Project Title: Concrete Barrier Design for Use in Front of a Slope of on MSE Wall
State Technical Representative: Dave Olson
TTI Project Manager: Nauman Sheikh
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Project Objective

Develop and test a design for a rigid concrete barrier that can be placed in front of slopes as steep as 1.5H:1V or on top of an MSE wall. The design would not require a moment slab and minimize the amount of widening behind the barrier. The design feature would be a concrete barrier with a single slope face. It should be assumed that the barrier would be precast with a 20' maximum length. Adjacent barrier segments will be connected using the grouted rebar-grid connection. The barrier would be tested using MASH-08 criteria.

Work Performed to Date

In the previous quarter, TTI researchers performed a surrogate bogie vehicle impact test to evaluate the response of a single grouted rebar-grid connection when embedded in a 10-inch soil layer. The researchers then incorporated the 10-inch soil layer into the finite element model of the bogie test and calibrated soil properties to match the barrier deflection observed in the test. The researchers had also started incorporating the soil embedment of the barriers in a 100-ft long system model to evaluate its performance under a test-level 3 (TL-3) impact conditions.

In this quarter, the researchers completed the development of the model for a 100-ft long installation, comprising of five 20-ft single-slope barrier segments, connected via grouted rebar-grid connection and embedded 10 inches in soil. The widening of the soil behind the barriers was two feet and the slope of the soil cut was 1.5H:1V, as in the bogie test with embedded barriers. A simulation was performed with a 2270-kg vehicle impacting the barrier at 25 degrees and 100 km/h (as required by MASH-08). Maximum permanent deflection of the barrier in the simulation was 10 inches. Figure 1 shows the deflection of the barrier before and after the impact.

The researchers performed another simulation where soil was also added to the front of the barrier. The vehicle mass and impact conditions were the same as before. Maximum permanent deflection of the barrier was 9.75 inches in this case. The results of the simulation are shown in figure 2. It should be noted that finite element model of the barrier does not incorporate concrete failure and therefore the barrier deflection measured in the simulation is a lower bound estimate of the actual deflection expected in a crash test. If significant spalling of concrete occurs at barrier connections during the crash test, maximum deflection may increase by a few inches due to additional slack and rotation of the barriers.

The vehicle was redirected successfully in both simulations, even though slightly greater vehicle roll was observed when the barrier was placed with soil on both sides. This was expected, as by adding soil to the front of the barrier, the barrier height was reduced by 10 inches, thus resulting in a slightly higher vehicle roll. As mentioned in the project proposal, due to absence of a validated MASH-08 vehicle model, the researchers increased the mass of the previously available NCHRP Report 350 design vehicle model to meet the weight requirements of MASH-08. This method allows for proper evaluation of the strength of the barrier connections and the resulting lateral deflection of the system due to higher vehicle mass. However, due to differences in design of key vehicle components such as the suspension, chassis, etc, the vehicle dynamics results from finite element simulations may not accurately predict the crash test results.

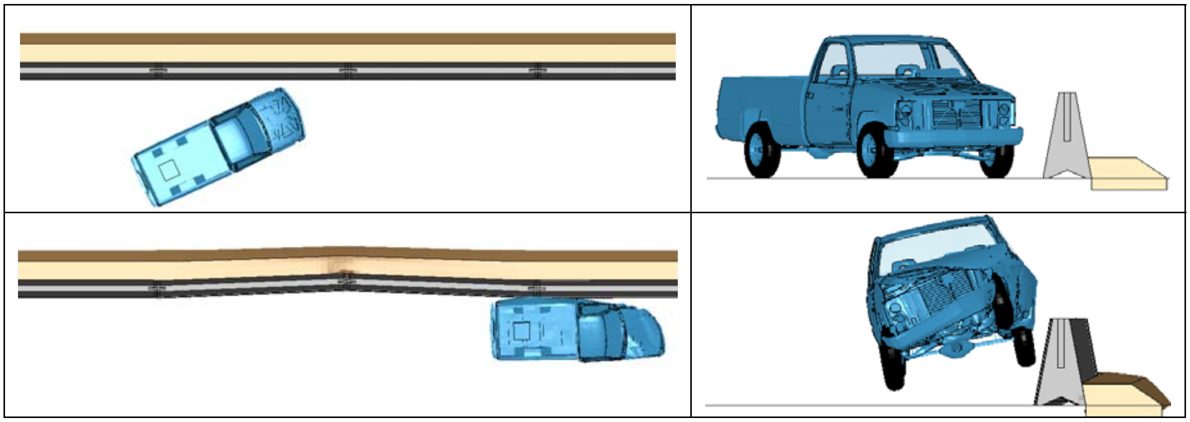

Figure 1: Simulation results with soil behind the barrier (Initial (top) and final (bottom) states).

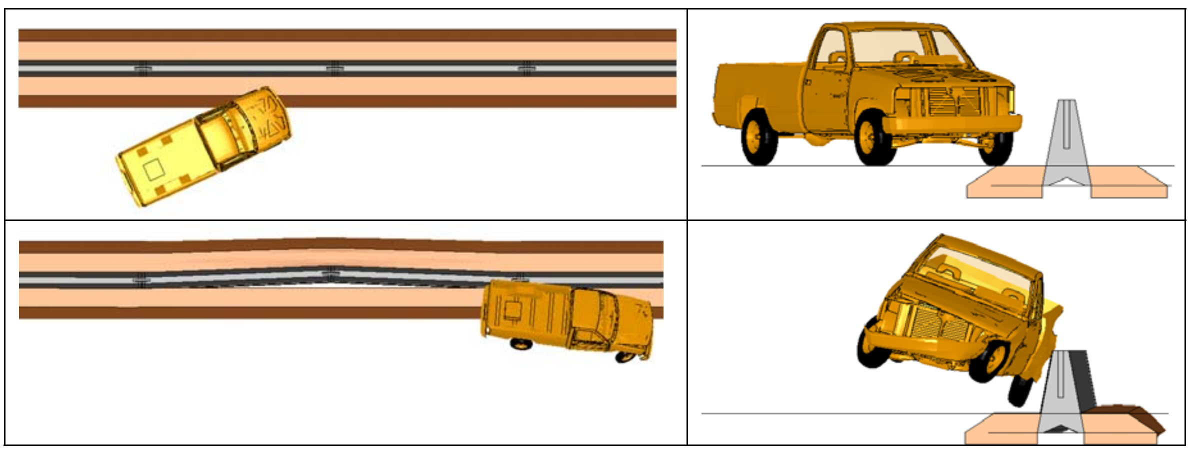

Figure 2: Simulation results with soil on both sides of barrier (Initial (top) and final (bottom) states).

Results of Work Performed

Results of the simulation performed with 100-ft long installation of SSB embedded 10 inches in soil and a 2-ft widening behind the barrier are shown in figure 1. Results of the simulation performed by adding soil layer in front of the barrier are shown in figure 2.

Work Remaining to be Completed

After conveying simulation analyses results to the Technical Representative and seeking approval to proceed, TTI researchers are now preparing for a full-scale crash test. The crash test will be performed to evaluate the embedded single-slope barrier design under MASH-08 test level 3 impact conditions. Once the crash test has been performed, TTI will prepare the final report documenting the research and the crash test results.