RESEARCH NOTES
THE ROADSIDE SAFETY RESEARCH GROUP
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Development and Crash Testing of a See-Through Steel Bridge Rail

RESULTS: A see-through steel bridge rail (Type California ST-20) was developed and tested. As tested, ST-20 was at the limits of NCHRP Report 350 TL-4 test matrix, and also met the requirements established by AASHTO Bridge Design Specifications for use as a bicycle rail, and is considered an aesthetically pleasing see-through bridge rail. Results from the test and computer modeling indicate that ST-20 passed NCHRP Report 350. However, the level of hood snagging demonstrated that the ST-20 pushed the limits of acceptability. In order to decrease the level of hood snagging, ST-20 was redesigned with deeper rail elements and given the new designation ST-20s.* Because ST-20s resisted hood snagging more than ST-20, California ST-20s was recommended (and approved) on California Highways requiring TL-4 bridge rails without further testing.

Why We Pursued This Research

California has numerous scenic highways, some of which must be able to handle everything from trucks to bicycles. Bridge rails handling highway-speed truck traffic, along with bicycle traffic, must meet NCHRP Report 350 TL-4 guidelines as well as AASHTO Bridge Design Specifications for bicycle rails. The problem is designing a bridge rail that minimizes the impact of scenic views, is acceptable as a bicycle rail, and has a TL-4 rating.

Many bridge rails have been designed to incorporate both aesthetics and function. For example in the 1950's, Baluster rails made of either steel or concrete were quite common, but were not very crashworthy. In the 1970's and 80's, a greater emphasis was placed on designing all-steel bridge rails, resulting in the Type 18 bridge rail in 1983 and Type 115 in 1989. Neither of these steel designs was tested to the current Report 350 guidelines.

What We Did

Since steel has a higher strength-to-weight ratio, and could therefore have greater see-through characteristics, it was decided the next series of see-through bridge rails would incorporate steel as the primary structural component. Work done in the mid 1990s by Wyoming Department of Transportation and Texas Transportation Institute was used as a starting point for the design work.

The Wyoming barrier was evaluated and later modified by Caltrans in order to lower the snag potential of the barrier. The new bridge rail designation was the California ST-10, which had the size of the face of the lower rail increased from 76mm to 102mm. Furthermore, the ST-10 was used as a starting point for the ST-20.

Figure 1 – Completed ST-20 Barrier Prior to Testing

Test barrier for the ST-20 was constructed at the north end of the Caltrans Dynamic Test Facility. The asphalt was cut away and the underlying earth was removed to allow for placement of an anchor block and a simulated bridge deck. The concrete was placed in three phases: the anchor block, the overhang deck, and the curb for the ST-20. Once the formwork for the anchor block was complete, the reinforcing steel was positioned. Holes were drilled in the forms where some of the connection steel passes between the anchor block and the overhang. In order to protect the structural integrity of the concrete, no vehicles were allowed on the anchor block during work on the overhang and curb sections.

* For simplicity, the final "approved" version of the ST-20 had the "s" dropped from the name.

Figure 2 – Site Excavation

One full-scale crash test was performed and evaluated in accordance with Report 350. Applied Research Associates, Inc. (ARA) performed computer modeling to determine the critical impact point. Because the computer modeling indicated a potential for hood snagging, it was determined that the critical impact point would be mid-span between posts. The resulting hood snagging led to a redesign, which was also evaluated by ARA.

What Can Be Concluded

Based on the performance of the computer modeling and the physical crash testing it can be concluded that the California ST-20s (see What The Researchers Recommend) bridge rail can successfully redirect a 2000-kg pickup truck and 8000-kg single unit cargo van. The damage to the California ST-20s in accidents similar to the testing done in this project will likely require minimal repairs, if any.

Figure 3 – Test 651 Vehicle Damage, Front Right Corner

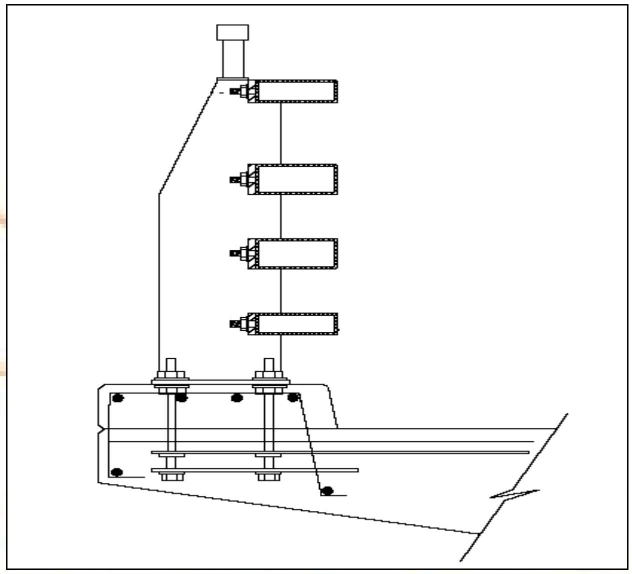

Figure 4 – California ST-20S (Approved)

What The Researchers Recommend

NCHRP Report 350 stipulates that crash test performance is assessed according to three evaluation factors: 1) Structural Adequacy, 2) Occupant Risk, and 3) Vehicle Trajectory. For Structural Adequacy, the vehicle was contained and smoothly redirected. For Occupant Risk, there were minor amounts of rail scraping and concrete spalling created during impact. Also, the hood rotated back toward the windshield putting the ST-20 at the limits of acceptability. Regarding Vehicle Trajectory, the test vehicle remained relatively straight after exiting the barrier. The exit angle and rate of return into traffic were minimal. Consequently, the California ST-20 as tested was not recommended for approval. A modified version of the ST-20 (designated the California ST-20s) with rail element 50mm deeper that the version tested was recommended (and later approved) for use as a TL-4 bridge rail. The approved version was later renamed the California ST-20.

For More Information About This Research

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