DEVELOPMENT OF APPROACH RAIL-BRIDGE RAIL TRANSITION USING ALUMINUM BALANCED SYSTEM

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ABRIDGMENT

A series of four vehicle crash tests was performed during the development of an approach rail-bridge transition using the Aluminum Association balanced rail system. Nominal impact conditions for the 4,000-lbm (1800-kg) cars were 60 mph (97 km/h) and 25 deg; the point of impact was immediately upstream from the bridge rail end. After each test, design modifications were incorporated in the installation to improve its performance. Features that were varied during the test series include the bridge curb, transition post spacing, soil reaction plates for posts, rail cross section geometry, and rail splice details. The final design, tested in the fourth test, exhibited acceptable vehicle redirective performance. Vehicle decelerations of 6.6 (long.) and 7.8 (lat.) g are moderately high but are judged acceptable.

•A SIGNIFICANT number of fatal highway accidents occur near, at, or on bridges. Olson and others (1) showed that approximately 22 percent of fatal single-vehicle accidents involve these bridge sites. An analysis of these fatal accidents by location shows that 73 percent of errant vehicles impact the approach guardrail and bridge end and 27 percent collide with the bridge railing. Performance of the barrier systems in the accidents has been inadequate as evidenced by the fact that 16 percent of the vehicles either vaulted or penetrated the installation and 52 percent pocketed or snagged.

As a result of these statistics, highway engineers recognized the need for structural continuity between approach guardrail and bridge rail installations in the 1969 AASHO bridge specification. However, the design of safely performing schemes has been slow because of the difficulty of achieving a gradual and nonsnagging transition from the more flexible approach guardrail to the stiffer bridge rail installations.

The Aluminum Association balanced system traffic barrier offers a unique situation because the barrier is used as both guardrail and bridge rail. Accordingly, a research program was undertaken to develop an effective transition for the AA balanced system. The finalized system is shown in Figures 1 and 2.

PROGRAM

The program consisted of four full-scale crash tests with nominal impact conditions of a 4,000-lbm (1800-kg) vehicle impacting at 60 mph (97 km/h) and 25 deg. The point of impact was immediately upstream from the bridge rail end, the most vulnerable area of a traffic barrier. During the test series, installation features were modified to improve dynamic performance; the modified features were bridge curb, transition post spacing, soil reaction plates, rail cross section, and splice bar length.

FINDINGS

A summary of results for the four tests is given in Table 1. Because tests AA-2, AA-3, and AA-4 were preliminary tests, the primary interest of this paper is directed to test AA-5.

Figure 1. Pretest photographs of test installation.

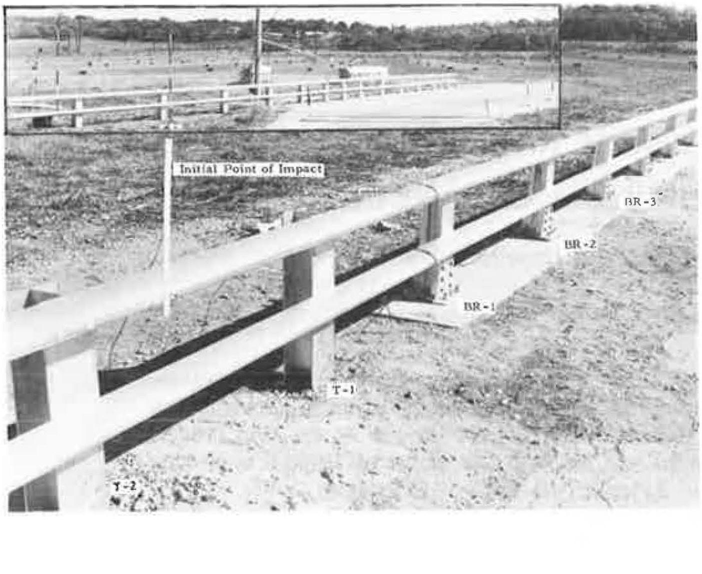

Figure 2. Details of approach rail-bridge rail test installation.

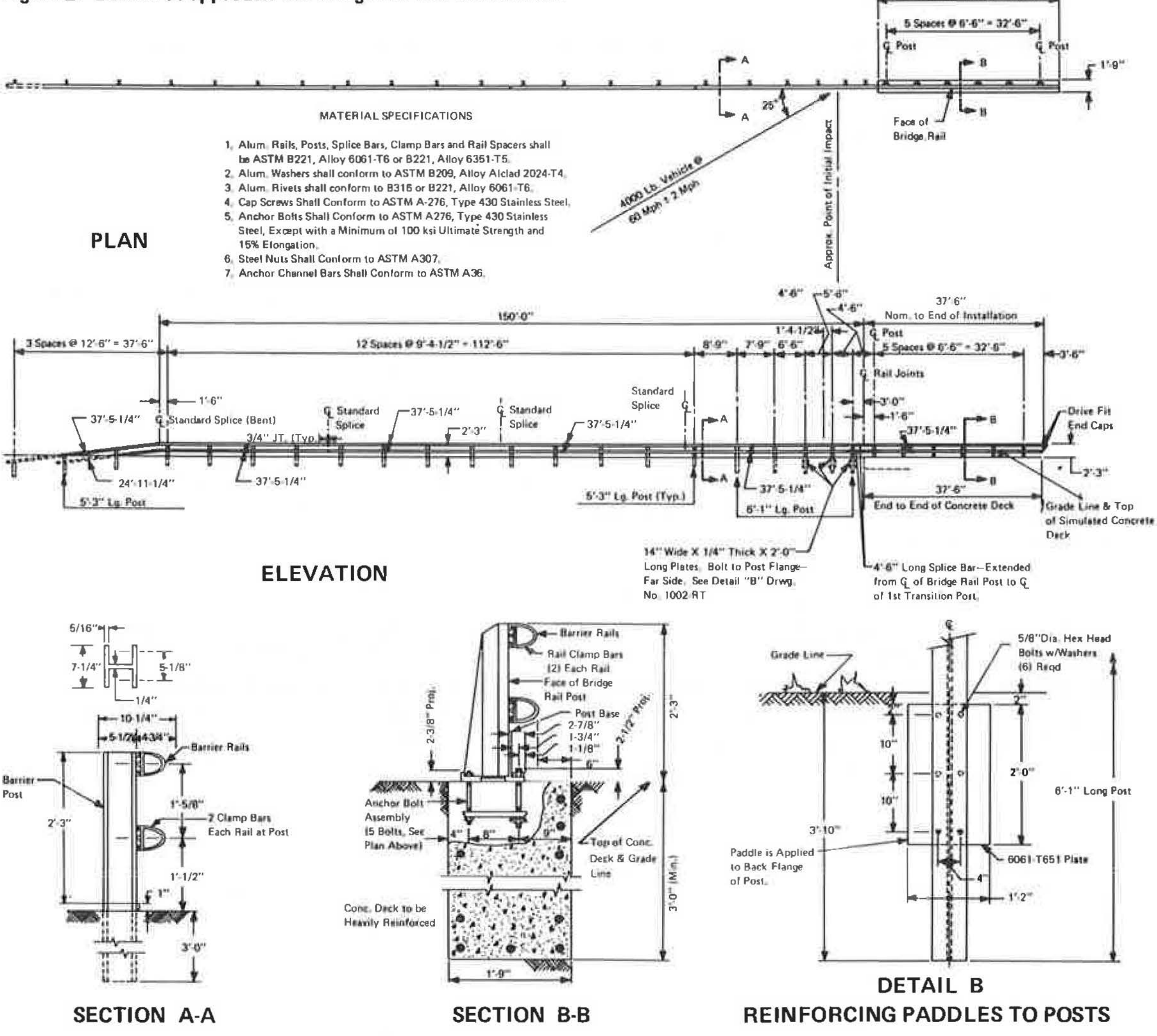

Table 1. Summary of test results.

Test	Impact Conditions: Vehicle Weight (lbm)	Speed (mph)	Angle (deg)	Location	Vehicle Decelerations (g)[a]: Long.	Lat.	Remarks
AA-2	3,997	58.2	26.7	8.5 ft upstream of bridge post 1	15.5	13.0	Vehicle snagged on concrete curb; both rails broke at end of transition connection splice bar
AA-3	4,050	63.7	25.0	1.0 ft downstream from transition post T3	14.2	14.0	Vehicle snagged on transition post; both rails failed at splice connection; excessive lateral deformation of transition post
AA-4	4,017	68.1	25.5	2.5 ft downstream from transition post T2	9.1	8.0	Vehicle redirected although snagging on transition post T1 occurred; top rail was severed after redirection
AA-5	3,965	58.0	23.0	0.8 ft downstream from transition post T2	6.6	7.8	Vehicle redirected although snagging on post T1 occurred

Note: 1 lbm = 0.45 kg; 1 mph = 1.6 km/h; 1 ft = 0.305 m.
[a]50 msec average.

Figure 3. Views of impacted rail showing (a) vehicle position after impact and (b) vehicle approach.

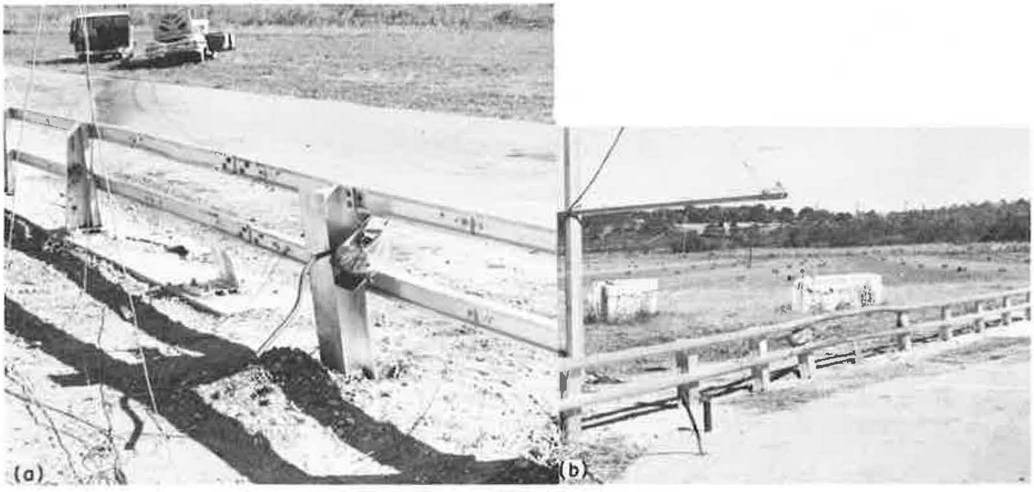

Figure 4. AA-5 test vehicle (a) before and (b) after impact.

After impacting the rail 0.8 ft (0.2 m) downstream from transition post T-2 (Fig. 1) at 58 mph (94 km/h) and 23 deg, the 3,965-lbm (1798-kg) AA-5 test vehicle was redirected at 20 deg after being in contact with the rail for 0.51 sec. Maximum lateral dynamic deflection of the system was 1.4 ft (0.45 m) and occurred between transition post T-1 and bridge post BR-2 (post BR-1 was taken out). Maximum vehicle accelerations were -6.6 (long.) and -7.8 (lat.) g. Installation damage is shown in Figure 3; vehicle damage is shown in Figure 4.

CONCLUSIONS

From the results of this test, the following conclusions are drawn:

1. The overall performance of the balanced system transition section was judged satisfactory considering the accepted performance criteria (2) and present traffic barrier technology.
2. Vehicle decelerations during redirection were moderate. It is conjectured that passengers restrained with lap belt and shoulder straps would probably have survived with only minor to moderate injuries.
3. The vehicle's 20-deg exit angle was relatively high and could possibly be a hazard to adjacent or following traffic.
4. Vehicle damage was extensive but is characteristic of damage for the severe test conditions involving relatively rigid traffic barrier systems.
5. The displacement of bridge post BR-1 could be a hazard, especially in urban areas where the bridge rail is installed on an overpass. The bridge post falling off the structure could endanger vehicular or pedestrian traffic below.

ACKNOWLEDGMENT

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REFERENCES

1. Olson, R. M., Post, E. R., and McFarland, W. F. Tentative Service Requirements for Bridge Rail Systems. NCHRP Rept. 86, 1970.
2. Michie, J. D., and Bronstad, M. E. Location, Selection, and Maintenance of Highway Traffic Barriers. NCHRP Rept. 118, 1971