U.S.Department
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Federal Highway Administration

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HIGH PRIORITY NATIONAL PROGRAM AREA

HIGHWAY SAFETY DESIGN PRACTICES AND CRITERIA

Safety Design Division, HSR-20

OBJECTIVE

To develop an integrated design process that systematically considers both the roadway and roadside in the development of cost-effective highway design alternatives.

SCOPE

This research program will include the identification of critical problem areas through analysis of accident trends and data; the establishment of relationships between highway design features and accidents; the development of procedures and criteria for evaluating the safety cost-effectiveness of design alternatives; development of a procedure for evaluating the design consistency of a roadway; and the establishment of concurrent procedures of evaluating the safety impacts of the roadway and roadside design phases. These procedures will incorporate the use of advanced technology, such as Computer Aided Design (CADD) systems, Geographic Information Systems (GIS), the Highway Vehicle Object Simulation Program (HVOSM), and expert systems into a dynamic model for evaluating alternative highway designs.

BACKGROUND

More than half (58.3 percent) of the 41,435 fatal accidents in 1987 involved only one vehicle. The highest percentage of the 24,159 single-vehicle accidents involved collisions with a fixed object. Past efforts to reduce accidents have been directed at providing a more forgiving roadside. While improved traffic barriers, clear roadsides, crash cushions, and breakaway supports have helped to reduce single-vehicle accident severity, this type of accident remains a major contributor to the fatality toll.

Currently, highway design is based on a series of discrete decisions. For example, the decisions on alignment are largely based on the constraints of environmental impacts, right-of-way costs, and construction costs. In the redesign of existing roadways, the available right-of-way is often the deciding factor. Once alignment is established, the highway is designed in two phases: roadway design and roadside design. Roadway design decisions are based on alignment, design speed, and agency design policies.

However, tradeoffs between various design elements based on safety considerations cannot be made because relationships between the design elements and safety generally have not been quantified; or, where relationships are known, they have not been incorporated into the agencies' practices. In the roadside design phase, the safety review is aimed at reducing the severity of run-off-the-road accidents. This review looks at obstacles located beyond the roadway shoulders and includes ditches, curbs, drainage structures, abutments,

slopes, trees, utility poles, and sign posts. Because the relationships between severity and roadside hazards have not been quantified, evaluation of alternative designs based on safety considerations is being made subjectively.

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CURRENT ACTIVITIES

This HPNPA will address all aspects of good highway safety design practices. Several studies were initiated in fiscal year 1989 that will form the basis for the research planned in this HPNPA:

NCHRP Project 15-12, "Roadway Widths for Low Traffic Volume Roads"

Roadway width standards for low-volume roads (less than 2,000 average daily traffic) were established many years ago based on limited research and engineering judgement. This study will develop an engineering analysis procedure for determining roadway widths for the construction and reconstruction of low-volume roads and recommend changes to the existing roadway width standards.

Compendium of the Safety Effectiveness of Highway Design Features

This study will critically review and synthesize the existing literature to determine the most appropriate relationships between accidents and geometric design elements. Where safety relationships have not been established, the appropriate experimental design will be developed for use in future studies.

NCHRP Project 22-7, Update of "Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances"

NCHRP Report 230 has served as the generally accepted guide for developing and evaluating roadside safety hardware since its publication in 1981. This study will incorporate the knowledge gained in this area as well as address the change in the vehicle fleet since that time.

Side Impact Test Criteria

Currently, roadside safety hardware is only tested for frontal impacts, yet thousands of people die each year in side impacts with fixed objects. This study is examining the side impact, fixed object problem and will result in recommendations on the feasibility of side impact performance requirements of roadside safety hardware.

Analysis of Guardrail and Median Barrier Accidents

As part of National Highway Traffic Safety Administration's National Accident Sampling System, a special study was conducted which collected detailed data on over 1,000 accidents involving longitudinal barriers. That data base has had only limited use and has never been fully analyzed. This study will involve extensive statistical and clinical analyses of that data to draw insights on the performance of our roadside hardware.

FUTURE ACTIVITIES

Research planned in geometric design includes:

1. State-of-the-Practice Review: Geometric Design Consistency

The extent to which current design procedures account for design consistency (the roadway designed for the drivers' perspectives) will be documented. This will include U.S. as well as European practices. The factors used to define and measure consistency will be identified as well as the method used to achieve a consistent highway design. Past research addressing the issue of design consistency will be critically reviewed and synthesized.

2. Conceptual Requirements for a Highway Safety Design Model

The primary purpose of the proposed model is to provide a tool for highway and traffic engineers to objectively assess alternative highway designs. The model will provide a safety value for discrete roadway sections as well as an overall safety value that reflects the type of roadway, vehicles, users, terrain, and expected environmental conditions. This study will develop the model structure, input, and output, and indicate "gaps" in the data necessary to exercise the model.

3. Development of the Relationship Between Accidents and Geometric Design Elements

Based on the results of the study entitled, "Compendium of Safety Effectiveness of Highway Design Features," a series of studies will be performed to develop the relationships between accidents and geometric design elements or combinations of elements. From these relationships, accident reduction factors will be developed for incremental changes to each design element or group of elements.

4. Development of Design Consistency Model

Based on the State-of-the-Practice study, this study will develop a model, including guidelines for incorporating

design consistency in the geometric design process. This will include developing any necessary equations or computer simulation programs for assessing the adequacy of the highway from the driver's perspective.

5. Field Test Design Consistency Model

One or two design organizations will use, evaluate, and recommend improvements to the model and procedure developed.

6. Development of Model to Integrate Accident Reduction Factors into the Design Process

Using the accident reduction factors previously developed, a model will be developed to integrate these factors into the design process.

7. Integrate Design Consistency Model with Accident Reduction Factors

The design consistency model and accident reduction model will be combined into a single model or process for use in the design of highways.

8. Develop Model for Evaluating Alternative Highway Designs

The roadside safety performance model, consistency model, and accident reduction model will be combined and integrated with existing computer-aided highway design models. The resultant model or process will provide the designer with a method of evaluating the cost implications and safety consequences of alternative highway designs.

Research planned in roadside safety includes:

1. Evaluation of Roadside Safety Simulation Methodologies

This study will involve the review of current roadside hardware simulation models and other commercially available simulation codes, the selection of features from these various programs, and the development of a new PC-based computer simulation model which combines the best features of these currently available codes.

2. Detailed Roadside Accident Studies

One or more studies will be conducted to determine the overall performance of current safety hardware. These will be preceded with a formal study design and pilot studies.

3. Development of Severity Indices for Roadside Benefit/Cost Model

Information from vehicle simulations, accident data, and full-scale crash tests will be used to develop detailed severity indices for various safety hardware systems.

4. Large-Scale Evaluation of Performance Envelopes of Standard Roadside Hardware

A series of full-scale crash tests will be conducted on standard safety hardware outside of standard test conditions to determine the performance envelopes of these systems.

5. Development of Roadside Safety Performance Model

A model will be developed to integrate all the information from the previous studies into a rational roadside design process.

Technology Transfer planned:

As promising results become available from various studies, this information will be made available to users. Potential activities will include the following:

1. Informational Guide on the Use of Accident Data in Geometric Design

A guide will be developed containing known relationships between accidents and geometric design elements.

2. Informational Guide on Accident Reduction Factors

A guide will be developed containing accident reduction factors for geometric design elements.

3. Training Course on Roadside Benefit/Cost Model

Once detailed severity indices are developed for various safety hardware systems, a course will be developed to train potential users of the Roadside Safety Benefit Cost Program they support.

4. Development of Cost-Effective Roadside Design Guidelines

Improved guidelines, based on the proposed accident research, will be developed for making cost-effective decisions on roadside safety.

5. Training Course on Roadside Safety Performance Model

A course will be developed for training potential users of the proposed safety performance model.

SUMMARY

It is expected that research in this High Priority National Program Area will result in an integrated system for making rational decisions at the design stage that will minimize single-vehicle accidents. Efforts will be made to automate this program by integrating the information developed into standard CADD software. This software will allow the user to make trade-offs between geometric design decisions and roadside design decisions to improve safety.