TEXAS TRANSPORTATION INSTITUTE
THE TEXAS A&M UNIVERSITY SYSTEM

Project Status Report 0-4703-1

Project 0-4703: Incorporating Safety into the Highway Design Process

Author: J. Bonneson, P.E., K. Fitzpatrick, P.E., M. Wooldridge, P.E., and D. Lord

A Plan for Incorporating Safety into the Highway Design Process

Public demand for safer streets and highways continues to grow. In response to this demand, state and national transportation agencies have developed safety programs that emphasize public education, accelerated highway renewal, community-sensitive street systems, and innovative technology to facilitate safe highway design.

Highway safety concerns are also evident in Texas. Crashes in Texas continue to increase and currently exceed 300,000 per year. Nearly 3800 motorists die annually on Texas highways. As part of its proactive commitment to improving highway safety, the Texas Department of Transportation (TxDOT) is moving toward including quantitative safety analyses throughout the project development process. This research project has as its objectives:

1. the development of safety design guidelines and evaluation tools to be used by TxDOT designers and
2. the production of a plan for the incorporation of these guidelines and tools in the planning and design stages of the project development process.

Research Approach

A six-year program of research was developed to satisfy the stated

objectives. The research approach consists of ten tasks that represent a logical sequence of needs assessment, research, evaluation, and workshop development. Three tasks have been completed in the first year of research; they include:

- review current design and safety evaluation processes,
- identify safety information sources, and
- assess the use of accident modification factors (AMFs) in design evaluation.

Review Evaluation Processes

The objective of this task was to identify the guideline information provided in various TxDOT manuals that identifies and addresses safety issues during the various stages of the project development process. This process consists of six stages: planning and programming, preliminary design, environmental, right-of-way and utilities, PS&E development, and letting. The planning and programming, preliminary design, and PS&E development stages are the focus of this research. The sequence of these stages in the development process is shown in Figure 1.

As indicated by Figure 1, evaluation tools are used by the designer to verify the performance potential of alternative designs. The evaluation quantifies the design's performance in terms of safety, operations, construction cost, etc. The objective of this evaluation is to ensure that the design offers a reasonable balance between cost and effectiveness. Tools are readily available to conduct level-of-service analyses and to estimate construction costs. Tools for quantifying an alternative's impact on safety are not as readily available at this time.

Identify Safety Information

The objectives of this task were to:

1. identify findings and tools from previous research that can be incorporated in the highway safety design process and
2. identify the research needed to supplement these findings and tools.

These objectives were achieved through a review of the highway safety research literature and a national "research-in-progress" database.

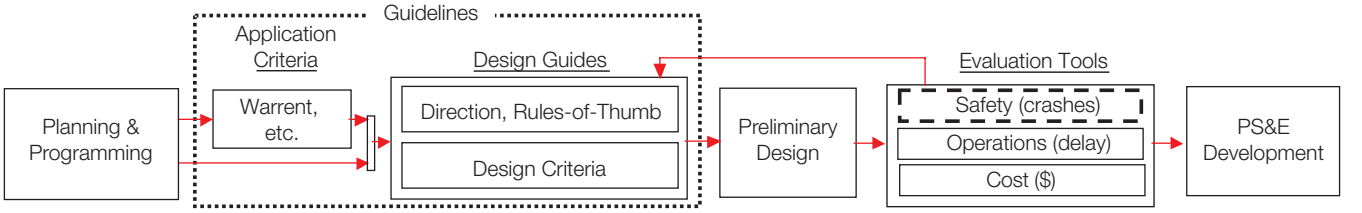

Figure 1. Components of the Project Development Process.

Several software-based tools and authoritative documents on the topic of safety evaluation were identified. They are listed at the end of this report along with a website address from which they can be obtained.

Assess the Use of AMFs

The objectives of this task were to:

1. identify potential applications of AMFs within the highway design process and
2. describe issues related to these applications.

AMFs describe the expected change in crash frequency due to a change in road geometry or traffic control. The literature review indicated that AMFs can be used to evaluate alternative design components, requests for design exception, and design consistency. Issues related to the use of AMFs include:

1. the limited number of design components for which accurate AMFs are available,
2. accuracy of combined AMFs when used to estimate the effect of several design components used together, and
3. potential for variation in AMF value with a change in related factors, such as traffic demand.

Findings

Safety-Conscious Design

To achieve further improvement in highway safety, it will be necessary to focus on design policies and technologies that:

1. reduce the likelihood of a crash and
2. reduce the severity of the crashes that do occur.

The use of safety evaluation tools in the design process is one way to accomplish these goals.

Safety-conscious design represents the explicit evaluation of the safety consequences associated with design alternatives. The Transportation Association of Canada recently incorporated safety-conscious design in its design guide for new location and reconstruction projects (i.e., the *Geometric Design Guide for Canadian Roads*). The justification offered for changing their design philosophy was the observation that:

1. the traditional approach to design has become less dependent on experience and judgment and more dependent on adherence to minimum criteria,
2. there is a belief among designers that safety is an automatic by-product of the design process, and
3. the difficulties associated with quantifying safety have relegated safety considerations to being only a secondary objective of the design process.

Safety-conscious design can be implemented by using safety evaluation tools to quantify the effect of alternative design choices on safety. At the highest level, safety-conscious design involves the use of evaluation tools and economic principles to evaluate the benefits and costs of design alternatives. In recognition of the time required to use the higher levels of safety-conscious design, the higher-level evaluations tend to be reserved for more complex design conditions or those that involve higher construction costs.

Project Development Process

The research team identified potential safety-related tasks that could be incorporated into the project development process. These tasks are identified in Table 1 along with the step within which they would be conducted.

The implementation of the proposed tasks will add time to the design process. However, by limiting the evaluation of safety to only "key" design elements, it is hoped that the additional time invested will be offset by a reduction in crashes and lower construction costs. This latter benefit is derived by limiting instances where a design component is over-designed (i.e., when estimated road-user benefits do not justify the component's construction cost).

Potential Refinements to Design Process

Highway safety is an important concern of TxDOT. However, the capability to more explicitly consider safety in the design process would be an improvement. Such capabilities may include:

- tools to quantitatively evaluate the safety effects of specific design components,
- tools to assist in the identification of atypical crash patterns at specific roadway locations,

Table 1. Potential Safety Tasks in the Project Development Process.

Stage	Step	Potential Safety-Related Task
Planning and Programming	Needs Identification	• Screen facilities for locations with safety needs.
Preliminary Design	Preliminary Design Conference	• Document safety needs. • Identify atypical conditions, complex elements, and high-cost components.
	Data Collection/Preliminary Design Prep.	• Diagnose safety data to identify crash patterns. • Refine project scope if necessary.
	Preliminary Schematic	• Perform preliminary level of safety analysis for "key" geometric elements.[1]
	Geometric Schematic	• Perform detailed level of safety analysis for "key" geometric elements.[1]
	Value Engineering	• Compare cost of specific elements and overall roadway with safety and operational benefits.
	Geometric Schematic Approval	• Document safety of design choices (use results for design exception request, if necessary).
PS&E Development	Final Alignments/Profiles	• Re-evaluate alignment, cross section, and roadside design to ensure acceptable level of safety.
	Traffic Control Plan	• Evaluate safety of long-term detour roadway design.

Note:
1. Key elements are those elements that are: (1) associated with the controlling criteria specified for the project and (2) used in situations where atypical conditions exist, the design is complex, or construction costs are high.

- guidance on the content of the safety evaluation conducted during the preliminary design stage, and
- guidelines for documenting a follow-up safety review of a completed project.

Implementation Plan

A unique feature of this project is that implementation products will be developed throughout its duration. Several products will be developed early in the project to facilitate timely dissemination of the research findings. Several of these products will be updated or refined during the research to ensure their content is current and comprehensive. In fact, an entire research task is devoted to the ongoing development and refinement of workshop materials. The main products of this research and their delivery dates are:

- *Roadway Safety Design Synthesis* (May 2005);
- *Roadway Safety Design Workbook* (interim: May 2005, final: February 2009);
- calibration factors for the *Highway Safety Manual* (October 2007); and
- roadway safety design workshop education materials (October of 2006, 2007, and 2008).

Of particular note in this list are the *Synthesis* and *Workbook* because of their more immediate dates of delivery. The purpose of the *Synthesis* is to promote the explicit and objective consideration of safety in the design process. To this end, it will focus on a presentation of the safety information reported in the literature. It is envisioned to be a reference document that will be useful to design engineers who desire additional safety information on a specific topic.

The *Workbook* will describe procedures for predicting the crash frequency associated with alternative design components. The designer will be able to use these procedures to evaluate alternative designs. The tools will be developed from the information in the *Synthesis* and from research conducted subsequent to its publication. The procedures will incorporate the information from the forthcoming *Highway Safety Manual*.

Ultimately, materials for a series of three highway safety design and evaluation workshops will be developed. Workshops will address rural highways as well as urban streets. An Internet clearinghouse will be developed and maintained during the latter four years of the project to facilitate implementation of the research project's findings and implementation of its products.

For More Details . . .

Related Reports and Tools:

- *Special Report 214: Designing Safer Roads — Practices for Resurfacing, Restoration, and Rehabilitation*. URL: http://www4.trb.org/trb/onlinepubs.nsf/web/trb_special_reports
- *NCHRP Report 482: Roadside Safety Analysis Program (RSAP) — Engineers Manual*. URL: http://gulliver.trb.org/publications/nchrp/nchrp_rpt_492.pdf
- *NCHRP Report 486: Systemwide Impact of Safety and Traffic Operations Design Decisions for 3R Projects*. URL: http://gulliver.trb.org/publications/nchrp/nchrp_486_full.pdf
- *NCHRP Report 500: Guidance for Implementation of the AASHTO Strategic Highway Safety Plan*. URL: http://www4.trb.org/trb/crp.nsf/All+Projects/NCHRP+17-18(3)
- *Treatments for Crashes on Rural Two-Lane Highways in Texas*. TxDOT Report FHWA/TX-02/4048-2. URL: http://tti.tamu.edu/documents/4048-2.pdf
- *A Review of Pedestrian Safety Research in the United States and Abroad*. FHWA Report RD-03-042. URL: http://www.walkinginfo.org/pdf/PedSynth/Ped_Synthesis_Report.pdf
- Strategic Highway Safety Plan Website. URL: http://safety.transportation.org/
- National Agenda for Intersection Safety. URL: http://safety.fhwa.dot.gov/fourthlevel/intersafagenda.htm
- Interactive Highway Safety Design Model (IHSDM). URL: http://www.tfhrc.gov/safety/ihsdm/ihsdm.htm
- Safety Analyst — Software for Identifying, Evaluating, and Treating Hazardous Locations. URL: http://www.safetyanalyst.org
- Highway Safety Manual. URL: http://www.highwaysafetymanual.org/

Research Supervisor: James A. Bonneson, Ph.D., P.E., Texas Transportation Institute, j-bonneson@tamu.edu, (979) 845-9906

Key Researchers: Kay Fitzpatrick, P.E., Texas Transportation Institute
Mark Wooldridge, P.E.,Texas Transportation Institute
Dominique Lord, Texas Transportation Institute

TxDOT Project Director: Elizabeth Hilton, P.E., ehilton@dot.state.tx.us, (512) 416-2689

To obtain copies of reports, contact Nancy Pippin, Texas Transportation Institute, TTI Communications, (979) 458-0481, or e-mail n-pippin@ttimail.tamu.edu. See our online catalog at http://tti.tamu.edu.

Report 0-4703-1

Disclaimer