Roadside Encroachment Parameters for Nonfreeway Facilities

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A recently published NCHRP report (1) has shed light on how to evaluate and compare the degree of hazard associated with roadside obstacles. To evaluate the effectiveness of roadside safety improvements, a probabilistic hazard index model was developed. This model accounts for (a) vehicular roadside encroachment rates, (b) percentile distribution for the lateral displacement of encroaching vehicles, (c) encroachment angle, (d) lateral placement of the roadside obstacle, (e) size of the obstacle, and (f) accident severity associated with the obstacle. The predicted difference between the hazard index before and after improvement indicates the effectiveness of the roadside safety improvement.

The objective of the research (2) described here was to enlarge the applicability of the hazard model developed in NCHRP Report 148 so that it can be used for predicting the effectiveness of roadside safety improvements on all classes of highway. This involved collecting additional data for estimating roadside encroachment rates, encroachment angle distributions, lateral displacement distributions, and obstacle severity indexes for all classes of highway other than freeways: urban arterial streets, rural two-lane highways, and rural multilane surface highways.

ROADSIDE OBSTACLE SEVERITY INDEXES

The severity index is a measure of the average consequence of a vehicle impact and is an integral part of the roadside hazard index model. Generally, any safety program is aimed at reducing total fatal, injury, and property damage accidents. Therefore, any improvement scheme that assigns higher weights to the more severe accidents will tend to satisfy these aims. The severity index considered here is the proportion of total accidents that are either fatal or nonfatal injury accidents.

So that the hazard model would be usable for all classes of highways, severity indexes were identified for the various roadside obstacles classified by type of highway. The major premise was that, as average operating speeds increase, the severity index of a particular roadside obstacle increases. Therefore, for a particular obstacle, the severity index is expected to increase from urban streets to rural at-grade highways to freeways.

Severity data on single-vehicle roadside obstacle accidents were requested from 34 city and 13 state agencies. Of these agencies, 8 cities and 10 states were able to provide data suitable to the needs of this study. City agencies were asked for accident severity data on urban roadside obstacles on streets with speed limits of 48 to 72 km/h (30 to 45 mph). State agencies were asked for accident severity data on roadside obstacles along rural nonfreeway roadways with speed limits of 80 to 112 km/h (50 to 70 mph).

The subject research report lists developed severity indexes for freeways, rural surface highways, and urban streets for the following roadside obstacles: utility poles, trees, sign posts, light poles, traffic signal poles, railroad signal poles, curbs, guardrails, roadside slopes, ditches, culverts, drainage inlets, bridge abutments and piers, bridge rails, retaining walls, fences, and fireplugs.

ROADSIDE ENCROACHMENTS

A roadside encroachment occurs when a vehicle leaves the traveled way either because of loss of driver control or because of an emergency maneuver to avoid collision with another vehicle. The parameters that describe the nature of these encroachments are the encroachment rate, distribution of encroachment angles, and distribution of lateral displacements of encroaching vehicles.

Because of time and funding constraints, estimates of the pertinent encroachment parameters were made by using roadside accidents as the basic data source. Officials of Kansas City, Missouri, and the Missouri State Highway Commission were very cooperative in providing the necessary accident data and roadway and traffic inventory data.

Publication of this paper sponsored by Committee on Operational Effects of Geometrics.

Table 1. Equations of roadside accident rate versus ADT for various classes of highway.

Highway Class	Regression Equation	Correlation Coefficient	Standard Error
Rural freeway	y = 0.476 + 0.000 172 (ADT)	0.731	1.330
Rural multilane divided	y = 0.663 + 0.000 113 (ADT)	0.641	0.861
Wide rural two-lane (roadbed ≥ 10.9 m)	y = 0.182 + 0.000 142 (ADT)	0.445	0.355
Narrow rural two-lane (roadbed < 10.9 m)	y = 0.159 + 0.000 142 (ADT)	0.590	0.400
Urban arterial streets	y = 0.474 + 0.000 254 (ADT)	0.608	2.570

Note: 1 m = 3.28 ft.

Encroachment Rates

Roadside encroachment rates are normally higher than reported roadside accident rates because all encroachments do not result in accidents. The only pure encroachment data available are those of Hutchinson and Kennedy (3) for freeway medians. Therefore, for this study, the encroachment rates were estimated from accident rates by multiplying all accident rates by the ratio of freeway encroachment rates (twice the median encroachment rate of Hutchinson and Kennedy) to freeway accident rates (measured in this study).

The accident data were analyzed by using simple linear regression analysis in which data points were weighted by roadway section length. To achieve maximum discrimination, several classification variables were also investigated including type of street, speed limit, frequency of fixed objects, and presence of curbs in urban areas and type of highway, roadbed width, and average operating speed in rural areas. Of these classification variables, type of highway in rural areas and roadbed width for two-lane rural highways were the only ones that provided some discrimination of accident rates.

The resulting roadside accident rate versus ADT relationships are shown in Table 1. These relationships are defined by the regression equations and the standard descriptors of goodness of fit, the correlation coefficient, r, and the standard error, S.E. The encroachment frequencies for highways other than freeways are estimated by multiplying the slope of each accident line by the ratio (5.23) of freeway encroachments to freeway accidents. These are simply order of magnitude estimates to be used in the absence of true encroachment data.

Encroachment Angles and Lateral Displacements

Collision diagrams from accident reports were used to record dimensions of accident encroachments for determining encroachment angles and the lateral displacements of encroaching vehicles. Lateral displacement was measured to the right-front corner of the vehicle at its final resting place and requires identification of either that dimension directly or the other two sides of the encroachment triangle. To compute the angle of encroachment requires that any two sides of the encroachment triangle be identified.

The subject research report shows resulting exceedance distributions for encroachment angles and lateral displacement distances for urban arterial streets and rural two-lane highways. With minor variations, these distributions are similar to those found for freeway medians by Hutchinson and Kennedy.

CONCLUSIONS AND RECOMMENDATIONS

Applying the developed roadside encroachment parameter estimates in the hazard model suggests that relatively little effectiveness can be gained by implementing roadside safety improvements on highways other than freeways. This negative conclusion, however, must be interpreted in light of the limitations of the data presented in this report. The roadside encroachment rates developed here are only average rates and do not account for higher rates at specific locations. For example, the encroachment rates for highway curves, for weaving sections, or for sections with extremely low skid resistance are expected to be much higher than the average. Unfortunately, the data needed to detect these variances from the average are difficult to compile and therefore have not been investigated by anyone.

Because the hazard index is directly proportional to encroachment rate, it is easy to investigate the sensitivity of the hazard index to a change in encroachment rate. For example, if the encroachment rate for a particular highway curve geometry is three times the average, the hazard index would be three times the average. If this kind of condition could be detected, more kinds of roadside hazard improvements at more highway locations could be justified.

To be able to identify and justify roadside safety improvements for highways other than freeways, therefore, requires further research to improve the precision of the hazard model so that it accounts for hazard-sensitive site-specific parameters.

REFERENCES

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