

JOINT TRANSPORTATION RESEARCH PROGRAM

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Development of a Design Flexibility Toolkit

Introduction

The American Association of State Highway and Transportation Officials (AASHTO) publication titled *A Policy on Geometric Design of Highways and Streets* (Green Book) provides guidance to the designer by referencing a recommended range of values for critical dimensions for the design of new alignments and those undergoing major reconstruction. These guidelines permit sufficient flexibility to encourage independent designs for specific situations. The approach allows the designer to use flexibility to introduce “lower than typical” design values for a specific element to address an impacted area. This process allows for adjusting almost every aspect of the geometric design and may require both state and federal approval. Use of design flexibility may include use of a design exception. The current version of the *Indiana Design Manual* (IDM) provides and promotes some level of flexibility, particularly on non-NHS routes. The selection of design criteria for a transportation project is typically screened by the highway system the project is located on, functional classification, area type, forecasted traffic data and classification of project type. The use of design exceptions is one way to obtain design flexibility. Design exceptions require appropriate level of justification.

A design flexibility toolkit would be an extremely useful tool for transportation designers to have. This toolkit would be a reference document and an on-line tool which could serve as a one stop location that illustrates the research behind the values for each design criteria element, potential safety and or operational effects of selecting certain values and potential compounding effects on operation if more than one design exception is utilized. The objective of this study was to develop a highway design flexibility toolkit that can be used by INDOT engineers as a design tool as well as a training tool.

The general research approach was to review the federal and state highway design standards; analyze the principles and reasoning behind these standards; identify the major factors affecting highway classifications and highway designs; and determine the areas of possible design flexibilities. The major tasks accomplished in this study include the following:

Literature Review and Questionnaire Survey: A comprehensive literature review was conducted to identify available methods and practices of applying highway design exceptions. Through the literature review, the design exception practices of some states were identified. In addition, a questionnaire survey was conducted to obtain specific information from the neighboring states.

Analysis of Impact of Major Design Controlling Criteria: The impacts of the major design controlling criteria were analyzed. The controlling criteria included design speed, lane width, shoulder width, bridge width, horizontal and vertical alignment, grade, stopping sight distance, cross slope, superelevation, and vertical and horizontal clearance.

Safety Evaluation of Design Exception Projects: A number of actual INDOT design exception projects were analyzed. A field visit was made to some of the design exception projects to examine the operations and verify the geometric dimensions. The computer software *Interactive Highway Safety Design Model* (IHSDM) and the *Highway Safety Manual* (HSM) were utilized to evaluate the safety impacts of these design exception projects.

Economic Analysis: An important factor for a design exception project is the cost of the project. Computer software was developed to conduct economic analysis of design exception projects to compare the life cycle costs of different design options. The software can be used to estimate the benefits and costs in terms agency cost, operation cost, and safety impact.

Development of the Design Flexibility Toolkit: The toolkit was developed with the analysis results to provide step-by-step instructions for engineers.

Findings

A thorough evaluation of IHSDM and HSM was conducted to explore the feasibility of using the tools for safety assessment of design exception projects. A case study was performed to illustrate the process of safety evaluation. It was demonstrated that IHSDM can be used

to generate quantitative measures of safety impacts of design exception projects. IHSDM is capable of analyzing safety impacts of an individual substandard element as well as combined effects of a number of substandard elements. With IHSDM, the sensitivity of substandard elements can be analyzed by changing the values of design criteria. Using different combinations of substandard elements, such as lane width and shoulder width combinations, designers can choose the best alternative that would minimize the negative safety impacts. It is therefore recommended that INDOT use IHSDM in design exception projects for safety impact assessment. IHSDM has incorporated most of the methods and calculations in HSM, but there are still some of the items in HSM that are not included in IHSDM. It is possible that designers may need to use HSM in addition to IHSDM for design exceptions, such as in evaluating safety impacts of roundabout intersections.

One of the commonly used methods for justifying design exception projects is to use the savings in construction cost. However, this method is not a reasonable one because it does not include the impacts of a substandard highway section to the highway safety and operations. In this study, benefit-cost analysis method was used to evaluate the effectiveness of design exceptions. An Excel based computer program was developed to conduct benefit-cost analysis for design exceptions. This method includes not only the savings in construction cost and other initial costs, but also the user benefits in terms of travel time, vehicle operation, and safety. The computer program will be a useful and convenient tool for INDOT to evaluate design exception projects.

The guidelines for development and evaluation of design exception projects were developed and presented. The guidelines recommend the steps for developing and evaluating design exception projects. The potential impacts of design exception elements to highway safety and operations are listed for the 13 controlling criteria to provide designers with important and easy to use information. The possible counter measures for each of the controlling criteria are listed in a one-page table for easy reference. It is recommended that IHSDM be used to analyze safety effects and the Excel based computer program be used to conduct benefit-cost analysis for design exception projects.

Implementation

This study provided INDOT with guidelines for design exception projects. The guidelines include the steps for developing and evaluating design exception projects. Following the recommended steps, a designer will be able to choose appropriate design exception elements in considerations of their individual potential impacts to highway safety and operations. Once the design exception alternatives are developed, the combined effects of the substandard elements on highway safety and operations can be analyzed with the IHSDM software package. Effective safety measures will be selected from the recommended list. The life-cycle benefit-cost will then be conducted with the Excel based computer program developed in this study. The final choice of the design exception alternative based on the thorough analyses outlined in this study will reflect the best available information and engineering rationale and judgment. In addition, the guidelines can also be used by INDOT as a training tool.

Recommended Citation

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