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Texas

Department of Transportation

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Federal Highway Administration
U.S. Department of Transportation

Research Summary Report

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KNOWLEDGE-BASED SYSTEM FOR BRIDGE RAIL DESIGN: *BREXS*

PROBLEM STATEMENT

Due to aging of the transportation infrastructure in the United States, many highway bridges require updating of existing rails to meet current safety requirements. Substandard or improperly designed bridge rails can cause significant damage to the bridge structure itself and be a potential hazard to motorists. Not only are railings on aging structures being carefully reviewed, but governmental jurisdictions are mandating that new bridges be equipped with safe, contemporary, containment rails.

Effective design of new or retrofit bridge rails depends on many interrelated factors: adherence to standard specifications, structural adequacy, tradeoffs between benefits and costs, safety of the habitat beneath a bridge, geometry of the structure, climate, geographic location, and aesthetics. Selection of the optimum rail that conforms to the above criteria is a challenging task that requires a high level of knowledge and experience from complementary disciplines, such as structural analysis, highway safety, economics, maintenance, and construction. Currently, these tasks are performed by experienced engineers scattered throughout the state.

Use of conventional analysis codes to evaluate design parameters for rail selection involves a steep learning curve and produces results that are not always trustworthy. Human expertise is effective but not conveniently accessible. For lack of a unified source, design engineers disbursed throughout the state make decisions for rail selection and installation based on their own experience and preference. Novice engineers are often forced to choose rails for use without the benefit of having access to a complete array of salient decision factors. Finally, no permanent documentation is available to describe the rationales used in selection of a particular safety rail.

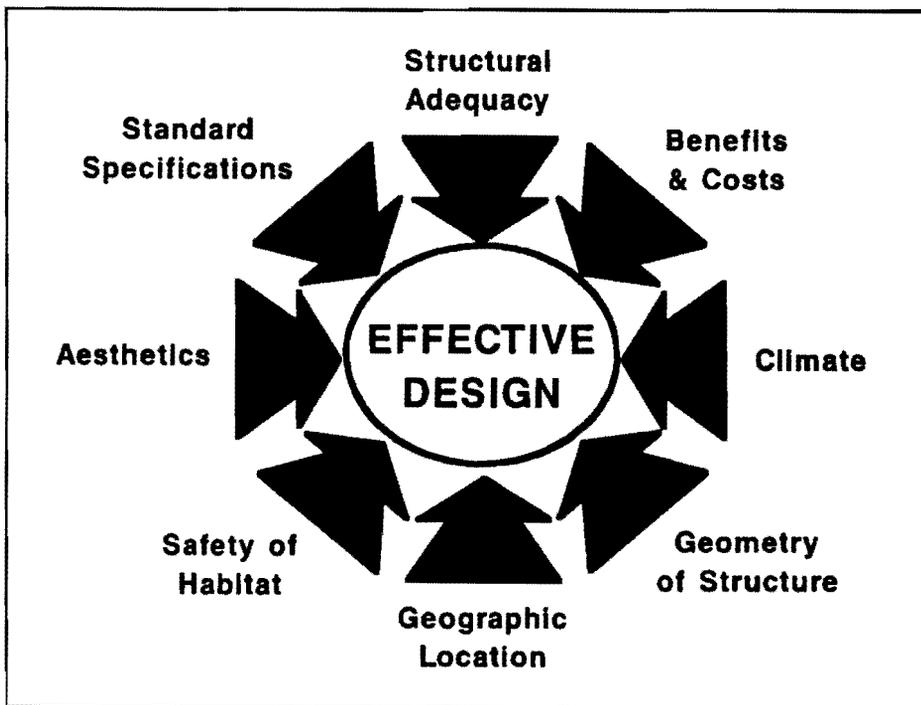
OBJECTIVES

The Texas Transportation Institute (TTI) conducted study 1240, "Expert System for Bridge Rail Design," in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA) to develop a knowledge-based system for selecting and designing bridge rails on new construction and retrofit projects. This Bridge Rail Expert System (BREXS) is an advisory system targeted for use on microcomputers by both experienced and inexperienced design engineers at the district and local levels throughout Texas. Its graphical, user-oriented interface facilitates easy operation. Researchers designed the system to be used mainly for the following purposes:

- Provide advice to less experienced engineers in bridge rail selection;
- Encourage more uniformity in the design/selection process at the 24 TxDOT district offices;
- Optimize the selection process according to cost, maintenance, safety, and aesthetics;
- Expedite the design process of retrofitting since the design review can be reduced and made less time consuming.

FINDINGS

BREXS is divided into two main parts: new construction and retrofit. In the first part, engineers can select the best bridge rail type if they know the conditions of the new bridge, its location, and optimization factors. The user provides a complete set of data,



runs the advisory program and then reviews the results. With BREXS, input data can be edited, reviewed, saved to a file, read from a file, and printed. Users are warned when the input data is not reasonable. After a complete set of data items is entered, the advisory program can be run with one command. Users are not required to answer any other questions, or set other options. Results of the current case can be displayed in a separate window, saved to a file, and/or printed. Old files from previous sessions can also be accessed.

In addition, a database of rail type information can be accessed. Records in the database can be easily edited or deleted, and new records can be inserted. Engineers can view cross-sections of rail types, one at a time, or in a separate window. This feature can be activated simultaneously with the database access to provide a complete reference to rail type. A help function is also available for users at any point.

The retrofit segment of BREXS includes the selection of rail type and its

best placement on the bridge. The user interface provides the same features as the new construction module. In addition, the user can access the existing bridge and a rail type and can select any of the recommended rail types to be drawn.

The advisory program is also capable of recommending rail types and their associated weights. This process depends on the case data and the chosen optimization factors. Users can optimize the choice over five factors: cost, maintenance, safety, aesthetics, and personal preference.

As with most expert systems, BREXS was designed to solve one specific problem in the domain of highway bridge design. Its scope is limited to the selection of rail types. BREXS' output is given as a set of options or alternatives and their associated weights—sometimes a single answer does not exist or is not known.

CONCLUSIONS

Field testing results concluded that the level of expertise of the prototype version of BREXS lay somewhere between that

of the state expert and the local expert. The advice of BREXS could not usually be distinguished from that of human experts.

Yet, observations of the state expert revealed that some factors, such as the effect of the length of the bridge, were missing. Sensitivity analysis, which involved observations made on the methods that human experts follow to select bridge rails, showed that BREXS has greater sensitivity than human experts.

Researchers concluded that BREXS required some additional modification before the final phase of development was complete. Although its overall performance level was adequate, it would benefit from minor changes in its knowledge base and the user interface program. These modifications would render it suitable for another iteration of validation. Budget and time constraints prevented this second iteration from being undertaken. The use of the program in each TxDOT district office will serve as the best check on its performance. Careful engineering judgment should always be applied to suggestions made by BREXS even after prolonged use of the system. Further research is needed to investigate the best approach for making use of BREXS or other expert systems in the area of transportation-related safety structures.

--Prepared by Kelly West, Science and Technology Writer, Texas Transportation Institute.

The information described in this summary is reported in detail in TTI Research Report 1240-1, "User Guide for Bridge Rail Expert System (BREXS)", September 1991, and TTI Research Report 1240-2F, "Knowledge-Based System for Bridge Rail Design," November 1991, P. N. Roschke, P. Premthamkorn, W.A. Mitri, and B. Wang. The contents of this summary do not necessarily reflect the official views of the Texas Department of Transportation or the Federal Highway Administration.