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Investigating and Developing a MASH Compliant Contraflow Ramp Closure Gate

INTRODUCTION

During contraflow and other emergencies, it is often necessary to close the highway on/off ramps. In 2015, the Louisiana Department of Transportation and Development (DOTD) developed a cost-effective portable, swinging gate arm that could be deployed and installed with minimal effort to replace six Triton Barrier per contraflow ramp closures. The new gate arm was designed to be installed parallel to traffic at specific locations. Then, when a ramp closure was required, the arm would be rotated into position to close off the ramp. However, since the gate assembly was designed to remain in place even when the ramp was open, the device needed to be evaluated as roadside safety hardware.

Figure 1. DOTD contraflow ramp closure gate

DOTD's gate arm is made of aluminum and fiberglass materials and is attached to a steel pole on a standard triangular slip base. In the past, 48-in. × 30-in. "Ramp Closed" signs have been mounted to the gate arm, and 12-in. × 36-in. object marker signs have been mounted to the post. The DOTD ramp closure gate is shown in Figure 1.

OBJECTIVE

The overall objective of this project was to provide a thorough crashworthiness evaluation of the DOTD ramp gate through computer simulations. Using the current DOTD gate system as a model, this project assessed the design according to the *American Association of State Highway and Transportation Officials Manual for Assessing Safety Hardware (MASH), Second Edition.*

SCOPE

The scope for the project included the research and evaluation of the DOTD contraflow ramp gate in accordance with MASH Test Level 3 (TL-3).

The project included the following tasks:

1. Reviewing the device to identify the system's component specifications and develop technical drawings.
2. Constructing the finite element (FE) model of the system based on the identified component specifications.
3. Conducting FE analysis based on the test conditions and evaluation criteria for MASH Tests 3-60, 3-61, and 3-62.
4. Based on the findings from the project tasks, recommendations to improve the system performance during impact were developed.

METHODOLOGY

Texas A&M Transportation Institute (TTI) researchers reviewed the DOTD contraflow ramp closure gate system and identified the component sizes and material properties and constructed the FE model of the device and the slip base system.

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MASH recommends evaluating support structures (including road closure gates) under Tests 3-60, 3-61, and 3-62. However, the location and angle of the impact on the device are not explicitly defined. In this situation, a parametric analysis of the assembly to understand the performance of the device under various impact conditions is required. Therefore, TTI performed computer simulations at various angles to identify the critical impact angle (CIA). Additionally, impacts at multiple locations along the length of the gate arm were simulated and evaluated. The three areas of evaluation criteria are structural adequacy, occupant risk, and vehicle trajectory after impact for support structures. Figure 2 shows the FE model of the ramp gate system and pickup truck assembly.

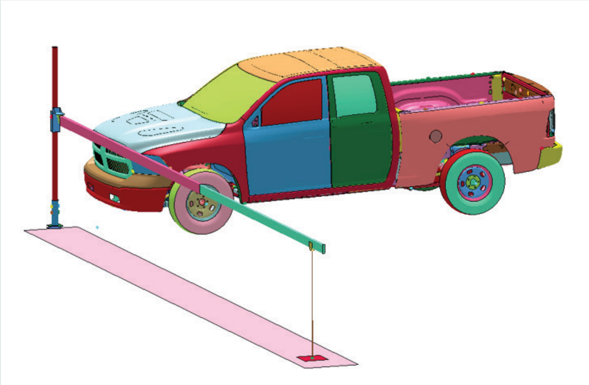

Figure 2. FE model of the ramp gate system and pickup truck assembly

CONCLUSIONS

The purpose of the study reported herein was to assess the performance of the contraflow ramp gate upon impact under MASH TL-3 conditions. The predictive FE simulations resulted in the following findings and conclusions:

1. During the MASH Test 3-60 simulation at the 0-degree impact location, the small car experienced significant damage to the windshield. Additionally, the 90-degree impact with failed shear pins indicated a possible impact of the gate arm with the windshield.
2. During the MASH Test 3-61 simulation at the pole location, severe damage/deformation of the windshield and/or the roof was observed. A 90-degree impact to the mid-span caused deformation only to the roof, while the impact at the end arm resulted in the lowest damage to the roof.
3. During the MASH Test 3-62 simulation of the contraflow ramp gate, the majority of the occupant compartment damage occurred as a result of the gate arm impacting the windshield.
4. Utilizing a heavier pole (Sch. 80) improved the system's performance during the impact with a pickup truck when the gate arm stayed attached to the pole. However, the same design change did not affect the failed outcome in small car impacts.
5. The current device configuration was not found to be MASH compliant for TL-3. Further design modification and testing are warranted to evaluate the crashworthiness of the device.

RECOMMENDATIONS

Based on the conclusions, the following solutions are provided for consideration to improve the system's performance:

1. The gate arm mounting height needs to be adjusted to avoid direct impact with the vehicle's windshield and roof in all three test conditions.
2. Keeping the pole attached to the arm during impact (i.e., not using shear pins) may help keep the system away from the occupant compartment during low-speed impact; however, this may not be helpful for high-speed impact conditions.