METHODOLOGIES FOR DEVELOPING GUIDELINES

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INTRODUCTION

Do we need guidelines or warrants for all six test levels? If not, what test levels are to be used for developing guidelines or warrants? I would argue that, even though *NCHRP Report 350* has six test levels, we can concentrate on only two basic levels, which are test levels 2 (70 km/h and 3 (100 km/h).

It is questionable that we will ever develop roadside safety features under Test Level 1 at 50 km/h (30 mph). First, 30-mph roadways are mainly urban streets where the use of roadside safety features is very infrequent. Second, the current vehicle population is designed for survivability at 30 mph, i.e., for a belted occupant and/or vehicles with airbags, a 30-mph head-on impact into a rigid barrier is a highly survivable impact. Finally, there is probably very little cost saving by designing for 30 mph instead of 45 mph (Test Level 2).

Test levels 4 through 6 all pertain to heavy trucks. Again, roadside safety features designed for truck impacts will have very limited applications. We simply cannot afford them except under special conditions, which are generally recognized by the highway agencies without the need for specific guidelines.

At the most basic level, one or more engineers responsible for the design, construction, and maintenance of the roadside safety features can get into a room and formulate the guidelines or warrants based on their expert opinion and engineering judgement as well as their collective expertise and experience. There is not much that can be said about decisions that are strictly based on expert opinion and engineering judgement or the collective expertise and experience of the decision-makers. However, in today's litigious society, such decisions are harder and harder to defend in court.

THE BENEFIT/COST ANALYSIS APPROACH

The benefit/cost analysis approach provides a more objective, systematic, and defensible means of arriving at the guidelines or warrants. The remainder of the presentation will concentrate on the benefit/cost analysis approach. However, it should be borne in mind that, even with the benefit/cost analysis approach, expert opinion and engineering judgement are still crucial to the development of the guidelines or warrants. Decisions, such as the selection of typical input values and benefit/cost ratio to be used with the analysis, still require expert opinion and engineering judgement on the part of the individuals developing the guidelines or warrants.

The basic concept of benefit/cost analysis is very simple. For any given safety improvement, there are benefits and costs associated with the improvement. Benefits are expressed in terms of reduction in accident costs and costs are related to construction and maintenance costs. To justify the improvement, the benefits should, as a minimum, equal to the costs (i.e., benefit/cost ratio of 1.0) for the improvement to be even considered. Since we are typically working with a limited budget that is much smaller than the identified need, we will try to prioritize the spending to maximize the return for the spent funds. In other words, we would like to spend the funds on projects that are most cost-beneficial.

The most commonly used benefit/cost procedures are:

- 1977 AASHTO Barrier Guide,
- Benefit Cost Analysis Program (BCAP),
- ROADSIDE Program,
- TTI Benefit/Cost Program,
- New Cost-Effectiveness Procedure, and
- NCHRP Project 22-9.

A benefit/cost procedure consists of:

1. An algorithm to predict the frequency of accidents;
2. An algorithm to predict the severity of accidents; and
3. A procedure to estimate accident costs and determine benefit/cost ratio.

Accident Frequency Prediction

There are two basic approaches for predicting accident frequency.

Most existing benefit/cost procedures are based on the encroachment probability model. Encroachment may be defined as the inadvertent or uncontrolled departure from the travelway by a vehicle.

The basic premise is that accident frequency and severity are directly related to encroachment frequency and severity. This model predicts accident frequency and impact conditions given encroachment frequency and characteristics, vehicle speed and angle, and a number of adjustment factors.

The primary advantage of the encroachment probability model is its versatility it can be used with any roadside object or feature, newly constructed or reconstructed roadways, and it is not based on historical data. The model suffers from several disadvantages: encroachment data are limited, numerous assumptions are made, and there is a lack of validation.

Accident data based regression models relate accident frequency and rates to independent variables such as ADT, horizontal curvature, and clear zone width. The accident data based regression model is a more simple and direct approach. On the other hand, police-level data may be of poor quality, the ADT term tends to dominate, predictability is poor, and human factors are unaccounted for. Also, many accidents go unreported.

Accident frequency prediction will probably play a lesser role in the development of guidelines or warrants for different test levels since the effect of test levels is mainly on the severity of accidents.

Accident Severity Prediction

Accident severity prediction is the second component of a benefit/cost procedure.

Accident severity is a function of:

- Nature of roadside object/feature;
- Test level;
- Effectiveness of safety appurtenances;
- Potential outcomes, e.g., penetration, rollover, redirection, etc.;
- Impact conditions; and
- Other factors, e.g., vehicle type and weight.

Severity indices are used surrogate for injury probability and severity. They may be obtained from accident data, full-scale crash testing, computer simulation, and field experience.

Cost Estimation and Benefit/Cost Determination

Finally, costs are estimated and the benefit/cost ratio is determined.

Direct costs include installation costs, routine maintenance, and salvage value. They are easily estimated with good accuracy.

The benefits are reduced accident frequency and/or severity.

Most states use National Safety Council estimates to measure accident costs. Accident costs may also be measured by willingness-to-pay or using NHTSA estimates.

To develop guidelines using the benefit/cost model, the following inputs are needed:

- Roadside safety feature for evaluation, e.g., guardrail;
- Test levels for evaluation, e.g., test levels 2 and 3
- Highway types for evaluation, e.g., two-lane undivided roadway;
- Typical values for site characteristics, e.g., ADT, lane width, horizontal curvature, vertical grade, lateral offset, etc.;
- Typical values for severity;
- Typical cost figures; and
- Benefit/cost ratio.

Once the input values listed above are selected, the mechanics of actually running the program are very direct. The program will then be executed repeatedly by varying the key variables over pre-selected ranges.