Project Summary

Texas Department of Transportation

0-5492: Hydraulic Performance of Bridge Rails and Traffic Barriers

Background

In 1986, the Federal Highway Administration (FHWA) specified in the National Cooperative Highway Research Program Report 350 that all highway bridges on the National Highway System and the Interstate Highway System must use successfully crash-tested bridge railing. Texas Department of Transportation (TxDOT) policy requires the use of successfully crash-tested bridge rails on all new bridge construction as well as existing bridges scheduled for safety rehabilitation. In general, crash-tested bridge rails have greater height and less open space when compared to bridge rails that have failed crash testing. The requirement to use successfully crash-tested rails poses a concern with respect to floodplain analysis. In the event that existing bridge rails are upgraded to crash-tested rails, the possible additional rail height and decreased open space may adversely impact the surrounding floodplain elevation. Construction or modification of bridge structures in communities that participate in the National Flood Insurance Program must meet regulatory requirements for surrounding floodplains mapped by the Federal Emergency Management Agency (FEMA). Typically, a floodplain analysis will model flow over the bridge as a simple broad crested weir. Construction of new structures or modification of existing structures, as in the case of safety rehabilitation, cannot result in an increase of the water surface profile for the one percent annual chance (100-year) flood event by more than one foot (30.5 cm). If the water surface profile is expected to increase by more than one foot, a FEMA map revision is required, which can be costly and time consuming. The use of crash-tested bridge rails with a greater height and less open space, especially in the safety rehabilitation of bridges, can raise issues with FEMA compliance due to poor hydraulic performance, requiring a floodplain map revision and delay of the project. Therefore, to prevent such setbacks, it is important to understand the hydraulic performance of various bridge rail types in order to determine the impact of different rails on the surrounding floodplains.

What the Researchers Did

The hydraulic performance of six different TxDOT rails, a two-tube steel railing used in Wyoming, and a weir rail were evaluated through physical model studies. Rating curves, which describe the relationship between the upstream specific energy (depth) and flow rate passing over and through the rail, were measured for each rail type. Measurements were calibrated to a three-parameter model that allows prediction of hydraulic performance of rail systems over a range of flow conditions. Submergence effects caused by backwater from downstream rails were evaluated through hydraulic model studies, and submergence hydraulic performance models were also developed.

Research Performed by:

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Four bridge rail systems were tested with rails in series, representing conditions with flow across the bridge superstructure with upstream and downstream rails. The hydraulic performance of a single rail system in skew orientation was evaluated through hydraulic model studies. Methods for incorporating bridge rail hydraulic performance characteristics in floodplain analysis models (HEC-RAS) were developed.

What They Found

The hydraulic performance of different bridge rail systems varies widely, primarily as a function of rail height and the amount of open space within the rail face. Using the hydraulic and submergence models with calibrated coefficients, the hydraulic performance of bridge rail systems can be accurately predicted for a range of flow conditions. Skew orientation has a negligible effect on bridge rail hydraulic performance. Of all the bridge rails tested, the Wyoming two-tube rail has the highest hydraulic efficiency, in that it will allow a given flow rate to pass the rail with the least required upstream headwater (upstream depth). The T101 rail is the TxDOT crash-tested rail with greatest hydraulic efficiency.

What This Means

This research program has provided information on the hydraulic performance of different TxDOT crash-tested rails that can be used in new bridge construction and bridge rehabilitation. A procedure has been developed for including the effects of bridge rail hydraulic performance in floodplain analysis models. This information and procedures allow the design engineer to predict the backwater effects of different bridge rail systems and determine whether a FEMA floodplain re-evaluation would be required based on rail hydraulic performance.

For More Information:
0-5492-1 Hydraulic Performance of Bridge Rails

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