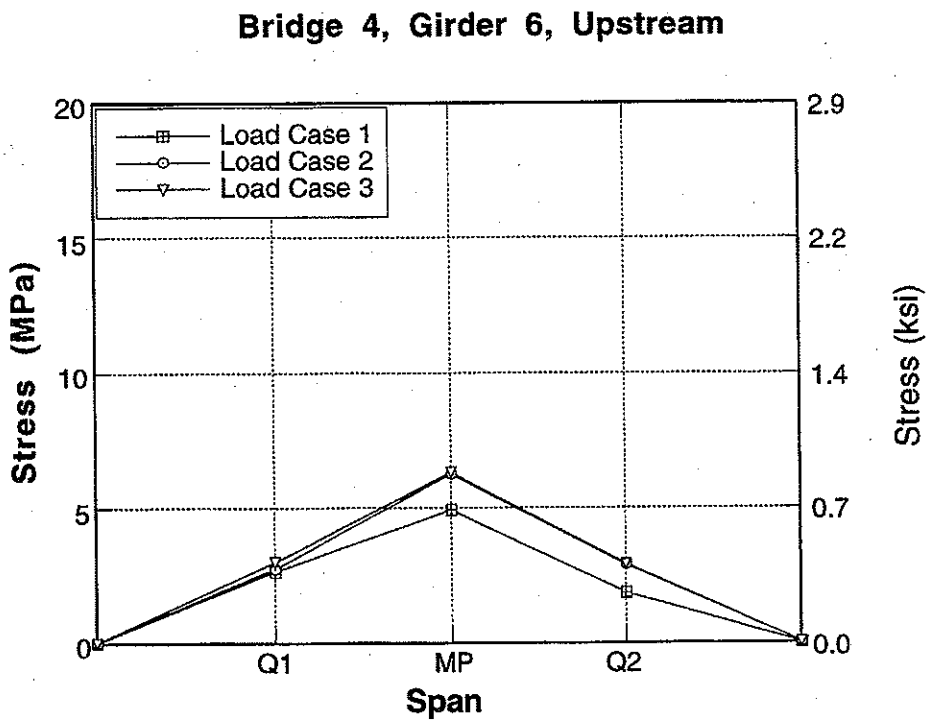


Figure A-157 : Longitudinal Distribution of Stresses for Bridge No. 4, Girder 6 due to Upstream Loading.

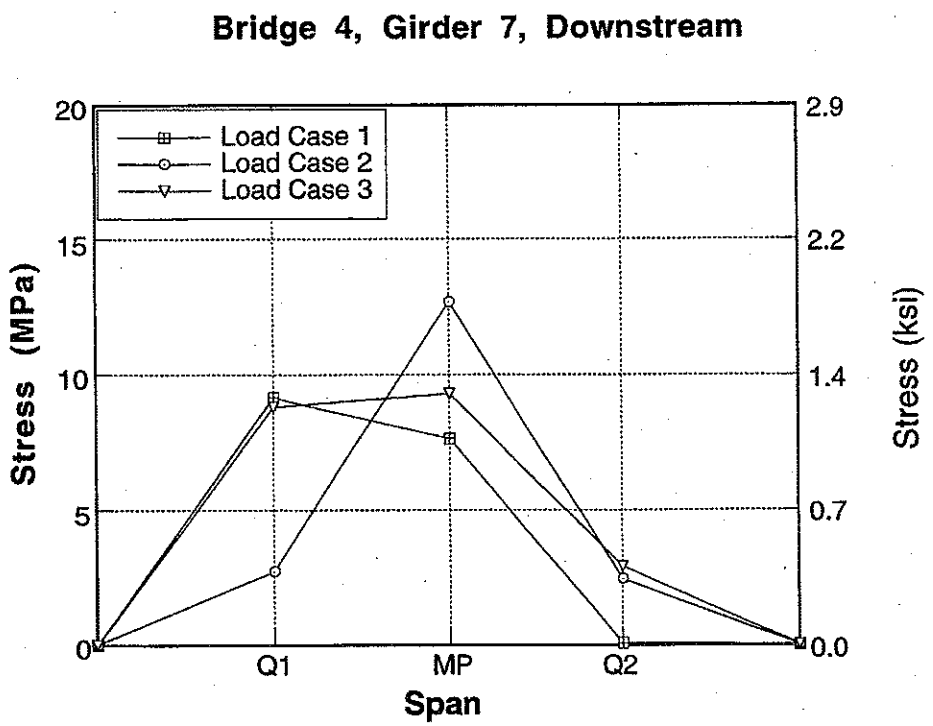


Figure A-158 : Longitudinal Distribution of Stresses for Bridge No. 4, Girder 7 due to Downstream Loading.

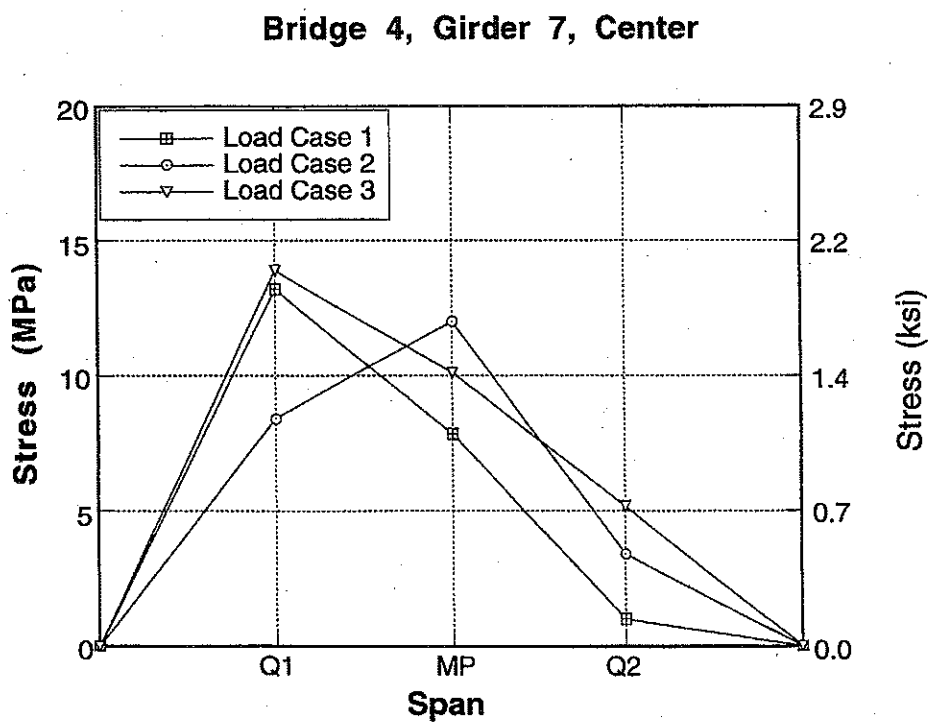


Figure A-159 : Longitudinal Distribution of Stresses for Bridge No. 4, Girder 7 due to Center Loading.

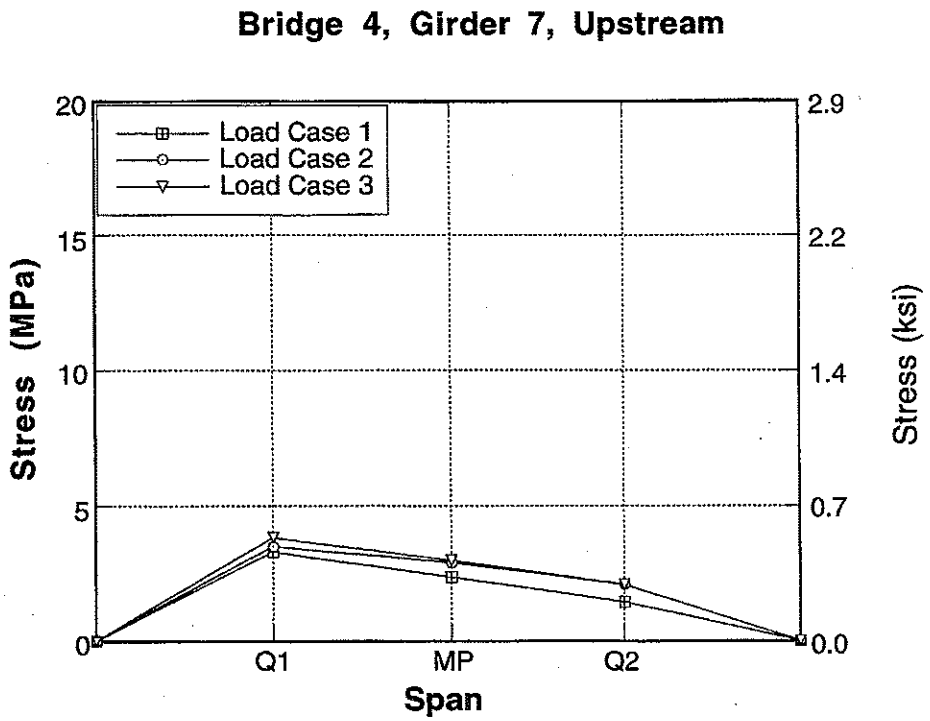


Figure A-160 : Longitudinal Distribution of Stresses for Bridge No. 4, Girder 7 due to Upstream Loading.

Note:

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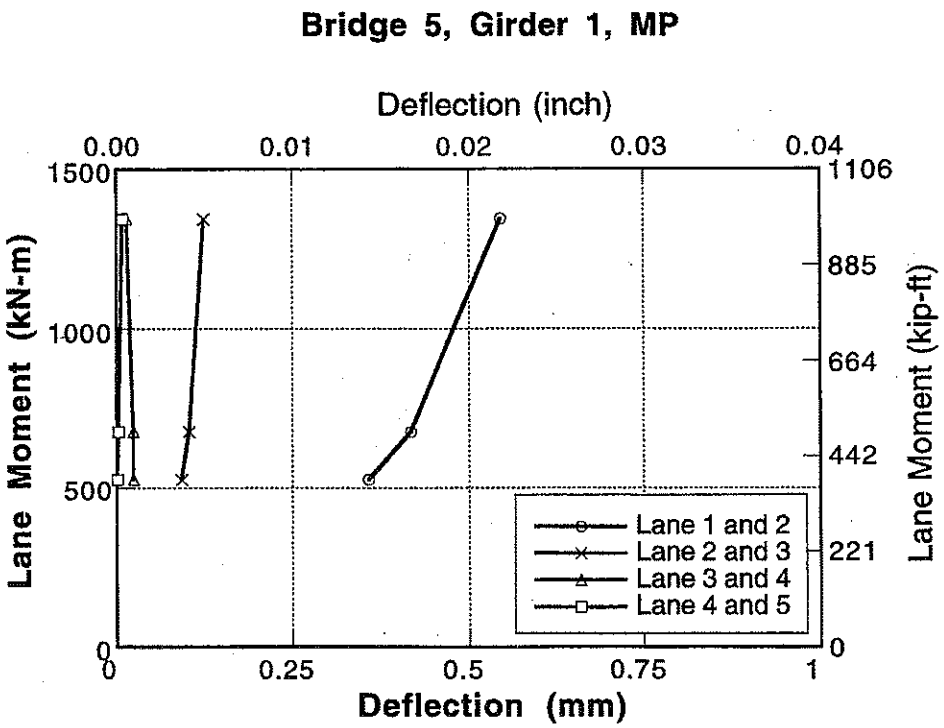
APPENDIX E - RESULTS FOR BRIDGE NO. 5

MDOT ID # B01-82081

M-153 bridge over Fellows Creek located in Clinton County, Michigan. Simply supported reinforced concrete T-beam structure.

Results for this bridge contain:

- Measured deflections vs calculated lane moment.
- Measured deflections vs analytical deflections.
- Girder distribution of measured deflections.



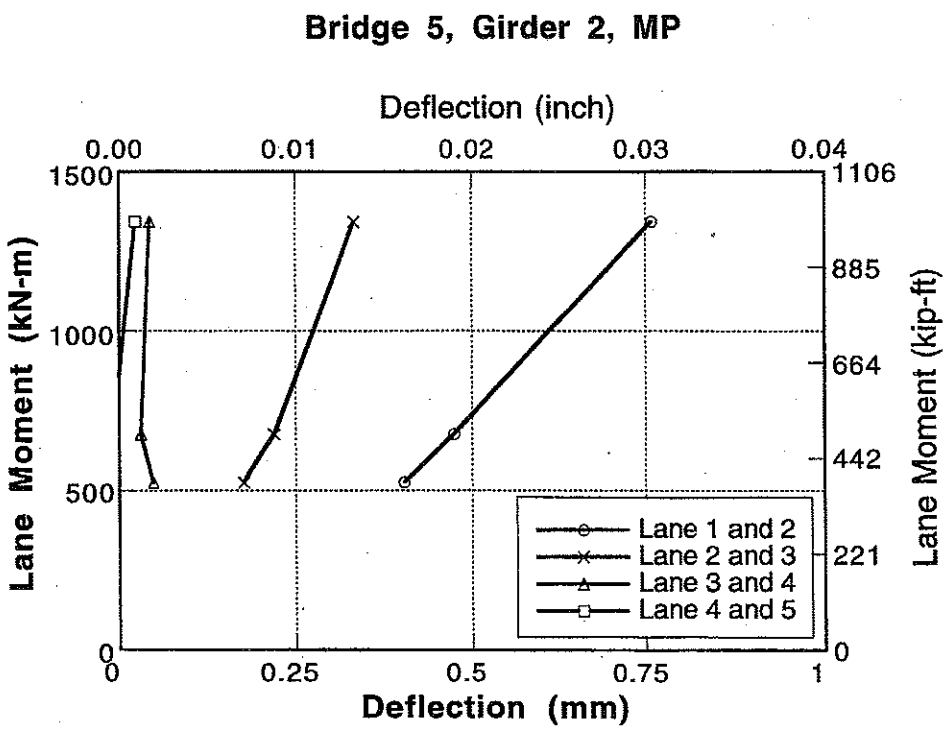
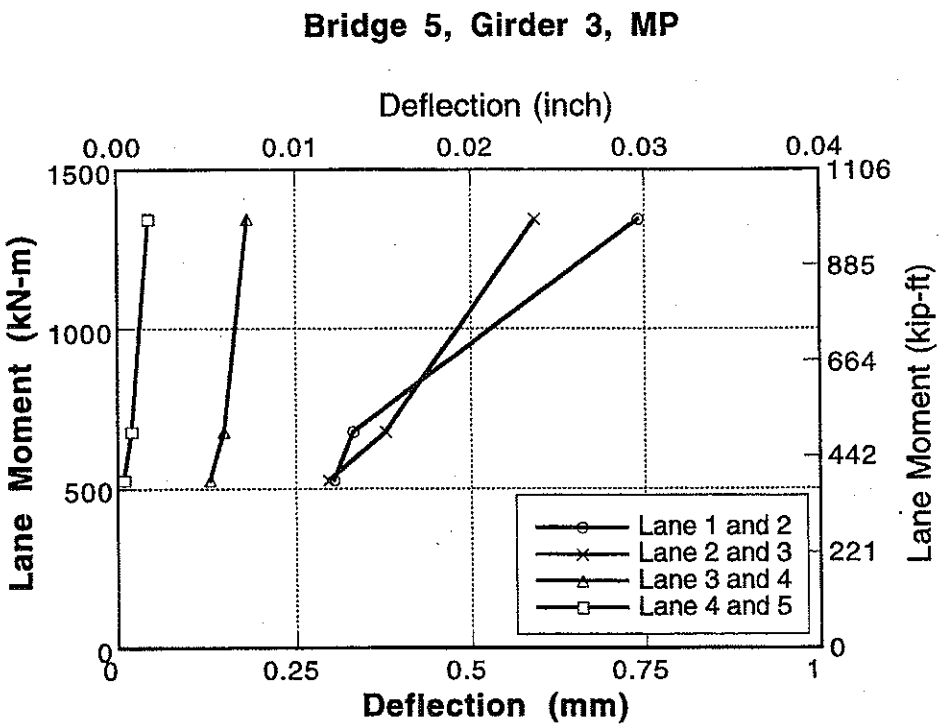


Figure A-161 : Deflection vs Lane Moment for Bridge No. 5, Girder 1 and 2.



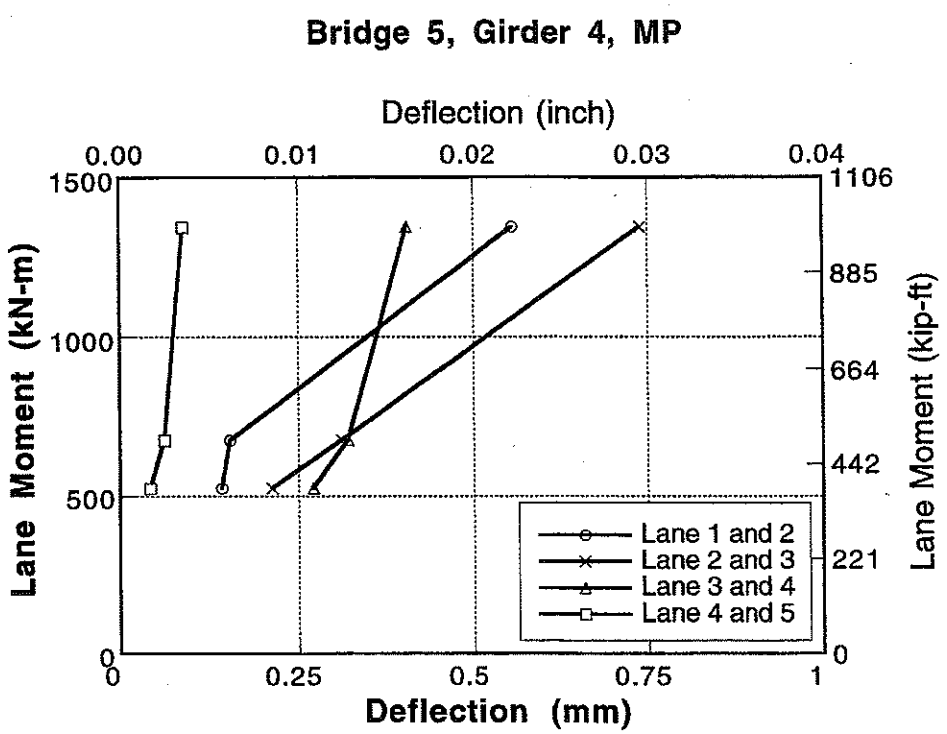
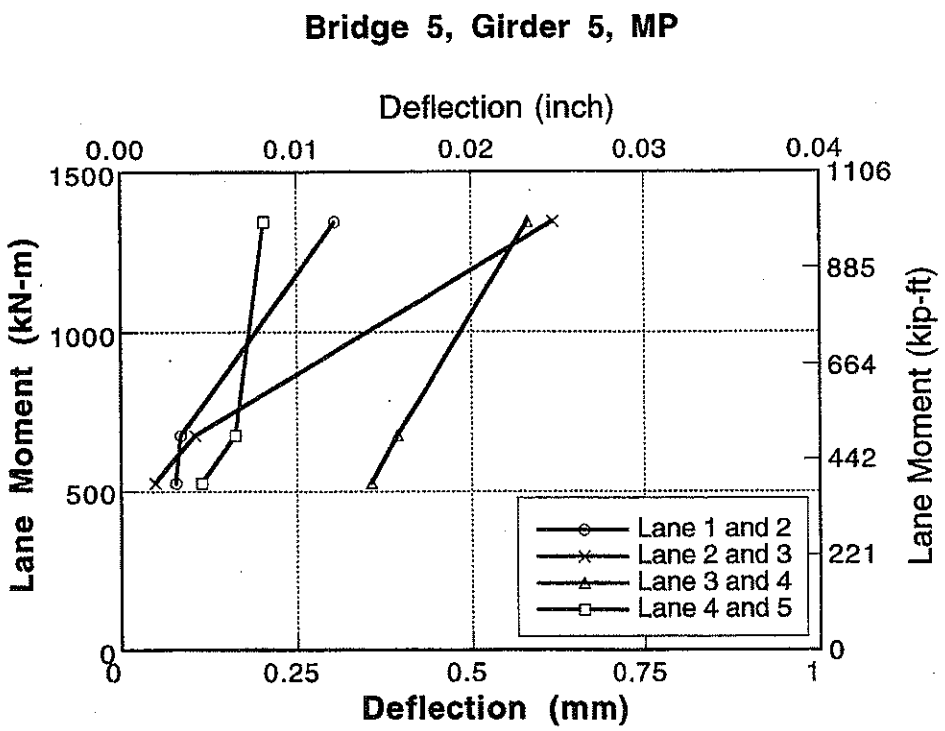


Figure A-162 : Deflection vs Lane Moment for Bridge No. 5, Girder 3 and 4.



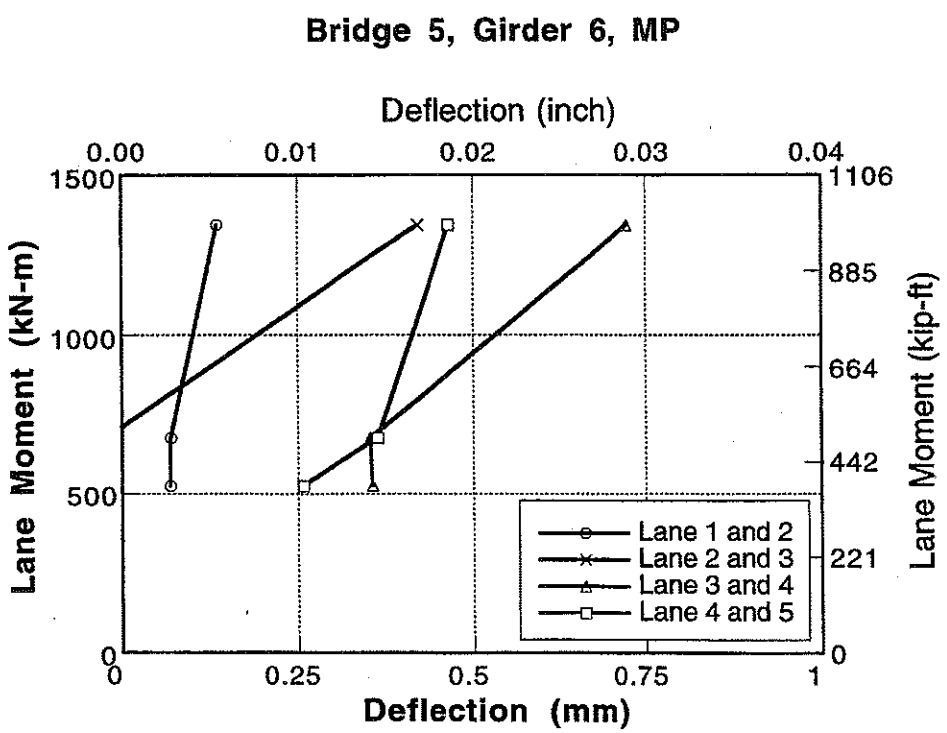
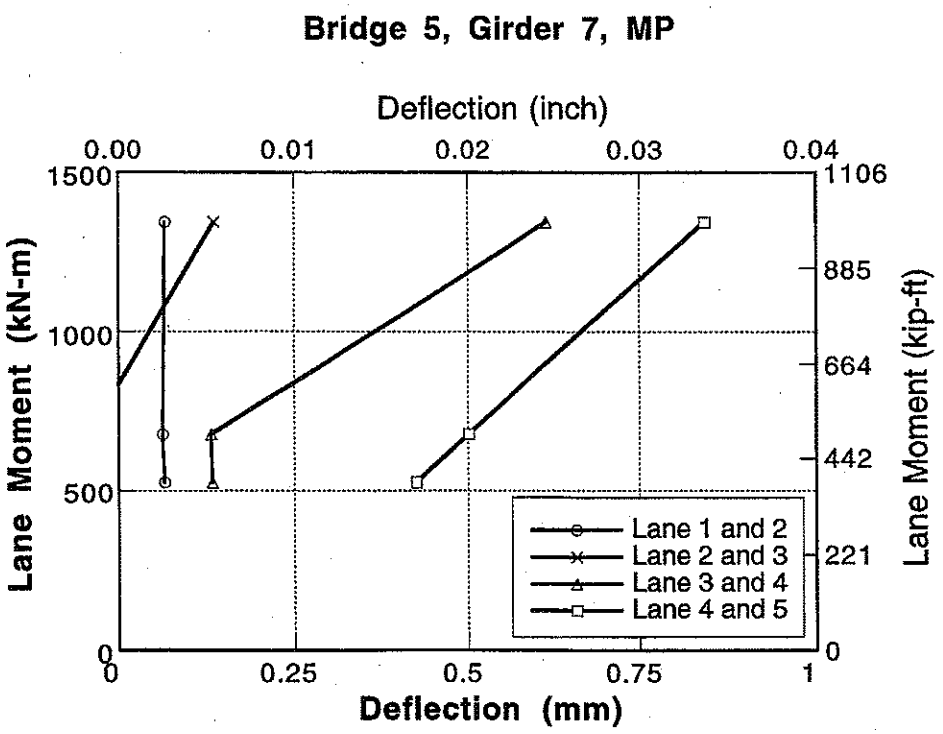


Figure A-163 : Deflection vs Lane Moment for Bridge No. 5, Girder 5 and 6.



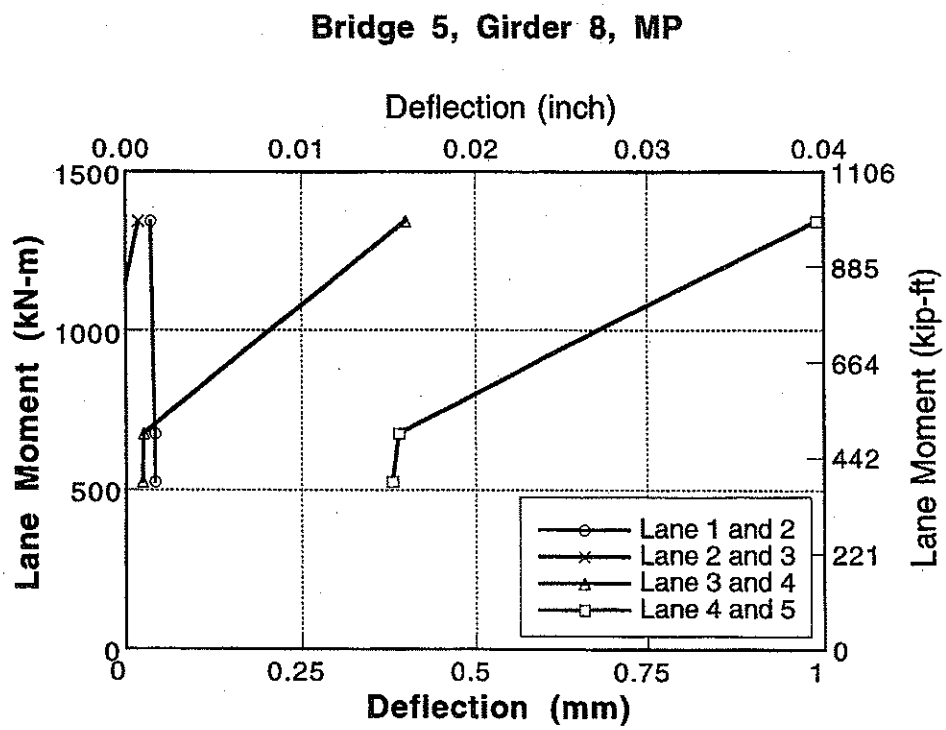


Figure A-164 : Deflection vs Lane Moment for Bridge No. 5, Girder 7 and 8.

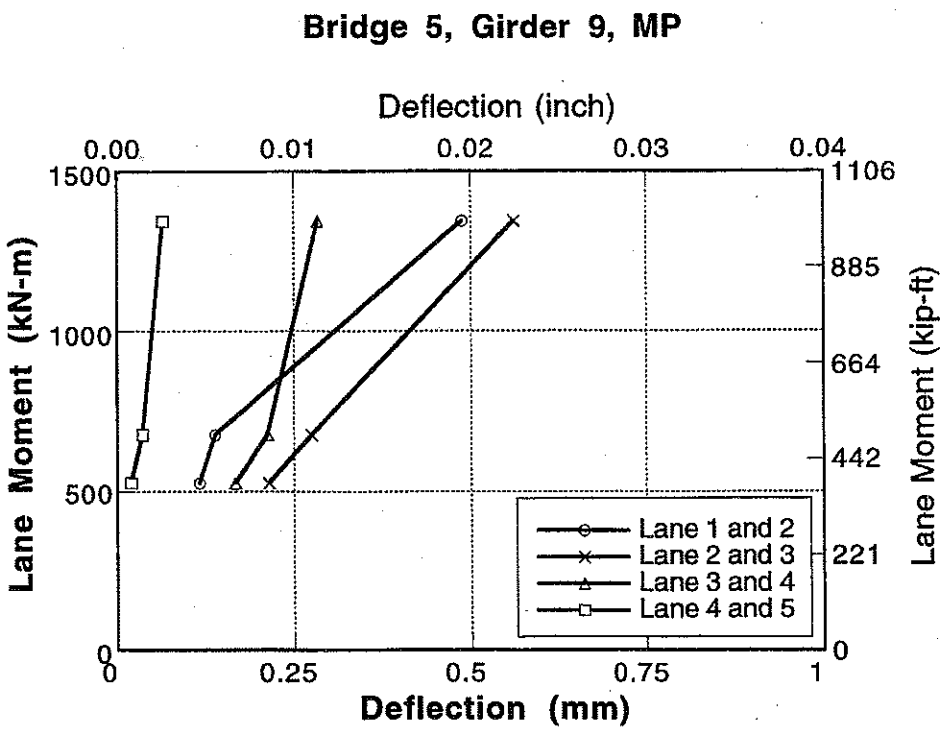
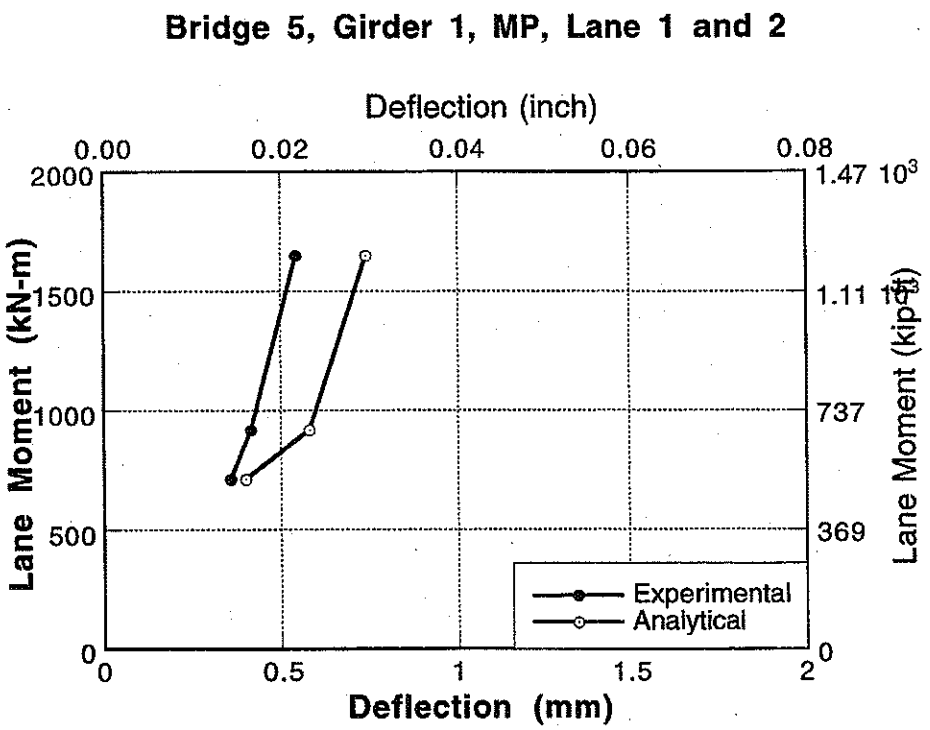


Figure A-165 : Deflection vs Lane Moment for Bridge No. 5, Girder 9.



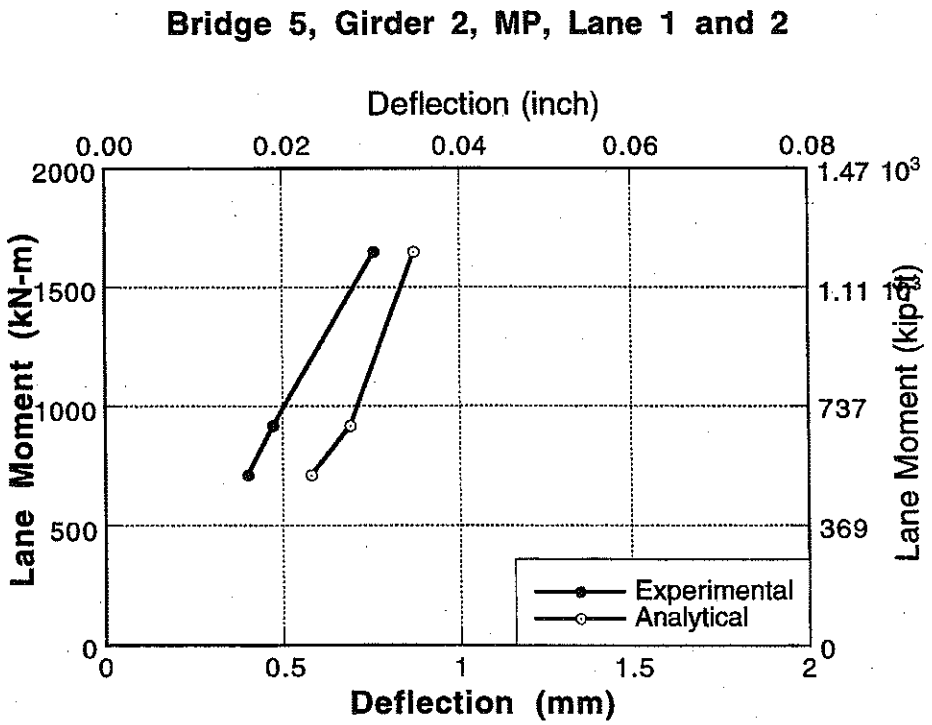
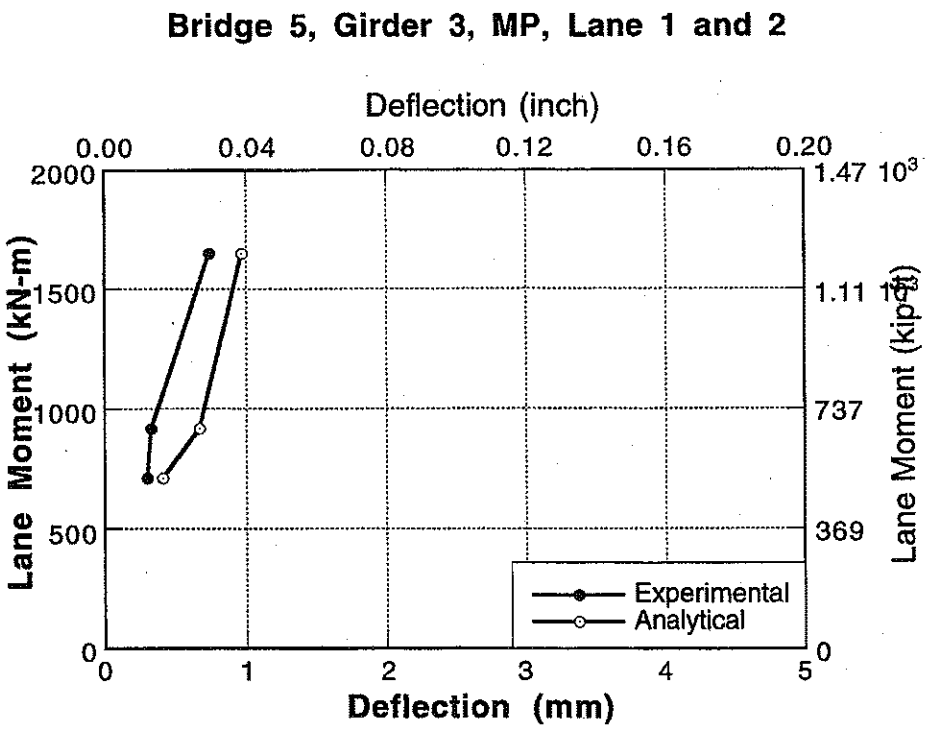


Figure A-166 : Experimental and Analytical Deflections for Bridge No. 5, Girder 1 and 2 for Lane 1 and 2 Loading.



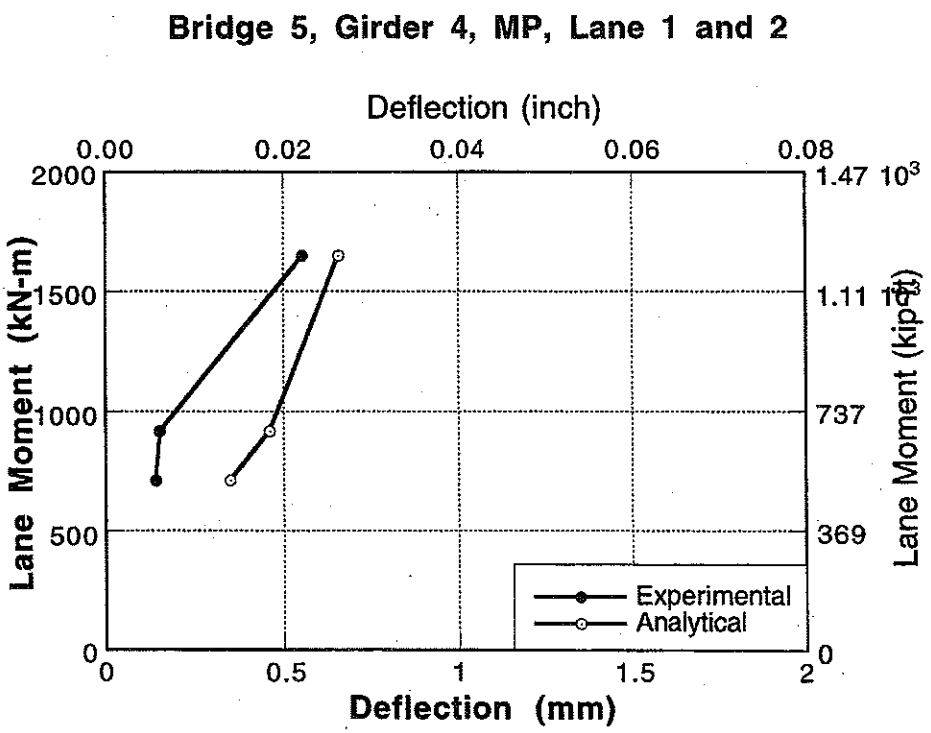
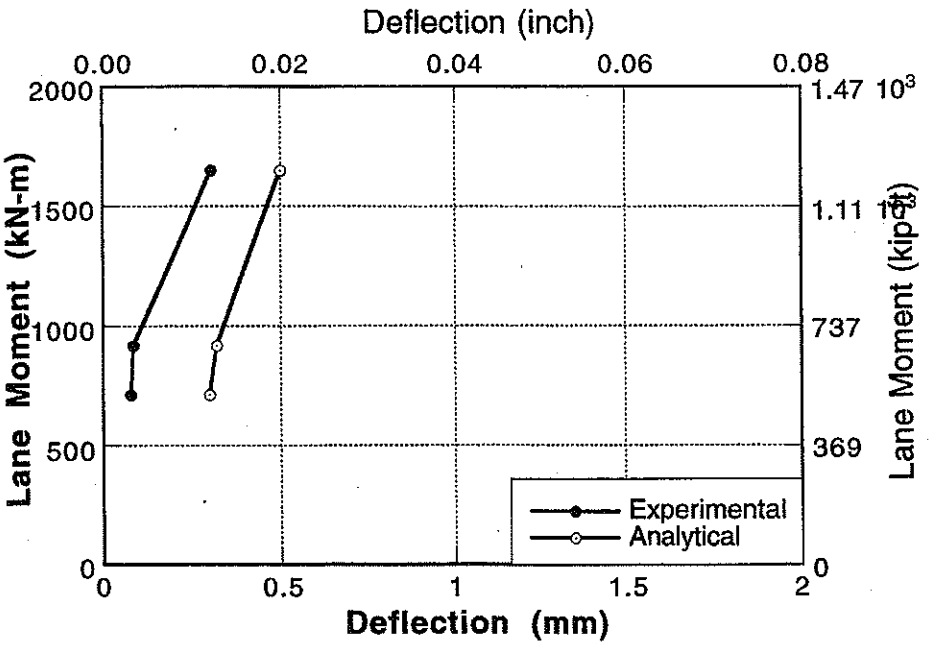


Figure A-167 : Experimental and Analytical Deflections for Bridge No. 5, Girder 3 and 4 for Lane 1and 2 Loading.

Bridge 5, Girder 5, MP, Lane 1 and 2



Bridge 5, Girder 6, MP, Lane 1 and 2

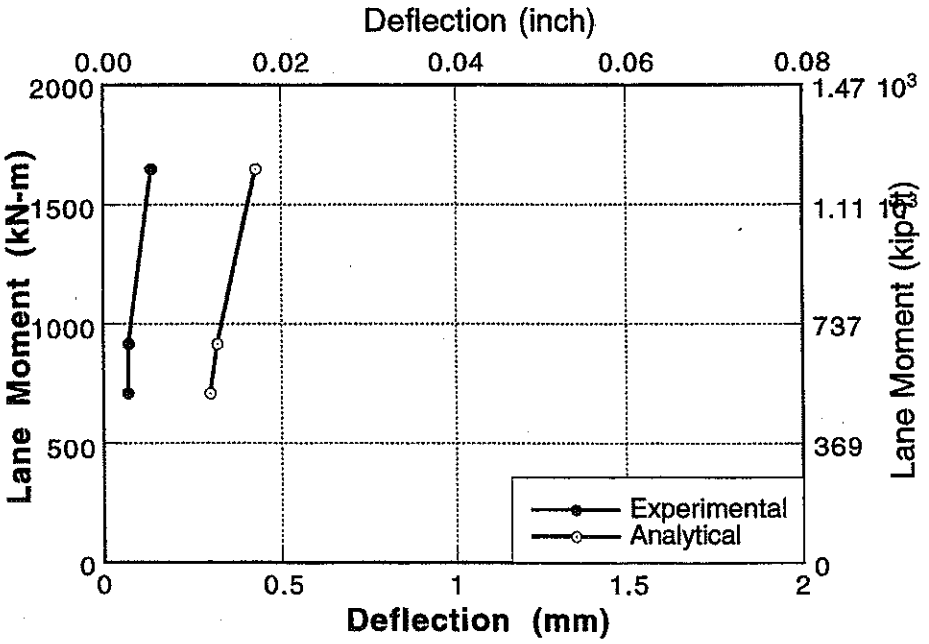
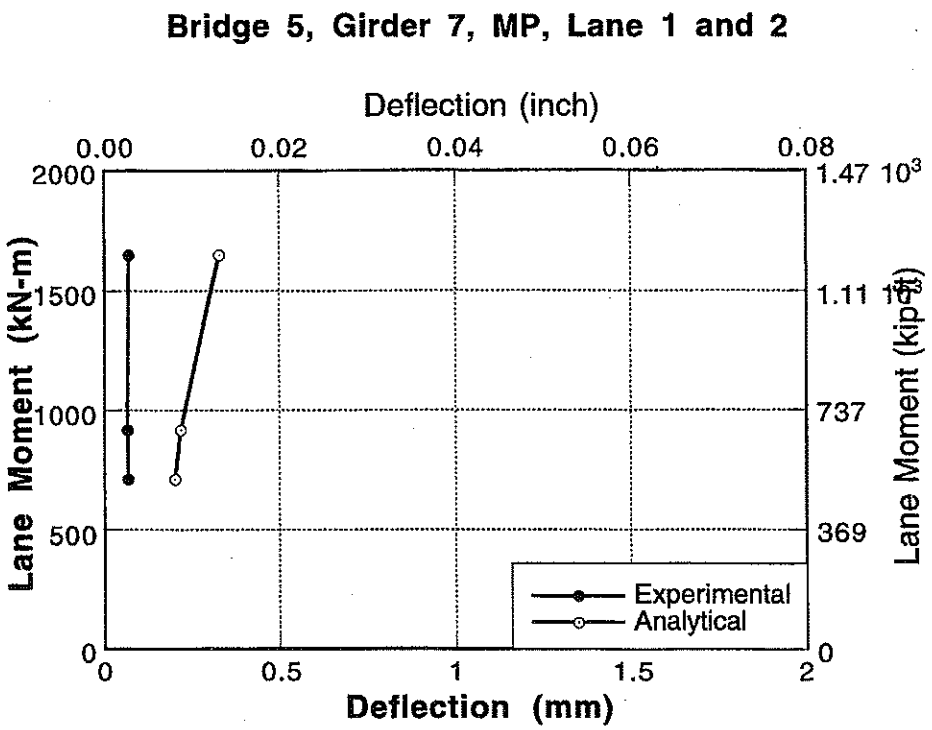


Figure A-168 : Experimental and Analytical Deflections for Bridge No. 5, Girder 5 and 6 for Lane 1 and 2 Loading.



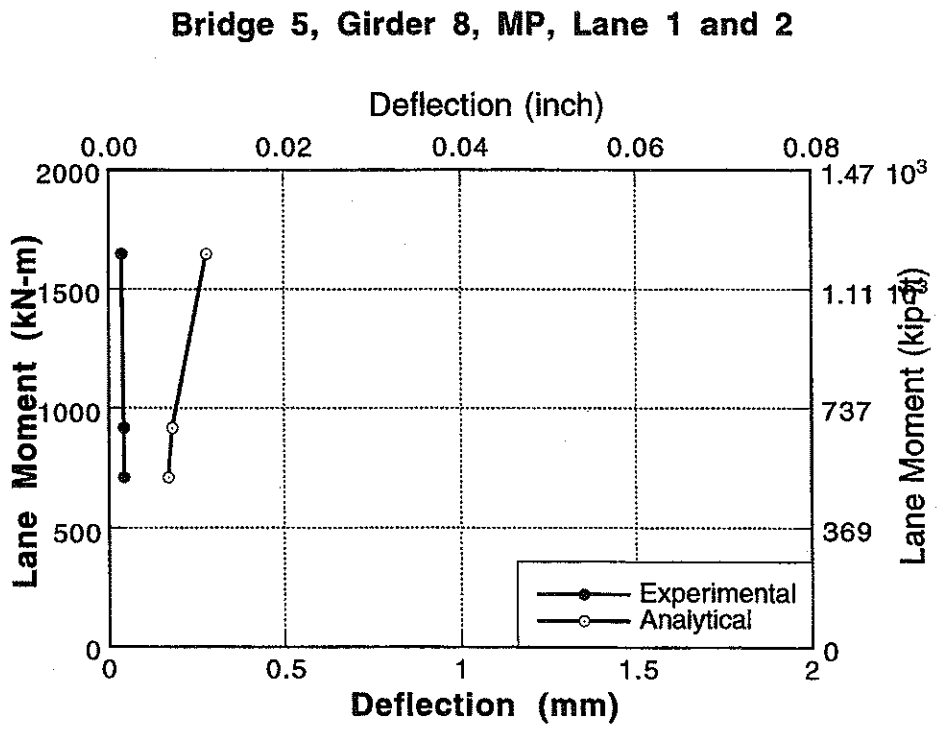


Figure A-169 : Experimental and Analytical Deflections for Bridge No. 5, Girder 7 and 8 for Lane 1 and 2 Loading.

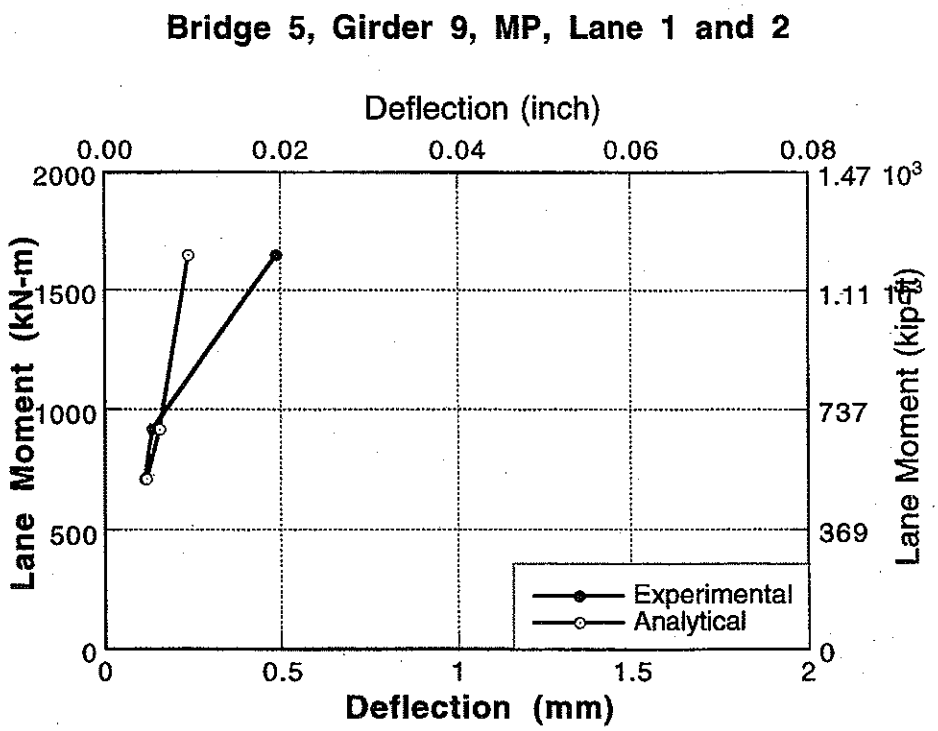
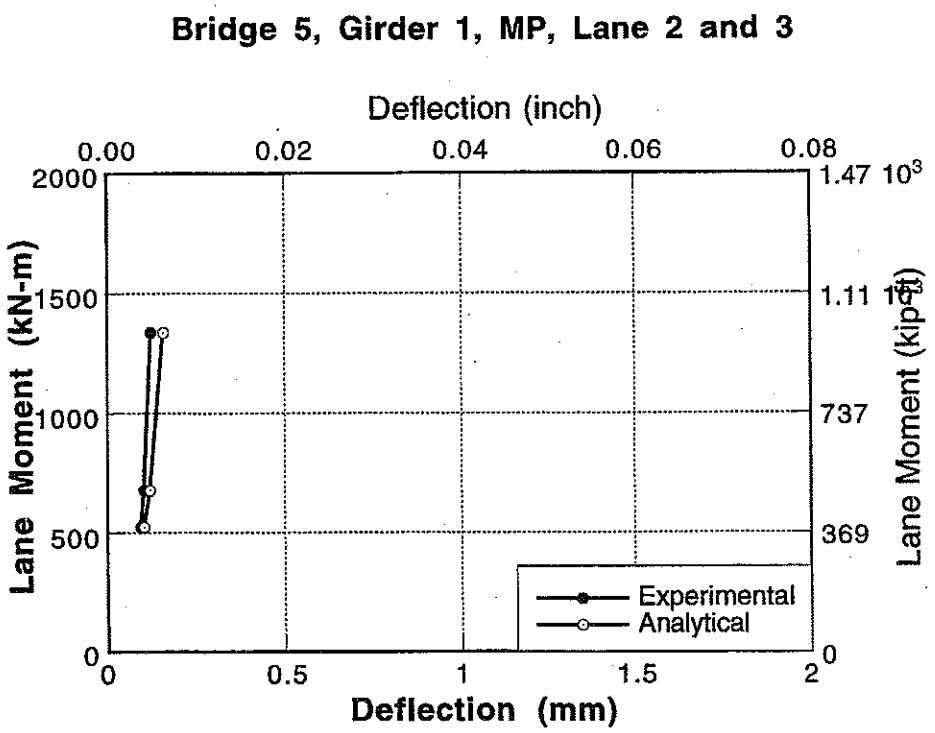


Figure A-170 : Experimental and Analytical Deflections for Bridge No. 5, Girder 9 for Lane 1 and 2 Loading.



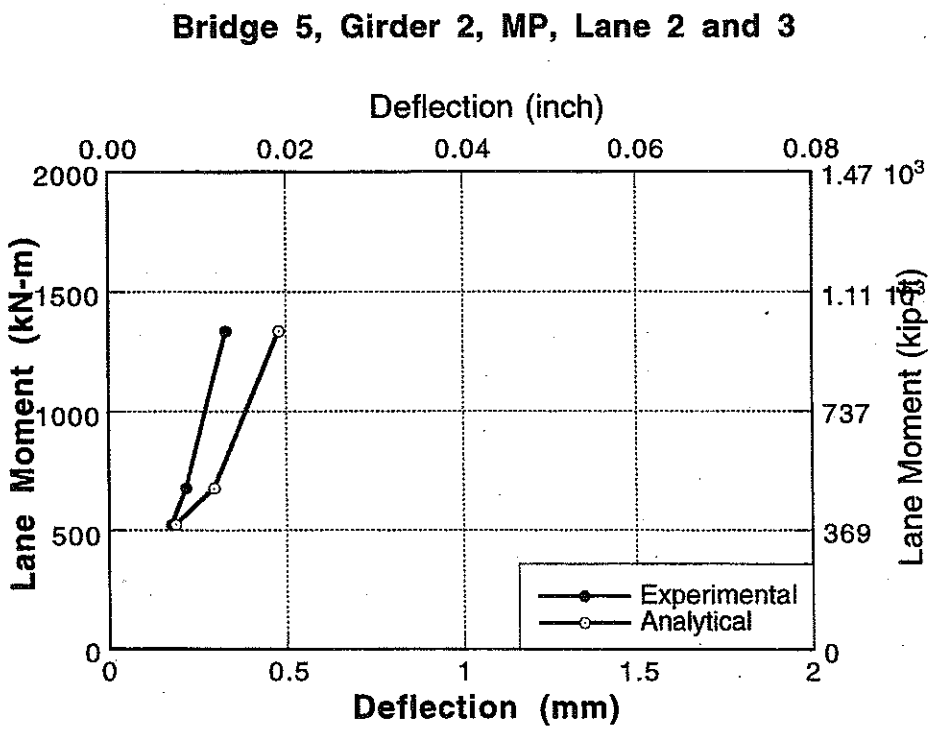
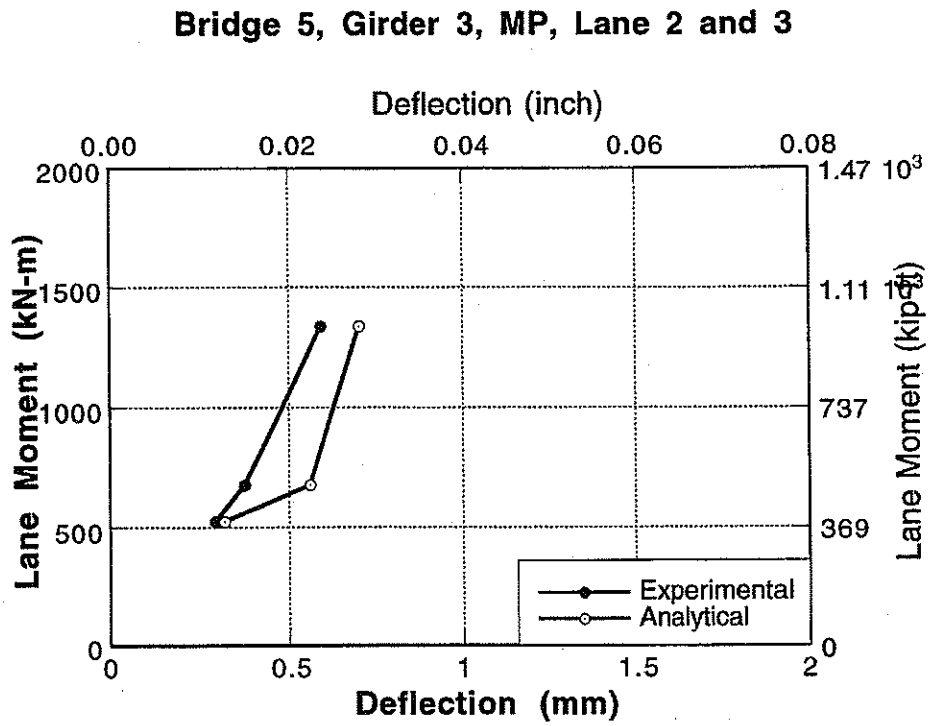


Figure A-171 : Experimental and Analytical Deflections for Bridge No. 5, Girder 1 and 2 for Lane 2 and 3 Loading.



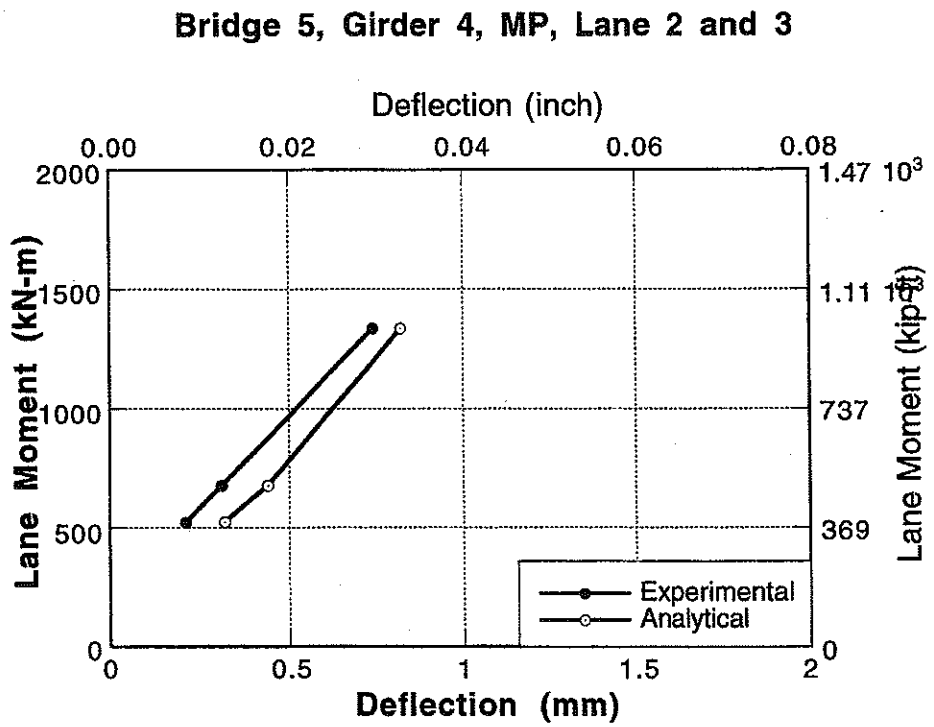
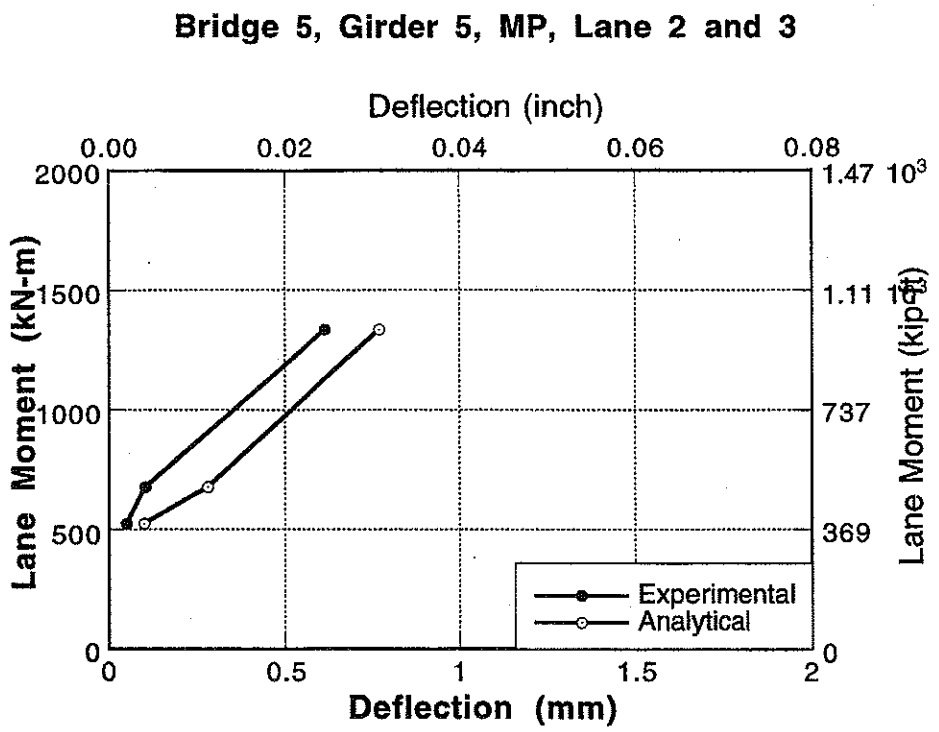


Figure A-172 : Experimental and Analytical Deflections for Bridge No. 5, Girder 3 and 4 for Lane 2 and 3 Loading.



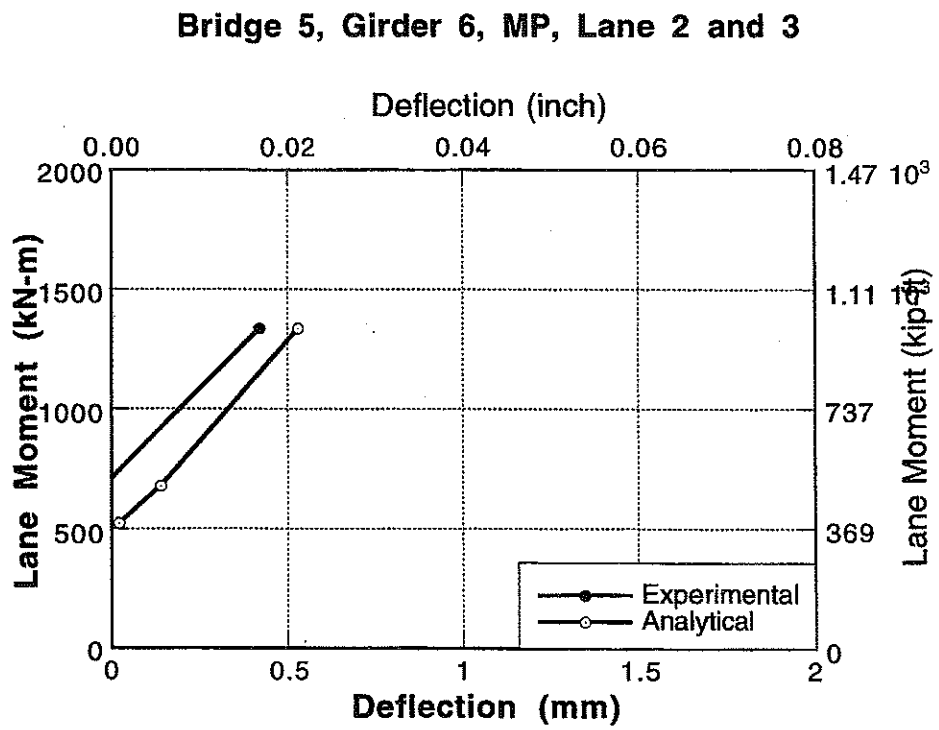
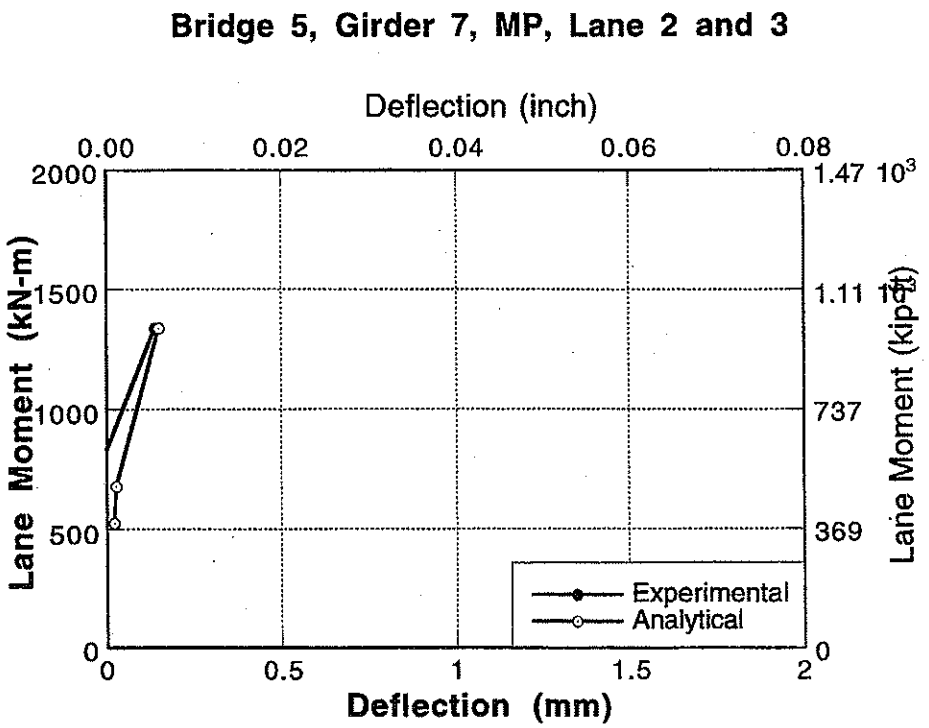


Figure A-173 : Experimental and Analytical Deflections for Bridge No. 5, Girder 5 and 6 for Lane 2 and 3 Loading.



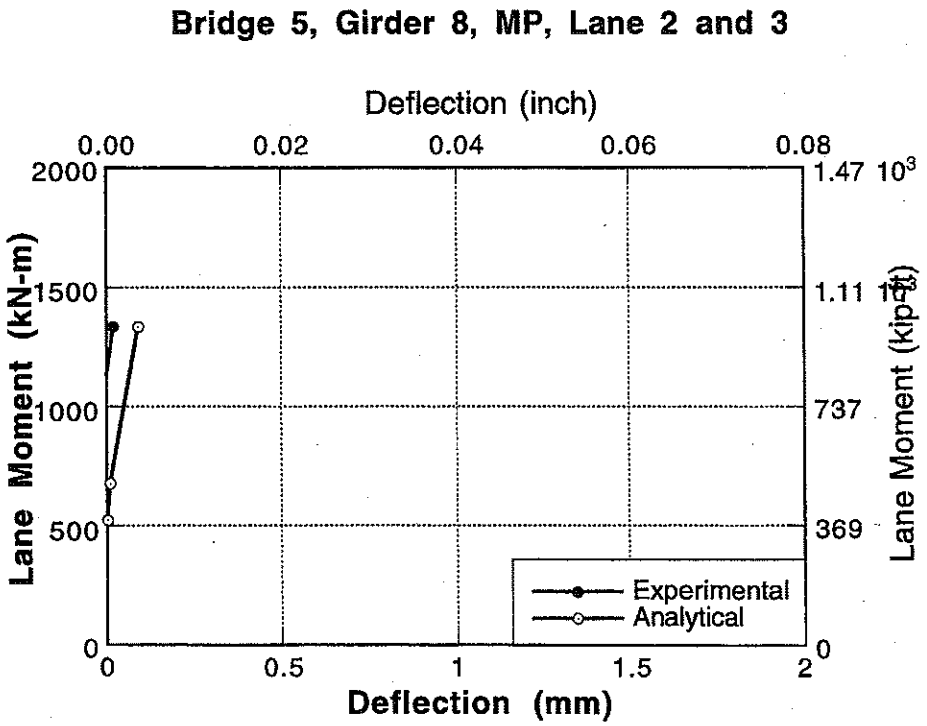


Figure A-174 : Experimental and Analytical Deflections for Bridge No. 5, Girder 7 and 8 for Lane 2 and 3 Loading.

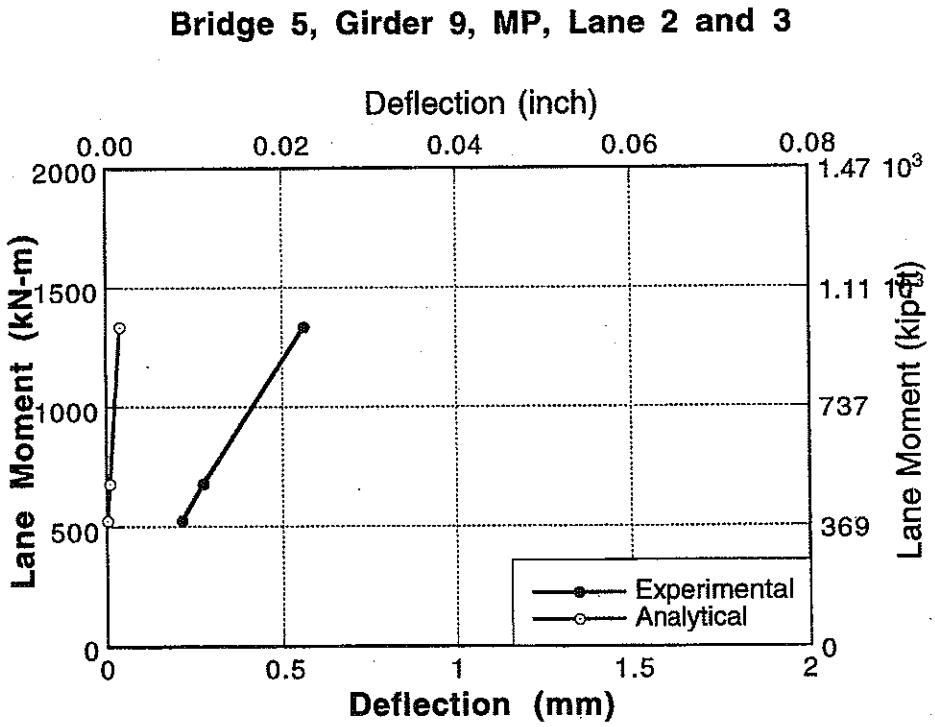
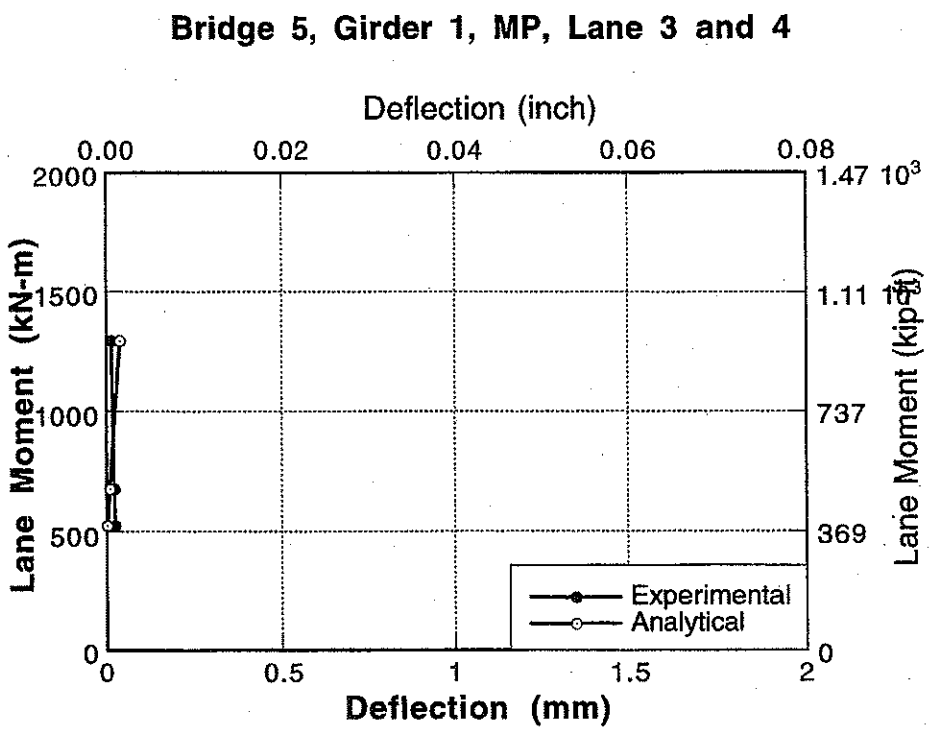


Figure A-175 : Experimental and Analytical Deflections for Bridge No. 5, Girder 9 for Lane 2 and 3 Loading.



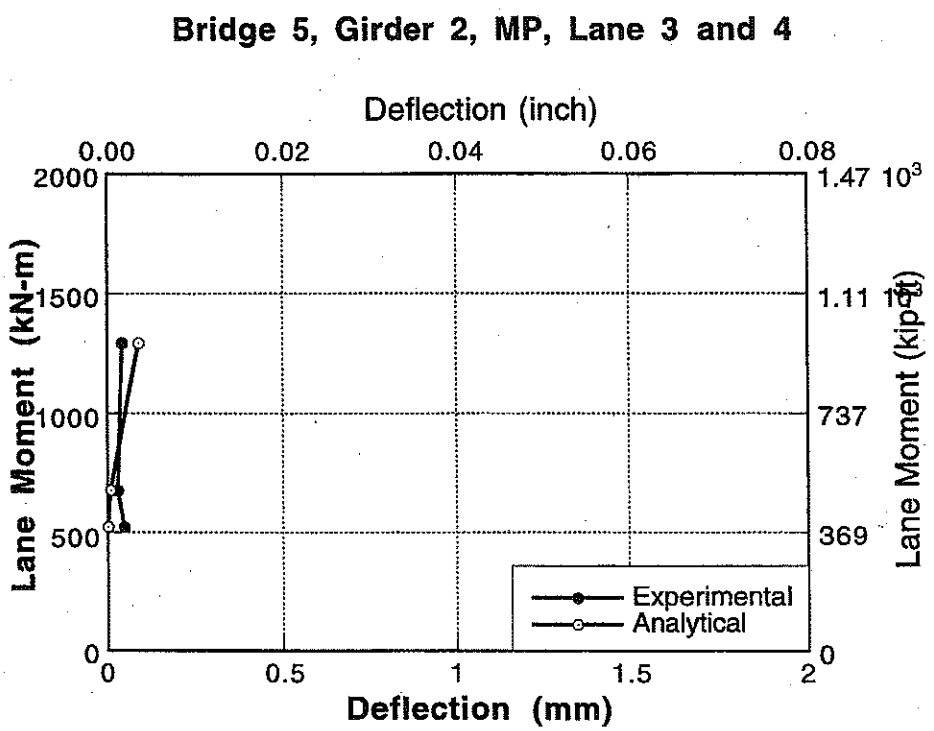
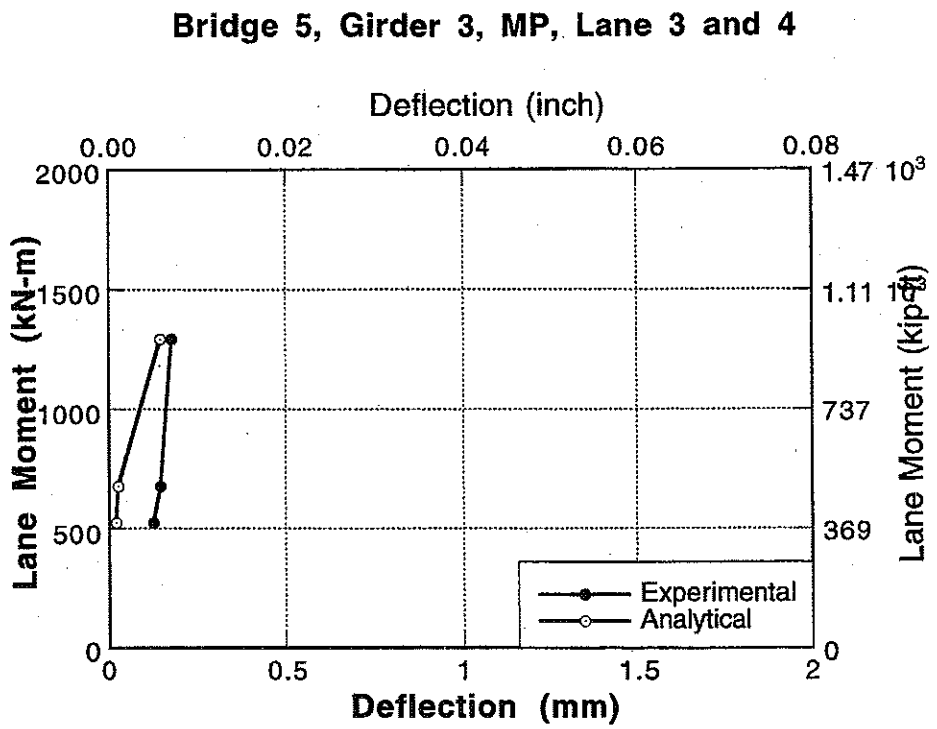


Figure A-176 : Experimental and Analytical Deflections for Bridge No. 5, Girder 1 and 2 for Lane 3 and 4 Loading.



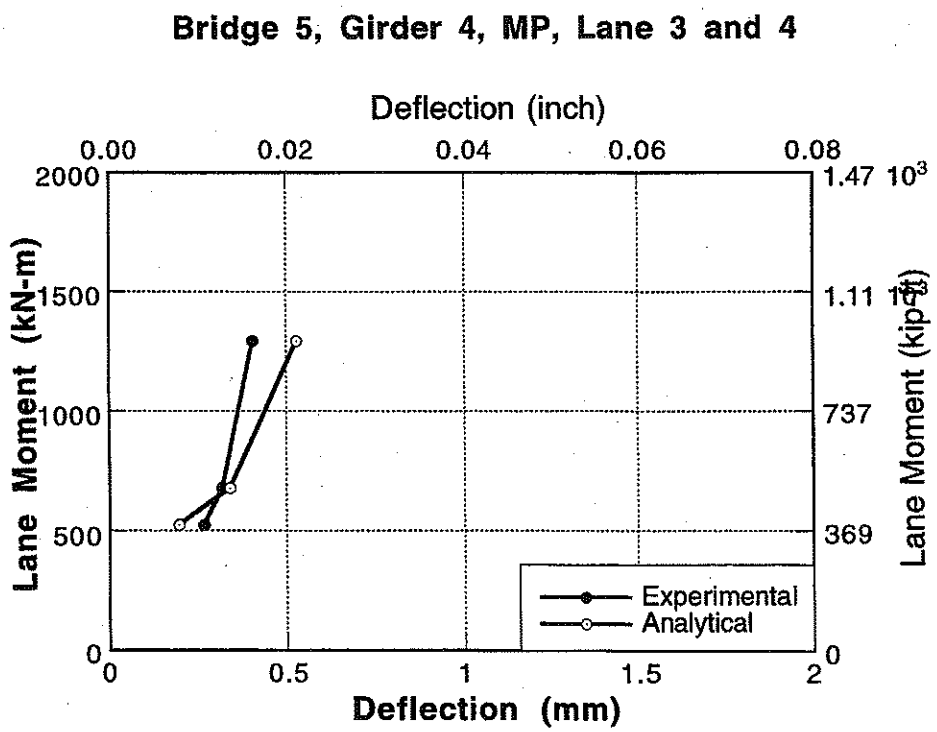
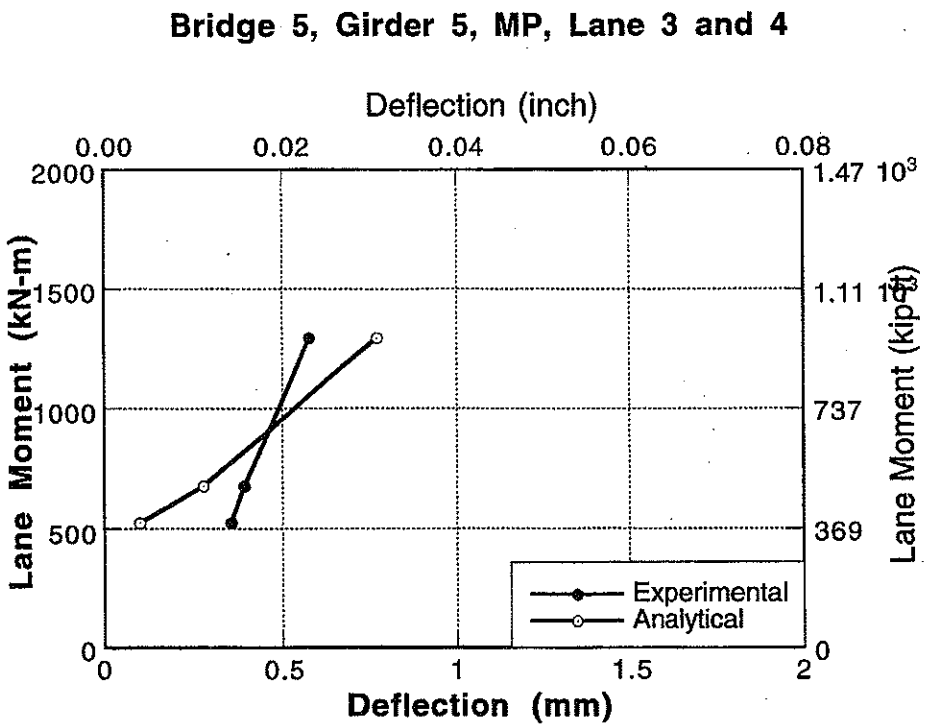


Figure A-177 : Experimental and Analytical Deflections for Bridge No. 5, Girder 3 and 4 for Lane 3 and 4 Loading.



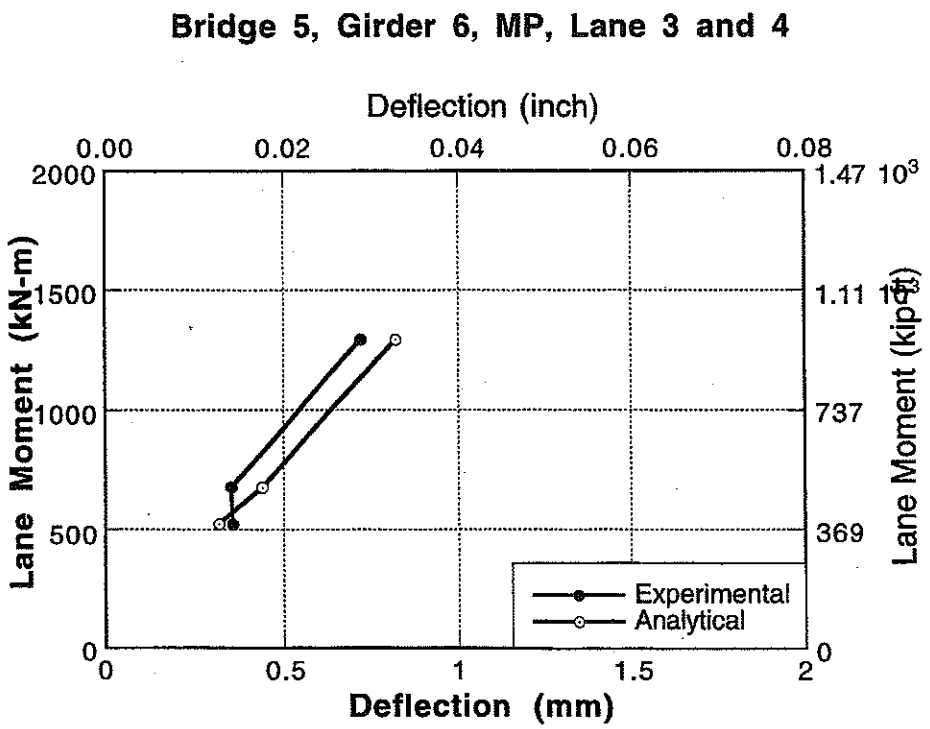
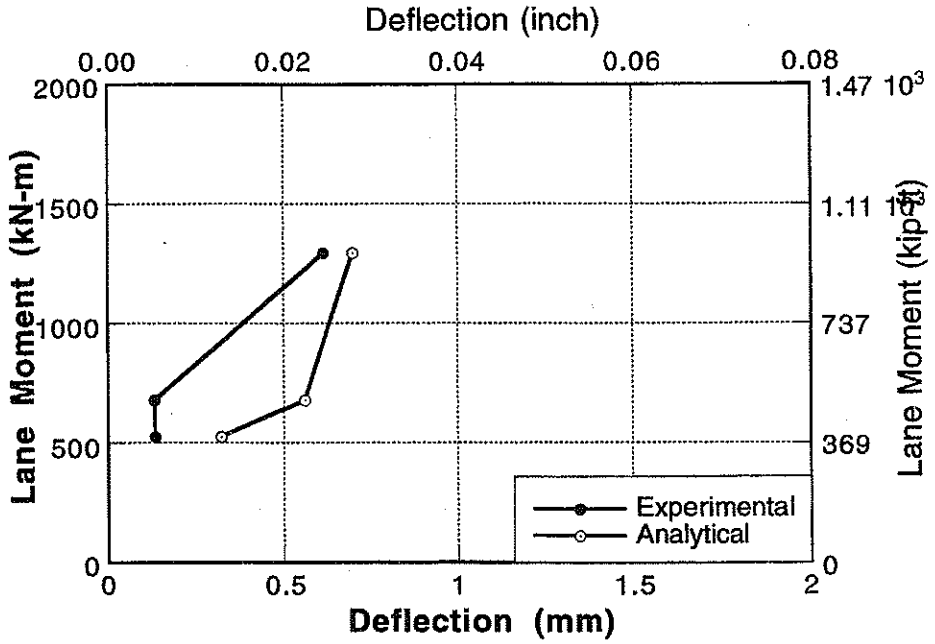


Figure A-178 : Experimental and Analytical Deflections for Bridge No. 5, Girder 5 and 6 for Lane 3 and 4 Loading.

Bridge 5, Girder 7, MP, Lane 3 and 4



Bridge 5, Girder 8, MP, Lane 3 and 4

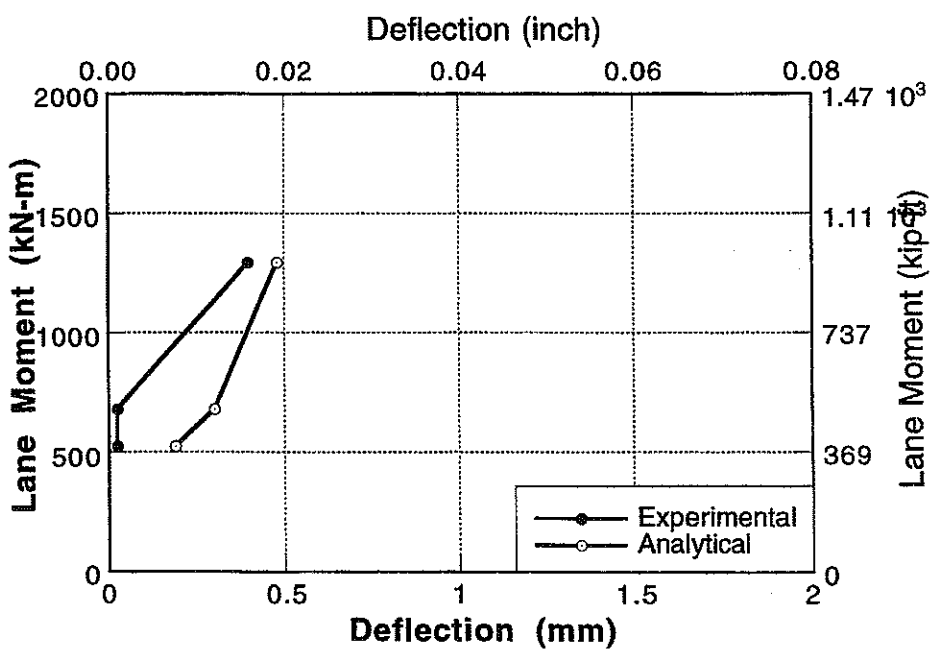


Figure A-179 : Experimental and Analytical Deflections for Bridge No. 5, Girder 7 and 8 for Lane 3 and 4 Loading.

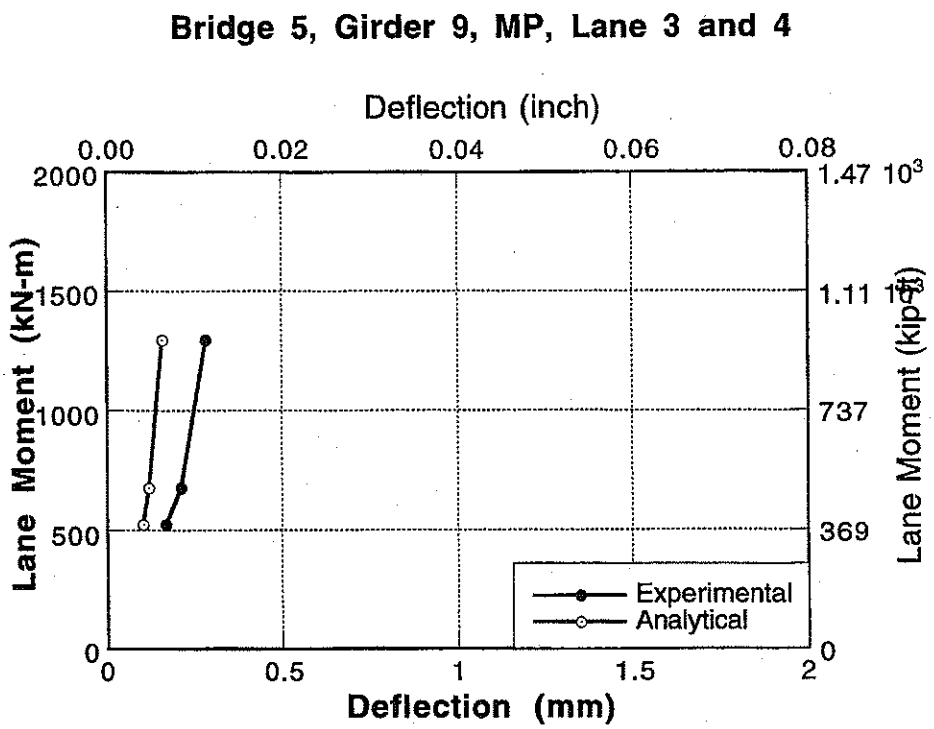
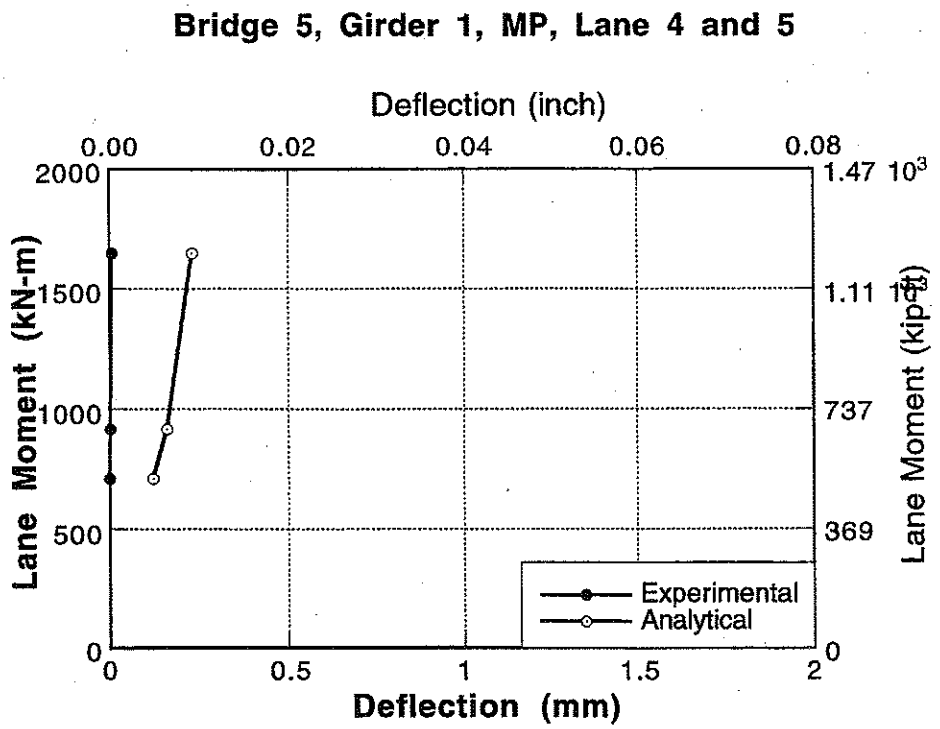


Figure A-180 : Experimental and Analytical Deflections for Bridge No. 5, Girder 9 for Lane 3 and 4 Loading.



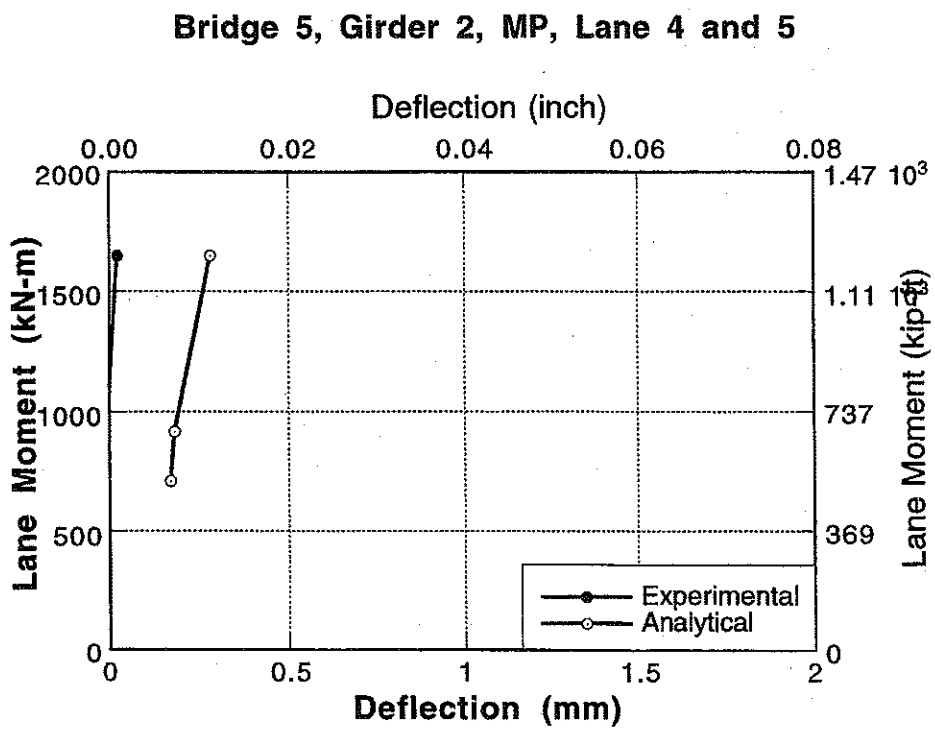
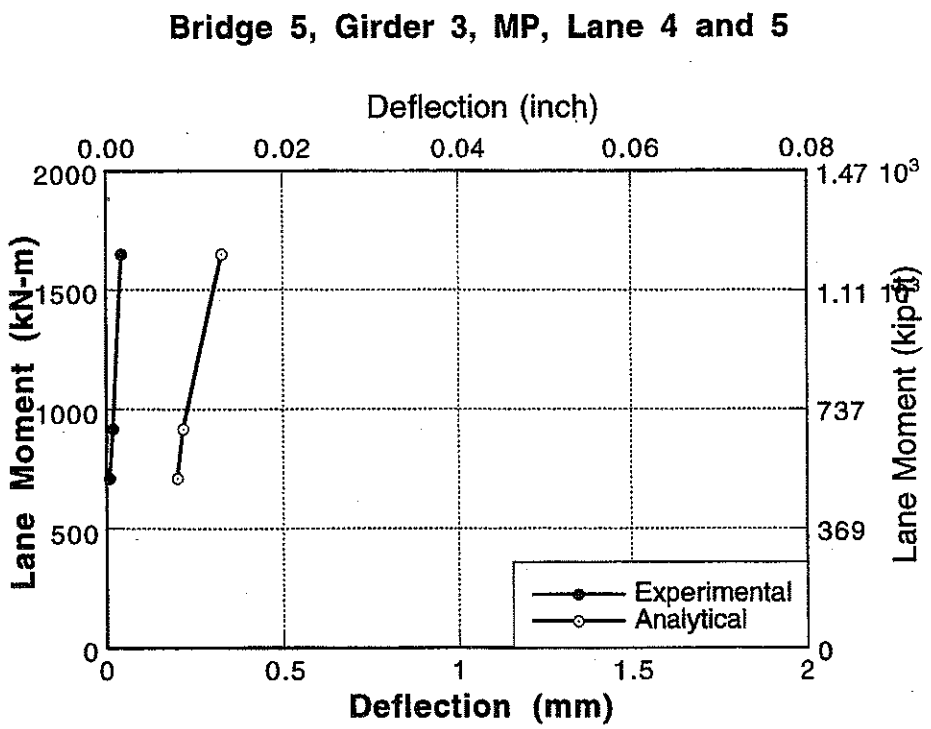


Figure A-181 : Experimental and Analytical Deflections for Bridge No. 5, Girder 1 and 2 for Lane 4 and 5 Loading.



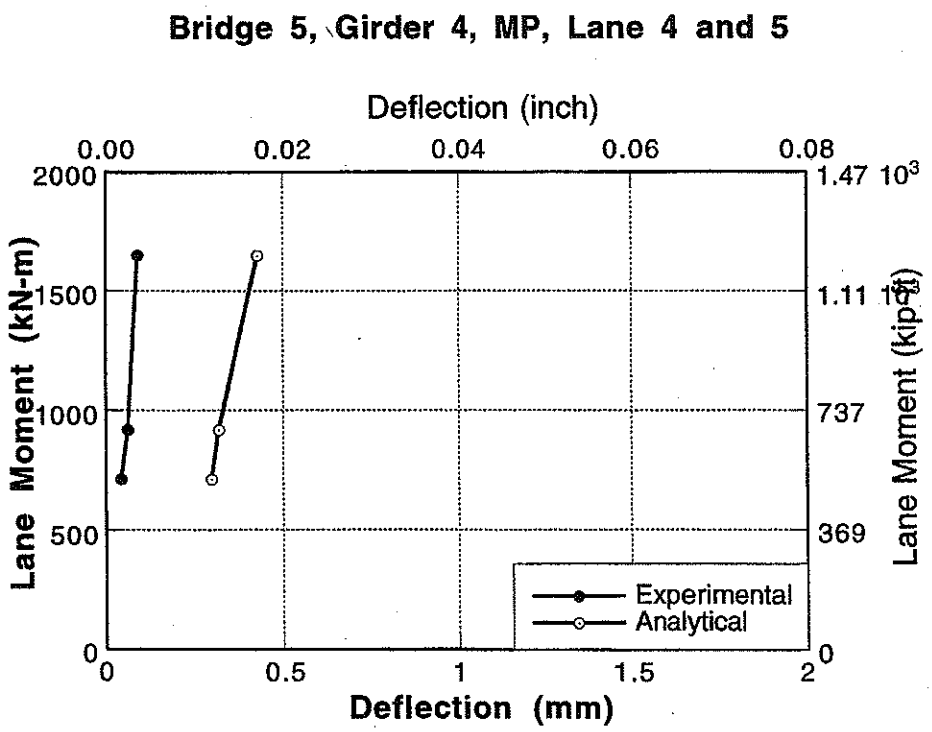
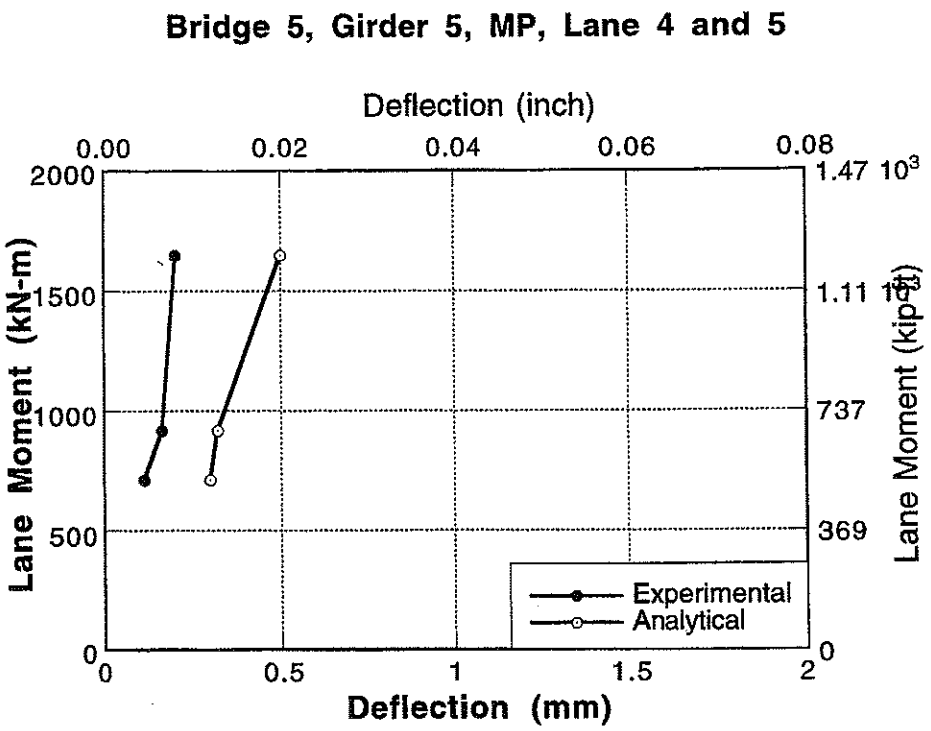


Figure A-182 : Experimental and Analytical Deflections for Bridge No. 5, Girder 3 and 4 for Lane 4 and 5 Loading.



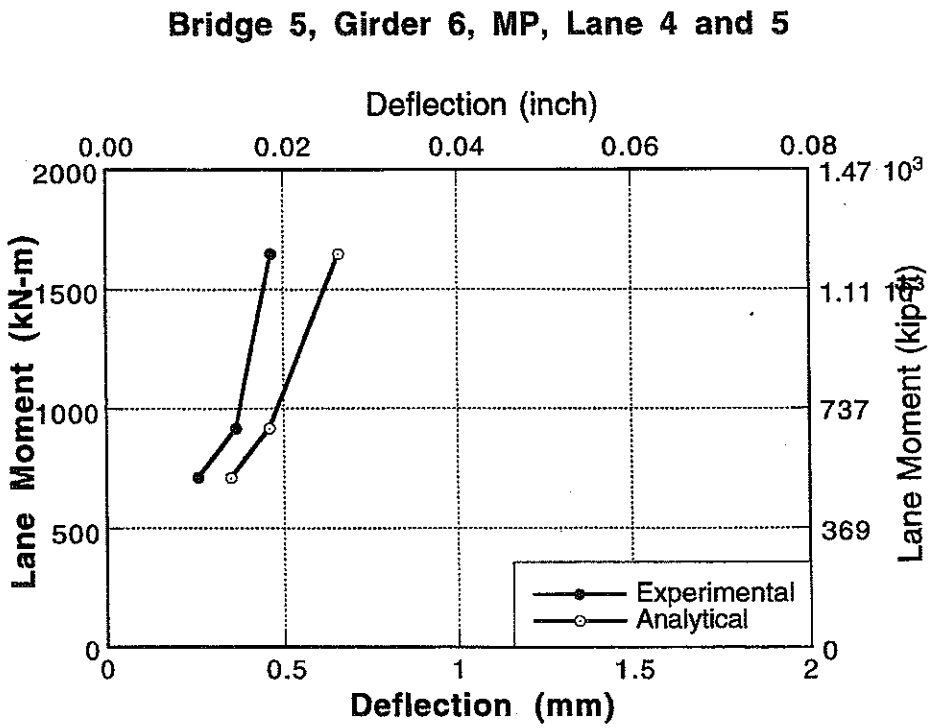
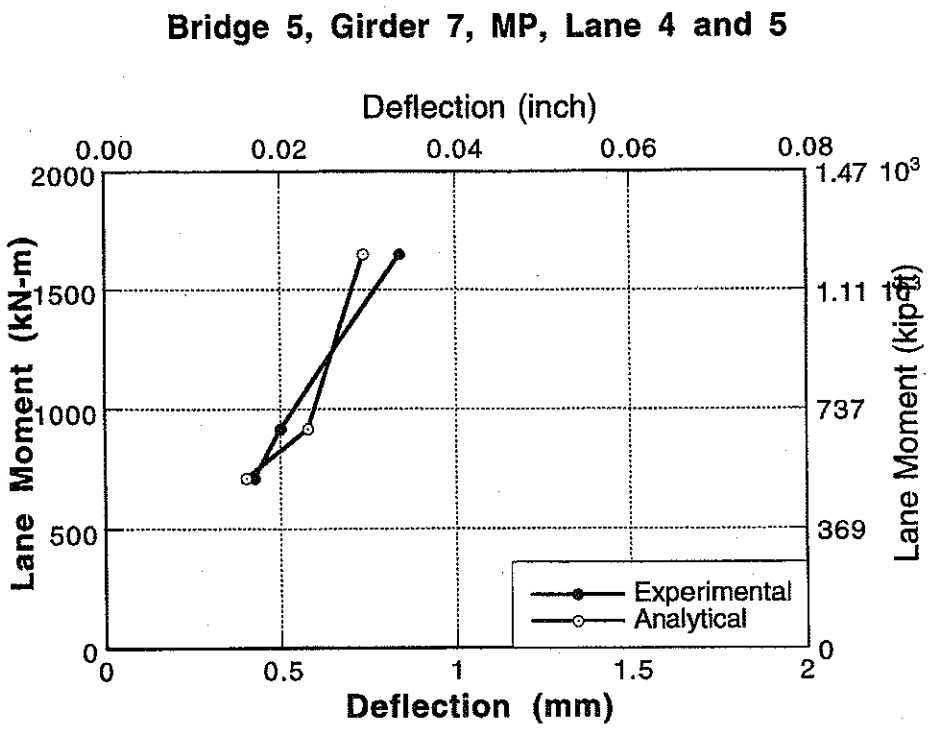


Figure A-183 : Experimental and Analytical Deflections for Bridge No. 5, Girder 5 and 6 for Lane 4 and 5 Loading.



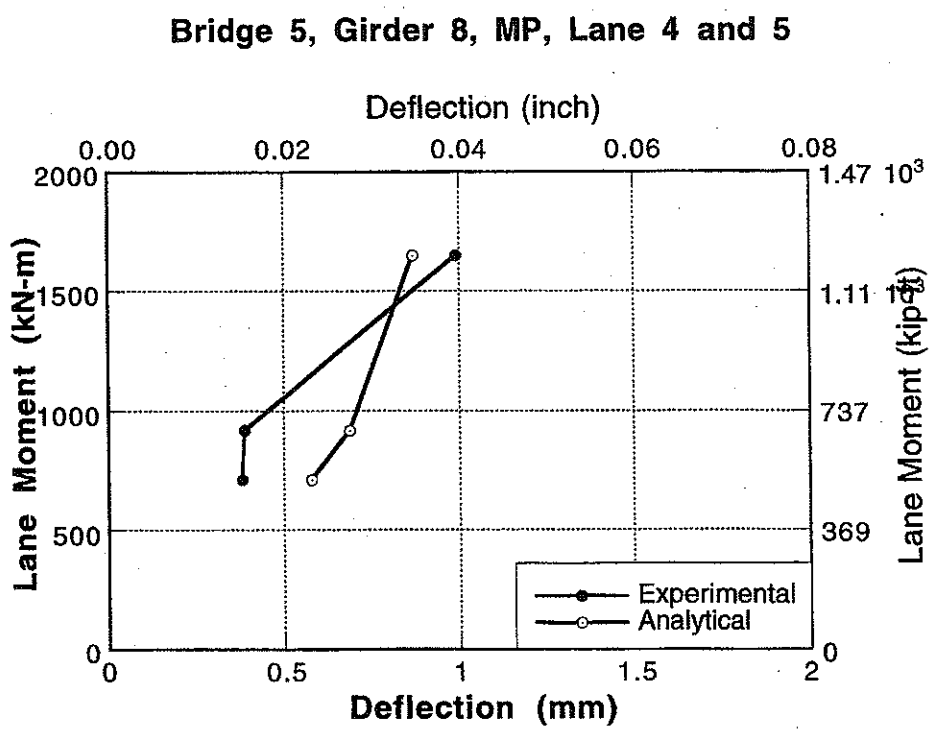


Figure A-184 : Experimental and Analytical Deflections for Bridge No. 5, Girder 7 and 8 for Lane 4 and 5 Loading.

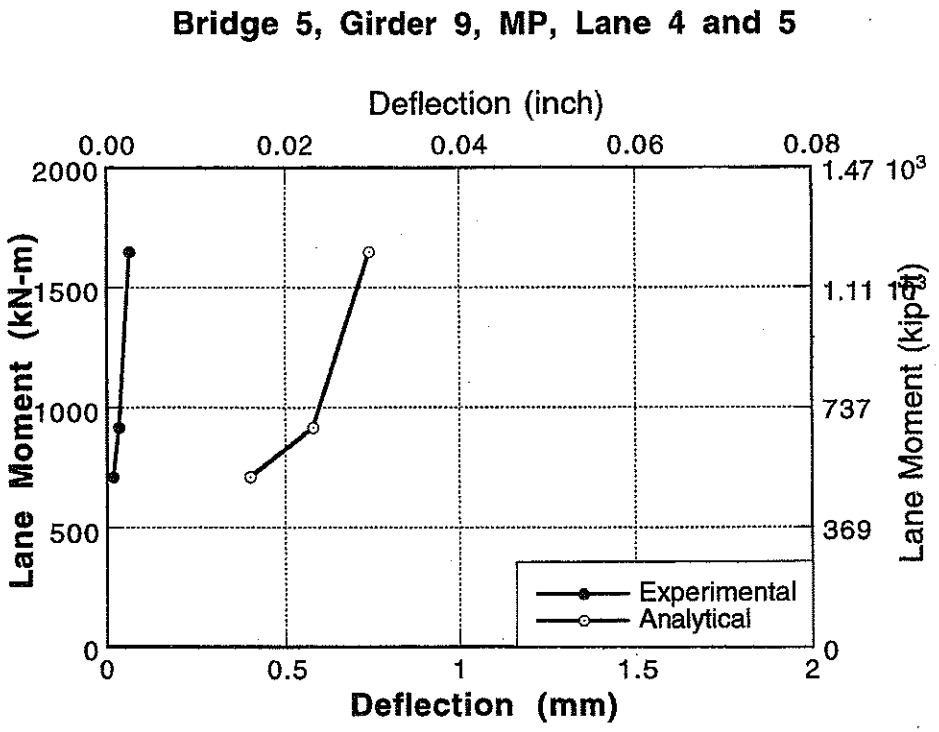


Figure A-185 : Experimental and Analytical Deflections for Bridge No. 5, Girder 9 for Lane 4 and 5 Loading.

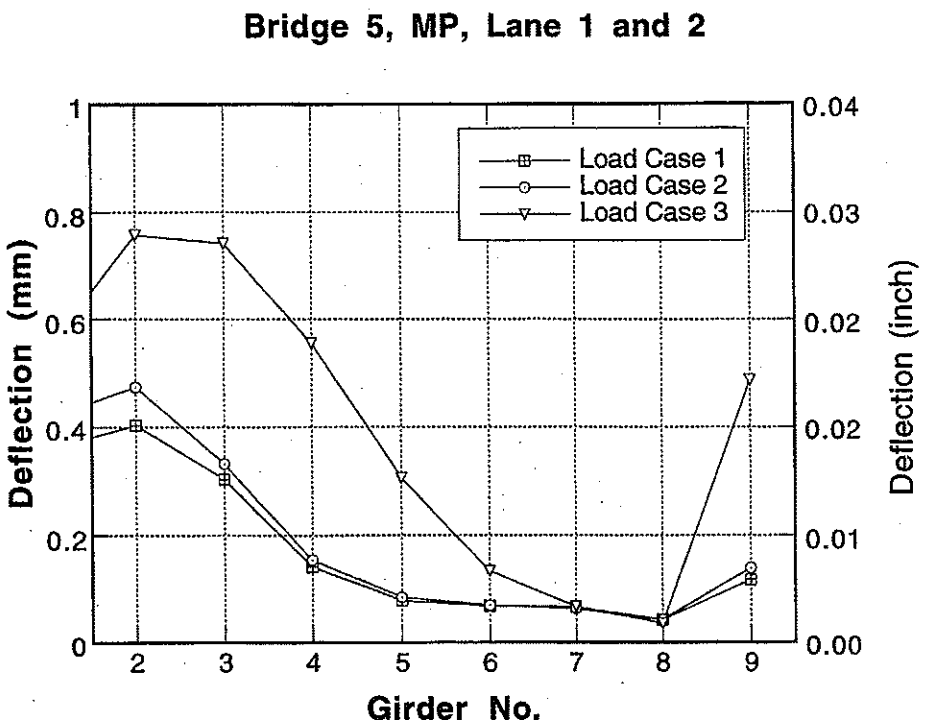


Figure A-186: Girder Distribution of Deflections for Bridge No. 5 due to Loading in Lane 1 and 2.

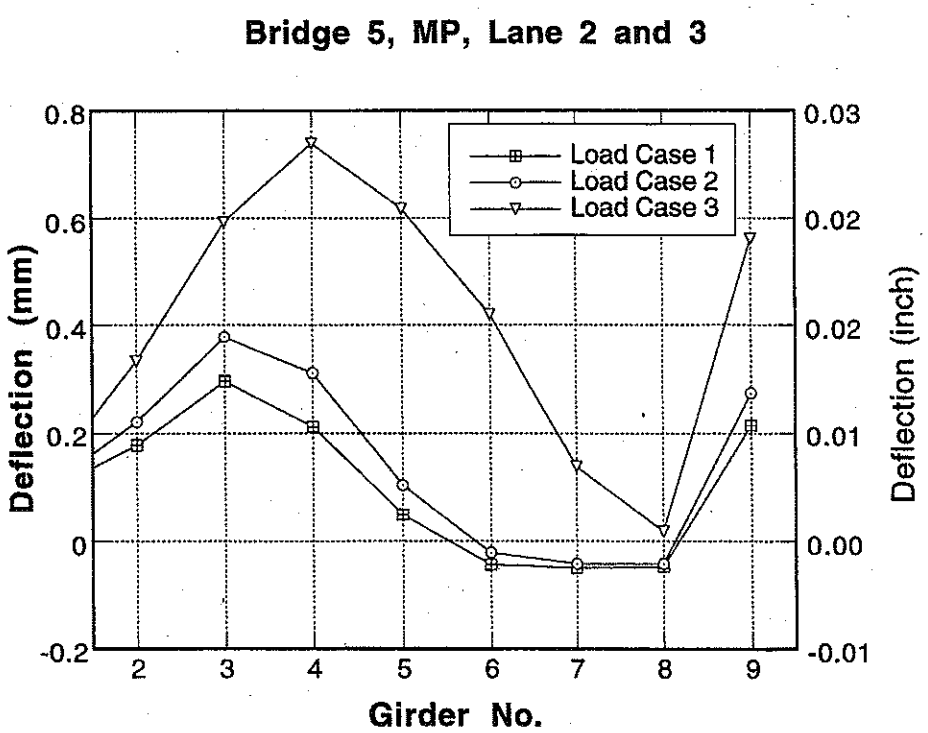


Figure A-187 : Girder Distribution of Deflections for Bridge No. 5 due to Loading in Lane 2 and 3.

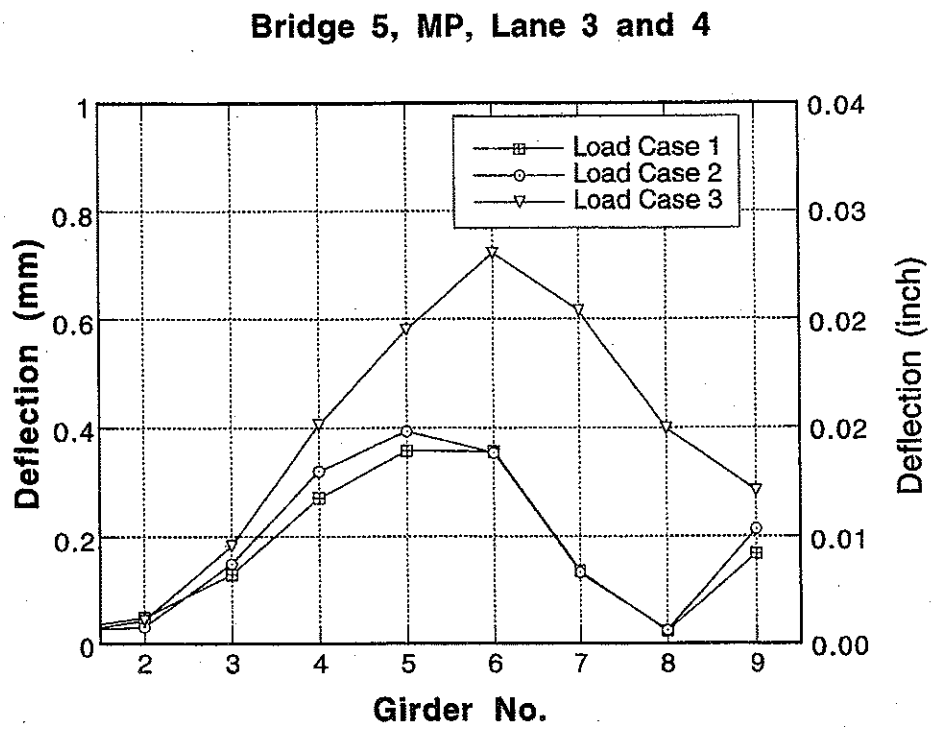


Figure A-188 : Girder Distribution of Deflections for Bridge No. 5 due to Loading in Lane 3 and 4.

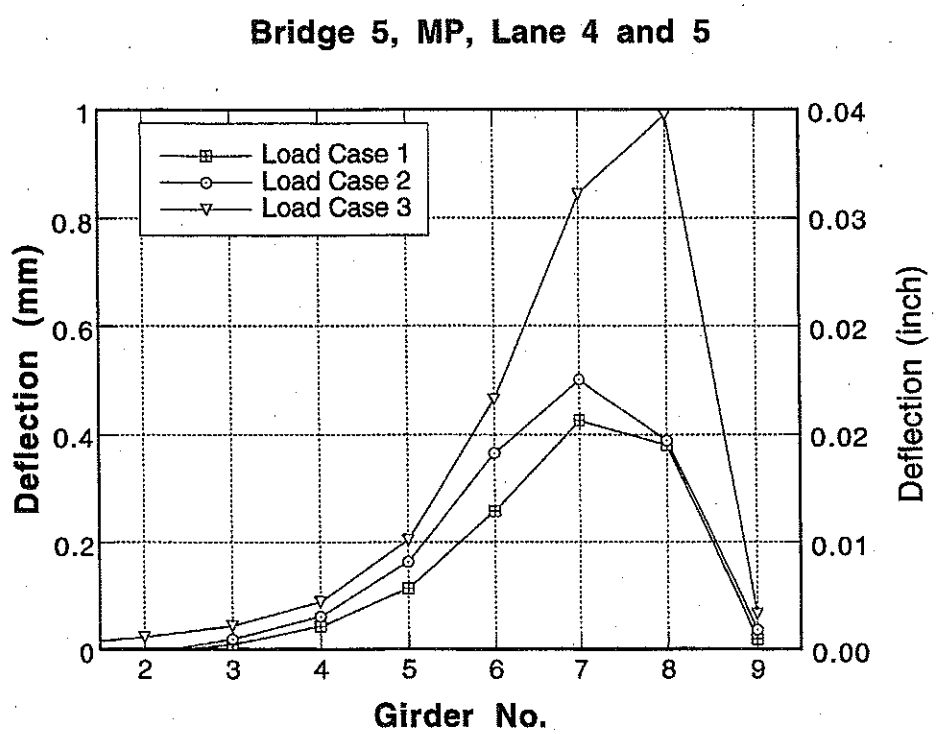


Figure A-189 : Girder Distribution of Deflections for Bridge No. 5 due to Loading in Lane 4 and 5.

APPENDIX F - Miscellaneous / Hand Calculations

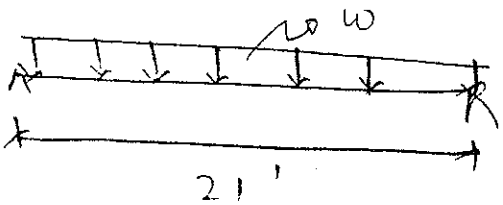
This contain:

- Tank and trailer weight information from the Michigan National Guard.
- Calculations for height of water tank.
- Effect of wider tank tracks.
- Information about SECAN
- Bridge No. 1 - Computer and Hand Calculations
- Bridge No. 2 - Computer and Hand Calculations
- Bridge No. 3 - Computer and Hand Calculations
- Bridge No. 4 - Computer and Hand Calculations
- Bridge No. 5 - Computer and Hand Calculations

Calculation for required height of water tank.

Bridge # 1

$$M_{target} = 383.64 \text{ k-ft}$$



$$w = \frac{383.64 \times 8}{(21)^2} = 6.95 \text{ k/ft}$$

say lane width = 12' $\Rightarrow$ w = 0.579 k/ft

$$\text{required height} = \frac{0.579}{(\text{density of water})} = \frac{0.579}{(62 \times 10^{-3})}$$

$$= 9.34 \text{ ft.}$$

Effect of wide tank track:

SECAN was used to analyze the structure. Bridge #1 was selected for this study. One M-60 tank and one 11-axle truck was placed in the maximum load position. Results are shown on next page

	Moment			
Girder	Tank		11-Axle	
No.	Composite	Noncomposite	Composite	Noncomposite
1	339.7	388.3	176.1	261.8
2	452.1	659.2	335.8	505.7
3	935.5	1024	710	791.5
4	1538	1401	1143	1053
5	1790	1587	1456	1211
6	1790	1587	1456	1211
7	1540	1401	1144	1053
8	936.5	1024	711.1	791.6
9	452.7	658.8	336.2	505.3
10	340.2	386.1	176.3	259.9
Σ	10114.7	10116.4	7644.5	7643.8
	Girder Distribution Factors			
Girder	Tank		11-Axle	
No.	Composite	Noncomposite	Composite	Noncomposite
1	0.03	0.04	0.02	0.03
2	0.04	0.07	0.04	0.07
3	0.09	0.10	0.09	0.10
4	0.15	0.14	0.15	0.14
5	0.18	0.16	0.19	0.16
6	0.18	0.16	0.19	0.16
7	0.15	0.14	0.15	0.14
8	0.09	0.10	0.09	0.10
9	0.04	0.07	0.04	0.07
10	0.03	0.04	0.02	0.03
Σ	1	1	1	1

USER MANUAL FOR COMPUTER PROGRAM

SECAN

SEMI-CONTINUUM METHOD OF ANALYSIS FOR BRIDGES

by

A.A.Mufti, B.Bakht, K.Mahesparan and L.G.Jaeger

MINISTRY OF TRANSPORTATION OF ONTARIO
RESEARCH AND DEVELOPMENT
STRUCTURES OFFICE

January 1992

Technical Report Documentatin Page

User Manual For Computer Program
Secan
Semi-Continum Method of Analysis for Bridges

Author(s): A.A.Mufti, B.Bakht, K.Mahesparan and L.G.Jaeger

Number:
Date of

Publication: May 1989

Ministry
Contract: B.Bakht

Participating
Agency or
Client

Abstract:

Over the past several years, Jaeger and Bakht have published extensively on the various aspects of the semi-continuum method of analysis. For this method, a bridge is idealized as an assembly of parallel beams interconnected by a transverse continuum. It has been demonstrated several times that despite the fact that it requires only a fraction of the computing power required by the grillage analogy method, the semi-continuum method gives results of comparable, even superior accuracy.

Research on the development of the semi-continuum method of analysis has led to three computer programs, namely SECAN1, SECAN2, and SECAN3. SECAN1 analyses single span bridges; SECAN2 analyses continuous span bridges and bridges with random intermediate supports; and SECAN3 is the same as SECAN1 except that it can handle the finite shear rigidity of the transverse medium. These programs were written as "research programs" without particular attention paid to the format of input and output.

All the three programs mentioned above have now been merged into a single multi-purpose program called SECAN. Despite the general nature of the combined program, the input, which has now been made conversational, still remains extremely simple requiring

typically only a few minutes work from the engineer for analyzing a bridge. Unlike the previous programs, the new program can now handle several load cases at a time.

Graphic facility has been added to the program to enable the drawing of the planform of the bridge showing the locations of loads. The program can also plot the distribution profiles of various responses of the bridge at specified transverse sections.

Results of a test on a bridge with steel girders and transverse timber decking are compared with those given by SECAN. The excellent comparison of the two sets of results demonstrates the accuracy of this program. The SECAN program is in the public domain and can be obtained without any charge.

Comments:
Key Words: Semicontinum Method, SECAN
Distribution:
Copyright
Status

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1/ Introduction

The name of the program, SECAN is an acronym derived from SEmi-Continuum ANalysis. This program can analyze right, simply supported bridges, transversely shear-weak simply supported bridges, continuous span bridges and bridges with random intermediate supports for lateral load distribution by the semi-continuum method. The program can be run on an IBM personal computer.

SECAN is based upon the semi-continuum method developed by Jaeger and Bakht (1,2,3,4,5,6 and 7). The method takes into account of nonzero values of torsional rigidities in both longitudinal and the transverse directions. Further, it can deal with girders of unequal flexural and torsional rigidities at unequal spacings.

The program can analyse several bridges with many load cases at a time, it can plot the planform of the bridge showing the locations of loads and the transverse profiles of longitudinal moments, longitudinal shears and deflections at specified transverse sections.

In the following chapters, instructions for data input, description of the output and instructions to run SECAN are presented. Several examples with input data sheet and computer output are given in Appendix I. Description of the variables used in the program is given in Appendix II, and the listings of the program in FORTRAN V and description of subroutines in Appendix III.

2/ Input Data Instructions

The input data required to run the program are described below. All the data, which are divided into 19 sets as follow, should be stored in SECAN.DAT file.

1. Number of bridges -- NB (max.5)

2. Control number (K) = 2 if intermediate results are required otherwise 1
   Title of problem (52 characters)

3. Number of harmonics -- N (max. 5)
   Number of girders -- NG(max. 20)
   Span Length -- SPAN
   Modulus of elasticity of the material of girders -- E
   Shear Modulus of the material of girders -- G
   Number of intermediate supports -- NCOL (max. 10)

4. Girder spacings -- GS (Starting from the left hand girder)

5. Moment of inertia of all girders -- GMI (Starting from the left hand girder)
   (Composite moment of inertia should be given if the girders are composite)

6. Torsional inertia of all girders -- GTI (Starting from the left hand girder)

7. Slab thickness -- T
   Modulus of elasticity of slab material -- EC
   Shear modulus of slab material -- GC
   Equivalent shear area /unit length -- SA (To be given as 0.0 if shear deformations are not to be considered)

8. (Not required if No. of supports is zero)
   Prescribed deflections at intermediate supports -- DELTA
   (To be given in ascending order of support identification numbers)
   The same number of entries is required, even if the numbers are zero, as the number of intermediate supports.

9. (Not required if No. of supports is zero)
   Flexibilities of intermediate supports -- FF (length per unit force)
   (In the same order as the entries in record 8)

10. (Not required if No. of supports is zero)
    Girder numbers under which each intermediate support is located -- KGIR
    (In the same order as entries in record 8)

11. (Not required if No. of supports is zero)
    Distances of intermediate supports from the left-hand abutment --XCOL
    (In the same order as entries in records 8 through 10)

12. Number of load cases -- NL (max. 5)

13. Number of concentrated load in one longitudinal line -- M (max. 7)

14. Magnitudes of M concentrated loads in one longitudinal line starting from the load closest to the left-hand simple support -- W

15. Distances of M concentrated loads in one longitudinal line from the left-hand simple support -- DLS

16. Number of longitudinal lines of concentrated loads -- NW (max. 10)

17. Transverse distances of NW longitudinal lines of concentrated loads from the outer left-hand girder -- DLG

18. Number of transverse reference sections -- NREF (max. 10)

19. Distances of NREF reference sections from the left-hand abutment -- XREF

It is noted that all the input data should be in compatible set of units. The data input sheet for SECAN is given in Figure 1 together with the limits of the various variables.

Repeat sets 13-19 NL times for different load cases
Repeat sets 2-19 NB times for different bridges

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Chapter 9.
Sec 9.2.2 P23

1.

No. of bridges (max. 5)

2.

Control No.	Title max. 52 characters

Control No. = 2 for diagnostic printing.
Otherwise = 1

3.

No. of harmonics (max. 5)	No. of girders (max. 20)	Span length	E of girder material	G of girder material	No. of inter. supports (max. 10)
	10				

4. Girder spacings, starting from left

5. Moment of inertia of girders, starting from left

6. Torsional inertia of girders, starting from left

7.

Slab thickness	E of slab material	G of slab material	Equivalent shear area

8. Prescribed deflections at intermediate supports

9. Flexibility of intermediate supports (in the same order as No. 8 above)

10. Girder No. under which each intermediate support is located (in the same order as No. 8 above)

11. Distances of each intermediate support from the left-hand abutment (in the same order as No. 8 above)

12.

No. of load cases (max. 5)

13.

No. of loads in one long.-line (max. 7)

14. Weights of loads in one longitudinal line starting from left

15. Distances of loads in one longitudinal line from the left abutment

16. No. of lines of loads (max. 10)

17. Transverse distances of lines of loads from the outer left girder

18. No. of ref. sections (max. 10)

19. Distances of reference sections from the left-hand abutment

Notes : Sets 8-11 are not required if simply supported bridge

Repeat sets 13-19 NL times for different load cases

Repeat sets 2-19 NB times for different bridges

Figure 1/ Input data sheet

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3/ Limits of the Program

1. Maximum number of bridges = 5
2. Maximum number of girders = 20
3. Maximum number of load cases =5
4. Maximum number of loads in one longitudinal line = 7
5. Maximum number of longitudinal lines of loads = 10
6. Maximum number of transverse reference sections = 10

4/ Output Description

SECAN, besides echo-printing the input data with appropriate labels, provides the reactions at the intermediate supports and deflections, longitudinal moments, and longitudinal shears at the specified reference sections. If the control number is set equal to 2, the program also prints the various vectors and matrices for the different steps of calculations.

To run SECAN with graphic facility, the user need to type 0 otherwise 1. When the program runs, the user need to type 0 or 2 to display each graphs on screen or on plotter. All the results are stored in SECAN.RES.

5/ How to Run SECAN

SECAN has been developed to run on personnel computers having the following minimum characteristics:

Math coprocessor
DOS
H-Graph software (if graphs are required)

The user can develop a data file using text editor or wordprocesor. Once the data are saved in SECAN.DAT file, the user can enter at the DOS prompt.

c:\>SECAN

The program will process and the following messages will successively appear on the screen.
START
READING DATA
FINISHED READING DATA
START COMPUTING
(Note: The program will process for a few seconds depending upon the hardware configuration)

TYPE --0-- IF GRAPHS ARE REQUIRED
TYPE --1-- IF GRAPHS ARE NOT REQUIRED
(Note: Type 0 to run SECAN with graphic facility otherwise 1)

GRAPH1 : PLANFORM OF THE BRIDGE SHOWING THE LOCATIONS OF LOADS
TYPE --0-- TO DISPLAY ON SCREEN
TYPE --2-- TO DISPLAY ON PLOTTER
(Note: The graph is displayed on screen or plotter depending on user's option)

GRAPH2 : MOMENT DISTRIBUTION PROFILE AT SPECIFIED TRANSVERSE SECTIONS
TYPE --0-- TO DISPLAY ON SCREEN
TYPE --2-- TO DISPLAY ON PLOTTER
(Note: The graph is displayed on screen or plotter depending on user's option)

GRAPH3 : SHEAR DISTRIBUTION PROFILE AT SPECIFIED TRANSVERSE SECTIONS
TYPE --0-- TO DISPLAY ON SCREEN
TYPE --2-- TO DISPLAY ON PLOTTER
(Note: The graph is displayed on screen or plotter depending on user's option)

GRAPH4 : DEFLECTION DISTRIBUTION PROFILE AT SPECIFIED TRANSVERSE SECTIONS
TYPE --0-- TO DISPLAY ON SCREEN
TYPE --2-- TO DISPLAY ON PLOTTER
(Note: The graph is displayed on screen or plotter depending on user's option)

COMPUTING FINISHED

When the DOS prompt returns, the user can examine the output file called SECAN.RES.

6/ Example of SECAN analysis of an existing bridge and comparison with test

The Lord's bridge, located in the township of Brighton, is a single span, single lane bridge comprising a laminated timber decking on eight rolled steel girders. Each girders has a W460X74 section. The timber decking in which the laminates laid transversely, are nailed together, is 150 mm thick. The timber decking is nailed to timber "nailing strips" of 200X100 mm section. These strips, running longitudinally, are bolted to the top flanges of the steel girders. The cross-section and elevation of the bridge are shown in Figure 2.1. As shown in this figure, the bridge has a width of 5.32 m and a span of 9.67 m.

A test was performed to evaluate this bridge under the test loads. Results from this test are used to demonstrate the validity of SECAN.

Distribution factors (DF), being the ratios of the actual and average girder responses, provide a non-dimensional measure of the load distribution characteristics of a girder bridge. The transverse distributions of DF for measured girder deflections at the midspan, are compared in Figure 2.2 and 2.3 for both eccentric and central loads by those obtained by SECAN. The comparisons given in Figure 2.2 and 2.3 confirm that SECAN, hence the semi-continuum method of analysis, can predict reliably the load distribution characteristics of a given bridge.The input data are shown in Figure 2.4.

SECAN graphic output, showing the planform of the bridge and the transverse distribution profiles of various responses at specified transverse section are given in Figures 2.4 through 2.12. The data points in the distribution profiles are discrete points; they are connected, however, in these figures by parabolic function to improve the readability. The output from the program follows the figures.

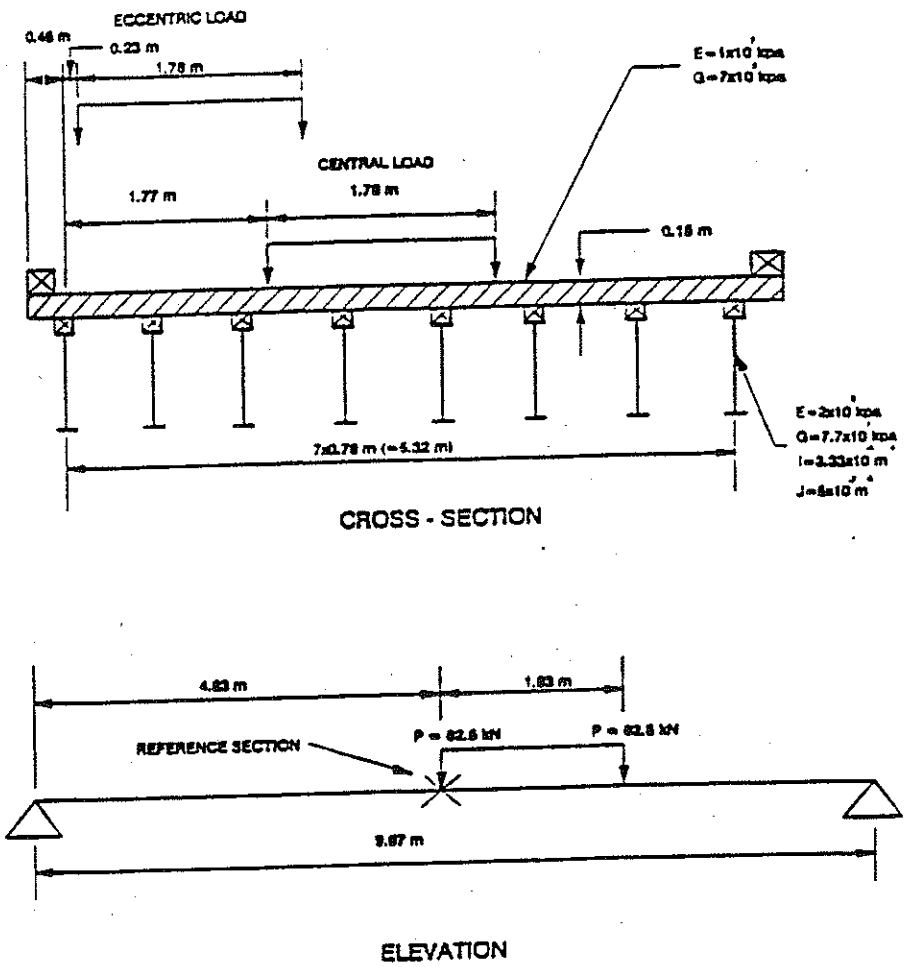


Figure 2.1/ Details of a Bridge and Loading used in Example 1

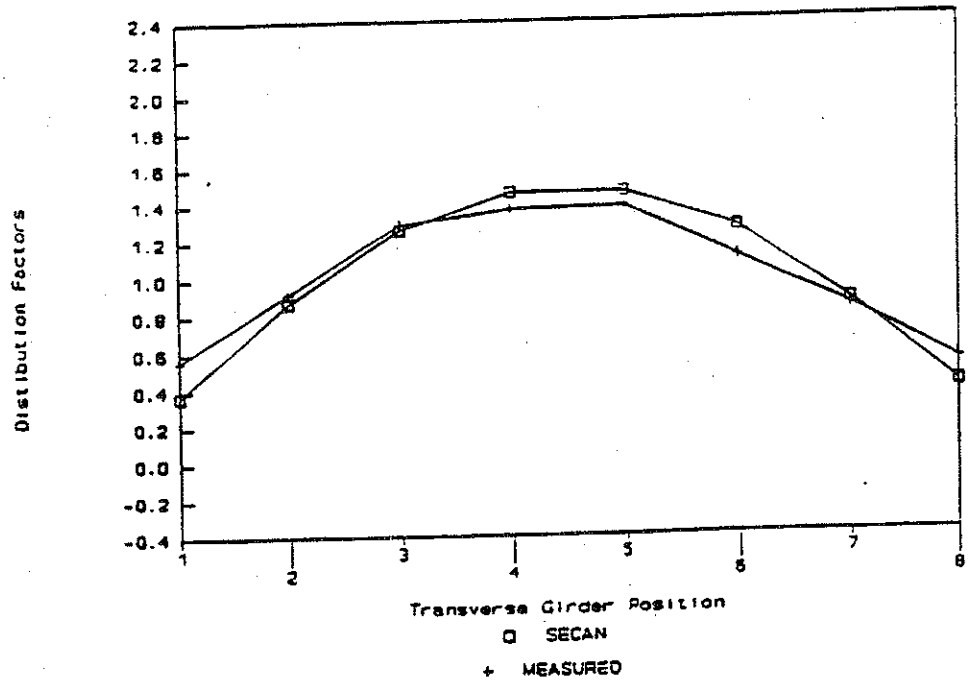


Figure 2.2/ Distribution Factors for Midspan Deflections (Central Load)

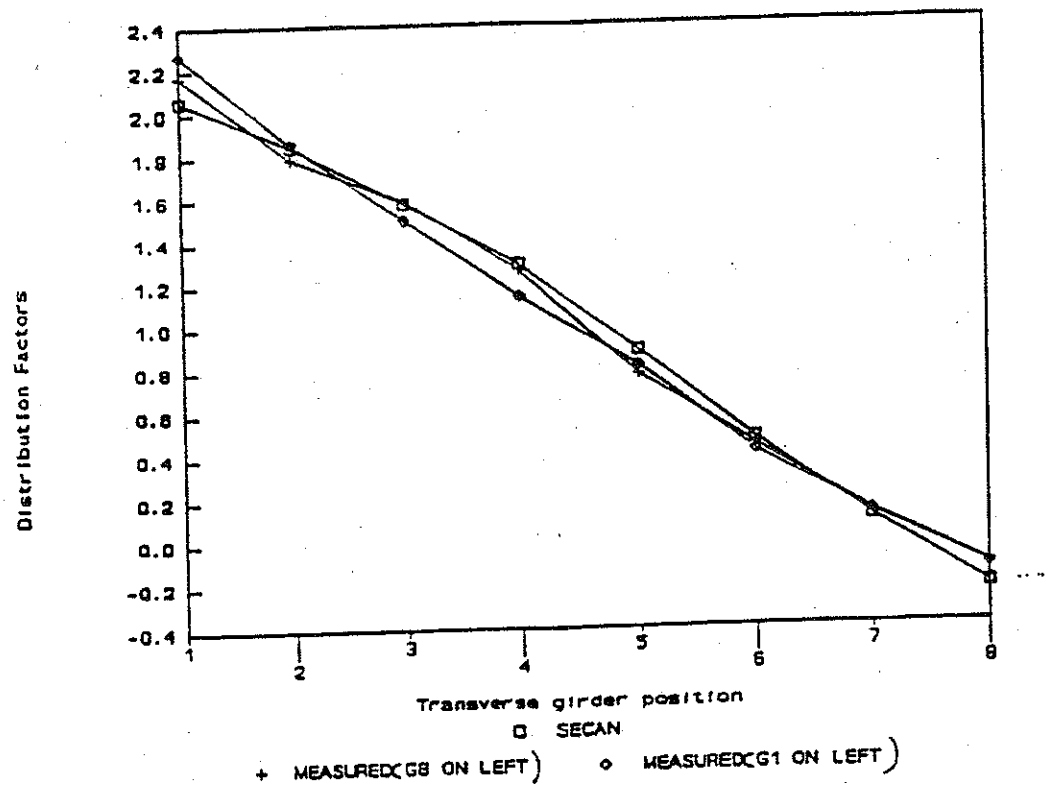


Figure 2.3/ Distribution Factors for Midspan Deflection (Eccentric load)

1.

No. of bridges (max. 5)
1

2.

Control No.	Title max. 52 characters
1	Example 1 (Lords Bridge)

Control No. = 2 for diagnostic printing. Otherwise = 1

3.

No. of harmonics (max. 5)	No. of girders (max. 20)	Span length	E of girder material	G of girder material	No. of inter. supports (max. 10)
5	8	9.67	200E6	77E6	0

4.

Girder spacings, starting from left								
0.76	0.76	0.76	0.76	0.76	0.76	0.76		

5.

Moment of inertia of girders, starting from left									
333E-6	333E-6	333E-6	333E-6	333E-6	333E-6	333E-6	333E-6		

6.

Torsional inertia of girders, starting from left									
5E-7	5E-7	5E-7	5E-7	5E-7	5E-7	5E-7	5E-7		

7.

Slab thickness	E of slab material	G of slab material	Equivalent shear area
0.15	10E6	7E5	0.

12.

No. of load cases (max. 5)
2

13.

No. of loads in one long.-line (max. 7)
2

14.

Weights of loads in one longitudinal line starting from left						
82.5	82.5					

15.

Distances of loads in one longitudinal line from the left abutment						
4.83	6.66					

16.

No. of lines of loads (max. 10)
2

17.

Transverse distances of lines of loads from the outer left girder									
1.77	3.53								

18.

No. of ref. sections (max. 10)
1

19.

Distances of reference sections from the left-hand abutment									
4.835									

13.

No. of-loads in one long.-line (max. 7)
2

14.

Weights of loads in one longitudinal line starting from left						
82.5	82.5					

15.

Distances of loads in one longitudinal line from the left abutment						
4.83	6.66					

16.

No. of lines of loads (max. 10)
2

17.

Transverse distances of lines of loads from the outer left girder									
0.39	2.19								

18.

No. of ref. sections (max. 10)
1

19.

Distances of reference sections from the left-hand abutment									
4.835									

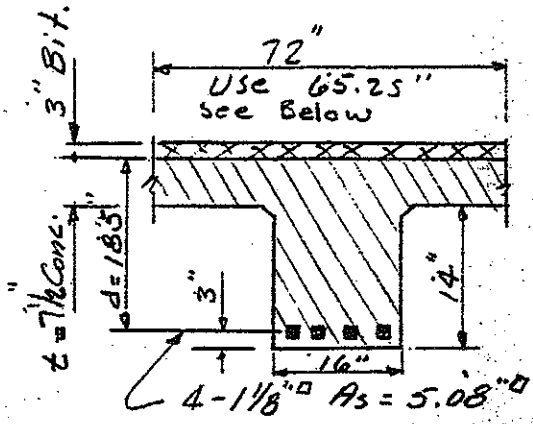
Note: Repeated sets 13-19 twice for two load cases

Figure 2.4 Input Data Sheet for Example 1.

Bridge #1

G. Raffo 5-22-72
Abbott 5-22-72

B06 of 08052
B2 of 8-15-21



Bridge Analysis

Use std. Br 24-TB-18 see early Bridges From Biennial Report, also See Field measurement.
One span 23' assume c.c Brg. = 21.7'
Year Built Uknown Est 1918 (1916 spec.)
Widened 1940 Both side. See OK
Clear Roadway = 26', Deterioration: c
Beam: Conc T Beam, Spacing = 6'
Slab thickness = 7½", 3" Asph.

Field measured { Beam 1'-4" x 1'-2" . n = 15 (1916 spec.)

L/4 = 21.75/4 = 5.4375 Control

p = As/bd = 5.08/65.25 x 18.5 = .00421 (Rectangular Sec. N.A. in slab)

J = .901, K = .298 (Table 7.13.01)

Jd = 16.67, Kd = 5.51

Dead Load:-

Bit:-	.25 x 6.0 x 144	= 216.0
Conc. Slab:-	.63 x 6.0 x 150	= 567.0
Conc. Beam:-	1.33 x 1.17 x 150	= 233.4
		1016.4

$M_{D.L.} = 1.016 \times 21.75^2/8 = 60.1'^k$

	Inventory Rating	Operating Rating
LL. Dist. Factor	S/12	S/13
ALL. stress	18 Ksi	25 Ksi
Beam / Lane	12/6 = 2.0	13/6 = 2.17
Res. M. / Lane steel Gov. = As fs Jd	5.08 x 18 x 16.67 x 2.0 x 1/12 = 254.1	5.08 x 25 x 16.67 x 2.17 x 1/12 = 382.8
D.L. M. / Lane	60.1 x 2.0 = 120.2	60.1 x 2.17 = 130.
Res. M. Avail. LL.I	133.9'^k	252.4

H Rating:- 15 x 133.9 / 1.3 x 130.5 = H 11.8 = 0.79

Gross Load:- HS20 = 134/226.2 = 0.59

One Unit:- 252.4 x 42 / 1.3 x 169.8 = 48 T
Two Unit:- 252.4 x 77 / 1.3 x 223 = 67 T ✓ = 0.87
Three Unit:- 252.4 x 77 / 1.3 x 197.8 = 75.6 T

HS20 = 252.4/226.2 = 1.12

After test

OP = 289.4 K-ft / lane

Experimental and Analytical Data for Bridge No. 1

Analytical vs Experimental Deflections

(in inch)	Girder #1		Girder #2		Girder #3
	Experimental	Analytical	Experimental	Analytical	Experimental
Downstream 1	0.004238	0.000148	0.009874	0.005572	0.029382
Downstream 2	0.005574	0.000376	0.016744	0.014160	0.062183
Downstream 3	0.006336	0.000380	0.017616	0.014320	0.066455
Center 1	0.007504	0.001518	0.019035	0.030010	0.050111
Center 2	0.009875	0.003858	0.036415	0.076460	0.112391
Center 3	0.010037	0.003901	0.035955	0.077240	0.111657
Upstream 1	0.012273	0.006888	0.026671	0.040460	0.046834
Upstream 2	0.020943	0.020290	0.064305	0.120500	0.121229
Upstream 3	0.022573	0.020490	0.066761	0.121400	0.12166
			maximum =	0.1779	inch

(in mm)	Girder #1		Girder #2		Girder #3
	Experimental	Analytical	Experimental	Analytical	Experimental
Downstream 1	0.1076452	0.00375666	0.2507996	0.1415288	0.7463028
Downstream 2	0.1415796	0.00955294	0.4252976	0.359664	1.5794482
Downstream 3	0.1609344	0.00965708	0.4474464	0.363728	1.687957
Center 1	0.1906016	0.0385572	0.483489	0.762254	1.2728194
Center 2	0.250825	0.0979932	0.924941	1.942084	2.8547314
Center 3	0.2549398	0.0990854	0.913257	1.961896	2.8360878
Upstream 1	0.3117342	0.1749552	0.6774434	1.027684	1.1895836
Upstream 2	0.5319522	0.515366	1.633347	3.0607	3.0792166
Upstream 3	0.5733542	0.520446	1.6957294	3.08356	3.090164
			maximum =	4.5187	mm

	Girder #4		Girder #5		Girder #6
Analytical	Experimental	Analytical	Experimental	Analytical	Experimental
0.023650	0.050017	0.056070	0.032116	0.046969	0.010213
0.060150	0.10772	0.144000	0.064162	0.120500	0.014857
0.060800	0.115482	0.145000	0.066851	0.121402	0.015054
0.068860	0.055669	0.068860	0.029017	0.030010	0.005871
0.176600	0.1276	0.176600	0.070109	0.076460	0.010604
0.177900	0.128596	0.177900	0.071721	0.077240	0.010654
0.048250	0.035922	0.020530	0.012965	0.004838	0.0042
0.144000	0.079895	0.060150	0.021158	0.014160	0.005762
0.145000	0.078709	0.060800	0.021289	0.014320	0.006262

	Girder #4		Girder #5		Girder #6
Analytical	Experimental	Analytical	Experimental	Analytical	Experimental
0.60071	1.2704318	1.424178	0.8157464	1.193	0.2594102
1.52781	2.736088	3.6576	1.6297148	3.0607	0.3773678
1.54432	2.9332428	3.683	1.6980154	3.0836	0.3823716
1.749044	1.4139926	1.749044	0.7370318	0.762254	0.1491234
4.48564	3.24104	4.48564	1.7807686	1.942084	0.2693416
4.51866	3.2663384	4.51866	1.8217134	1.961896	0.2706116
1.22555	0.9124188	0.521462	0.329311	0.1228852	0.10668
3.6576	2.029333	1.52781	0.5374132	0.359664	0.1463548
3.683	1.9992086	1.54432	0.5407406	0.363728	0.1590548

Analytical
0.007957
0.020290
0.020490
0.001518
0.003858
0.003901
0.000128
0.000376
0.000380
Analytical
0.2021078
0.515366
0.520446
0.0385572
0.0979932
0.0990854
0.00326136
0.00954786
0.009652

Bridge # 1

Analysis

Year Built is 1918.

Compressive strength (f_c') = 2000 psi (for 1921)

$E = \cancel{2540}$ 2550 ksi

$$G = \frac{E}{2(1+\nu)} = \frac{2550}{2 \times 1.15} = 1108 \text{ ksi}$$

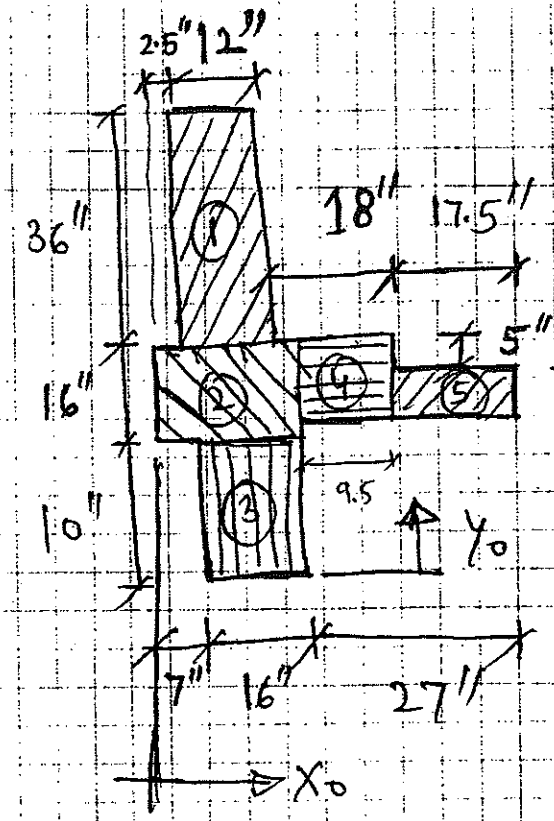
Bridge # 1

$f_c' = 2000$ psi

$E = \boxed{2549120 \text{ psi}}$

$G = \dfrac{E}{2(1+\nu)} = \dfrac{2549120}{2(1+0.15)} = \boxed{1108320 \text{ psi}}$

External Girders



correct everything for 75"

$$X_o = \frac{(432\times 8.5 + 368\times 11.5 + 160\times 15 + 114\times 27.75 + 122.5\times 41.25)}{(432+368+160+114+122.5)}$$

$$= \frac{18520.625}{1196.5}$$

$$= \boxed{15.48''}$$

$$Y_o = \frac{(432\times 44 + 368\times 18 + 160\times 5 + 114\times 20 + 122.5\times 17.5)}{(432+368+160+114+122.5)}$$

$$= \frac{30855.75}{1196.5} = \boxed{25.8 \text{ in}}$$

Bridge #1

$$I_{yy} = \left[46656 + 432 \times (18.2)^2\right] + \left[7851 + 368 \times (7.8)^2\right]$$

$$+ \left[1333.3 + 160 \times (20.8)^2\right] + \left[1368 + (114) \times (5.8)^2\right]$$

$$+ \left[500.2 + 122.5 \times (8.3)^2\right]$$

$$= \left[189751.7\right] + \left[30240.12\right] + \left[70555.7\right]$$

$$+ \left[5203.0\right] + \left[8939.225\right]$$

$$I_{yy} = \boxed{304690.0 \text{ in}^4}$$ External Girder

Assume

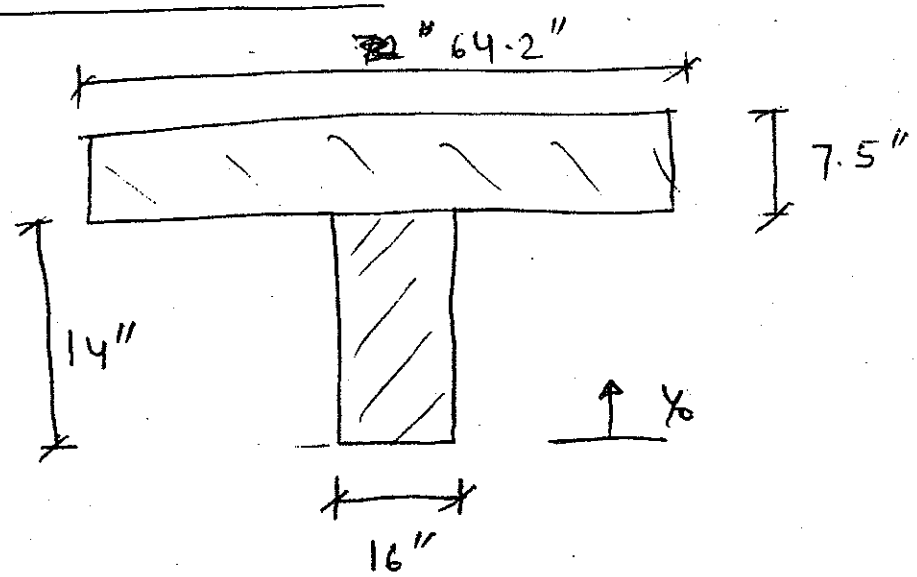
J = 3x Internal = 65178 in^4

Check if J is sensitive

Bridge #:

$$b_e = \min \begin{cases} 0.25L \\ S \\ 12t \end{cases}$$

Internal Girder



$$Y_o = \frac{(481.5 \times 17.75 + 224 \times 7)}{(481.5 + 224)} = \frac{10114.625}{705.5}$$

$$= 14.34''$$

$$I_{yy} = \left[2257.0 + 481.5 \times (3.41)^2\right] + \left[3659 + 224 \times (7.34)^2\right]$$

$$= 7855.93 + 15727.134$$

$$= \boxed{23583.0 \text{ in}^4}$$ Internal Girder

Assume

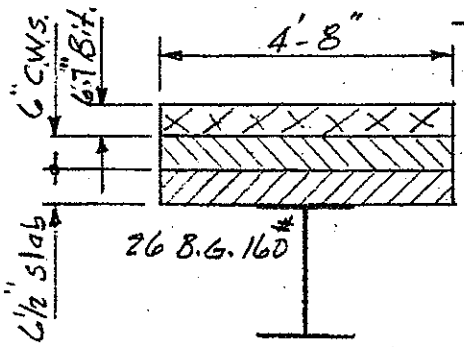
$J = 21{,}726 \text{ in}^4$

Bridge # 2

G. Raffo 3-2-73
RISCH 6-28-73

B02 of 38071
B1 of 38-17-1

Bridge Analysis



One span 50' (c-c. Brg. = 48'-3")
Built 1926; Deterioration = 5%
Slab thickness = 6½", C.W.S. = 6", Bit 6.7" o"
Bm. 26 B.G. 160# Spa. 4'-8"
S = 427 X .95 = 406 in³

Dead Load :-

Bit :- .55 X 4.67 X 144 = 370
Conc. :- 1.04 X 4.67 X 150 = 729
Beam :- = 160
Conc. Diaph. :- .75 X 2.1 X 4.60 X 4 X 150 / 48.25 = 90
} = 1349#/'

$M_{D.L.}$ = 1.349 (48.25)² / 8 = 393 '^K

	Inv. Rating	Oper. Rating
L.L. Dist. Factor	S / 11.5	S / 14.5
ALL. Stress	16.5 Ksi	~~22.5 Ksi~~ ⇒ Fy=30Ksi
Stringer/Lane	11.5 / 4.67 = 2.46	14.5 / 4.67 = 3.10
Res. mom./Lane	406 X 16.5 X 2.46 / 12 = 1373	406 X 22.5 X 3.10 / 12 = 2360
D.L. mom./Lane	393 X 2.46 = .967	393 X 3.10 = 1218
avail. mom./Lane	406 '^K	1142 '^K

H Rating :- 406 X 15 / 414 = H 14.7

Two Unit :- 1142 X 77 / 1196 = 73.5 T
(1199)

LVDT Data for Bridge #2							
Analytical Results (Non-composite section)						C : Composite Model	
						NC : Non-composite Mo	
(in inch)	Mid-Span						
Load Cases	**Girder 2**			**Girder 3**			**Girder 4**
	Exp.	Ana. (C.)	Ana. (N.C.)	Exp.	Ana. (C.)	Ana. (N.C.)	Exp.
Downstream 1	0.0192	0.0120	0.0468	0.0331	0.0289	0.1028	0.0481
Downstream 2	0.0260	0.0174	0.0677	0.0456	0.0419	0.1488	0.0692
Downstream 3	0.0385	0.0225	0.0877	0.0664	0.0542	0.1927	0.0984
Downstream 4	0.0405	0.0240	0.0933	0.0709	0.0577	0.2050	0.1070
Center 1	0.0385	0.0432	0.1719	0.0563	0.0790	0.2338	0.0732
Center 2	0.0582	0.0623	0.2483	0.0881	0.1150	0.3416	0.1165
Center 3	0.0735	0.0811	0.3230	0.1120	0.1490	0.4420	0.1490
Center 4	0.0810	0.0863	0.3438	0.1243	0.1587	0.4708	0.1667
Upstream 1	0.0569	0.0665	0.2666	0.0746	0.1035	0.3013	0.0836
Upstream 2	0.0881	0.0974	0.3906	0.1210	0.1541	0.4477	0.1315
Upstream 3	0.1146	0.1257	0.5040	0.1563	0.1979	0.5753	0.1695
Upstream 4	0.1244	0.1339	0.5368	0.1707	0.2110	0.6132	0.1849
				maximum=	0.6328		
(in mm)	Mid-Span						
Load Cases	**Girder 2**			**Girder 3**			**Girder 4**
	Exp.	Ana. (C.)	Ana. (N.C.)	Exp.	Ana. (C.)	Ana. (N.C.)	Exp.
Downstream 1	0.4872	0.3048	1.1877	0.8398	0.7343	2.6111	1.2228
Downstream 2	0.6596	0.4420	1.7198	1.1574	1.0643	3.7795	1.7579
Downstream 3	0.9771	0.5720	2.2268	1.6863	1.3777	4.8946	2.4992
Downstream 4	1.0287	0.6088	2.3693	1.8008	1.4658	5.2070	2.7170
Center 1	0.9769	1.0973	4.3663	1.4303	2.0058	5.9385	1.8591
Center 2	1.4773	1.5824	6.3068	2.2365	2.9210	8.6766	2.9580
Center 3	1.8656	2.0597	8.2042	2.8452	3.7846	11.2268	3.7850
Center 4	2.0566	2.1915	8.7325	3.1571	4.0310	11.9583	4.2346
Upstream 1	1.4442	1.6886	6.7716	1.8938	2.6289	7.6530	2.1246
Upstream 2	2.2367	2.4742	9.9212	3.0745	3.9141	11.3716	3.3412
Upstream 3	2.9113	3.1928	12.8016	3.9700	5.0267	14.6126	4.3047
Upstream 4	3.1600	3.4011	13.6347	4.3353	5.3594	15.5753	4.6961
				maximum=	16.0731		

del

		Girder 5			Girder 6		
Ana. (C.)	Ana. (N.C.)	Exp.	Ana. (C.)	Ana. (N.C.)	Exp.	Ana. (C.)	Ana. (N.C.)
0.0522	0.1649	0.0613	0.0806	0.2288	0.0690	0.1058	0.2823
0.0756	0.2395	0.0908	0.1179	0.3355	0.1044	0.1574	0.4200
0.0979	0.3099	0.1281	0.1522	0.4328	0.1458	0.2022	0.5396
0.1042	0.3298	0.1405	0.1621	0.4610	0.1609	0.2155	0.5752
0.1087	0.2817	0.0781	0.1210	0.3007	0.0716	0.1111	0.2837
0.1614	0.4186	0.1211	0.1801	0.4491	0.1098	0.1658	0.4235
0.2076	0.5382	0.1563	0.2310	0.5758	0.1425	0.2124	0.5428
0.2212	0.5737	0.1766	0.2463	0.6139	0.1610	0.2264	0.5786
0.1193	0.3095	0.0799	0.1107	0.2848	0.0665	0.0842	0.2331
0.1772	0.4614	0.1242	0.1648	0.4241	0.0981	0.1232	0.3422
0.2277	0.5924	0.1587	0.2116	0.5447	0.1252	0.1591	0.4413
0.2428	0.6316	0.1724	0.2256	0.5806	0.1356	0.1694	0.4701

		Girder 5			Girder 6		
Ana. (C.)	Ana. (N.C.)	Exp.	Ana. (C.)	Ana. (N.C.)	Exp.	Ana. (C.)	Ana. (N.C.)
1.3246	4.1885	1.5570	2.0477	5.8115	1.7529	2.6873	7.1704
1.9210	6.0833	2.3068	2.9947	8.5217	2.6523	3.9980	10.6680
2.4864	7.8715	3.2525	3.8659	10.9931	3.7033	5.1359	13.7058
2.6467	8.3769	3.5679	4.1173	11.7094	4.0869	5.4737	14.6101
2.7610	7.1552	1.9840	3.0734	7.6378	1.8197	2.8219	7.2060
4.0996	10.6324	3.0747	4.5745	11.4071	2.7877	4.2113	10.7569
5.2730	13.6703	3.9693	5.8674	14.6253	3.6190	5.3950	13.7871
5.6185	14.5720	4.4844	6.2560	15.5931	4.0894	5.7506	14.6964
3.0302	7.8613	2.0302	2.8118	7.2339	1.6896	2.1392	5.9207
4.5009	11.7196	3.1554	4.1859	10.7721	2.4922	3.1293	8.6919
5.7836	15.0470	4.0300	5.3746	13.8354	3.1811	4.0411	11.2090
6.1671	16.0426	4.3777	5.7302	14.7472	3.4435	4.3028	11.9405

Girder 7			**Girder 8**			**Girder 9**	
Exp.	Ana. (C.)	Ana. (N.C.)	Exp.	Ana. (C.)	Ana. (N.C.)	Exp.	Ana. (C.)
0.0709	0.1138	0.3101	0.0629	0.0983	0.3053	0.0494	0.0637
0.1045	0.1692	0.4623	0.0918	0.1467	0.4539	0.0654	0.0935
0.1444	0.2174	0.5935	0.1252	0.1883	0.5833	0.0903	0.1206
0.1583	0.2317	0.6328	0.1373	0.2008	0.6217	0.0987	0.1285
0.0626	0.0837	0.2363	0.0444	0.0520	0.1735	0.0232	0.0246
0.0918	0.1230	0.3480	0.0621	0.0756	0.2530	0.0354	0.0358
0.1187	0.1582	0.4475	0.0805	0.0976	0.3263	0.0470	0.0462
0.1334	0.1685	0.4767	0.0894	0.1038	0.3473	0.0538	0.0492
0.0552	0.0539	0.1696	0.0361	0.0291	0.1069	0.0238	0.0117
0.0779	0.0782	0.2465	0.0485	0.0422	0.1549	0.0305	0.0170
0.0987	0.1012	0.3188	0.0611	0.0546	0.2006	0.0317	0.0220
0.1062	0.1077	0.3393	0.0655	0.0581	0.2134	0.0333	0.0234

Girder 7			**Girder 8**			**Girder 9**	
Exp.	Ana. (C.)	Ana. (N.C.)	Exp.	Ana. (C.)	Ana. (N.C.)	Exp.	Ana. (C.)
1.8001	2.8905	7.8765	1.5984	2.4966	7.7546	1.2538	1.6185
2.6530	4.2977	11.7424	2.3318	3.7262	11.5291	1.6608	2.3752
3.6683	5.5220	15.0749	3.1801	4.7828	14.8158	2.2935	3.0632
4.0201	5.8852	16.0731	3.4882	5.1003	15.7912	2.5075	3.2639
1.5895	2.1267	6.0020	1.1275	1.3195	4.4069	0.5898	0.6259
2.3312	3.1242	8.8392	1.5777	1.9210	6.4262	0.8997	0.9101
3.0152	4.0183	11.3665	2.0448	2.4778	8.2880	1.1949	1.1740
3.3884	4.2799	12.1082	2.2711	2.6365	8.8214	1.3663	1.2492
1.4031	1.3691	4.3078	0.9169	0.7394	2.7153	0.6038	0.2972
1.9782	1.9860	6.2611	1.2307	1.0716	3.9345	0.7738	0.4308
2.5072	2.5705	8.0975	1.5514	1.3873	5.0952	0.8040	0.5578
2.6975	2.7356	8.6182	1.6639	1.4762	5.4204	0.8449	0.5933

		Quarter Points					
		Girder 5					
		Q1			**Q2**		
Ana. (N.C.)		Exp.	Ana. (C.)	Ana. (N.C.)	Exp.	Ana. (C.)	Ana. (N.C.)
0.2736		0.0347	0.0520	0.1451	0.0523	0.0636	0.1846
0.4012		0.0544	0.0785	0.2208	0.0674	0.0878	0.2524
0.5176		0.0873	0.1060	0.3008	0.0896	0.1098	0.3136
0.5513		0.0963	0.1131	0.3209	0.0961	0.1164	0.3323
0.1080		0.0424	0.0731	0.1807	0.0743	0.1051	0.2654
0.1571		0.0701	0.1137	0.2814	0.0972	0.1396	0.3497
0.2026		0.1062	0.1595	0.3974	0.1167	0.1699	0.4250
0.2156		0.1226	0.1704	0.4245	0.1284	0.1796	0.4489
0.0500		0.0462	0.0677	0.1734	0.0794	0.0958	0.2476
0.0724		0.0750	0.1046	0.2683	0.1017	0.1272	0.3281
0.0937		0.1103	0.1465	0.3767	0.1211	0.1556	0.4009
0.0997		0.1219	0.1564	0.4023	0.1295	0.1645	0.4237
		Quarter Points					
		Girder 5					
		Q1			**Q2**		
Ana. (N.C.)		Exp.	Ana. (C.)	Ana. (N.C.)	Exp.	Ana. (C.)	Ana. (N.C.)
6.9494		0.8816	1.3195	3.6855	1.3286	1.6149	4.6888
10.1905		1.3814	1.9947	5.6083	1.7132	2.2309	6.4110
13.1470		2.2167	2.6924	7.6403	2.2765	2.7889	7.9654
14.0030		2.4459	2.8727	8.1509	2.4411	2.9566	8.4404
2.7432		1.0769	1.8562	4.5898	1.8861	2.6695	6.7412
3.9903		1.7804	2.8880	7.1476	2.4688	3.5458	8.8824
5.1460		2.6977	4.0513	10.0940	2.9642	4.3155	10.7950
5.4762		3.1141	4.3282	10.7823	3.2621	4.5618	11.4021
1.2697		1.1734	1.7206	4.4044	2.0177	2.4336	6.2890
1.8387		1.9059	2.6568	6.8148	2.5826	3.2309	8.3337
2.3810		2.8027	3.7211	9.5682	3.0755	3.9522	10.1829
2.5334		3.0958	3.9726	10.2184	3.2881	4.1783	10.7620

Bridge #2											
Experimental and Analytical Stress (using S.S. moments)											
multiply moment by (y/EI), where factor =					0.001	(Composite Section)					
					0.002	(Non-Composite Section)					
At Mid-Span											
(in ksi)	**Girder 2**			**Girder 3**			**Girder 4**			**Girder 5**	
Load Cases	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp	Exp.	Comp
Downstream 1	0.34	0.24	0.53	0.56	0.59	1.16	0.00	1.06	1.82	0.96	1.55
Downstream 2	0.40	0.35	0.75	0.72	0.85	1.65	0.00	1.53	2.68	1.59	2.40
Downstream 3	0.44	0.46	0.98	0.84	1.10	2.15	0.00	1.99	3.46	1.89	3.05
Downstream 4	0.45	0.49	1.04	0.91	1.17	2.29	0.00	2.11	3.68	2.05	3.26
Center 1	0.45	0.88	1.90	0.69	1.52	2.43	0.00	1.82	2.58	0.97	2.05
Center 2	0.67	1.26	2.78	1.39	2.34	3.82	0.00	3.41	4.89	1.91	3.75
Center 3	0.81	1.64	3.60	1.70	2.99	4.83	0.00	4.15	5.94	2.23	4.55
Center 4	0.88	1.75	3.84	1.93	3.20	5.18	0.00	4.43	6.34	2.53	4.89
Upstream 1	0.54	1.26	2.78	0.84	1.70	2.78	0.00	2.01	2.78	0.84	1.83
Upstream 2	0.93	1.99	4.38	2.22	3.27	5.22	0.00	3.68	5.32	1.83	3.49
Upstream 3	1.07	2.51	5.53	2.58	3.95	6.35	0.00	4.48	6.41	2.07	4.23
Upstream 4	1.17	2.69	5.92	2.81	4.22	6.78	0.00	4.82	6.89	2.24	4.52
At Mid-Span											
(in MPa)	**Girder 2**			**Girder 3**			**Girder 4**			**Girder 5**	
Load Cases	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp	Exp.	Comp
Downstream 1	2.37	1.68	3.65	3.86	4.07	8.01	0.00	7.31	12.58	6.63	10.68
Downstream 2	2.75	2.43	5.20	4.96	5.85	11.42	0.00	10.57	18.50	10.98	16.58
Downstream 3	3.07	3.15	6.77	5.82	7.59	14.86	0.00	13.70	23.85	13.01	21.03
Downstream 4	3.11	3.35	7.19	6.25	8.07	15.79	0.00	14.57	25.42	14.12	22.52
Center 1	3.12	6.07	13.14	4.77	10.50	16.76	0.00	12.52	17.78	6.67	14.12
Center 2	4.63	8.70	19.17	9.56	16.17	26.37	0.00	23.53	33.74	13.18	25.85
Center 3	5.57	11.35	24.87	11.70	20.61	33.36	0.00	28.62	40.98	15.35	31.40
Center 4	6.09	12.07	26.50	13.34	22.06	35.76	0.00	30.55	43.75	17.48	33.74
Upstream 1	3.70	8.66	19.17	5.79	11.72	19.17	0.00	13.88	19.22	5.83	12.61
Upstream 2	6.42	13.74	30.19	15.32	22.55	36.04	0.00	25.41	36.69	12.65	24.10
Upstream 3	7.39	17.32	38.12	17.80	27.28	43.83	0.00	30.92	44.25	14.25	29.20
Upstream 4	8.10	18.57	40.84	19.37	29.12	46.77	0.00	33.24	47.53	15.43	31.17

	Girder 6			Girder 7			Girder 8			Girder 9		
N-Comp	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp
2.37	0.72	1.75	2.57	0.00	1.90	2.79	0.93	1.58	2.80	0.77	1.19	2.83
3.76	1.57	3.33	4.91	0.00	3.52	5.33	1.79	3.13	5.30	1.14	1.91	4.50
4.73	1.54	4.04	5.96	0.00	4.27	6.43	2.09	3.76	6.44	1.42	2.40	5.67
5.07	1.63	4.31	6.36	0.00	4.60	6.90	2.28	4.01	6.87	1.52	2.58	6.08
2.69	0.40	1.83	2.56	0.00	1.59	2.41	0.64	1.05	1.91	0.33	0.50	1.22
5.18	1.20	3.52	4.96	0.00	2.51	3.91	0.99	1.53	2.83	0.47	0.72	1.75
6.23	1.44	4.25	5.98	0.00	3.16	4.89	1.25	1.98	3.64	0.60	0.94	2.26
6.69	1.59	4.53	6.39	0.00	3.39	5.24	1.43	2.10	3.88	0.68	1.00	2.41
2.58	0.46	1.61	2.39	0.00	1.09	1.87	0.45	0.60	1.21	0.16	0.24	0.57
4.97	0.85	2.52	3.84	0.00	1.58	2.76	0.65	0.85	1.72	0.21	0.34	0.81
6.01	1.03	3.18	4.82	0.00	2.05	3.55	0.79	1.11	2.24	0.24	0.45	1.05
6.42	1.11	3.41	5.17	0.00	2.18	3.79	0.85	1.18	2.38	0.26	0.47	1.11

	Girder 6			Girder 7			Girder 8			Girder 9		
N-Comp	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp
16.32	4.96	12.04	17.74	0.00	13.11	19.26	6.42	10.88	19.31	5.34	8.21	19.54
25.94	10.81	23.01	33.91	0.00	24.30	36.75	12.32	21.58	36.57	7.87	13.20	31.06
32.65	10.65	27.88	41.10	0.00	29.48	44.35	14.44	25.94	44.41	9.80	16.57	39.13
35.00	11.27	29.76	43.86	0.00	31.71	47.61	15.71	27.70	47.42	10.49	17.78	41.92
18.55	2.73	12.61	17.63	0.00	10.97	16.66	4.42	7.27	13.19	2.25	3.48	8.42
35.76	8.30	24.28	34.25	0.00	17.33	26.99	6.86	10.58	19.54	3.22	5.00	12.06
42.99	9.92	29.31	41.29	0.00	21.81	33.74	8.60	13.64	25.08	4.11	6.47	15.62
46.17	10.96	31.28	44.09	0.00	23.36	36.18	9.86	14.52	26.75	4.69	6.88	16.60
17.79	3.18	11.09	16.50	0.00	7.55	12.90	3.13	4.11	8.33	1.10	1.64	3.90
34.28	5.85	17.36	26.50	0.00	10.93	19.04	4.47	5.89	11.89	1.48	2.37	5.56
41.47	7.08	21.96	33.28	0.00	14.15	24.52	5.45	7.65	15.46	1.62	3.07	7.23
44.27	7.67	23.51	35.68	0.00	15.07	26.13	5.89	8.13	16.44	1.79	3.27	7.68

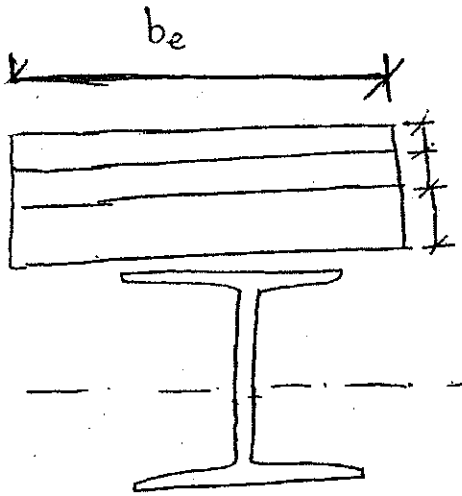
	At Quarter Points									
	Girder 2						**Girder 4**			**Girder 7**	
	Q1			**Q2**			**Q1**			**Q1**	
	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp	Exp.	Comp
	0.21	0.15	0.32	0.28	0.19	0.41	0.28	0.84	1.63	0.19	3.26
	0.23	0.23	0.50	0.27	0.26	0.57	0.42	1.16	2.14	0.34	3.47
	0.26	0.32	0.68	0.27	0.33	0.70	0.76	1.43	2.56	0.99	3.74
	0.28	0.34	0.72	0.27	0.35	0.75	0.84	1.52	2.70	1.14	3.86
	0.17	0.72	1.66	0.52	0.51	1.07	0.10	2.91	4.20	0.10	1.83
	0.33	0.98	2.19	0.54	0.81	1.73	0.29	3.30	4.79	0.33	2.17
	0.53	1.20	2.65	0.57	1.12	2.45	1.04	3.63	5.24	1.07	2.47
	0.61	1.27	2.80	0.63	1.20	2.63	1.37	3.76	5.40	1.31	2.59
	0.14	1.54	3.19	0.86	0.53	1.38	0.09	3.35	4.89	0.14	0.88
	0.33	1.78	3.74	0.79	0.97	2.33	0.39	3.59	5.24	0.38	1.21
	0.73	1.99	4.31	0.78	1.67	3.75	1.32	3.89	5.68	0.76	1.49
	0.82	2.08	4.51	0.81	1.79	4.01	1.56	4.02	5.86	0.83	1.57
	At Quarter Points									
	Girder 2						**Girder 4**			**Girder 7**	
	Q1			**Q2**			**Q1**			**Q1**	
	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp	Exp.	Comp
	1.45	1.05	2.19	1.91	1.31	2.80	1.97	5.82	11.22	1.33	22.50
	1.59	1.61	3.45	1.89	1.83	3.94	2.88	8.03	14.80	2.32	23.94
	1.81	2.18	4.66	1.85	2.27	4.85	5.22	9.89	17.63	6.81	25.82
	1.91	2.33	4.98	1.88	2.41	5.16	5.77	10.49	18.60	7.87	26.63
	1.20	5.00	11.42	3.60	3.49	7.40	0.71	20.06	28.99	0.66	12.59
	2.25	6.75	15.12	3.76	5.58	11.91	2.01	22.80	33.03	2.29	14.94
	3.66	8.25	18.29	3.96	7.76	16.94	7.17	25.08	36.14	7.39	17.06
	4.24	8.74	19.31	4.38	8.30	18.13	9.46	25.91	37.27	9.01	17.85
	0.94	10.63	22.00	5.96	3.64	9.50	0.64	23.11	33.71	0.99	6.10
	2.25	12.27	25.83	5.47	6.72	16.04	2.68	24.79	36.14	2.60	8.36
	5.04	13.74	29.74	5.36	11.49	25.87	9.10	26.87	39.22	5.22	10.25
	5.65	14.32	31.14	5.57	12.33	27.65	10.78	27.74	40.43	5.75	10.87

				Girder 9					
	Q2			Q1			Q2		
N-Comp	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp
4.89	1.70	0.68	1.10	0.18	1.49	3.32	1.10	0.51	1.40
5.24	1.75	1.33	2.04	0.30	1.71	3.88	1.13	0.93	2.36
5.69	1.74	2.85	4.32	0.82	1.92	4.45	1.22	1.60	3.85
5.87	1.75	3.08	4.69	0.95	2.00	4.66	1.28	1.72	4.12
3.03	0.84	0.76	1.10	0.09	0.35	0.89	0.32	0.35	0.79
3.47	0.93	1.32	1.94	0.24	0.51	1.28	0.41	0.51	1.20
3.91	0.96	2.13	3.30	0.52	0.66	1.61	0.48	0.66	1.58
4.08	1.06	2.28	3.53	0.62	0.70	1.71	0.56	0.70	1.68
1.70	0.65	0.66	1.01	0.08	0.15	0.34	0.22	0.18	0.43
2.22	0.69	1.03	1.66	0.17	0.23	0.54	0.26	0.26	0.61
2.63	0.72	1.41	2.41	0.26	0.31	0.72	0.29	0.32	0.75
2.78	0.77	1.51	2.58	0.28	0.33	0.77	0.31	0.34	0.80

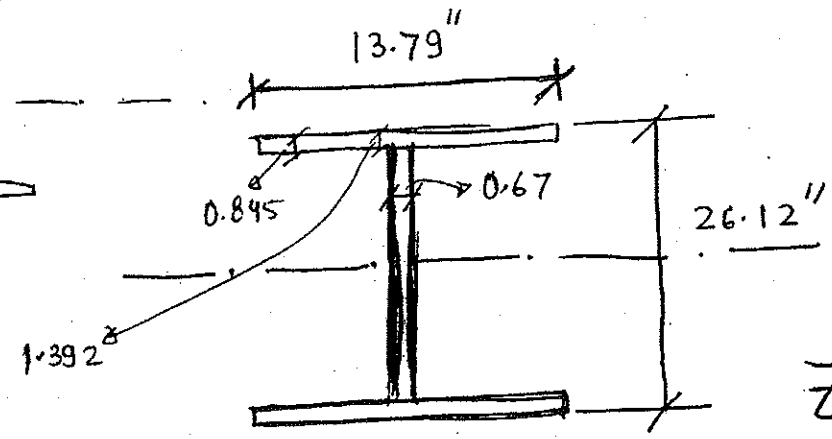
				Girder 9					
	Q2			Q1			Q2		
N-Comp	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp	Exp.	Comp	N-Comp
33.74	11.72	4.70	7.61	1.27	10.29	22.88	7.61	3.55	9.64
36.18	12.07	9.19	14.04	2.05	11.79	26.75	7.80	6.42	16.29
39.29	12.02	19.64	29.82	5.64	13.23	30.72	8.43	11.06	26.55
40.50	12.09	21.26	32.39	6.54	13.79	32.14	8.80	11.86	28.41
20.88	5.77	5.27	7.59	0.62	2.41	6.14	2.19	2.40	5.43
23.93	6.39	9.09	13.37	1.63	3.55	8.84	2.83	3.55	8.28
26.97	6.64	14.70	22.74	3.61	4.56	11.10	3.31	4.56	10.87
28.14	7.29	15.75	24.37	4.31	4.86	11.81	3.85	4.85	11.61
11.73	4.51	4.52	6.96	0.56	1.03	2.38	1.51	1.27	2.96
15.31	4.74	7.09	11.46	1.20	1.58	3.72	1.81	1.77	4.18
18.18	4.98	9.74	16.60	1.82	2.13	4.99	1.97	2.21	5.18
19.17	5.32	10.41	17.78	1.95	2.27	5.33	2.13	2.34	5.50

Stress due to dead load.

say $f_y = 30$ ksi. Bridge # 2



$$\sigma = \frac{M}{S}$$



$I_x = 5576.6$

$Z = 481.17 \text{ in}^3$

$f_y Z = 1203$ K-ft.

average of $(1.392, 0.845) = 1.1185''$

Calculate I

$$I = \frac{0.67 \times (26.12)^3}{12} + \left[\frac{13.12 \times (1.1185)^3}{12} + 13.12 \times 1.1185 \times (12.5)^2\right] \times 2$$

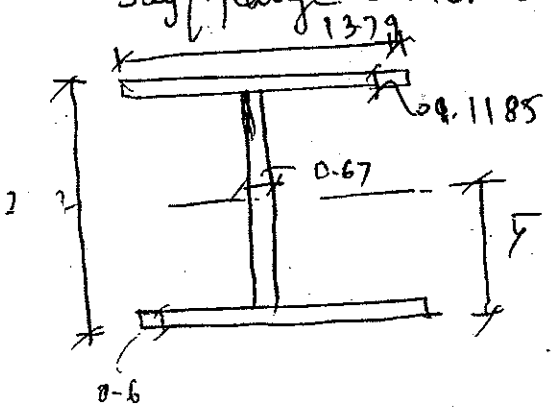
$$= \left[2292.93 + 1.53\right] \times 2 + 994.98$$

$$= 994.98 + 4585.9 + 3.06$$

$$= 5583.9 \text{ in}^4$$

$$S = 427.6 \text{ in}^3$$

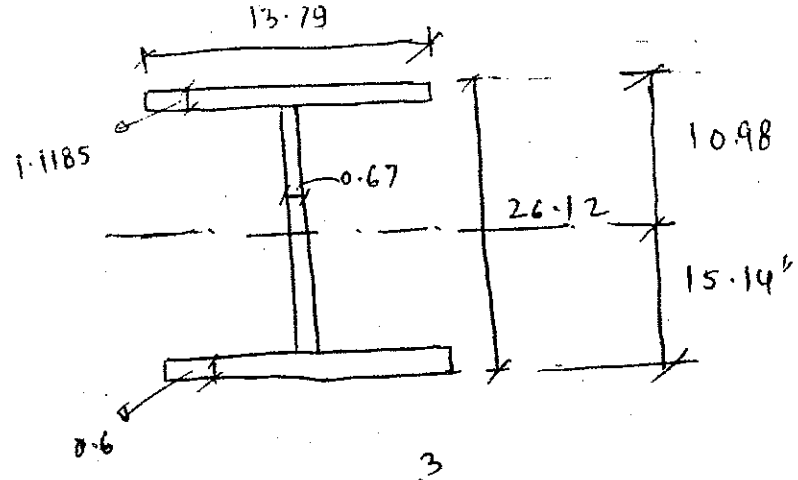
Say ~~flange~~ down thickness is reduced to 0.609. ≃ 0.6 in.



$$\Rightarrow \bar{y} = \frac{0.6 \times 13.79 \times 0.3 + 1.1185 \times 13.79 \times 25.57075 + 0.67 \times 24.401 \times 12.8007}{0.6 \times 13.79 + 1.1185 \times 13.79 + 24.4015 \times 0.67}$$

$$= \frac{606.168}{40.04712} = 15.14''$$

Bridge # 2



$$I = \frac{0.67 \times (26.12)^3}{12} + 0.67 \times 26.12 \times (2.08)^2 + \frac{13.12 \times (1.1185)^3}{12}$$

$$+ 1.1185 \times 13.12 \times (10.42)^2 + \frac{13.12 \times (0.6)^3}{12} + 13.12 \times 0.6 \times (14.84)^2$$

$$= 994.98 + 75.71 + 1.53 + 1593.33 + 0.236 + 1733.6$$

$$= 4399.4 \text{ in}^4$$

$$\therefore \boxed{S_{bottom} = 290.6 \text{ in}^3}$$ 32% reduction

$\Rightarrow$ Stress at lower flange tip due to dead load

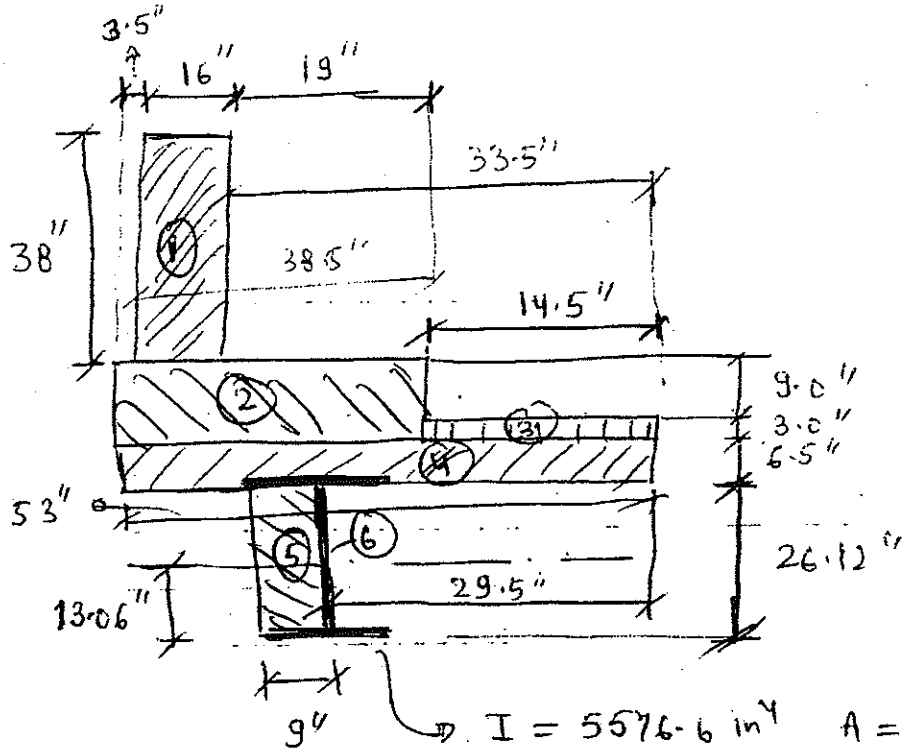
$= 16.23$ ksi

remaining stress $= 13.77$ ksi

strain $= 459 \cdot \mu\varepsilon$

External Girder

bridge # 2



$n = 12$

$I = 5576.6 \text{ in}^4$ $A = 46.85 \text{ in}^2$

$A_1 = 608 \text{ in}^2$, $A_2 = 462 \text{ in}^2$, $A_3 = 17.5 \text{ in}^2$, $A_4 = 344.5 \text{ in}^2$
$A_5 = 235.08 \text{ in}^2$, $A_6 = 46.85 \text{ in}^2$

$$Y_0 = \frac{1}{185.8}\left[\frac{1}{12}\left[608 \times 63.62 + 462 \times 38.62 + 17.5 \times 34.12 + 344.5 \times 29.37 + 235.08 \times 13.06\right] + 46.85 \times 13.06\right]$$

$= 34.81$ inch.

$$I_1 = \frac{16 \times 38^3}{12 \times 12} + \frac{16 \times 38 \times 28.81^2}{12} = 48151.04 \text{ in}^4$$

$$I_2 = \frac{1}{12}\left[\frac{38.5 \times 12^3}{12} + 38.5 \times 12 \times 3.81^2\right] = 1020.87 \text{ in}^4$$

$$I_3 = \frac{1}{12} \times \left[\frac{14.5 \times 3^3}{12} + 17.5 \times 0.69^2\right] = 3.41 \text{ in}^4$$

$$I_4 = \frac{1}{12}\left[\frac{53 \times 6.5^3}{12} + 344.5 \times 5.44^2\right] = 950.7 \text{ in}^4$$

$$I_5 = \frac{1}{12}\left[\frac{9 \times 26.12^3}{12} + 235.08 \times 21.75^2\right] = 10381.08 \text{ in}^4$$

$$I_6 = \left[5576.6 + 46.85 \times 21.75^2\right] = 27739.58 \text{ in}^4$$

Total $I = 88246.678 \text{ in}^4$

J (external)

$J_1 = \frac{1}{12} \times \frac{1}{3} \times (38 \times 16^3) = 4323.6 \text{ in}^4$

$J_2 = \frac{1}{12} \times \frac{1}{3} \times (38.5 \times 12^3) = 1848.0 \text{ in}^4$

$J_3 = \frac{1}{12} \times \frac{1}{3} \times (14.5 \times 3^3) = 10.875 \text{ in}^4$

$J_4 = \frac{1}{12} \times \frac{1}{3} \times (58.3 \times 6.5^3) = 444.74 \text{ in}^4$

$J_4 = \frac{1}{12} \times \frac{1}{3} \times (26.12 \times 9^3) = 528.93 \text{ in}^4$

$J_5 = 17.653 \text{ in}^4$

Total $J = 7173.8 \text{ in}^4$.

~~take J = 1035 in⁴~~

Bridge No. 3											
Experimental and Analytical Stresses											
North Span											
	At Mid-Span										
	Girder 2			**Girder 3**			**Girder 4**			**Girder 5**	
	Exp.	Comp.	Ncomp.	Exp.	Comp.	Ncomp.	Exp.	Comp.	Ncomp.	Exp.	Comp.
6 barriers	4.15	4.71	12.81	3.64	3.80	9.65	3.30	2.68	7.07	2.42	2.02
Downstream 1	4.42	6.15	15.96	4.68	7.48	17.34	6.12	9.66	19.88	6.33	13.24
Downstream 2	4.37	6.31	16.29	4.76	7.88	18.14	6.46	10.43	21.35	7.08	14.75
Downstream 3	4.34	7.35	18.60	5.12	10.55	23.76	8.27	15.48	30.55	10.64	22.49
Center 1	7.53	10.79	25.77	9.14	14.97	28.23	9.98	17.41	28.91	12.53	19.58
Center 2	7.53	11.45	27.26	9.70	16.47	30.90	11.31	20.91	34.16	14.96	23.26
Center 3	7.63	15.86	36.54	12.25	24.18	43.41	15.41	30.21	48.07	20.00	34.43
Upstream 1	10.39	16.24	38.77	15.04	19.79	36.48	12.84	19.49	32.47	13.41	16.42
Upstream 2	11.27	19.51	44.57	16.75	23.33	42.46	14.71	23.12	38.24	14.91	19.87
Upstream 3	13.91	26.38	61.34	22.78	33.37	59.20	18.08	33.76	54.04	17.75	28.93
South Span											
	At Mid-Span										
	Girder 2			**Girder 3**			**Girder 4**			**Girder 5**	
	Exp.	Comp.	Ncomp.	Exp.	Comp.	Ncomp.	Exp.	Comp.	Ncomp.	Exp.	Comp.
8 barriers	6.38	6.28	17.08	4.68	5.07	12.87	2.49	3.57	9.42	0.86	2.70
Downstream 1	7.91	7.72	20.23	6.97	8.75	20.56	7.25	10.56	22.24	8.88	13.92
Downstream 2	7.90	7.88	20.56	7.12	9.15	21.36	7.45	11.32	23.71	9.89	15.42
Downstream 3	8.10	8.92	22.87	7.59	11.82	26.98	9.47	16.37	32.91	14.08	23.16
Center 1	10.21	12.36	30.04	11.78	16.24	31.45	10.80	18.30	31.26	16.12	20.25
Center 2	9.97	13.02	31.53	12.61	17.74	34.12	12.94	21.80	36.51	19.92	23.94
Center 3	10.84	17.43	40.81	16.67	25.45	46.62	16.49	31.10	50.42	29.98	35.10
Upstream 1	14.52	17.81	43.04	18.73	21.06	39.70	16.60	20.38	34.83	15.80	17.10
Upstream 2	16.18	21.08	48.84	21.55	24.60	45.67	19.39	24.01	40.60	19.28	20.55
Upstream 3	19.44	27.95	65.61	27.29	34.64	62.42	22.01	34.66	56.39	23.94	29.61

Experimental and Analytical Stresses for Bridge No. 3

	Girder 6			Girder 7			Girder 8			Girder 9	
Ncomp.	Exp.	Comp.	Ncomp.	Exp.	Comp.	Ncomp.	Exp.	Comp.	Ncomp.	Exp.	Comp.
5.66	2.12	2.01	5.66	2.49	2.65	7.06	3.08	3.75	9.65	4.76	4.69
23.83	7.89	16.42	27.38	11.38	19.49	32.47	10.04	19.79	36.48	10.36	16.24
26.43	9.39	19.87	32.57	13.59	23.12	38.24	12.10	23.33	42.46	12.41	19.51
38.66	13.64	28.93	46.40	19.43	33.76	54.04	15.29	33.37	59.20	14.52	26.38
30.42	13.21	19.46	30.42	13.47	17.09	28.91	10.74	14.54	28.23	8.10	10.51
36.10	15.94	23.14	36.10	16.50	20.56	34.15	11.65	16.00	30.90	8.18	11.15
51.45	20.32	34.22	51.45	19.87	29.65	48.08	13.61	23.43	43.41	8.57	15.36
27.38	10.24	13.24	23.83	7.01	9.66	19.88	6.90	7.48	17.34	7.78	6.15
32.57	10.74	14.75	26.43	7.46	10.43	21.35	7.16	7.88	18.14	7.99	6.31
46.40	13.02	22.49	38.66	8.42	15.48	30.55	7.60	10.55	23.76	8.03	7.35

	Girder 6			Girder 7			Girder 8			Girder 9	
Ncomp.	Exp.	Comp.	Ncomp.	Exp.	Comp.	Ncomp.	Exp.	Comp.	Ncomp.	Exp.	Comp.
7.55	1.32	2.68	7.55	1.74	3.53	9.42	3.15	5.00	12.87	6.84	6.25
25.72	11.94	17.09	29.27	12.94	20.37	34.83	15.58	21.04	39.70	19.36	17.80
28.31	14.11	20.54	34.46	15.08	24.00	40.60	16.86	24.58	45.67	21.37	21.07
40.54	17.18	29.60	48.29	19.55	34.64	56.39	18.94	34.62	62.42	23.30	27.94
32.31	13.88	20.13	32.31	8.46	17.97	31.26	8.61	15.79	31.45	7.95	12.07
37.99	17.59	23.81	37.99	10.74	21.44	36.51	9.07	17.25	34.12	7.92	12.71
53.33	21.65	34.90	53.33	13.54	30.54	50.44	10.84	24.68	46.62	8.30	16.92
29.27	8.61	13.91	25.72	3.16	10.54	22.24	5.54	8.73	20.56	8.14	7.71
34.46	9.01	15.42	28.31	3.33	11.31	23.71	5.54	9.13	21.36	8.22	7.87
48.29	10.93	23.16	40.54	3.62	16.36	32.91	5.72	11.80	26.98	8.01	8.91

Experimental and Analytical Stresses for Bridge No. 3

		At Quarter Points								
		Girder 5			**Girder 5**			**Girder 6**		
		Q1			**Q2**			**Q1**		
Ncomp.		Exp.	Comp.	Ncomp.	Exp.	Comp.	Ncomp.	Exp.	Comp.	Ncomp.
12.81		2.97	1.43	4.02	2.29	1.43	4.02	2.35	1.43	4.02
38.77		5.00	7.37	13.08	4.99	11.78	21.78	3.75	7.93	13.72
44.57		5.30	8.45	14.78	5.28	12.18	22.11	4.06	9.21	15.77
61.34		8.75	16.72	29.26	6.18	16.09	28.05	13.35	24.69	39.06
25.76		6.72	8.85	13.98	15.62	22.51	35.31	7.15	8.77	13.98
27.25		7.28	10.51	16.26	15.73	22.01	34.21	8.23	10.43	16.26
36.53		14.00	28.64	43.51	15.87	26.69	40.47	15.41	28.49	43.51
15.96		7.29	7.93	13.72	13.58	19.34	31.05	7.77	7.37	13.08
16.29		7.77	9.21	15.77	12.55	18.81	30.34	8.25	8.45	14.78
18.60		11.00	24.69	39.06	13.04	23.05	36.56	10.23	16.72	29.26
		At Quarter Points								
		Girder 5			**Girder 5**			**Girder 6**		
		Q1			**Q2**			**Q1**		
Ncomp.		Exp.	Comp.	Ncomp.	Exp.	Comp.	Ncomp.	Exp.	Comp.	Ncomp.
17.09		2.06	1.91	5.36	0.67	1.91	5.36	0.04	1.90	5.36
43.04		4.30	7.84	14.42	6.38	12.26	23.12	0.82	8.41	15.06
48.84		4.26	8.93	16.12	6.43	12.65	23.45	0.91	9.69	17.11
65.61		7.28	17.20	30.60	6.98	16.57	29.39	6.72	25.17	40.40
30.03		3.16	9.33	15.32	12.43	22.99	36.65	0.79	9.25	15.32
31.52		3.66	10.99	17.60	11.76	22.49	35.55	1.21	10.90	17.60
40.80		10.36	29.11	44.85	11.86	27.17	41.81	6.17	28.97	44.85
20.23		5.80	8.41	15.06	9.50	19.82	32.39	2.11	7.84	14.42
20.56		6.64	9.69	17.11	8.30	19.28	31.68	2.13	8.93	16.12
22.87		9.33	25.17	40.40	8.28	23.53	37.90	2.78	17.20	30.60

Girder 6		
Q2		
Exp.	Comp.	Ncomp.
2.62	1.43	4.02
13.93	19.34	31.05
14.94	18.81	30.34
15.67	23.05	36.56
17.87	22.44	35.31
17.87	21.92	34.21
18.81	26.55	40.46
8.99	11.78	21.78
9.13	12.18	22.11
9.99	16.09	28.05
Girder 6		
Q2		
Exp.	Comp.	Ncomp.
1.12	1.90	5.36
21.87	19.82	32.39
22.05	19.28	31.68
23.21	23.53	37.90
25.65	22.91	36.65
24.57	22.40	35.55
27.11	27.02	41.80
10.28	12.26	23.12
10.70	12.65	23.45
11.51	16.57	29.39

Bridge #3 (Analytical Modeling)

year built : 1931

exterior girders

$30'' \times 163^{\#}$, $A = 48.00\ in^2$, $d = 30.65''$, $b = 10.68''$

$I = 7270.7\ in^4$, $J = 18.3\ in^4$

interior girders

$30'' \times 129^{\#}$, $A = 37.52\ in^2$, $d = \cancel{37.5}\ 30.125^{\#}$, $b = 10.53''$

$I = 5566.5\ in^4$, $J = 9.0\ in^4$

Slab

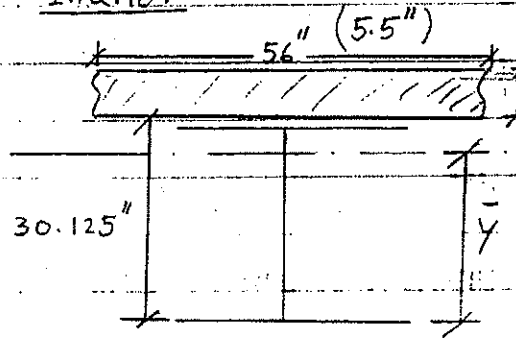
Concrete slab thickness = ~~6''~~ 6.5'', wearing surface = 6.5''

$f_c' = 2500$ psi, $E_c = 2850$ ksi, $G = 1240$ ksi

$E_s = 29{,}000$ ksi, $G_s = 11154$ ksi

$n = 10.18$

Interior



$$\bar{y} = \frac{(37.52 \times 15.0625 + 68.75 \times 36.375)}{(37.52 + 68.75)} = 28.85''$$

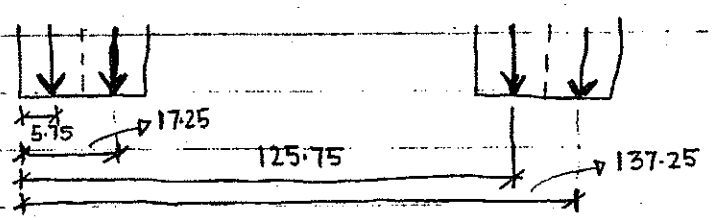
$$I_{comp} = \left[5566.5 + 37.52 \times (13.79)^2\right] + \left[895.2 + 68.75 \times (7.525)^2\right]$$

$$= 12701.5 + 4788.2 = \underline{17489.7\ in^4}$$

$$J_{comp} = \underline{4062\ in^4}$$

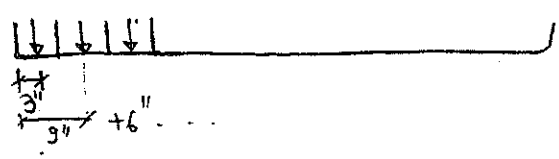
Load

(transverse)



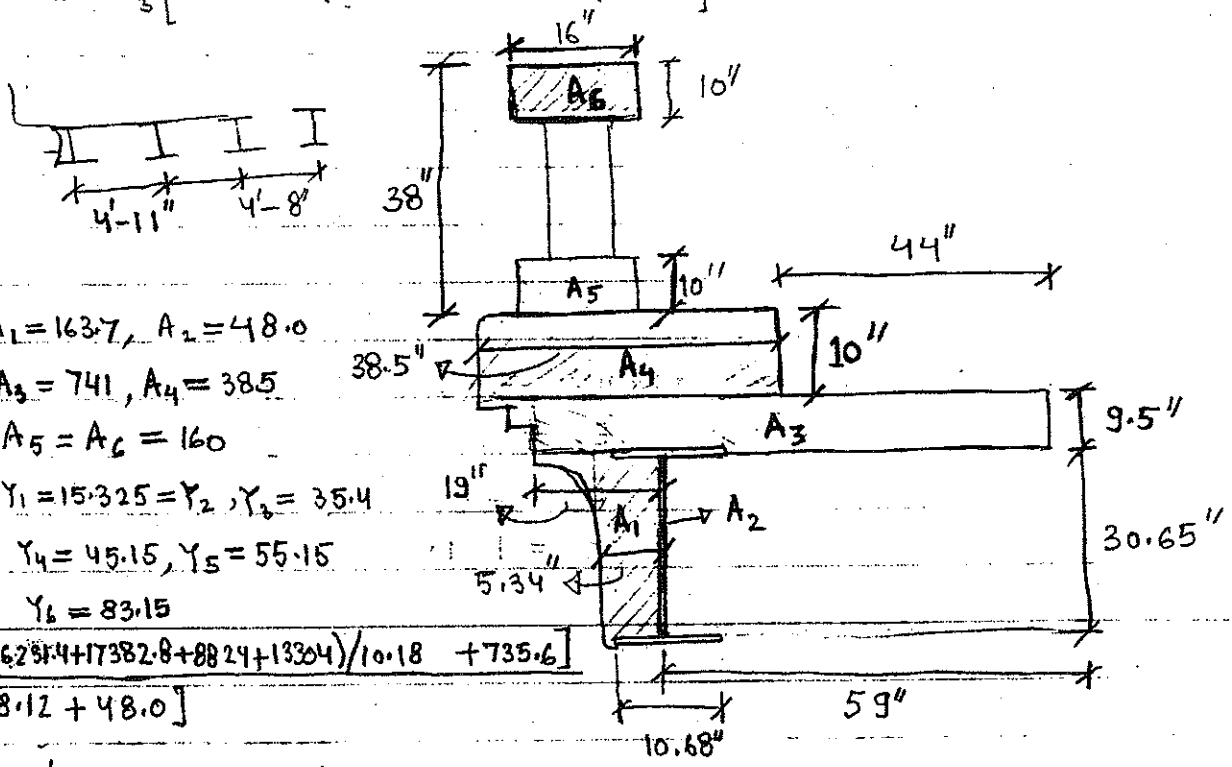
downstream	76.75	88.25	196.75	208.25
center	189.25	200.75	309.25	320.75
↑up = down↓				

(longitudinal)



$$J_{int} = \Sigma \frac{bt^3}{3} = 2 \times \frac{1}{3} \times 10.53 \times \left(\frac{1.215 + 0.8}{2}\right)^3 + \frac{1}{3} \times 27.7 \times (0.58)^3 = 8.98 \text{ in}^4 \approx 9 \text{ in}^4$$

$$J_{ext} = \frac{1}{3}\left[2 \times 10.68 \times (1.2725)^3 + 27.7 \times (0.73)^3\right] = 18.3 \text{ in}^4.$$



$A_1 = 163.7$, $A_2 = 48.0$

$A_3 = 741$, $A_4 = 385$

$A_5 = A_6 = 160$

$Y_1 = 15.325 = Y_2$, $Y_3 = 35.4$

$Y_4 = 45.15$, $Y_5 = 55.15$

$Y_6 = 83.15$

$$\bar{Y} = \frac{\left[(2508.7 + 2625.4 + 17382.8 + 8824 + 13304)/10.18 + 735.6\right]}{\left[158.12 + 48.0\right]}$$

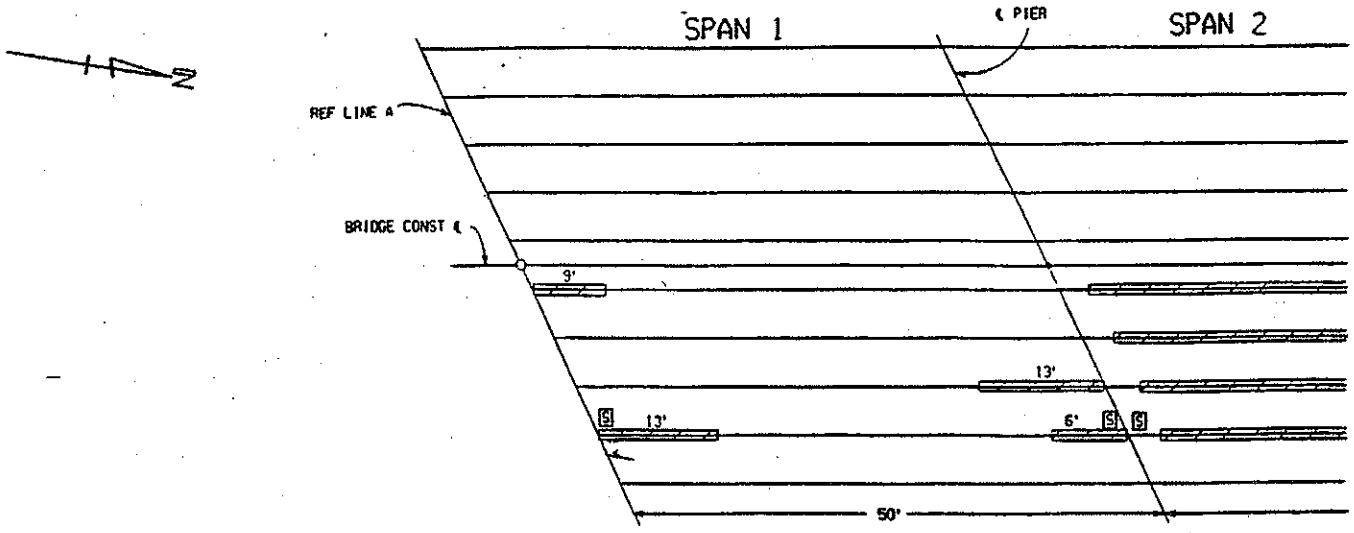
$$= 7440.0 / 206.124 = 36.1 \text{ in}$$

$$(I_{ext})_{comp} = \left[1258.6 + 6939.1\right]_1 + \left[7270.7 + 20717\right]_1 + \left[547.44 + 35.7\right]_3 + \left[315.2 + 3037.5\right]_4$$
$$+ \left[130.98 + 5703.8\right]_5 + \left[130.98 + 34793\right]_6 = 80940.0 \text{ in}^4$$

$$(J_{ext})_{comp} = \left[2 \times 16 \times \frac{10^3}{3} + 38.5 \times \frac{10^3}{3} + 78 \times \frac{9.5^3}{3} + 30.65 \times \frac{5.34^3}{3}\right] \times \frac{1240}{11154} + 18.3 = 4290.7 \text{ in}^4$$

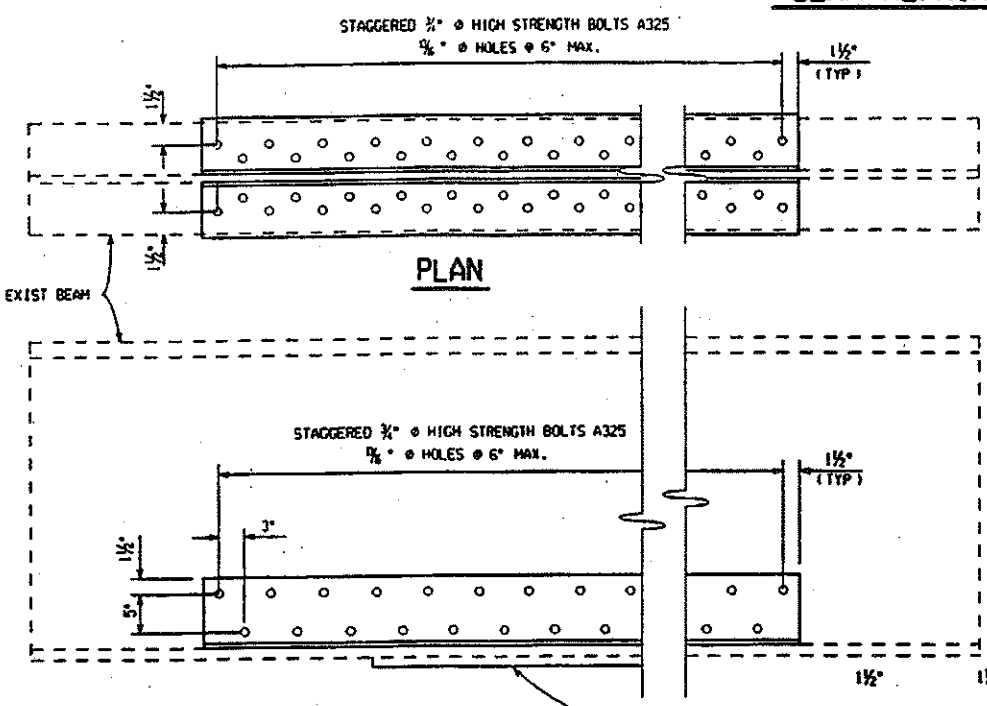
Bridge #3

CONTROL SECTION B01 OF 78011 JOB NO.



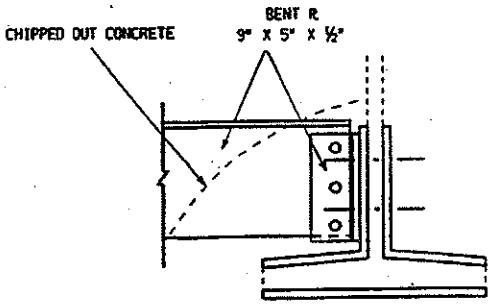
BEAM REPAIR LOCATION DIAGRAM

South



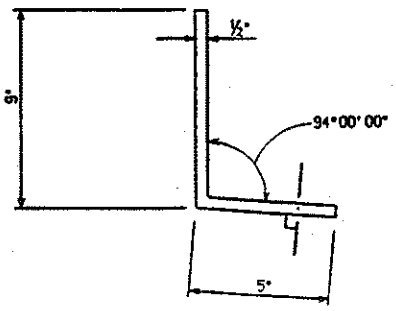
PLAN

ELEVATION



DIAPHRAGM DETAIL

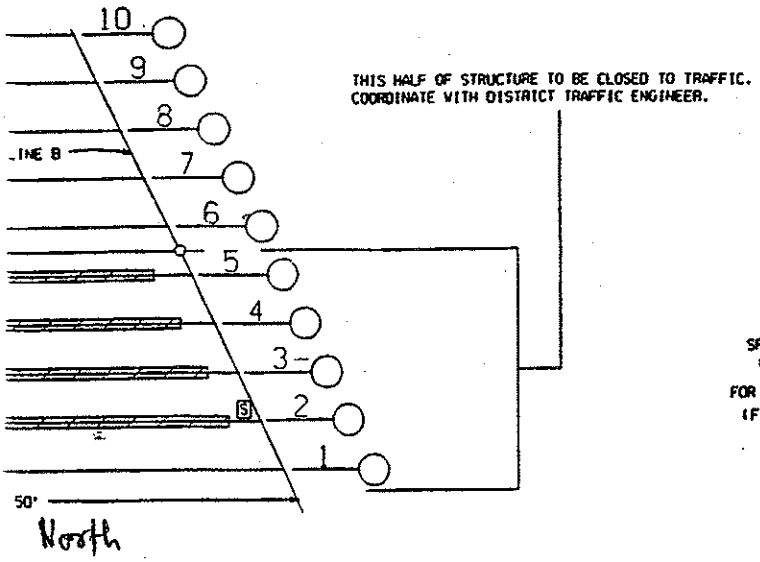
* CONCRETE DIAPHRAGM TO BE HANDCHIPPED OUT TO ALLOW FOR PLACEMENT OF THE BENT PLATE. (APPROXIMATE SECTION 1' WIDE X 9" HIGH)

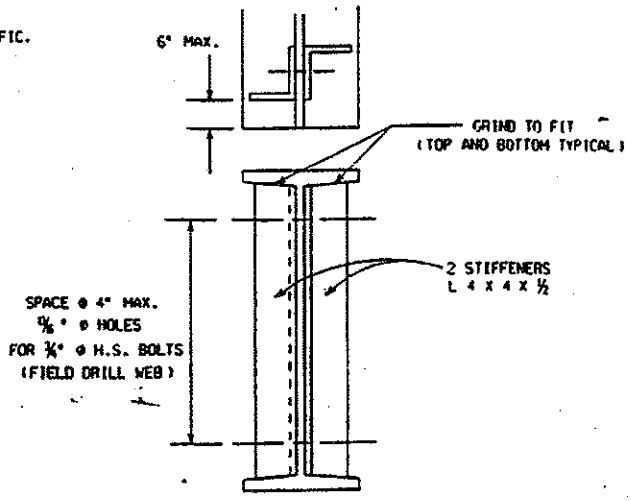


BENT PLATE DETAIL

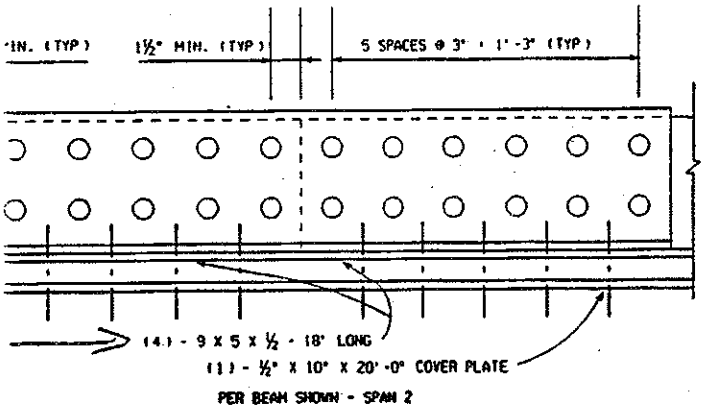
(SHOP PRIME)

Bridge #3

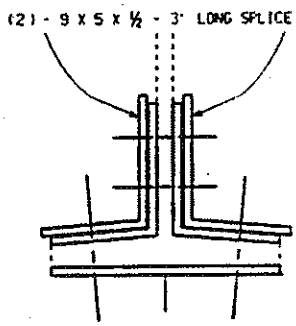




STIFFENER DETAIL [S]



SPLICE DETAIL ELEVATION



SPLICE DETAIL SECTION

** LEAVE 2' OF BENT PLATE UNDRILLED. (SEE DIAGRAM)
EXISTING BEAM IS TO BE CLEANED AND PRIMED IN REPAIR AREAS PLUS 3" OUTSIDE PERIMETER OF REPAIR.

ALL BOLTS ¾" ø H.S. GALV.

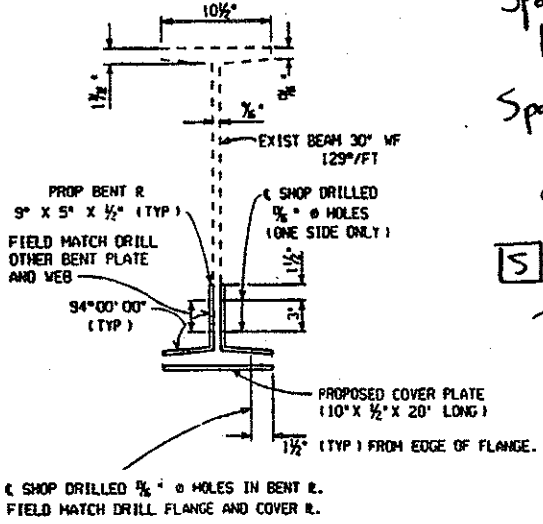
Discussed Taylor 9/21/95

Span 1 bent PL only - (No coverplate) for length shown

Span 2 bent PL & cover PL
Bent PL ~36' long centered in Span
Cover PL 20' long centered in Span

[S] = Bearing Stiffener added

TJD



MICHIGAN DEPARTMENT OF TRANSPORTATION

M-103 OVER THE WHITE PIGEON RIVER

DETERIORATED BEAM REPAIR

REVISIONS			
NO.	DESCRIPTION	DATE	BY

SQUAD BOSS	TARAZI	
DRAWN BY	NEMETH	9-20-95
CORRECTED BY		
CHECKED BY	LOT	
SHEET	OF	

B01 OF 78011

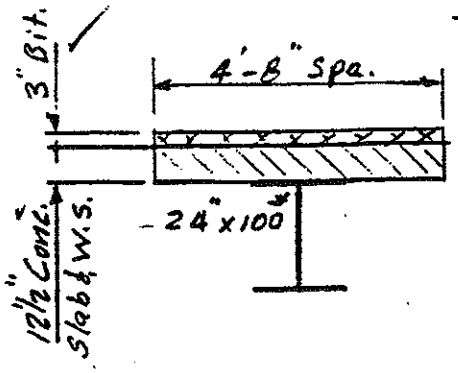
FILE NAME: B0178011.B03

Bridge #4

G. Raffo 2-2-73
Arrett 3-13-73

B01 of 19062
B1 of 19-12-4

Bridge Analysis



One span 40', C-C Brg. = 38'-6"
Built 1929, Deterioration = ±3%
Rdwy = 40'-0", Bit. surface = 3"
Slab thickness & C.W.C. = 12½"
Bm. 24" I 100# (C.B.), Spa. 4'-8"
S = 251.7 x .97 = 244 in³

Dead Load:

Bit: .25 x 4.67 x 144 = 168
Conc.: 1.04 x 4.67 x 150 = 729
Bm.: = 100
Conc. Diaph. = .75 x 2.0 x 4.6 x 2 x 150 / 38.5 = 54
1051#/'

M D.L. = 1.051 (38.5)² / 8 = 195 'K

	Inventory Rating	Operating Rating
L.L. Dist. Factor	S/11.5	S/14.5
ALL. stress	16.5 Ksi	22.5 Ksi
Stringer/Lane	11.5/4.67 = 2.46	14.5/4.67 = 3.10
Res. mom./Lane	244 x 16.5 x 2.46/12 = 825	244 x 22.5 x 3.10/12 = 1418
D.L. mom./Lane	195 x 2.46 = 480	195 x 3.10 = 605
avail. mom./Lane	345 'K	813 'K

H Rating :- 345 x 15 / 325 = H 15.9

Two Unit Vehicle :- 813 x 77 / 831 = 75.3 T

bridge # 3
Ext. 30 x 163#
Int. 30 x 129#

If composite then.
Res. mom/lane = 2528.0 kft/lane (OP)
avail. mom/lane = 1923.0 kft/lane
OP-Rating factor = 1923/831 = 2.31

Experimental and Analytical Deflections for Bridge No. 4

Bridge No. 4											
Experimental and Analytical Strains				(assuming Simple Supports)							
(deflection in mm)											
	At Mid-Span										
	Girder 2			**Girder 3**			**Girder 4**			**Girder 5**	
	Exp.	Comp.	Ncomp	Exp.	Comp.	Ncomp	Exp.	Comp.	Ncomp	Exp.	Comp.
Downstream 1	0.00	0.07	0.29	0.05	0.21	1.17	0.11	0.49	2.31	0.37	0.94
Downstream 2	0.00	0.08	0.35	0.10	0.26	1.41	0.24	0.59	2.79	0.53	1.13
Downstream 3	0.00	0.10	0.42	0.11	0.31	1.71	0.18	0.71	3.38	0.57	1.37
Center 1	-0.01	0.71	3.43	0.72	1.38	5.13	1.21	2.06	6.65	1.59	2.42
Center 2	-0.02	0.85	4.13	0.96	1.67	6.21	1.70	2.52	8.12	2.16	2.95
Center 3	-0.02	1.03	5.01	1.07	2.02	7.46	1.81	2.99	9.62	2.30	3.51
Upstream 1	-0.04	1.69	9.33	1.34	2.11	8.53	1.32	2.07	7.28	1.06	1.54
Upstream 2	-0.05	2.09	11.39	1.82	2.57	10.39	1.74	2.54	8.91	1.34	1.86
Upstream 3	-0.05	2.44	13.52	1.91	3.06	12.36	1.78	2.99	10.54	1.41	2.24
					Maximum =	13.52	mm				

Experimental and Analytical Deflections for Bridge No. 4

	Girder 6			Girder 7			Girder 8			Girder 9		
Ncomp	Exp.	Comp.	Ncomp	Exp.	Comp.	Ncomp	Exp.	Comp.	Ncomp	Exp.	Comp.	Ncomp
3.80	0.86	1.54	5.55	1.29	2.07	7.28	1.40	2.11	8.53	1.09	1.69	9.33
4.58	1.14	1.86	6.74	1.72	2.54	8.91	1.82	2.57	10.39	1.43	2.09	11.39
5.54	1.24	2.24	8.07	1.80	2.99	10.54	1.94	3.06	12.36	1.55	2.44	13.52
7.49	1.69	2.40	7.50	1.50	2.00	6.65	0.91	1.28	5.13	0.45	0.62	3.43
9.16	2.22	2.92	9.16	1.94	2.44	8.12	1.10	1.55	6.21	0.57	0.75	4.13
10.85	2.36	3.47	10.85	2.05	2.89	9.63	1.21	1.87	7.46	0.59	0.91	5.00
5.55	0.66	0.94	3.80	0.44	0.49	2.31	0.19	0.21	1.17	0.04	0.07	0.29
6.74	0.79	1.13	4.58	0.49	0.59	2.79	0.22	0.26	1.41	0.04	0.08	0.35
8.07	0.84	1.37	5.54	0.51	0.71	3.38	0.23	0.31	1.71	0.05	0.10	0.42

Experimental and Analytical Deflections for Bridge No. 4

At Quarter Points						
Girder 5						
Q1			**Q2**			
Exp.	Comp.	Ncomp	Exp.	Comp.	Ncomp.	
0.37	0.68	2.80	0.29	0.65	2.57	
0.46	0.80	3.23	0.43	0.80	3.23	
0.49	0.97	3.95	0.47	0.96	3.90	
1.48	1.90	5.96	0.95	1.54	4.70	
1.58	2.05	6.33	1.43	2.05	6.33	
1.86	2.57	7.98	1.64	2.48	7.71	
0.79	1.17	4.26	0.64	1.01	3.62	
0.89	1.31	4.71	0.88	1.31	4.71	
0.97	1.62	5.84	0.93	1.58	5.70	

Experimental and Analytical Deflections for Bridge No. 4

Bridge No.4											
Experimental and Analytical Strains				(assuming Simple Supports)							
(stresses in MPa)											
Composite Factor =			####								
Non-Composite Factor =			####								
	At Mid-Span										
	Girder 2			**Girder 3**			**Girder 4**			**Girder 5**	
	Exp.	Comp.	Ncomp	Exp.	Comp.	Ncomp	Exp.	Comp.	Ncomp	Exp.	Comp.
Downstream 1	0.10	0.59	1.27	0.97	1.91	5.12	1.34	4.40	10.13	2.06	8.47
Downstream 2	0.11	0.71	1.52	1.17	2.30	6.12	1.62	5.28	12.11	2.13	10.20
Downstream 3	0.20	0.86	1.86	1.35	2.79	7.50	1.79	6.45	14.86	2.48	12.36
Center 1	1.80	6.39	15.00	7.08	12.44	22.21	5.76	18.15	28.37	11.32	21.39
Center 2	2.27	7.66	18.07	10.13	15.39	28.07	9.64	24.78	38.41	7.22	28.53
Center 3	2.54	9.35	21.87	9.58	17.85	31.52	7.68	24.69	38.73	11.66	29.43
Upstream 1	5.05	14.65	39.94	10.42	18.74	36.51	6.59	18.09	31.06	8.03	13.76
Upstream 2	7.81	21.47	53.48	15.13	24.78	48.88	10.66	25.39	42.27	5.86	17.47
Upstream 3	6.48	19.02	54.88	12.84	25.83	50.11	7.74	24.18	42.22	8.44	19.45

Experimental and Analytical Deflections for Bridge No. 4

	Girder 6			**Girder 7**			**Girder 8**			**Girder 9**		
Ncomp	Exp. _	Comp.	Ncomp	Exp.	Comp.	Ncomp	Exp.	Comp.	Ncomp	Exp.	Comp.	Ncomp
16.57	5.94	13.76	23.94	7.63	18.09	31.06	7.09	18.74	36.51	6.60	14.65	39.94
20.16	7.62	17.47	31.00	12.70	25.39	42.27	10.94	24.78	48.88	9.33	21.47	53.48
24.01	7.85	19.45	33.55	9.28	24.18	42.22	8.84	25.83	50.11	8.17	19.02	54.88
31.96	10.05	21.18	31.96	7.84	17.55	28.37	5.96	11.54	22.21	2.39	5.60	14.99
43.50	15.87	28.27	43.50	12.19	24.05	38.41	8.08	14.31	28.07	2.89	6.71	18.06
43.45	13.05	29.13	43.48	10.08	23.80	38.76	7.83	16.53	31.52	3.31	8.20	21.85
23.94	4.92	8.47	16.57	2.37	4.40	10.13	1.31	1.91	5.12	0.22	0.59	1.27
31.00	6.25	10.20	20.16	2.91	5.28	12.11	1.63	2.30	6.12	0.29	0.71	1.52
33.55	6.26	12.36	24.01	3.00	6.45	14.86	1.64	2.79	7.50	0.29	0.86	1.86

Experimental and Analytical Deflections for Bridge No. 4

Quarter Points										
Girder 4						**Girder 5**				
Q1			**Q2**			**Q1**			**Q2**	
Exp.	Comp.	Ncomp	Exp.	Comp.	Ncomp	Exp.	Comp.	Ncomp	Exp.	Comp.
2.03	3.10	7.48	1.83	3.12	6.81	2.06	6.62	13.78	1.69	5.35
2.11	3.76	8.68	2.61	3.76	8.68	2.13	7.21	14.01	2.56	7.21
2.53	4.52	10.45	2.71	4.53	10.30	2.48	8.88	17.73	2.60	8.60
11.63	19.29	30.07	2.11	8.03	12.54	11.32	22.45	34.81	0.87	9.28
7.84	13.93	21.72	5.27	13.93	21.72	7.22	16.85	24.79	3.83	16.85
12.27	22.43	34.84	8.12	20.17	31.41	11.66	25.85	39.56	6.37	23.10
9.93	20.51	33.31	0.66	7.17	13.56	8.03	12.93	23.09	1.73	6.95
4.82	13.39	23.44	3.78	13.39	23.44	5.86	11.34	19.58	4.59	11.34
9.70	23.21	38.49	5.18	20.59	34.73	8.44	15.60	27.69	5.25	14.29

Experimental and Analytical Deflections for Bridge No. 4

	Girder 6						Girder 7					
	Q1			Q2			Q1			Q2		
Ncomp	Exp.	Comp.	Ncomp	Exp.	Comp.	Ncomp	Exp.	Comp.	Ncomp	Exp.	Comp.	Ncomp
9.75	6.92	12.93	23.09	1.69	6.95	11.80	9.14	20.51	33.31	0.07	7.17	13.56
14.01	4.33	11.34	19.58	4.52	11.34	19.58	2.72	13.39	23.44	2.45	13.39	23.44
16.85	7.26	15.60	27.69	4.75	14.29	25.17	8.80	23.21	38.49	2.92	20.59	34.73
13.06	10.44	22.31	34.81	1.02	9.14	13.07	13.15	19.29	30.07	1.00	8.03	12.54
24.79	6.30	16.68	24.79	4.22	16.68	24.79	8.39	13.93	21.72	3.41	13.93	21.72
35.03	10.60	25.64	39.56	6.07	22.88	35.03	13.87	22.43	34.84	5.17	20.17	31.41
11.80	2.64	6.62	13.78	1.85	5.35	9.75	3.30	3.10	7.48	1.45	3.12	6.81
19.58	2.74	7.21	14.01	2.89	7.21	14.01	3.50	3.76	8.68	2.10	3.76	8.68
25.17	2.98	8.88	17.73	2.85	8.60	16.85	3.84	4.52	10.45	2.11	4.53	10.30

Bridge #4

Built in 1929

Exterior Girders

$24\frac{5}{6}'' \times 120^{\#}$, $A = 35.29\ in^2$, $d = 24.31''$, $b = 12.089''$

$I = 3669.7\ in^4$, $J = 7.9\ in^4$

Interior Girder

$24'' \times 100^{\#}$, $A = 29.41\ in^2$, $d = 24.0''$, $b = 12.00''$,

$I = 3020.5\ in^4$, $J = 4.58\ in^4$

Slab

concrete slab $= 6.5''$, wearing surface $= 6.0''$

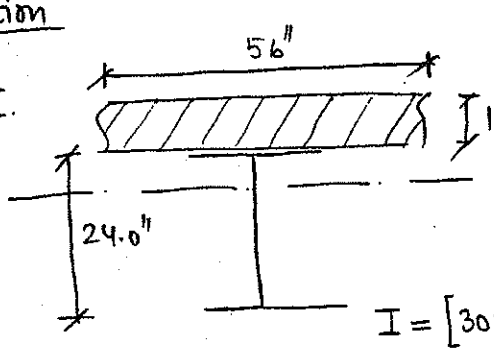
$f' = 2500\ psi$, $E_c = 2850\ ksi$, $G_c = 1240\ ksi$

$E_s = 29{,}000\ ksi$, $G_s = 11154\ ksi$

$n = 10.18$

Composite Section

Interior



$$\bar{y} = \frac{(68.76 \times 30.25 + 29.41 \times 12)}{(68.76 + 29.41)}$$

$$= 24.78''$$

$$I = [3020.5 + 4803.5] + [895.3 + 2057.4]$$

$$\left\{ \begin{array}{l} I = 10776.7\ in^4 \\ J = 4057.7\ in^4 \end{array} \right\} \Rightarrow S = 434.9\ in^3$$

exterior

$A_1 = 60.31\ in^2$, $A_2 = 25.7$, $A_3 = 21.5$, $A_4 = 45.3$, $A_5 = 35.29$,

$y_1 = 59.8''$, $y_2 = 37.21''$, $y_3 = 12.155''$, $y_4 = 29.06''$, $y_5 = 12.155''$

$$\bar{y} = \frac{(3606.54 + 956.3 + 261.33 + 1316.4 + 428.95)}{(60.31 + 25.7 + 21.5 + 45.3 + 35.29)} = \frac{6569.5}{188.1} = 34.93''$$

$$(I_{ext})_{comp} = [7401.8 + 37302.8]_1 + [99.1 + 133.6]_2 + [1058.4 + 11152.1]_3 + [340.4 + 1560.9]_4 + [3669.7 + 18305.0] = \underline{81024.0\ in^4}$$

$$(J_{ext})_{comp} = [52394.7 + 4035.2 + 5907.33 + 13860.9] \times \frac{1240}{11154} + 7.9 = \underline{8479.0\ in^4}$$

Kuo 5/14/73 Bridge # 5 B1 of 82-2-20

B01 of 82081

Bridge Analysis (Conc. T-beam)

1 Span @ 27' c-c brg. = 25.5' ± Information comes from F.H.

Rdwy = Wayne Co. has plans A-9-1 25W

Built in 1920 A-9-1 26W

Loading = H20

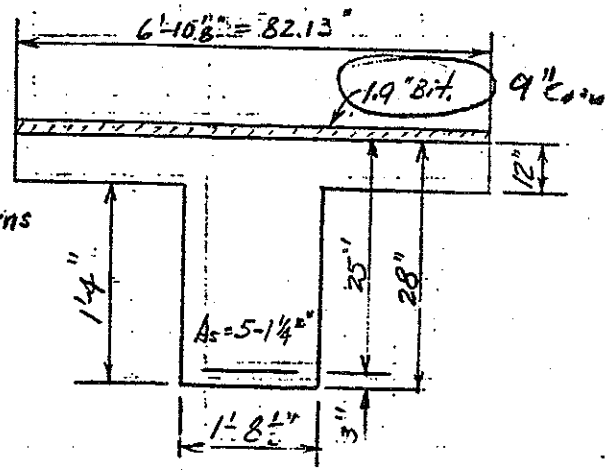
Bit. = 1.9"

Bm spacing = 6'-10 1/8"

n = 12 , d = 25"

Eff. Width $b = \frac{1}{4} \times 25.5 = 6.375' = 6'-4\frac{1}{2}" = 76.5"$ Governs

$A_s = 5 \times (1.25) = 7.81 \text{ in}^2$



$$P = \frac{A_s}{b \cdot d} = \frac{7.81}{76.5 \times 25} = 0.00408$$

$$Pn = 0.0490, \quad \frac{t}{d} = \frac{12}{25} = 0.48$$

This T-bm works as rectangular bm.

$j = 0.905$, $jd = 0.905 \times 25 = 22.6"$

Dead Load: Bit. $= 0.16 \times 6.84 \times 144 = 158$ #/'

Flange $= 1.0 \times 6.84 \times 150 = 1026$ #/'

Web $= 1.71 \times 1.33 \times 150 = 341$ #/'

1525 #/'

$M_{DL} = \frac{1}{8} \times 1.525 \times (25.5)^2 = 124$ K'

	Inventory 18	Operating 25
f_s ksi		
R.M. $= A_s f_s jd$	$\frac{1}{12} \times 7.81 \times 18 \times 22.6 = 265$	$\frac{1}{12} \times 7.81 \times 25 \times 22.6 = 368$
$-M_{DL}$	$= -124$	-124
Avail Multiplier K'/Lane	$\frac{12}{6.84} \times 141 = 247$	$\frac{12}{6.84} \times 244 = 424$

HS20 $= 247/280 = 0.88$

H Rating $= \frac{247}{199} \times 15 = H\,18.6 = 1.24$

Operating Rating $= \frac{424}{400} \times 77 = 82$ Ton $= 1.06$

HS20 $= 424/280 = 1.51$

Experimental and Analytical Deflections for Bridge No. 5

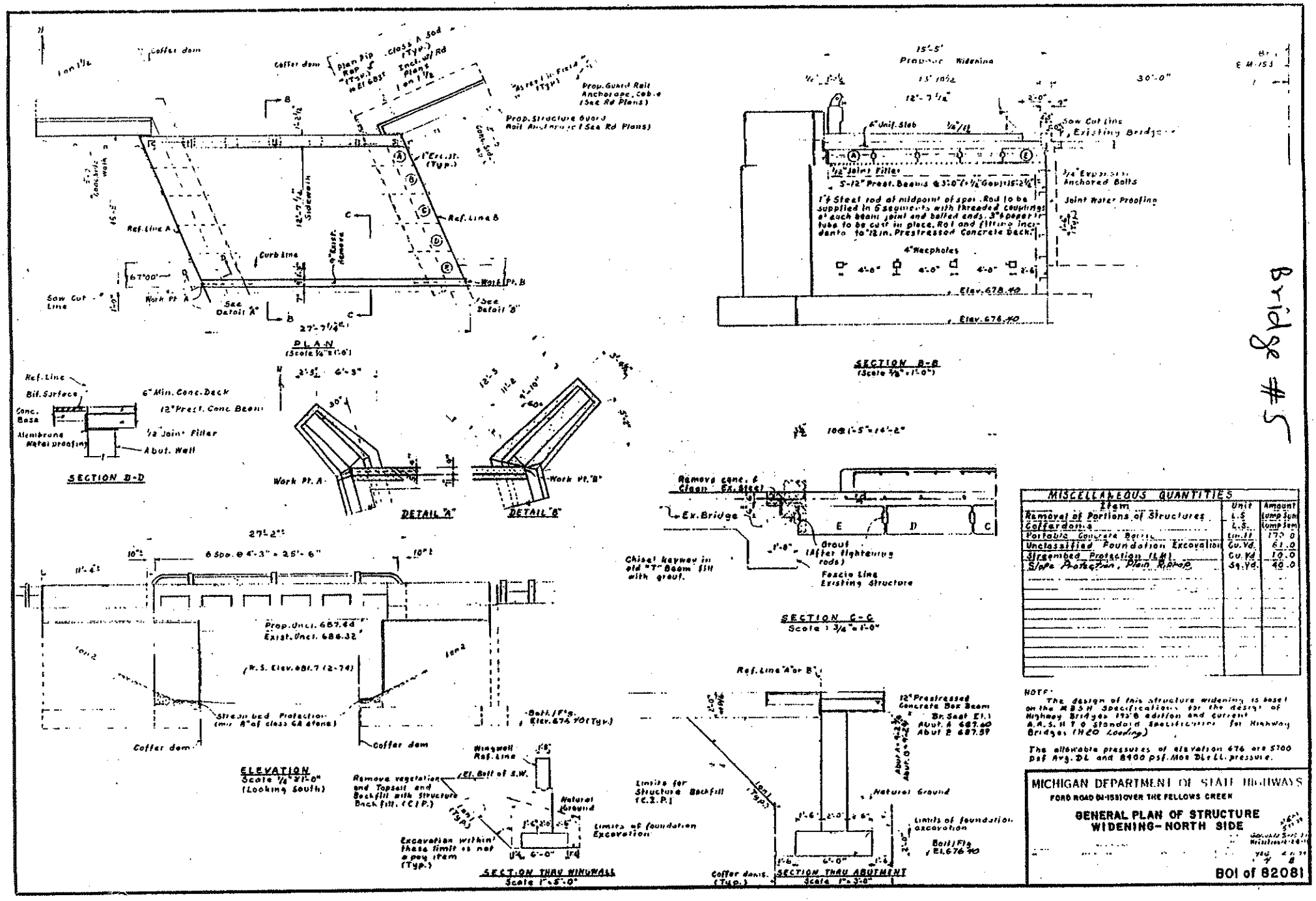
Bridge No. 5							
Comparison of analytical and measured deflections in mm							
	GIRDER 1		GIRDER 2		GIRDER 3		GIRDER 4
	Measured	Analytical	Measured	Analytical	Measured	Analytical	Measured
Lane 1&2 - 1	0.3581	0.4014	0.4035	0.5798	0.3039	0.4014	0.1418
Lane 1&2 - 2	0.4164	0.5798	0.4743	0.6900	0.3315	0.5798	0.1535
Lane 1&2 - 3	0.5445	0.7400	0.7581	0.8700	0.7415	0.7400	0.5558
Lane 2&3 - 1	0.0920	0.1020	0.1779	0.1900	0.2962	0.3200	0.2121
Lane 2&3 - 2	0.1018	0.1198	0.2206	0.3000	0.3778	0.5600	0.3118
Lane 2&3 - 3	0.1233	0.1590	0.3338	0.4820	0.5930	0.7000	0.7395
Lane 3&4 - 1	0.0241	0.002	0.0485	0.0020	0.1293	0.0200	0.2710
Lane 3&4 - 2	0.0232	0.01	0.0307	0.0100	0.1487	0.0260	0.3204
Lane 3&4 - 3	0.0147	0.04	0.0438	0.0900	0.1819	0.1500	0.4056
Lane 4&5 - 1	0.0005	0.3014	-0.0079	0.1680	0.0086	0.2014	0.0418
Lane 4&5 - 2	0.0028	0.3200	-0.0084	0.1800	0.0189	0.2180	0.0614
Lane 4&5 - 3	0.0081	0.7400	0.0225	0.2800	0.0432	0.3300	0.0881

Experimental and Analytical Deflections for Bridge No. 5

	GIRDER 5		GIRDER 6		GIRDER 7		GIRDER 8	
Analytical	Measured	Analytical	Measured	Analytical	Measured	Analytical	Measured	Analytical
0.3500	0.0781	0.3	0.0679	0.3000	0.0663	0.2014	0.0418	0.1680
0.4600	0.0843	0.32	0.0692	0.3200	0.0639	0.2180	0.0419	0.1800
0.6600	0.3057	0.4999	0.1346	0.4300	0.0675	0.3300	0.0360	0.2800
0.3200	0.0485	0.1000	-0.0441	0.0200	-0.0496	0.0200	-0.0469	0.0020
0.4400	0.1039	0.2800	-0.0211	0.1400	-0.0423	0.0260	-0.0424	0.0100
0.8200	0.6176	0.7700	0.4200	0.5300	0.1377	0.1500	0.0184	0.0900
0.2000	0.3579	0.1000	0.3571	0.3200	0.1348	0.3200	0.0240	0.1900
0.3400	0.3939	0.2800	0.3543	0.4400	0.1323	0.5600	0.0254	0.3000
0.5300	0.5804	0.7700	0.7215	0.8200	0.6158	0.7000	0.3983	0.4820
0.3000	0.1133	0.3	0.2576	0.3500	0.4256	0.4014	0.3799	0.5798
0.3200	0.1621	0.32	0.3649	0.4600	0.5009	0.5798	0.3889	0.6900
0.4300	0.2033	0.4999	0.4653	0.6600	0.8429	0.7400	0.9901	0.8700

Experimental and Analytical Deflections for Bridge No. 5

GIRDER 9						
Measured	Analytical					
0.1164	0.3014					
0.1390	0.3200					
0.4880	0.7400					
0.2148	0.002					
0.2749	0.01					
0.5619	0.04					
0.1678	0.1020					
0.2129	0.1198					
0.2832	0.1590					
0.0194	0.4014					
0.0364	0.5798					
0.0658	0.7400					



MISCELLANEOUS QUANTITIES		
Item	Unit	Amount
Removal of Portions of Structures	L.S.	Lump Sum
Coffer dams	L.S.	Lump Sum
Portable Concrete Barrier	Lin. ft.	175.0
Unclassified Foundation Excavation	Cu. Yd.	61.0
Streambed Protection (L.H.)	Cu. Yd.	10.0
Slope Protection, Plain Riprap	Sq. Yd.	40.0

NOTE:

The design of this structure widening is based on the M.B.S.H. Specifications for the design of Highway Bridges 1973 edition and current A.A.S.H.T.O. Standard Specifications for Highway Bridges (H20 Loading)

The allowable pressures of elevation 676 are 5700 psf Avg. DL and 8400 psf. Max DL+LL pressure.

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

FORD ROAD (M-153) OVER THE FELLOWS CREEK

GENERAL PLAN OF STRUCTURE WIDENING - NORTH SIDE

BOI of B2081

Bridge #5