Abridgment

Effect of Guardrails on Interstate Bridges on Vehicle Speed and Lateral Placement

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West Virginia University conducted a research study to determine the best shoulder and curb widths on highway bridges from the standpoint of safety, operational, and cost. A major objective of the study was to determine the behavior of traffic (speeds and lateral placements) on long-span bridge structures with different shoulder and curb widths. A secondary objective was to determine whether the addition of a guardrail barrier flush with the face of a curb on a bridge affects the lateral placement and speed of moving vehicles on the structure.

Data were collected in the vicinity of and on a bridge on I-79 approximately 1.6 km (1 mile) from the downtown area of Fairmont, West Virginia, for speeds and lateral placements with various bridge shoulder curb widths with a guardrail type of barrier both flush with the face of the curb and offset 0.6 m (2 ft) from the face of the curb. Ten conditions were studied and are reported in this paper. Two were a base condition (no guardrail or curb present) with and without a sign saying TEST BRIDGE AHEAD. Four were a guardrail mounted flush with the curb 0.6, 1.2, 1.8, and 2.4 m (2, 4, 6, and 8 ft) from the parapet. Three were offset guardrails 1.2, 1.5, and 2.4 m (4, 5, and 8 ft) from the parapet. One was only a curb 2.4 m (8 ft) from the parapet.

The site, data collection procedure, and data reduction procedure are identical to those used by Roberts in a paper in this Record. Further information on the data collection procedure is contained in Byrne and others in a paper in this Record. Much greater detail on results may be found in Byrne (1).

RESULTS

The data were analyzed by using the analysis of variance technique and Tukey tests to find significant differences between speeds and placements for different conditions and positions. Position refers to tape switch trap position. Positions 1 and 2 were 300 and 150 m (1000 and 500 ft) upstream of the bridge. Positions 3, 4, and 5 were at the upstream end, middle, and downstream end of the bridge respectively. Position 6 was 150 m (500 ft) downstream of the bridge.

The following analyses were performed for both speed and placement:

1. One-way analysis of variance for each condition at all positions to determine whether there is any significant difference between positions for any condition,
2. One-way analysis of variance for all conditions at each position to see whether there is any significant difference between conditions for each position,
3. Two-way analysis of variance for all conditions at all positions to determine whether there is any interaction between positions and conditions, and
4. Tukey's test to find the significant difference between positions and conditions.

The one-way analysis of variance of speeds showed that there is a significant difference between speeds at positions for the following conditions: (a) 0.6-m (4-ft) guardrail, (b) 1.8-m (6-ft) guardrail, and (c) 2.4-m (8-ft) curb. For the other seven conditions, there was no significant difference between speeds within positions.

The one-way analysis of variance of placement showed that there is a significant difference in placements between positions for each condition except the base condition with sign. The analysis of variance of speeds and placements for conditions within positions showed that there is a significant difference between both speeds and placements for all conditions and for each position.

The two-way analysis of variance of speeds revealed a significant difference between speeds for positions and conditions for all combinations except for base conditions. For the base conditions, there was no significant difference between conditions, but there was a significant difference between positions. However, there was no interaction of positions and conditions.

The two-way analysis of variance of placements showed a significant difference for positions and conditions as well as significant interactions between positions and conditions for vehicle placements. Breaking down

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the two-way analysis of variance to related conditions shows interaction within the guardrail conditions and the offset guardrail conditions but not within the two base conditions and the 2.4-m (8-ft) conditions.

The last statistical test run was Tukey's test, which shows where significant differences exist within conditions and positions. Tukey's test was run twice on the main effects of speeds because there was no interaction (as shown in the two-way analysis of variance). The first run was for six positions and overall means of 10 conditions. The second run was for the overall means for each condition at all positions.

Tukey's test was run 16 times on simple effects of placements inasmuch as there was interaction. The first 10 were for each condition at all positions. The rest were for all conditions at each position.

There was no significant difference between the two base conditions in speeds and placements at all positions. Also the least frequency of significant differences within positions was observed in the two base conditions; the greatest frequency was observed in the 1.8-m (6-ft) guardrail, 2.4-m (8-ft) guardrail, 1.8-m (6-ft) offset guardrail, and 2.4-m (8-ft) curb conditions.

Figure 1 shows the mean placements for the guardrail conditions. The maximum placements occurred at positions 1 and 3 for the 0.6-m (2-ft) guardrail condition and at position 3 for the 1.2-m (4-ft) guardrail condition. These two conditions are not significantly different at position 3, but they are at position 1 where the difference is 0.113 m (0.37 ft). The maximum placement occurred at position 4 for the 1.8 and 2.4-m (6 and 8-ft) guardrail conditions, but these were not significantly different from each other at all positions.

Figure 2 shows the mean placements for the offset guardrail conditions. The maximum placement occurred at position 4 for the 1.8 and 2.4-m (6 and 8-ft) offset guardrail conditions, while the maximum placement occurred at position 3 for the 1.2-m (4-ft) offset guardrail condition. Note the inconsistencies where the placements for the 1.2-m (4-ft) offset guardrail condition are greater than those for the 1.8 m (6-ft) offset guardrail condition at positions 1, 2, 3, 4 and 6.

In addition there was no significant difference in placements for the 1.2-m (4-ft) guardrail and offset guardrail conditions at positions 2, 3, 5 and 6, and there was no significant difference between the 1.8-m (6-ft) guardrail and offset guardrail conditions at all positions.

Mean speeds were at a maximum mostly at position 6, and they were at a minimum mostly at position 1. In general, mean speeds increased at positions 2 and 3, then decreased at positions 4 and 5, and then increased again at position 6. The increase in speed is attributed to the 5 percent grade. The decrease in speed is attributed to the guardrail and the bridge.

Placements at positions 3 and 4, the beginning and the middle of the bridge, are in general the highest and significantly different from the other positions. The mean placement was at a maximum at position 4, 1.23 m (4.03 ft) for the 2.4-m (8-ft) guardrail condition, while the maximum mean placement at position 3 was 1.17 m (3.89 ft) for the 2.4-m (8-ft) offset guardrail condition.

Figure 1. Mean placements for guardrail conditions at positions.

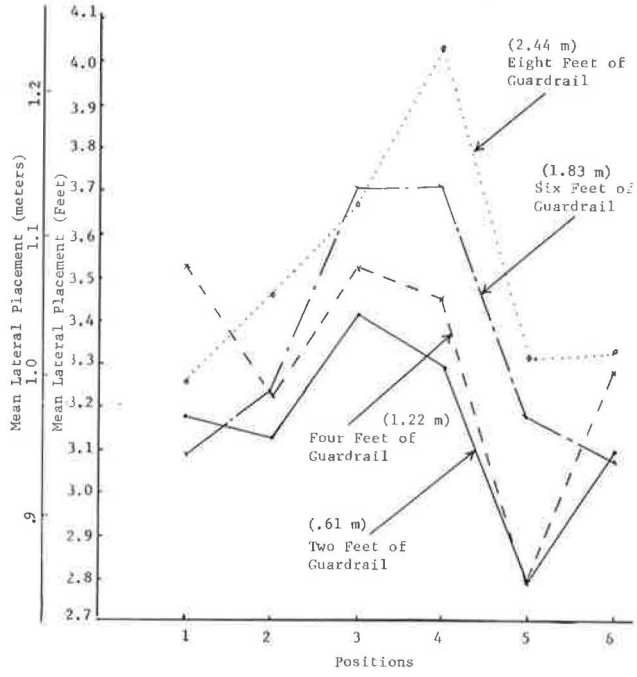
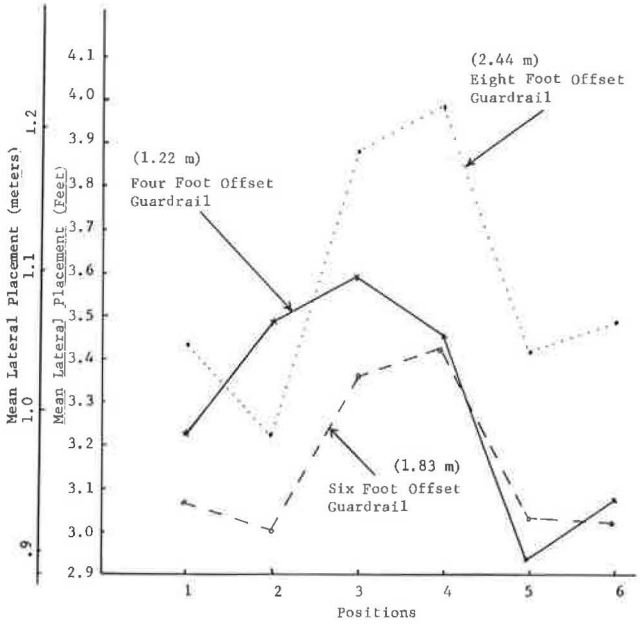


Figure 2. Mean placements for offset guardrail conditions at positions.



CONCLUSIONS

The following conclusions are drawn regarding speed.

1. There is a significant difference in speeds between positions and conditions but no interaction between positions and conditions, as was shown in the two-way analysis of variance.
2. There is no significant difference in speed between the base conditions with and without the sign.

The following conclusions were reached regarding placements.

1. There is a significant difference and interaction in placements between positions and conditions.
2. There is a significant difference in placement between positions for the base condition with no sign, but there is no significant difference in placement between positions for the base condition with the sign.
3. Placements at positions 3 and 4, which are at the beginning and the middle of the bridge, are, in general, the highest and significantly different from the other positions.
4. Vehicles move away from the shoulder as they

approach the bridge and cross it but tend to move back toward the shoulder at the lower end of the bridge. This is particularly true for the 2.4-m (8-ft) conditions.

There is no significant difference in placement for the 2.4-m (8-ft) guardrail, 2.4-m (8-ft) offset guardrail, and 2.4-m (8-ft) conditions at all positions.

Wider guardrails have a definite effect on vehicle placement, particularly in the center of the bridge where the average maximum placements occurred.

ACKNOWLEDGMENTS

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REFERENCE

1. B. F. Byrne, ed. Bridge Shoulder Width Study. West Virginia Department of Highways, Research Project 36, final rept.