Project Title: W-Beam Guardrail Post Installation in Rock
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Project Objective

The objective of this project is to develop cost effective guidelines for placement of W-beam guardrail posts in rock by optimizing current placement guidelines and by investigating sensitivity of W-beam guardrail performance to post embedment depth.

Work Performed to Date

In previous quarters, TTI researchers had performed 12 pendulum tests to determine the response of W-beam guardrail posts at various depths in soil. Simulation models of these tests were then developed and calibration of the soil properties was performed to achieve a post-soil response similar to the one observed in the tests. The researchers also started development of the system model of W-beam guardrail. Details of this work can be found in previous quarter reports.

In this quarter, the researchers completed the development and validation of the W-beam guardrail system model. Using this model, the researchers have also started the parametric evaluation of W-beam guardrail performance when one or more posts have a reduced embedment depth due to the presence of rock.

The W-beam guardrail system model is shown in figure 1 and 2. The model comprised of 13 posts that were spaced at 1905 mm from post centers. The rail height was 531 mm to the center of the rail. The posts were embedded 1118 mm into the ground. To reduce size of the model and thus reduce computational cost and time, the end terminals of the W-beam guardrail were not modeled explicitly. Instead, the nodes at each end of the W-beam guardrail were constrained such that their longitudinal and vertical movement was prevented. The lateral movement however was not constrained. This is similar to the presence of an end terminal, which provides tension in the rail by constraining its longitudinal movement, but does not significantly constrain its lateral movement.

A 2000-kg vehicle impacted the W-beam guardrail system with a speed of 100 km/h and an angle of 25 degrees as shown in figure 2. The model comprised of approximately 400,000 nodes and 360,000 elements.

The researchers also started the parametric analysis using the W-beam guardrail system model. A simulation with one of the posts missing was performed. Other simulations are currently being performed.

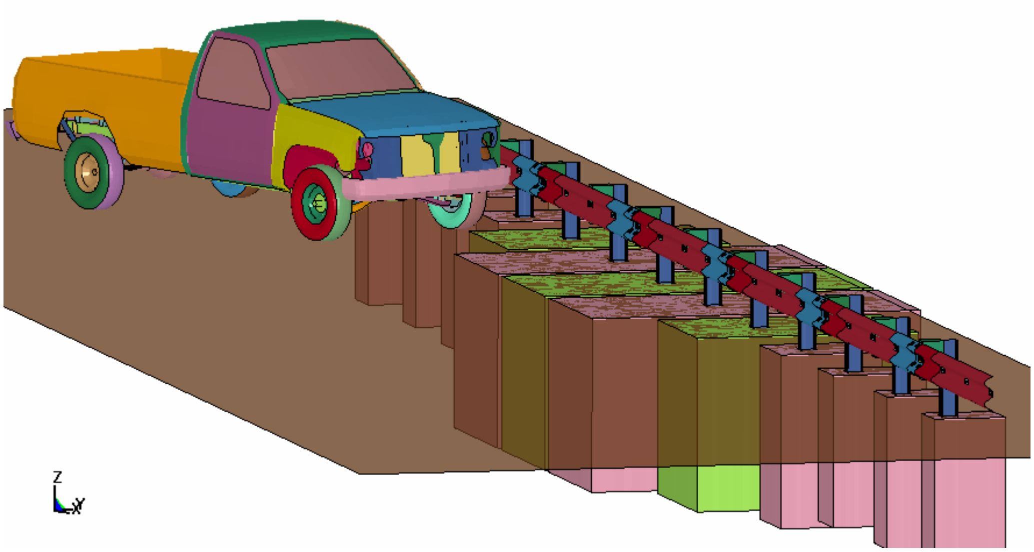

Figure 1: W-beam guardrail system model.

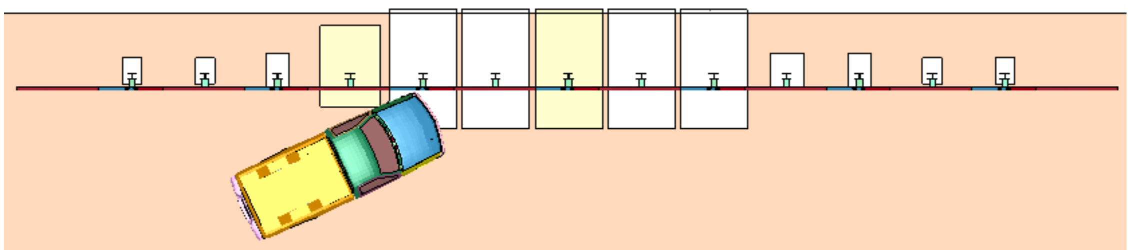

Figure 2: W-beam guardrail system model (top view).

Results of Work Performed

The W-beam system model was validated using test results of four previously available W-beam guardrail crash tests. In these tests, a 2000-kg vehicle impacted the W-beam guardrail system at a speed of 100 km/h and an angle of 25 degrees. The rail height, post spacing, post embedment depth, and other such design factors were the same. The main difference between these systems was the type of blockout used. The tests were as follows:

1. 1996, Timber blockouts (405421-1)
2. 1997, Recycled polyethylene blockouts (400001-MPT1)
3. 2001, Composite blockouts (400001-TRB3)
4. 2002, Recycled polymer blockouts (400001-MON1)

While different variations of blockouts were tested, the performance of these blockouts was essentially the same in all of the tests. Thus the crash test results give a range of W-beam performance for the purpose of validating simulation results.

Figure 3 shows the deformed state of the model after vehicle impact. Table 1 shows a comparison of some of the outcomes of the crash analysis of the W-beam guardrail system. Figure 4 shows a comparison of simulation and test results at approximately 0.24 seconds and 0.48 seconds. As can be seen from the figure, a reasonable correlation in vehicle dynamics exists between simulation and test results. Figure 5 shows comparisons of vehicle's yaw, pitch, and roll angles, respectively. The results obtained from simulation analysis adequately correlate to the range of results obtained from crash testing.

Since adequate correlation was established between simulation and test results, the W-beam system model can be used for the parametric analysis. The parametric analysis is currently underway.

Work Remaining to be Completed

Parametric simulations are being performed to evaluate the performance of W-beam guardrail when embedment depth of one or more posts is compromised by the presence of rock. Simulation results of this parametric study will be used to develop guidelines for installation of guardrail posts when rock is encountered.

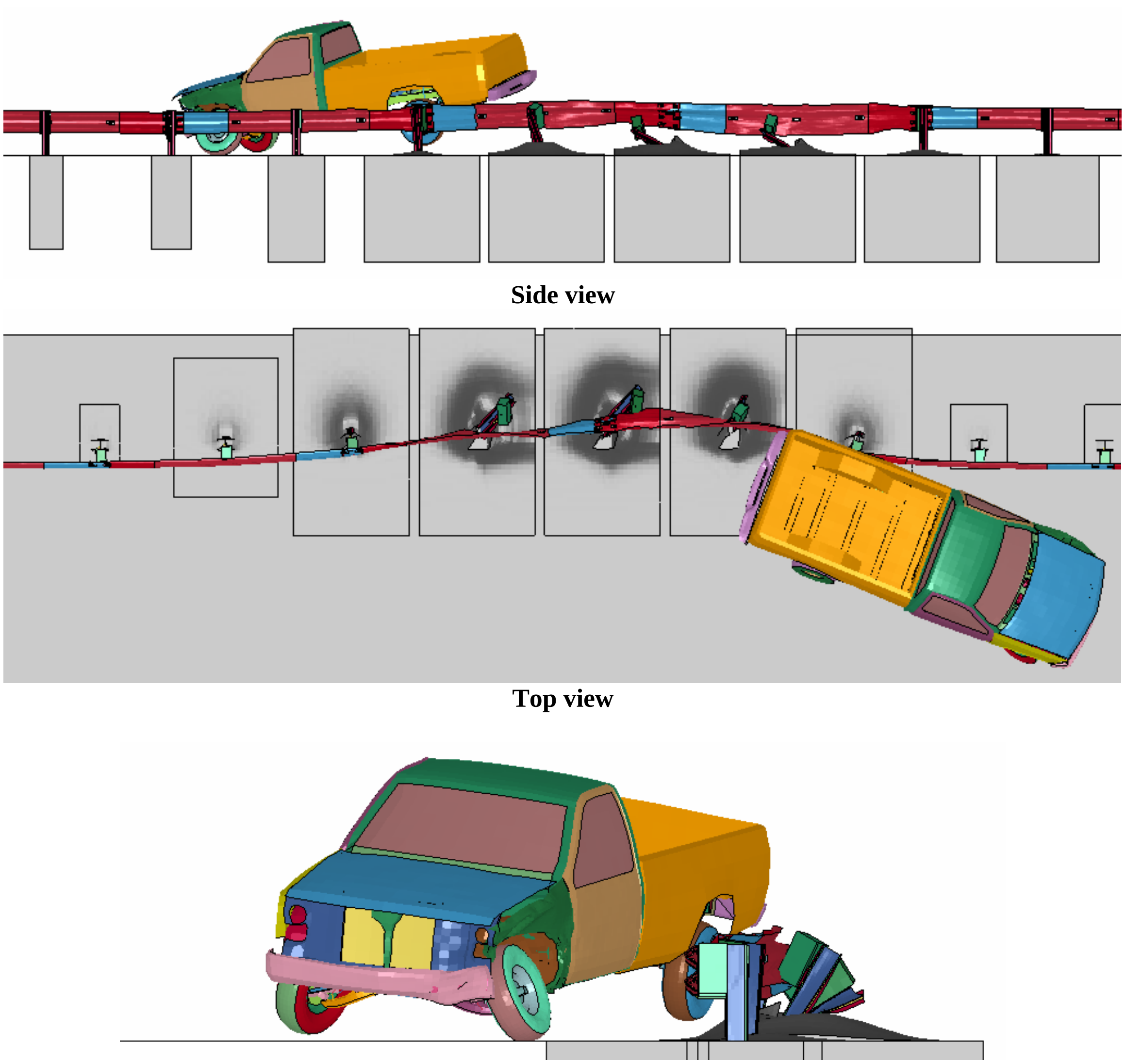

Figure 3: Results of the W-beam guardrail simulation.

Table 1: Comparison of several post-impact parameters

	Simulation	405421-1	400001MPT1	400001TRB3	400001MON1
Max. dynamic deflection (m)	0.9	1	1.3	0.89	0.837
Max. static deflection (m)	<0.75	0.7	0.72	0.4	0.256
Total contact length (m)	7.6	5.8	10.3	8.13	unknown
Number of posts where rail detached	3	3	5	2	3
Vehicle exit speed (km/h)	54	55	46.12	59.4	49.4

Figure 4: Comparison between test and simulation.

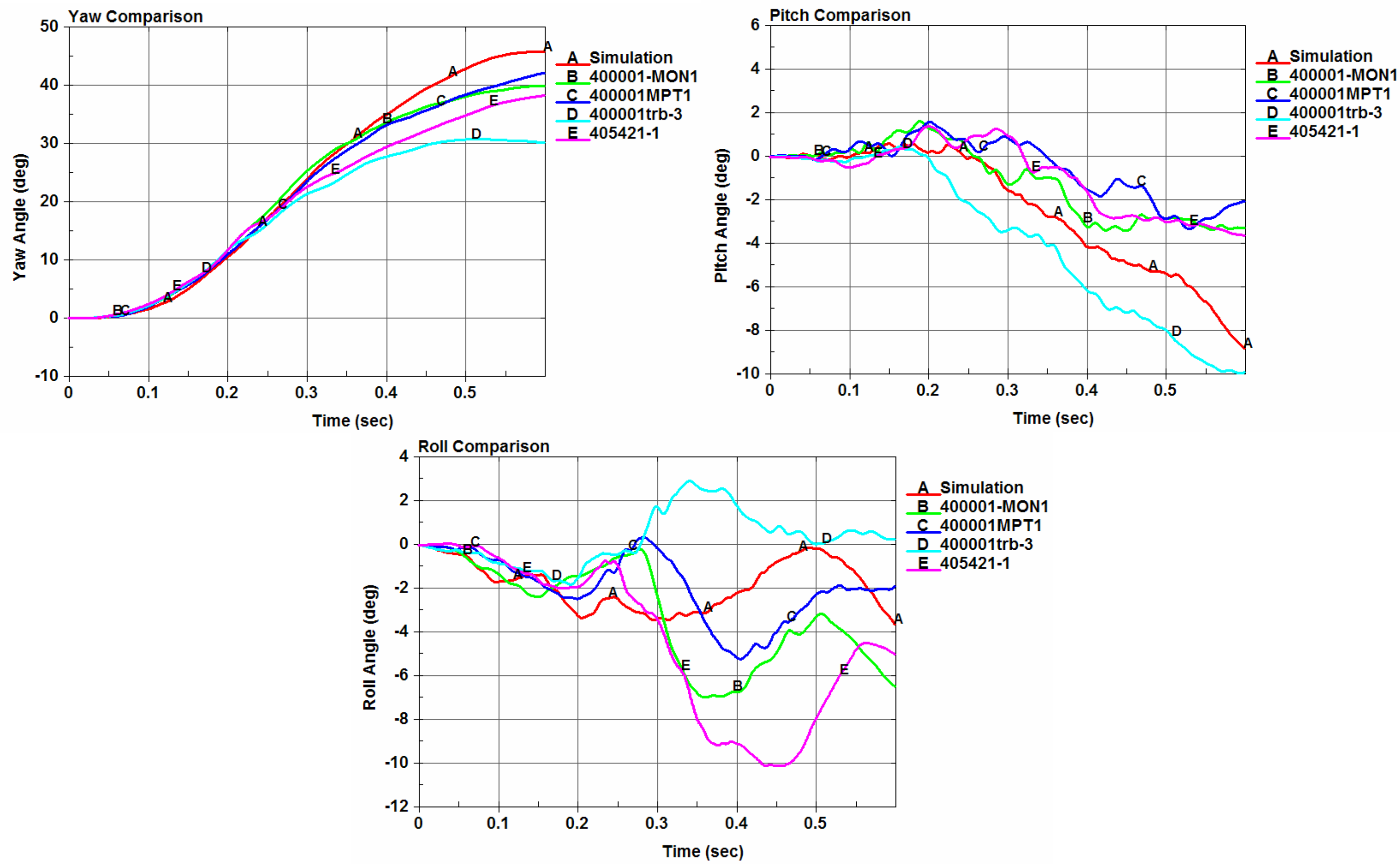

Figure 5: Comparison of vehicle's yaw, pitch, and roll angles