RESEARCH NOTES

THE ROADSIDE SAFETY RESEARCH GROUP

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Development and Crash Testing of an Aesthetic, See-through Bridge Rail, Type 90

RESULTS: A new, aesthetic, see-through bridge rail design was developed and crash tested in an effort to meet National Highway Safety Research Program (NCHRP) Report 350 test level 4. The Type 90 bridge rail design was successfully crash tested and is recommended for operational use as a Test Level 4 bridge rail.

Why We Pursued This Research

In recent years there has been an increasing emphasis on aesthetics in bridge rail design. During this time substantial effort has been afforded to develop bridge rails that are crashworthy, aesthetically acceptable and low-maintenance. Other aesthetic bridge rails have proven to be crashworthy and low-maintenance but their "see-through" characteristics are relatively limited. To satisfy local agencies and the public, the Department of Transportation (Caltrans) had to develop a TL-4 bridge rail design for use on scenic highways that are not only crashworthy and low-maintenance, but also aesthetically pleasing and easy to see through. The objective of this project was to develop and crash test such a bridge rail that would successfully contain 820 kg to 8000 kg vehicles impacting between 80 and 100 km/hr and at angles of 15° to 25°, respectively.

Figure 1 – Type 90 Bridge Rail

What We Did

The bridge rail design was developed by Caltrans Structures Design in conjunction with Applied Research Associates, who performed the finite element model crash test simulations. The design utilizes a steel rail with posts spaced 3 meters apart atop a “reverse-slope” concrete curb. This means that the top of the curb is closer to the roadway than the bottom, which is the opposite of the other concrete bridge rails such as the Type 736 and Type 80. The purpose of the reverse-slope curb is to raise the reaction point between the vehicle and barrier, thereby minimizing vehicle roll.

After a successful simulation of a 2000-kg Pickup crash test, design details were then provided to the Caltrans Roadside Safety Research Group. The Roadside Safety Research Group then had a 24.2-m test section built at the Caltrans Dynamic Test Facility.

A total of four vehicles were used during development, all of which complied with NCHRP Report 350. However, there was a problem with the first small car test (820 kg), which had to be repeated. All vehicles were in good condition, free of major damage, and were not missing structural parts. The pickup (2000 kg) and large truck (8000 kg) were self-powered, and a speed control device limited acceleration once the impact speed was reached. Steering was accomplished by means of a guidance rail anchored to the ground. A short distance before the point of impact, each vehicle was released from the guidance rail. Remote braking was possible at any time during the test by means of radio control.

In order to improve control and safety of test vehicles, additional modifications were implemented. The first modification was substituting a safety fuel tank for the stock fuel tank. Also, gaseous carbon dioxide was added to the stock fuel tank in order to purge the gas vapors and eliminate oxygen. For the large truck, another modification was to relocate the vehicle battery to the cargo area.

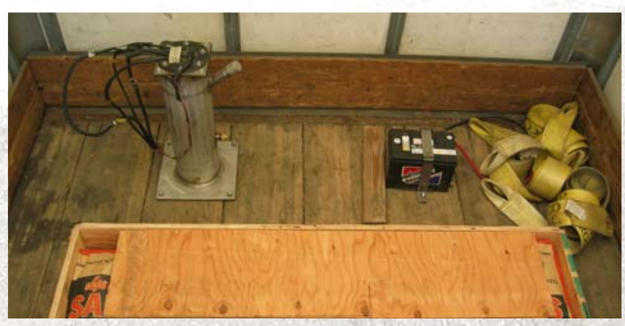

Figure 2 – Safety Fuel Tank & Battery in Truck Cargo Area

Other equipment added to the test vehicles included one pair of 12 V, wet cell motorcycle batteries to run the additional equipment, accelerator switch to actuate the pneumatic ram attached to the pedal, ignition cut-out module to regulate the speed of the vehicle, microswitch to control the ignition circuit, and a 4800-kPa carbon dioxide system to control brake and gas pedals, as needed.

After integrating the accelerometer data, the acceleration, velocity, and distance vs. time of the test vehicles could be determined.

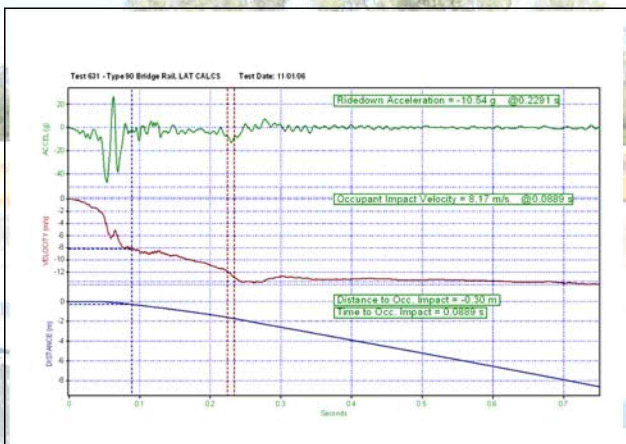

Figure 3 – Longitudinal Acceleration, Velocity, and Distance vs. Time for Test 631

What Can Be Concluded

The design performed as expected. None of the vehicles demonstrated a large tendency to roll or launch. The impacts were generally slightly more severe (higher Occupant Impact Velocities and Ridedown Accelerations) than with other sloped profile barriers. However, both of values were within the acceptable range of Report 350 for all vehicles. Additionally, vehicle damage for all vehicles was in the acceptable range for NCHRP Report 350 and within the maximum allowed by FHWA.

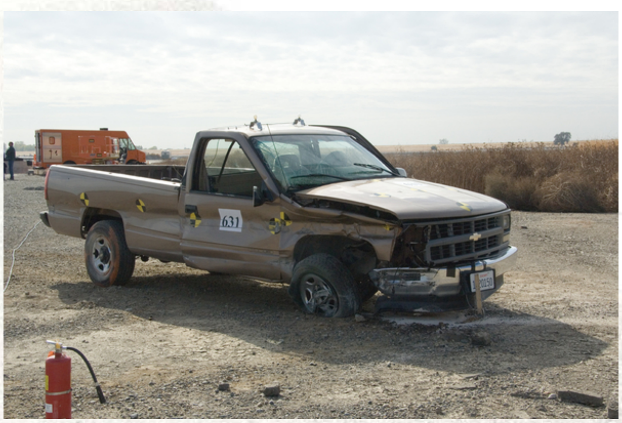

Figure 4 – Test 631 Vehicle Post-Impact

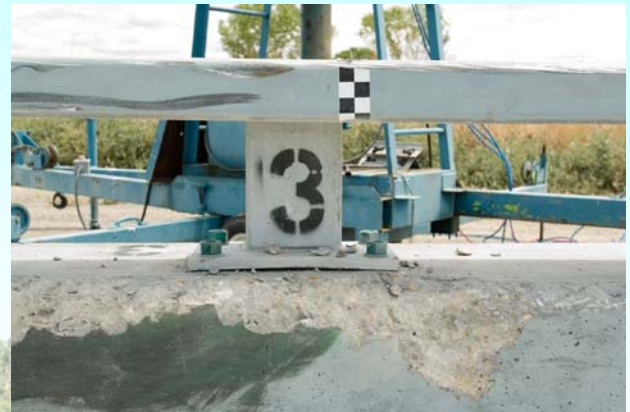

Figure 5 – Test Article Post after Test 634 Impact

What The Researchers Recommend

NCHRP Report 350 stipulates that crash test performance is assessed according to three evaluation criteria: 1) Structural Adequacy, 2) Occupant Risk, and 3) Vehicle Trajectory. The Type 90 bridge rail design rated acceptable in all these categories. For Structural Adequacy, the only damage more significant than minor concrete spalling occurred during the 8000-kg test. The post mounting plate was bent and there was minor weld cracking at the plate-post seam. For Occupant Risk, there were no signs of snagging of the rail, as well as no sign of spalling concrete penetrating the occupant compartment of the vehicles. Finally for Vehicle Trajectory, the test vehicles remained relatively straight after impact. Therefore, the Type 90 bridge rail is recommended as an NCHRP Report 350 Test Level 4 bridge rail.

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