C32 Method for Predicting Rear Impact Force Levels Associated with Bumper Override and Sheet Metal Crush

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The goal of this presentation is to provide an accurate analytical reconstruction tool to estimate crash force levels associated with rear-impacts that involve "bumper override" and large "sheet-metal crush damage".

This presentation will impact the forensic science community by providing a simplified means for evaluating "average-peak-G" force levels needed to assess vehicle rear-impact seat performance as related to occupant loads and injury risk for both front seated adults, and rear seated children located behind, when large amounts of "offset sheet metal override crush" are experienced.

In many rear-impact accidents the front bumper of a large striking vehicle, like a pick-up or tractor-trailer type vehicle, eventually "overrides" the stiffer rear bumper structure of a smaller struck vehicle, like a minivan or sedan, and then induces a significant amount of "less-stiff" "sheet-metal crush" deformation that tends to complicate reconstruction of "average-peak-G" force levels experienced by the struck vehicle. The accuracy of these "average-peak-G" force levels is important in assessing the struck vehicle occupant interactions and performance of safety devices such as "seat systems" and "restraints" needed to hold front occupants securely in place and free from contact impact with rear occupants, like children, or non-yielding structures located behind. Unfortunately, most reconstruction programs and methods rely on high "linear-stiffness" parameters obtained from "moving-rigid-barrier" rear impact tests that simultaneously engage the "stiffer" bumper floor structure and the "less stiff" vehicle body sheet metal structure. The use of such "simultaneously" measured "linear-stiffness" parameters, especially in cases where "bumper override" and larger amounts of offset "sheet-metal" body-crush takes place, tends to "over-estimate" the impacted vehicle "peak force" levels, thus complicating the injury risk assessment of "seat system and restraint" safety performance.

In the current study, both "vehicle-to-vehicle" dynamic crash tests and quasi-static "bumper-override" and offset "sheet-metal" body crush tests were run to delineate and assess the stiffness effects associated with large amounts of offset "sheet-metal" body crush characteristics. The "bumper-override" and offset "sheet-metal" body crush "quasi-static" tests were run on a complete minivan vehicle and a sedan where a "barrier face" simulating the "front of a tractor-trailer vehicle" was laterally offset to overlap only about one-half of the test vehicle and was then slowly pushed into the top edge of the vehicle rear-bumper, causing the vehicle to "squat" on the rear suspension, allowing the "barrier face" to "only engage and crush" the sheet-metal body structure of the test vehicle. The measured forces and deformations from these offset "sheet-metal" body crush tests were used to calculate energy levels that were then compared to energy calculations made using the traditional "linear-stiffness" parameters obtained from "moving-rigid-barrier" rear impact tests. These comparisons indicated that the offset "sheet-metal" body crush energy was actually only about one-half the energy levels obtained from the traditional "linear-stiffness" parameters.

Next, "vehicle-to-vehicle" rear-impact crash tests were run on a popular family minivan and a sedan vehicle where the vehicles were impacted by a 20,000kg tractor-trailer rig traveling at about 40kph and inducing large amounts of offset "sheet-metal" body crush. In addition, "vehicle-to-vehicle" tests were also run on the minivan with impact from a pick-up and a mid-size truck that also induced offset "sheet-metal" body crush. Next, the struck vehicle crush energy from the above tests was analyzed in two parts by using the traditional "linear-stiffness" parameters obtained from "moving-rigid-barrier" rear impact tests to estimate crush energy for the "bumper engaged" portion of the crush, and then the offset "sheet-metal" body crush "energy" was calculated and adjusted as per the quasi-static test results. Both energy contributions were next added together and then used to calculate "fixed barrier" equivalent velocities for the stuck vehicles of the crash experiments. The average of the "fixed barrier" velocity was then divided into the maximum measured total crush to get an estimate of crash pulse duration. Finally, a trapezoidal crash pulse shape was assumed with equal 1/3-time increments for "rise," "dwell," and "decline" portions of the pulse. The area under the assumed pulse was then equated to the "fixed barrier" velocity to obtain an estimate of the "average-peak-G" force levels. This value was then compared to the measured maximum slope gradient of the experimental crash "speed-change" curve. The values of calculated "average-peak-G" force levels compared within about 10 percent of the measured maximum slope gradient for the tests examined. The method has application to cases with large amounts of offset "sheet-metal" body crush.

Rear-Impact, Bumper Override, Average-Peak-G

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