A Desktop Model for Computing Acceleration Severity Index (ASI) for Rigid Barriers as a Function of Impact Configuration

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Abstract

Acceleration Severity Index (ASI) is a vehicle occupant risk indicator measured during homologation of road safety barriers. Efforts to correlate occupant injury risk with ASI exist (Li et al., 2015; Roque & Cardoso, 2013; Shojaati, 2003). Hence there is value in exploring how ASI might vary with impact configuration (impacting vehicle mass, speed and angle). This paper describes the development and testing of a desktop model for predicting ASI in impacts with rigid barriers as a function of impact configuration. The efficacy of the model is tested against published data.

Background

Burbridge and Troutbeck (in press) report on the results from full-scale crash tests into a range of road safety barriers, and conclude, among other things, that occupant risk measured in terms of ASI is likely to be a function of the speed, mass and angle of the impact as well as the flexibility of the barrier system. Subsequent review and analysis of the same data (with slight amendment) suggests that the relationship between barrier flexibility and the reciprocal of ASI (1/ASI) is a linear function, and that the shape (slope) of the linear function is a function of impacting vehicle mass, speed and angle (Figure 1).

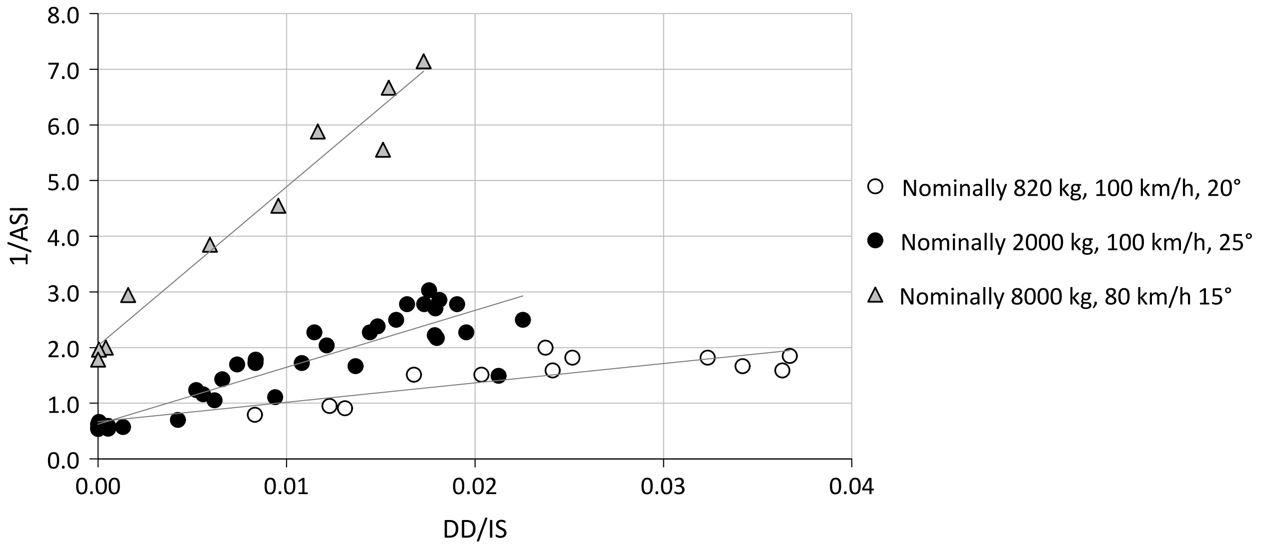

Figure 1. Analysis of data from Burbridge and Troutbeck

Similar relationships are evident in re-analysis of parametric crash testing reported by Hammonds and Troutbeck (2012)(Figure 2), and in analysis of data reported by Anghileri et al (Figure 3).

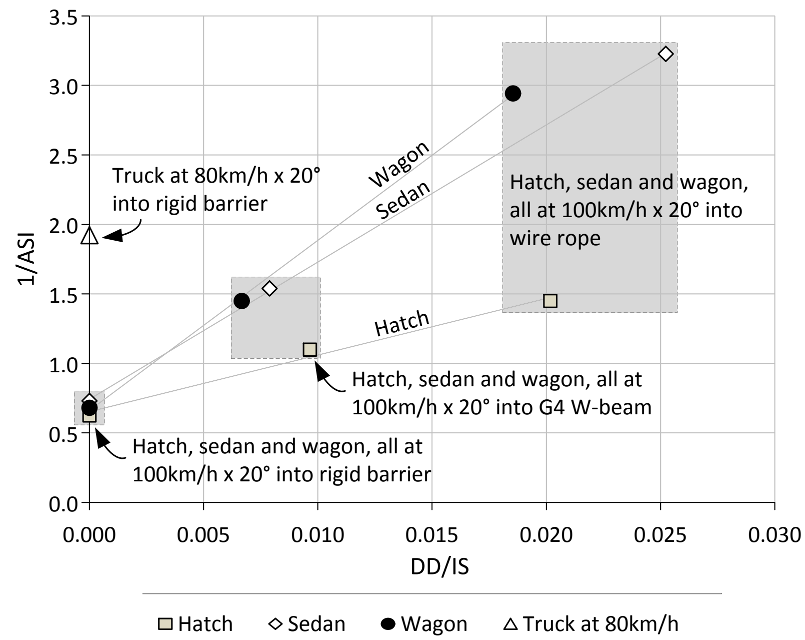

Figure 2. 1/ASI v flexibility plot using data from crash testing reported by Hammonds and Troutbeck (2012)

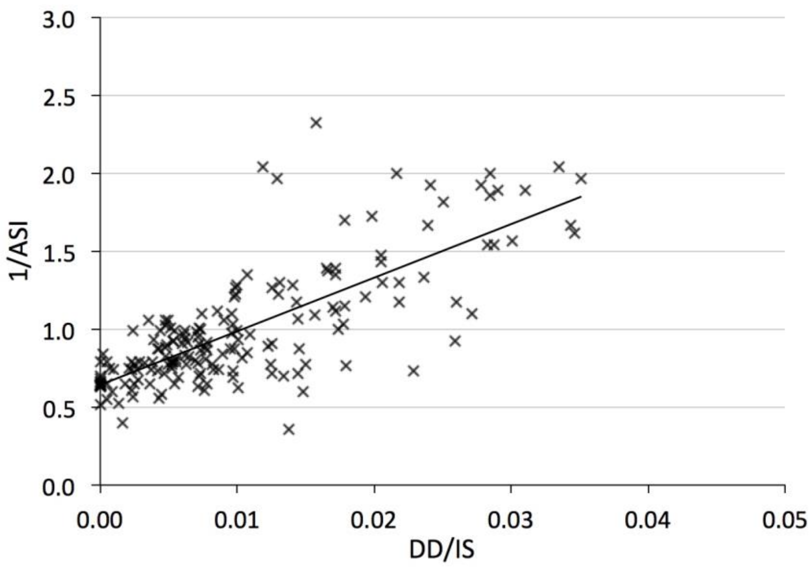

Figure 3. 1/ASI v flexibility plot of 174 no. EN1317 TB11 test results from Anghileri et al (2005)

In summary, it is conjectured that:

$$\frac{1}{ASI} = a\frac{DD}{IS} + b \qquad \text{Equation 1}$$

and thus:

$$ASI = \frac{1}{a\frac{DD}{IS} + b} \qquad \text{Equation 2}$$

where 'a' is the slope of the proportional relationship between 1/ASI and flexibility, while 'b' is the y-intercept. So for rigid barriers (where dynamic deflection is zero):

$$ASI = \frac{1}{b} \qquad \text{Equation 3}$$

The hypothesis then is that 'b' is a function of mass, speed and angle, such that:

$$b = K_b m^{\alpha_b} v^{\beta_b} (sin\,\theta)^{\gamma_b} \qquad \text{Equation 4}$$

and thus:

$$ASI = \frac{1}{K_b m^{\alpha_b} v^{\beta_b} (sin\,\theta)^{\gamma_b}} \qquad \text{Equation 5}$$

where K_b, α_b, β_b and γ_b are constants.

The broad objectives of this study are to construct and then test a desktop model that will predict ASI for impacts into rigid barriers according to the expression in Equation 5.

Method

A least sum of the squared differences (SSD) regression is undertaken for 35 full scale impacts into barriers where impacting vehicle mass, speed, angle, ASI and zero dynamic deflection are reported in order to determine 'best-fit' values for K_b, α_b, β_b and γ_b. (Test data will be tabulated and reported with source cited in the full paper submission).

Analysis of the results includes correspondence plotting and CUmulative REsidual (CURE) graphs (Hauer, 2015) for each independent variable, accompanied by some discussion of the limitations of the model.

The model is then used to predict values for ASI for various impact configurations, which are compared with values generated in corresponding parametric simulations conducted earlier by Montella and Pernetti (2004).

Discussion and conclusions

The study is expected to conclude that the model has some level of validity, but is observed to contain some bias which could be attributable to (for example) variation in the stiffness of standard crash test vehicles between and across crash test protocols and questionable independence of the independent variables. The model would benefit from further refinement, ideally based the results from full scale crash testing in configurations beyond those prescribed in the test protocols.

References

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