Impact Design of Crash Cushions for Nonstationary Barriers

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Nonstationary traffic barriers such as sign trucks with crash cushion attachments can be designed by using barrier resistance charts and acceleration-time diagrams.

Simple equations for both methods were derived and results were compared with more complex computer simulations to illustrate the usefulness of the simple equations. In particular, an equation for a movable barrier resistance chart was derived from the general differential equation, and usage of the chart is discussed and exemplified.

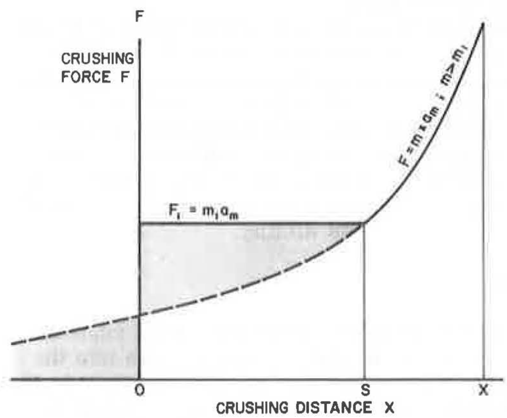
The acceleration-time diagram method is in the form of sets of simple equations based on two (or more) steps of constant crushing forces, and the method can be applied in this form for design purposes.

Feasibility of the methods with regard to angular impacts can be shown by means of a few computer simulation results. The equations for drawing the barrier resistance chart and for calculating the crushing time of the first constant part of the chart are shown in Figure 1 where

S = stroke or crushing distance of first constant part,
X = stroke or crushing distance beyond S for m,
T = crushing time pertaining to S for m,
m = mass of impacting car,
m_1 = mass of smallest car to be protected,
M = mass of sign truck,
a_m = permissible deceleration of impacting car,
V = impact velocity, and
F_1, F = resisting force of ideally shaped barrier material.

Area under the chart represents dissipated impact energy. If resisting forces of actual materials are lower, the strokes (S or X) must be correspondingly larger.

Figure 1. Barrier resistance chart.



$$S = \frac{M}{m_1 + M} \times \frac{V^2}{2 a_m}$$

$$X = \left[\ln\left(\frac{m}{m_1}\right) - \ln\frac{m+M}{m_1+M} + \frac{M}{m+M} \right] \times \frac{V^2}{2a_m}$$

$$T = \frac{KV}{F_1}\left[1 - \sqrt{1 - \frac{2F_1 S}{KV^2}}\right] ; \quad K = \frac{Mm}{M+m}$$

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