THE UNIVERSITY of ADELAIDE

CENTRE FOR AUTOMOTIVE SAFETY RESEARCH

Alternative injury response functions for evaluating head accelerations, with application to pedestrian headform testing

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by
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Abstract

Impact testing of vehicles and helmets is performed under the specifications of a test protocol to ensure that regulatory standards and community expectations are met in terms of head injury safety. Impact severity is usually measured using the acceleration of the impactor (or dummy head) that is recorded during the impact. A specification that is defined in these testing protocols is the injury response function (IRF) that is used to summarise the magnitude of the recorded acceleration. There are various IRFs that can be chosen to summarise the acceleration data. This thesis examines several of these IRFs that are based on linear acceleration. The aim was to describe the differences between the IRFs and examine what differences might arise in the designs in response to the requirements of the IRF. There has historically been disagreement on the best way to assess injury risk, but the debate is only important to the extent that the design requirements are affected by the choice of IRF.

Four IRFs were examined in detail. These were the Head Injury Criterion (HIC), the Peak Virtual Power (PVP), the 3 millisecond clip (a_3) and the peak acceleration (a_m).

Simple acceleration pulse shapes were used to determine some of the properties of each of the IRFs. These included the role of the pulse shape, the stopping distance, the impact velocity and the coefficient of restitution on the value of each of the IRFs. The effect of the pulse shape on the value of the IRFs was examined using these simple pulse shapes that had been normalised for a constant impact velocity and stopping distance.

Equations predicting the value of each IRF were then derived that used the

stopping distance, the impact velocity and the coefficient of restitution as predictors.

The properties found using the simple pulse shapes were then examined using the real test data that included 247 tests obtained from a pedestrian testing protocol. The predictions of the equation for each IRF were compared to the test data using a linear regression. The remaining variation in the value of each IRF was attributed to the effect of the pulse shape.

In most cases, the measured relative severities of the impacts were not greatly affected by the choice of IRF, but there were some discrepancies. The characteristics of the pulse shapes that gave rise to these discrepancies were identified. These were identified by subtracting the effect of the stopping distance, the impact velocity and the coefficient of restitution from the value of the IRF for each test to determine an adjusted IRF value for each test. These adjusted IRF values were ranked and compared to determine the discrepant tests.

Differences in the magnitude of the effect of the pulse shape, the maximum stopping distance, the impact velocity and the coefficient of restitution on the value of each of the IRFs were found theoretically and these were verified in the experimental data.

The effect of the choice of threshold on determining the tests that were considered 'safe' and 'unsafe' was also examined. Sensitivity and Negative Predictive Value were used to determine thresholds that were conservative compared with HIC > 1000. The effect of the threshold was shown to be a very important parameter in a testing protocol.

It is concluded that there are some differences between the IRFs that were examined in detail. However, in general, the choice of IRF does not appear to greatly affect the ultimate design of crashworthy structures.

Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Jeffrey K Dutschke and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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