



Engineering Sciences Section – 2008

C9 Motor Vehicle Pitch Associated With Hard Brake Application

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Attendees will be provided with data collected from hard-brake testing including change in bumper heights and vehicle pitch.

The change in bumper height associated with hard braking is important in addressing vehicle compatibility issues and reconstruction. To these authors' knowledge, this type of objective data has not been previously published.

Collision forces are best managed when there is full engagement of the involved vehicles' bumpers. This allows the collision forces to be best managed by the structural portions of each vehicle, such as the bumper structures and the frame. Static geometrical incompatibility may exist as a result in the difference in bumper heights, as illustrated in Figure 1 below.

However, because forward vehicle pitch during hard braking effectively lowers a vehicle's front bumper height, while raising its rear bumper height, a dynamic mismatch in bumper height leading to an under-ride can be produced by hard braking by either one or both involved vehicles.

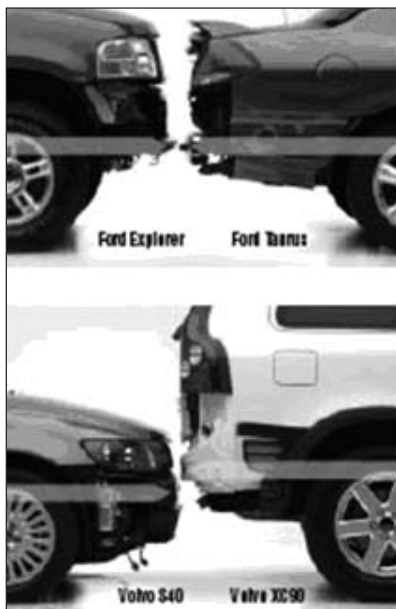


Figure 1: Geometrical Compatibility and Incompatibility¹

Since the structural portions of the striking vehicle's bumper are effectively bypassed, the striking vehicle typically sustains substantial crush to the relatively easily damaged structures above and behind its front bumper, while the struck vehicle sustains relatively minor, if any, structural damage.

In understanding this acquired or dynamic structural incompatibility, it would be helpful to be able to quantify the amount of bumper height change associated with hard braking. Such data may also be helpful in resolving some reconstruction issues. However, prior to this study, there is not any known published data regarding the change in bumper height associated with hard braking.

The purpose of this study is to provide empirical data regarding vehicle pitch and the resultant change in bumper height during hard braking. Seven vehicles representing most passenger vehicle types were selected for this study.

Data was collected while each vehicle underwent hard acceleration to at least 40 mph, maintaining that speed for a few seconds, and then hard braking to a stop. A Racelogic VBOX III, a GPS based system, was used to collect longitudinal acceleration data. In addition, the VBOX III was used to collect data from external sensors for brake pedal force, vehicle pitch rate and bumper height.

Each vehicle was subjected to a series of hard braking events. The maximum changes in bumper heights were averaged for each vehicle and are presented in Figure 2 below. Front bumper heights are shown to decrease or dip down as a negative change in bumper height, while rear bumper heights were raised or experienced a positive change in bumper height.

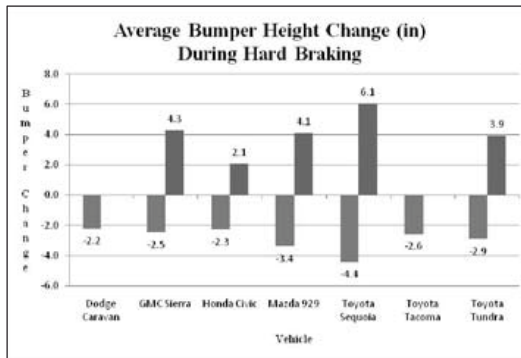


Figure 2: Change in Bumper Height During Hard Braking

The front bumper dip ranged between 2.2 and 3.9 inches for all the vehicles, with the exception of the Toyota Sequoia whose front bumper dipped down 4.4 inches.

The rise in rear bumper height for most vehicles ranged between 3.9 and 4.3 inches. However, the Toyota Sequoia, a large SUV, exhibited a rise in rear bumper height of 6.1 inches, and the Honda Civic, a small passenger vehicle, exhibited a rise in rear bumper height of only 2.1 inches. Data loss precluded collection of rear bumper height data during testing of the Dodge Caravan and the Toyota Tacoma.

Bonus Information: During the hard braking tests, the average deceleration for these vehicles ranged from 0.69 and 0.86 g's, as depicted in Figure 3.

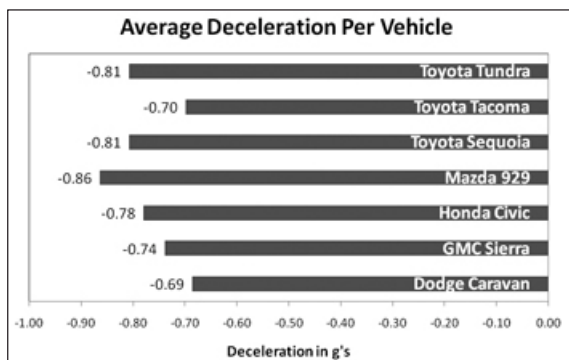


Figure 3: Test Vehicle Decelerations

The changes in the front and rear bumper heights were also measured during hard acceleration for these same vehicles. The average rise in front bumper height for each vehicle ranged between 1.5 to 2.2 inches, with the exception of the Toyota Sequoia whose front bumper raised an average of 2.7 inches. The average rear bumper dip ranged from 0.7 to 1.7 inches for all the vehicles with the exception of the Dodge Caravan's rear bumper height which dipped 2.4 inches.

Intuitively, when occupants enter the vehicle, the suspension is loaded causing the vehicle's bumper heights to be lowered. With different numbers of occupants and weights added to the same vehicles listed above, the average change in front and rear bumper heights ranged between 0.5 and 1.2 inches.

Conclusion: It should be noted that this study involves a relatively small number of vehicles, it is not all inclusive, and clearer trends may emerge with the addition of more vehicles.

While preliminary, it is believed that this is the first presentation of vehicle pitch and bumper height change associated with hard braking.

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Reference:

¹ "Status Report" Insurance Institute for Highway Safety, Volume 39, Number 9, September 13, 2004.

Pitch, Bumper, Under-ride