



Design Flexibility Considerations for Built Urban Environments

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DESIGN FLEXIBILITY CONSIDERATIONS FOR BUILT URBAN ENVIRONMENTS

This digest contains excerpts from a study conducted for NCHRP Project 20-05, "Synthesis of Information Related to Highway Problems." The study was conducted by Nikiforos Stamatiadis, University of Kentucky, Lexington. Donna Vlasak is the Senior Program Officer for this study.

SUMMARY

Roadway designers rely on design standards (mandatory practice), guidelines (recommended practice, but not mandatory), and policies to develop a roadway facility that will be safe, address mobility concerns, accommodate the physical and social environment, and be financially feasible. Balancing these elements becomes a critical part of the design process and sometimes it may not be practical to strictly conform to existing guidelines or standards. To address potential conflicts, the roadway design may need to deviate from the prevailing guidelines and policies. The increased density of development and populations in built urban environments and the need for contextual designs to address community needs could result in a more frequent need for design exceptions or variances. An understanding of the impacts of such alternative designs on both the safety and the operational character of the roadway is essential.

In large cities, limited right-of-way, human and natural environmental issues, pedestrian and bicyclist accommodation, and aesthetic concerns often require a more contextual design to be used than in non-built environments. It is therefore often required to develop unique solutions that may not conform to existing guidelines and require the use of design exceptions or vari-

ances. The objective of this report is, therefore, to (1) understand why such departures from the guidelines may be needed or desired, (2) identify processes that successfully manage such design procedures, and (3) determine means that could assist designers to streamline this process and provide a timely procedure for addressing design exceptions or variances. These three objectives were addressed through a survey of design and variance procedures of both local transportation agencies for large cities, as well as state departments of transportation (DOTs).

A response rate of 69% (27 of 39) from both local agencies and state DOTs was achieved providing a wider-ranging geographic and population size cross-section perspective of design solutions from two distinctly different municipal entities. The outcome of this effort, further defined, attempted to offer state-of-the-practice information about proactively addressing design issues in a collaborative manner.

Local roads are the primary responsibility of municipal transportation and public works agencies for large urban centers and these agencies are often involved in all phases of the project development process. Most agencies reported the use of design standards (68%), whereas a few use design guidelines (21%) in roadway design. The use of guidelines appears to also provide a

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greater flexibility to agencies when design exceptions are considered, as was noted in the correlation of the frequency of design exception applications and design documents used. This may be a practice that agencies need to review to improve their design exception process and allow for greater flexibility if needed. It should also be noted here that even though the *Green Book (A Policy on Geometric Design of Highways and Streets)* provides flexibility for design, this flexibility may not be adequate when urban designs are considered, as was documented by the responses of several agencies.

There are a variety of constraints that may require design flexibility in a project and understanding their influence is critical in determining the reasons for variance from the typical design. The survey respondents identified right-of-way restrictions or limitations as the primary reason for considering flexibility. The need to accommodate pedestrians and bicyclists also ranked high in the reasons for design flexibility and thus underscore the potential influence that non-motorized users have on the design of urban streets. The limited right-of-way and the need to accommodate all users of the facility in urban areas may be the most critical aspects of roadway design and thus require significant flexibility and, often, innovative design. Additional reasons for design exceptions noted by the respondents included a mixture of design features, operational considerations, financial constraints, and safety considerations, all of which have a significant impact on developing a project solution, and may often require balancing to reach this solution. The answers conform to a priori expectations, because all are factors that have to be considered.

Design exceptions or variances are widely used by local transportation agencies of built urban environments. Of interest was that one-half of the respondents indicated that they consider design exceptions for a select type of projects, whereas the others noted that they consider them for all project types. The agencies noting that they consider design exceptions for select types of projects have their own design guidelines. This finding could support the assumption that these agencies feel comfortable with the existing flexibility in their design documents and do not see the need for design exception in any but a few project types. The 13 criteria provided by FHWA for use in design exceptions are adequate for most agencies. A few agencies noted the use of operational capacity and clear zone as addi-

tional criteria incorporated in their documentation process. Therefore, it appears that the existing criteria cover adequately the spectrum of needs for design exceptions, but the consideration of the other two (operational capacity and clear zone) may be added to the list to provide the flexibility needed to meet the needs of the built urban environment. The question regarding the level of flexibility of the criteria used as they compare to the values of the *Green Book* showed that all agencies but one believe that they are less strict or the same. This appears to indicate that the processes that are in place adequately address flexibility. It should also be noted that the *Green Book* provides such flexibility but case studies that showcase such contextual examples in built environments are needed.

Design exception requests in built urban environments are mostly within the transportation agency's staff supervision and responsibility even for agencies that rely on consultants to complete their design. Design exception applications are mostly submitted in the design phase of the project development process. This is probably a reasonable point in the project development process to address the need for flexibility and, therefore, there is no need for altering the practice. This approach will also provide a timely identification and resolution of possible problem areas and thus reduce any potential delays owing to the review of the application. The review of design exceptions is mostly completed by the agency's design team or group, even if it was prepared by agency staff. In such cases, local agencies noted that they have a separate design exception committee or that the documents are reviewed by the agency's legal office. The review time could also be related to the number of design exceptions that an agency typically completes within a year; however, there was no correlation between the number of design exceptions and review time.

One can assume that efforts to improve a process start with a review of current practices and the identification of areas that need to be addressed. However, most agencies responded that they have not conducted a review of their design exception process. This could be an indication of the lack of staff to complete this effort, not concern about the existing processes or the low number of design exception applications. The latter assumption was verified by two agencies that have not conducted a review because they have fewer than five design exceptions per year and short review time (three to six months). The responses provided did not allow for the identification

of a pattern regarding when an agency needs to conduct a review of its practices.

Several of the agencies noted that they are involved in a variety of efforts to improve their design process for timely resolution of potential issues. These efforts include the development of improved guidance, clarification of the controlling criteria, and training of personnel. These efforts could positively affect both timely preparation and review of design exception applications. Moreover, this variety of approaches indicates that each agency should determine what may be the most appropriate method to improve their design exception process. Among the comments received regarding lessons learned and efforts to improve, the most common theme was development of checklists and clarification of the ranges for the criteria to be used.

This report provides a review of the design exception or variance practices for transportation agencies in built urban environments. Even though a reasonable understanding of the state of practice as it exists could be gleaned from the findings of this study, there are additional topics of interest relative to this issue that can only be addressed by additional research. The size, type, context, and number of projects that an agency deals with may partially explain the great variability noted in the responses of the agencies. However, the comments received could also indicate that the variability may be the result of knowledge gaps or documents used. Therefore, topics recommended for future studies include an evaluation of costs and benefits from design exceptions, clarification of the impacts of design elements, exploration of the tort liability implications, and review of *Green Book* guidance for urban streets and roads.

This report attempts to identify the state of practice for both local and state transportation agencies' perspectives of built urban environments regarding their approaches to issues with design exceptions. In general, the findings show a varied approach and no significant issues with the current practice. Agencies need to conduct an internal review to determine whether there are issues with the timely completion and review of such applications and reconsider the documents they use in their roadway design. Because urban areas have different requirements than rural environments and each project has a unique context may require such varied approach in design exception practices and efforts to streamline it could be unique to each agency.

INTRODUCTION

Background

Every roadway design starts with the intent to provide a facility that will be safe, address mobility concerns, accommodate the physical and social environment, and be financially feasible. To achieve such a design, designers rely on design guidelines and policies. Sometimes, however, it may not be practical to conform to all of these guidelines. For example, it is possible that adherence to a certain geometric specification may create environmental implications, affect historical structures, be economically unfeasible, or affect a community in an undesirable way. As a result of the increased density of development and populations in built urban environments as well as the need to develop more contextual designs to address community concerns these conflicts may occur more often in urban environments. To address such issues, the roadway design may need to deviate from the prevailing guidelines and policies and thus processes to address this need to be established.

An understanding of the impacts of such alternative designs on both the safety and the operational character of the roadway is essential. The AASHTO publication, *A Policy on Geometric Design of Highways and Streets* (commonly referred to as the *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 (1). These guidelines (not standards) permit sufficient flexibility to encourage distinctive independent and appropriate designs for specific situations. However, there are two areas of concern regarding this flexibility. The first deals with the notion that the guidelines have been developed mainly for “idealized” design circumstances, typically without right-of-way, utility, historic, built urban form or other constraints that are frequently encountered in urban areas. The second deals with the degree of uncertainty that such flexibility can bring, because there is a lack of data that quantify potential trade-offs when evaluating design options. Even though the *Green Book* indicates that the referenced guidelines provide for a safe, comfortable, and aesthetically pleasing roadway, there is little information regarding the safety and operational consequences that may result from deviating from the recommended range of values.

An aspect that should also be noted is the need for closer cooperation from the outset of the project

among the various agencies as well as with the affected stakeholders and parties. Such interactions could identify potential areas where non-conforming designs will need to be addressed and develop solutions that are more appropriate and within the context of the project area. Central to this is the development of a purpose and need statement that is agreed on by all involved parties (agency representatives and stakeholders), where the goals of the project are clearly identified and provide the basis for developing a contextual design.

These issues are more apparent in large cities where following the *Green Book* guidelines is often not feasible. Limited right-of-way, human and natural environmental issues, pedestrian and bicyclist accommodation, and aesthetic concerns often require a more flexible design to be utilized. It is, therefore, often necessary to develop solutions that do not conform to current practices (based on the *Green Book*, other local guidelines, or standards) and require the use of design exceptions. Such processes often result in longer times for project completion and sometimes in higher costs. It is therefore important to understand why such departures from the values of existing practices may be needed, identify processes that successfully manage such design procedures, and determine means that could assist designers for projects in large cities to streamline this process and develop a timely procedure for addressing design exceptions or variances.

Report Objective

The objective of this report is to address these issues through a nationwide survey of both cities and state DOTs. This report addresses the following focus areas:

- Processes followed by agencies in developing and completing design exceptions, including responsibilities and documentation requirements;
- Magnitude of the issues to be addressed, such as frequency of revisions, number of applications, project delivery implications, and constraints requiring design exceptions;
- Level of required documentation dependent on contextual issues;
- Efforts for improving the process followed; and
- Documentation of successful and problematic design flexibility and variance requests.

The outcome of this study will provide transportation agencies with an understanding of the existing

processes and identify means for proactively addressing design issues in a collaborative manner between cities and DOTs to deliver the appropriately contextual project.

Report Organization

To complete this effort a two-phased approach was undertaken. The first phase involved a literature review and the development of a survey questionnaire to be used to solicit information on the state of the practice of design exceptions for built urban environments. In the second phase, the survey was administered to collect the required data to be used in the analysis to develop the report on best practices on design flexibility considerations for large cities. A 69% response rate (27 of 39) was obtained from surveying both local agencies and state DOTs. This report documents the findings of both perspectives.

This report begins with a literature review identifying major areas of concern and then presents the state of the practice regarding design exception in built urban environments as it was manifested through the survey. Case studies provide in-depth examples of these issues. The final chapter provides a summary of the report and suggests future study topics.

LITERATURE REVIEW

Introduction

Roadway projects in built urban environments often pose specific challenges to designers and planners. Such projects typically present a full range of geometric and traffic operational problems, coupled with increasingly restrictive environmental and right-of-way constraints. These projects may require the use of flexibility in design and variation from the traditionally used values or solutions. Among key issues typically faced by designers are:

- The reconstruction of older roads inevitably requires addressing outdated geometric design guidelines. For example, a road previously designed to 60 mph criteria may no longer meet current criteria for the same design speed.
- Many such projects are often driven by the need to expand road capacity or changes in traffic patterns. The addition of lanes or introduction of turning lanes to accommodate increased

forecasted traffic is often a key issue owing to right-of-way or community cohesion.

- Pedestrian and bicycle activity across or along the roadway. Such activity is particularly important for roadways with commuter or tourist and commercial destinations.
- Restrictive right-of-way often limits the ability to achieve the desired cross-section dimensions and elements. Even where right-of-way is available, context-sensitive issues such as existing trees, sidewalks, and building set-back lines become concerns to key stakeholders.
- On-street parking issues often require special attention.
- Large vehicles (heavy trucks and tour buses) are more often encountered in large cities and require special considerations in roadway design.
- Public involvement issues dealing with community vision and commercial interests often lead to differences in priorities between local and commuter traffic.
- Cost.

In summary, such projects typically require adjustments in the design aspects and impact the choices that affect cross-section elements. Several agencies dealing with urban roadways have developed typical cross sections, but they have not tied these to the vertical and horizontal alignment issues included in the *Green Book*. The literature review conducted for this report examined existing design policies and past research that dealt with design flexibility and exceptions attempting to relate them to the issues presented previously regarding roadway design in built urban environments.

Urban Design Guides

Project constraints and context-sensitive solutions that do not meet applicable design standards are often implemented through the use of the design exception process. The design exception process is discussed in further detail in the next section. Although design exceptions provide an avenue to implement non-standard design practices, they often can increase the work load and potentially impact the proposed solution. *NCHRP Synthesis 316* surveyed all state highway agencies and of the 46 agencies responding, all identified one or more specific problems in the process (2). These included lack of supporting documentation for the request, cost-intensive and cumbersome

resource requirements for the design exception, and inadequate guidance from the state transportation agencies (STAs) or FHWA in support of design exception requests. To streamline or eliminate the need for design exceptions, some agencies have developed independent design guidelines for urban areas to provide additional guidance and standards for meeting typical urban constraints.

The majority of urban street design guides are published by local or regional planning agencies. Examples of those identified by this preliminary literature review included:

- Metropolitan Council, St. Paul, Minnesota (3)
- City of San Diego, California (4)
- City of Stockton, California (5).

In addition to these local agencies, the Maryland State Highway Association has published the guide *When Main Street is a State Highway*, to address issues relating to the presence of high-volume highways at urban centers (6). A similar guide was developed by the Oregon DOT dealing with street design for state roads through urban areas (7). The ITE has also recently published *Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities*, which presents potential solutions to addressing the constrained environment of urban areas (8). In addition to constraints presented by the urban landscape, these guides often attempt to address the additional challenge of incorporating other modes of transportation as well as provide a space for residents to live and play. As such, urban street design guides often focus on additional elements other than those contained in traditional roadway design guides. Morrish et al. (9) focused on five design elements, primarily concentrating on the roadway cross section and the connections to the community and adjacent land uses. These elements include street and right-of-way issues, access and land use connections, and planning concerns for community connections (Figure 1). These issues are very similar to the problems identified earlier and demonstrate the difference in needs for urban environments when compared with rural areas. Moreover, the right-of-way constraints imposed by “immovable” objects (i.e., buildings) are typically the most fundamental difference in the roadway design between urban and rural areas.

These local and national guides and recommended practices have varied guidelines as well as multiple goals and objectives. The following list attempts to






	Curb to Curb	Defines basic movement parameters: number of lanes, lane width, modes served, and edge and median condition
	Right of Way	Defines the place between curb to curb space and adjoining property; establishes view shed parameters
	Access Management	Establishes frequency of access to property; speed related
	View Shed	Defines relationship between adjacent land uses and road users; varies with rate of speed
	Community Connections	Defines planning areas served by roadways.

Figure 1 Urban design elements (9).

summarize only some of the benefits associated with urban-specific street design:

- Reduce impervious street surface to improve water quality;
- Balance the needs of emergency vehicles with everyday traffic concerns;
- Promote an interconnected street network that includes pedestrian and bicycle access;
- Create a more attractive and safe pedestrian environment;
- Reduce peak energy demand through the incorporation of urban heat island reduction measures into the appropriate site and street design guidelines;
- Promote pedestrian- and transit-friendly design of city streets;
- Provide capacity and operational improvements to streets to minimize congestion and focus on persons and goods, not just vehicles;
- Create a more aesthetic environment for the community;
- Provide an integrated planning approach, one that gives equal consideration to land use and transportation throughout the planning process, which is preferable to independent planning;

- Encourage pedestrian and bicycle travel; and
- Reduce the potential for speeding.

Design Exceptions

Roadway projects where design element trade-offs are to be considered typically incorporate a full range of geometric and traffic operational problems, coupled with increasingly restrictive environmental constraints. These problems may require variation from the normally used guidance values or traditional solutions. However, one should keep in mind that every project is unique in terms of the geometric conditions, traffic, safety history, purpose and need, project context, community character, and public priorities. What is reasonable or may work in one location may not be appropriate in another for any number of technical or context-sensitive reasons. Some projects require adjustments in horizontal and vertical alignment, whereas others may require choices that affect cross-section elements and design speed. The literature review conducted for this synthesis examined these major categories and the findings are presented here as they may be applicable to design variances. The reader is encouraged to review *NCHRP Synthesis 299*, which presents an extensive

literature review on geometric design elements for improving safety and operations (10).

The *Green Book* provides guidance and control values for the design of new alignments or those undergoing major reconstruction that allow flexibility. For most control values, the *Green Book* indicates that the recommended ranges provide a safe, comfortable, and aesthetically pleasing roadway. However, there are cases where additional flexibility is necessary and therefore the design exception or variance process is available. This allows other design values to be considered for a specific element to provide a proper fit to the situation. The exception process allows for adjusting almost all elements of geometric design and, as determined by the project, may require both state and federal approval. It should be pointed out that there is little research that quantifies such decisions and their impact on safety (2,11). The use of design exceptions can frequently be avoided by varying other parameters of the project (e.g., design speed) that may affect the specific design element. For example, the use of a lower design speed allows for the use of shorter stopping sight distances and thus the length of required vertical curves could be reduced.

The concept of guidelines was emphasized even more in *Flexibility in Highway Design* (12), a recent publication by the U.S.DOT and is even further stressed in the *AASHTO Guide for Achieving Flexibility in Highway Design* (13). These publications attempt to reinforce the concept of design flexibility and to deemphasize the approach of using the maximum or highest values in the *Green Book* regardless of project characteristics and context. This previous approach typically leads to roadways with less emphasis on the design's impact on human and natural environments and increases the possibility of creating wide swaths of pavement cutting through communities and natural resources. This approach has typically been justified by arguing that it results in a design with increased safety; however, this has not been always quantified. A critical review of design guidelines by Hauer (14) stated that several design guidelines are based on empirical data from several decades ago, but some have not been validated through research. Also, research demonstrated that other design values lower than those suggested in the *Green Book* work well to achieve flexibility in design while balancing the concerns of safety and capacity.

As noted earlier, a design exception process has been in place for several years, initiated by FHWA

for roadway projects that could not meet the current design criteria (15). This policy identified 13 elements that could be considered for a design exception: design speed, lane width, shoulder width, bridge width, structural capacity, horizontal alignment, vertical alignment, grade, stopping sight distance, cross slope, superelevation, vertical clearance, and horizontal clearance (other than clear zone).

Design exceptions are becoming more common in roadway design and have been increasing in frequency in several states to address designs that do not meet typical design values. Little research has been conducted to date to understand the implications of design exceptions on either the safety or the operational performance of a project. A design exception is the course of action by which a designer can introduce a design value other than what would have been typically used for the specific roadway and it is often in contrast to the traditionally used range of values for that geometric element (2). This process makes it possible for roadways to be constructed or reconstructed in areas that may not allow for the full use of or typical design values. Frequently, 3R (resurfacing, restoration, and rehabilitation) projects may require the reconstruction of sections that were designed several years ago with design values that were valid then but not now. In these cases, upgrading the entire roadway to current values may be extremely difficult or not economically feasible. However, the consideration of improving roadway geometry is often required to address safety, capacity, environmental, or community issues. Therefore, such projects with any of these limitations often require designers to seek a design exception (16). Common design exceptions required in redesign of existing highways typically deal with reduced available right-of-way, requiring adjustments to cross-section elements and modification of the design speed (16). The most frequent design elements utilizing design exceptions are horizontal alignment (changes in the radius of the curve), shoulder widths, stopping sight distance, lane width, and design speed (2).

Design exceptions are necessary when desired design values cannot be achieved in a project. According to the survey conducted for *NCHRP Synthesis 316* (2), transportation agencies in 24 states indicated that they have more strict guidelines for design than those provided in the *Green Book*. In these states, design exceptions are required to move the project forward when the lower-end values are not achievable. The same survey also indicated that a small number of

STAs (20%) predict an increase in design exceptions because of demanding regulations and context-sensitive design issues (2).

Design exceptions have been viewed as a potential legal liability to designers and STAs. Excluding six states, sovereign immunity has been eliminated across the nation and tort laws have been enacted, leaving designers in the situation of being legally responsible for designs they create (17). Highway design has been considered a discretionary function and deviation from design guidelines does not necessarily constitute negligence; however, there is always the potential that jurors may interpret that departure from design guidelines as such. An important concept in utilizing design exceptions is to ensure that documentation of all decisions exists to assist the highway agency in lawsuit cases.

Design Factors

The *Green Book* lacks background information sufficient for understanding the safety and operational implications of combinations of critical geometric features. It should be noted that *A Guide for Achieving Flexibility in Highway Design* provides some information on these areas but also lacks any quantifiable relationships for the values of various design elements (13). Another *Green Book* topic requiring additional background information for designers centers on the relative importance of various geometric elements on safety. It is apparent that not all geometric elements have the same impact on safety and operational effectiveness, and the selected design value can affect additional elements. For example, the choice of a design speed of 45 mph or less for a road allows the designer to use a smaller minimum curve radius, a narrower clear zone, a shorter vertical curve, and shorter sight distances than a higher design speed. In this case, the impact is significantly greater than when selecting a single design element to be adjusted. Moreover, roadway elements can exert varying degrees of influence even through a single element. For example, lane width will exert an impact on a two-lane roadway different from that exerted on a four-lane roadway. Therefore, a priority list is needed to identify the relative significance of each geometric element. Given the current definition of the design speed, it appears that it is probably the most important design element to be selected, because it has the potential to affect the values used for almost all other design elements (1,13).

As noted previously, design speed is probably the most important element of roadway design, because it affects almost every roadway aspect. Most studies dealing with safety and speeds typically consider speed limit and thus little is known about the influence of design speeds on safety. It could be assumed that there are some relationships between design speeds and speed limits; however, because of the methods used to establish speed limits in many states, it is not feasible to develop a systematic relationship. Current design approaches for highway design emphasize speed as a surrogate for quality and efficiency. This approach could be viewed as reasonable for rural areas where high speeds are frequently desirable, but not for roads in built urban environments.

An issue that has recently received additional attention is the impact of design speed on creating a consistent driving environment and thus affecting operating speeds. To reduce such inconsistencies between design and operating speed, the use of operating speed as a supplement to the design speed has been discussed (18). A recently completed NCHRP study attempted to document relationships among *design*, *operating*, and *posted* speeds and to propose recommended changes for their use in design (19). The research concluded that design speed had no significant influence on operating speeds, and that there was no definable relationship between the two. The study also noted that one-third of the 40 states that responded to the mail-out survey have used the expected operating speed to select the design speed, and that approximately one-half have used the anticipated posted speed. An important finding was the negligible impact on operational speeds of the presence of curb and gutter in built-up areas. This finding could be of significance here, because curb and gutter design has been used in addressing right-of-way constraints in built urban environments.

The need to re-evaluate the use of design speed as suggested in the *Green Book* has also been argued and European practices can be used as models (20). The differences between design and operating speeds were also discussed in *Special Report 214: Designing Safer Roads*, where procedures for addressing this problem were discussed (21). Disparities between speeds create some of the problems in design consistency and are central to resolving that issue. A recent report that examined the relationship between operating and design speeds for urban areas concluded that the use of operating speeds as a controlling design speed produces more consistent designs (22).

Design Goals

An issue relative to operating and design speeds is the underlying concept of *mobility*; local and non-local drivers tend to conceive this term differently. It is reasonable to assume that non-local drivers define mobility as higher speeds that reduce travel times. On the other hand, local drivers may consider high speeds detrimental to the community as well as a safety issue. Traditional design practices aim to provide “as high a design speed as is practical” and equate such a choice as “surrogate for design quality” (13). The basic premise for such designs is the desire to reduce travel times and these designs are often viewed as the “best or safest possible approach” (13). A report that examined geometric design practices in European countries revealed that part of the general philosophy for highway design and project development is to tolerate higher congestion and slower speeds to achieve safety goals (23). Design solutions that reduce motor vehicle speeds or reduce the space available to vehicles may increase trip times, a consequence often viewed as appropriate by European agencies. They consider design solutions that promote higher travel speeds as contributory to more severe crashes and, indeed, as detrimental to roadway safety. Therefore, developing roadway designs that could balance these two issues may require the use of trade-offs in the perceived values of various design elements.

The idea that wider and more lanes improve mobility is also a concept that should be revisited. The desirable level-of-service values suggested in the *Green Book* should be viewed as starting points and not as absolute values to be achieved at the expense of other concerns. It is reasonable to assume that striving to achieve a certain level-of-service often requires more lanes than may be needed if a roadway was designed in a manner that enforces lower operating speeds. An additional benefit of lower speeds is the potential reduction in the severity level for crashes, as is the case for roundabouts (24,25). In the United States, the concept of mobility is often understood as providing roadways that will assist motorists in driving as quickly as possible through an area. However, this approach may be contrary to the desires of community or may be in conflict with environmental concerns owing to a wider roadway footprint. It is possible for example that a four-lane design may achieve the desired level-of-service letter grade but with a higher expected operating speed. A two-lane alter-

native design may result in a lower level-of-service grade but with a lower operating speed. In this example, if the objective is to impact operating speeds, the reduced level-of-service should be secondary. Proper evaluation of such alternatives is essential in determining the appropriate design and demonstrates the trade-offs that need to be considered.

To find the most appropriate solution to mobility problems in a project area, it is a necessity to examine a wide range of design choices that consider all relative issues to address the specifics of the project. Design choices should first be developed on a conceptual scale and include all reasonable capital, policy, program, management, and modal alternative solutions to the mobility problem(s). To properly examine the full range of design choices, the project team must identify and consider all natural, human, and cultural resources within the project area. This will allow for an understanding of the context and the issues to be addressed and provide for developing a contextual solution. At the same time, several alternative designs must be developed and evaluated while developing the design options. This will allow for addressing and capturing all issues as they may relate to the project. Stakeholders and citizens advisory committees could be solicited to assist in the development and evaluation of design options to produce a solution that satisfies the community needs and desires. Although it is not expected that the stakeholders and public will begin to draw lines on paper or provide detailed designs, it is crucial to understand community preferences. This will assist the designer when faced with trade-offs and choices within the design constraints. Understanding these preferences is the key in delivering a solution truly sensitive to its context and community.

Safety Trade-Offs

A number of studies have examined cross-section elements and attempted to develop models or relationships that could estimate safety implications from varying individual components. The findings of *NCHRP Report 330* indicated that the overall safety of urban arterials typically improves after the implementation of strategies that involve the use of narrower lanes (26). It should be noted that most of these strategies involved projects with restricted rights-of-way and arterials with speeds of 45 mph or less. The study also concluded that even though the use of narrower lanes, when considered alone, may

increase specific crash types (such as sideswipes), the presence of other design features, such as the addition of two-way left-turn lanes, may offset these increases and produce an overall improved safety. This study also underscores the potential of interactive effects between various design elements and suggests careful evaluation of the use of narrower than typically used lanes.

A more recent review of the safety in geometric design standards by Hauer (14) critically examined the belief that adherence to design standards is directly linked to safe roadways. This review indicated that design guidelines have an inherent safety level; however, little is known about the impacts of using flexibility in applying them in roadway design. Another issue that was identified by Hauer was the notion that there are two different kinds of safety. One could be called nominal safety and is measured “in reference to compliance with standards, warrants, guidelines, and sanctioned design procedures” (14). Substantive safety is another kind based on the roadway’s actual safety performance—that is, crash frequency and severity. Designing nominally safe roads does not ensure a substantive safe roadway as well, because adherence to values of each guideline does not necessarily produce a safe design. Several of the studies examined here focused on developing models that investigate and quantify the substantive safety changes from altering design dimensions (27). Another aspect of safety that was noted by Fambro et al. (28) is the concept that safety is a continuum and not a single yes or no decision. This implies that a change in the value chosen for a particular design element “can be expected to produce an incremental, not absolute change in crash frequency and severity” (28). However, it is necessary to better understand the effect of these incremental changes on safety levels. Such efforts are essential in understanding and quantifying the substantive safety of a roadway. This is more critical for projects where design flexibility is considered. Stakeholders do not easily accept designs that are considered nominally safe, but require the evaluation of design alternatives which may deviate from the nominal designs.

An additional concept that merits attention is that of the presence of a tipping point, which is the principle that small changes have little or no effect on a system until a crucial point is reached (29). This concept, which has been extensively used in epidemiological research, could also be used in roadway design because of the available flexibility in the

values of design elements. It could be hypothesized that safety and operational consequences from altering the values of design elements while remaining within the suggested *Green Book* values are minimal and thus do not create significant problems. Moreover, small departures from these values may have no significant impact until they reach a critical point where safety will be significantly affected. Therefore, this safety consequence tipping point for any single design value may not be detectable. Highway design typically requires a multiple-level assurance by professional engineers that the approved design will not result in unacceptable levels of safety consequence. Projects requiring a design exception could be considered as those that are the furthest from the most desirable design value. NCHRP Project 15-22 noted that the small deviations reported in the case studies analyzed indicated that in general a conservative approach is taken when considering values that vary from traditional design (30).

A recently completed guide on design exception mitigation strategies provides a review of the areas where such variance can be applied and identifies means that could be used as solutions to address design exceptions and variances (31). It should be noted that the report focuses on rural areas, but there are some concepts that could be used in built-up areas as well. For example, varying cross-section elements to manage speeds when design speed is considered as a varying element can be used both in urban and rural environments. An issue that is also discussed is the lack of documentation of known effectiveness of several of the proposed mitigation measures and the need for developing means and measures to address this issue.

Significant research efforts have been devoted to the development of the *Highway Safety Manual* that will be able to quantify the effects of such design element trade-offs (32). This document will provide needed guidance on the safety implications from selecting specific values for various design elements and allow designers to better understand what the implications from their design choices are. The manual will provide estimates of the number of crashes per year for various roadway facilities based on functional classification. Urban arterials are among the facilities to be included in the manual.

It is apparent that a designer will often need to weigh different alternatives and determine the most appropriate solution for the project while considering all requirements. This could require balancing of

safety needs with mobility, community desires, environmental constraints, and fiscal considerations. There is very little guidance on how to balance these elements and select an appropriate solution. That each project is unique and has specific demands on developing the final solution creates additional complexity on this issue. Weighted score techniques and priority goal evaluations are techniques that could be used in resolving such conflicts.

Summary

The literature review identified a few design guides used by various local agencies for addressing typical environments in urban areas. However, these guides address only one aspect of roadway design (cross-section dimensions) without considering the remaining contributing design elements such as vertical and horizontal alignment and design speed. Conversely, the *Green Book* addresses these issues but does not fully consider the implications and constraints that urban environments pose on the designs proposed. Therefore, a balance between these two approaches is needed.

A number of constraints for urban environments were identified at the beginning of this section that could pose problems for roadway designers. The existing flexibility in the design guides allows for addressing these constraints, but often there is a need for design exceptions to be considered and included in the process. Even though this approach is not desirable because it has the potential to increase the time and cost of the project, it may be necessary in order to develop an appropriate design. The literature review identified areas where this process can be used and allow for more appropriate designs. However, very little work has been completed that attempts to quantify the relationships between safety and design variances. Most of the work completed has focused on two-lane rural roads and rural environments in general. Even though some of the experience is applicable in urban environments, there is inadequate information regarding any association between typical and other than typical design values for urban constrained environments.

SURVEY

Procedures

In addition to the review of the literature and current design documents, a survey was conducted to collect information on the current practices of de-

sign exceptions in built urban environments (see Appendix A for survey; web-only: http://trb.org/news/blurb_detail.asp?id=10263).

The results of the survey could identify where the industry stands in regard to this issue and then could be used in identifying areas of success as well as areas where additional attention is needed. Therefore, the results of this survey form the foundation for any suggested practice changes and identification of future areas of study.

The survey was designed to identify the current practices of large city transportation agencies (such as departments of public works and engineering) and state DOTs regarding flexible design practices and the potential use of design exceptions in their areas. Each potential candidate was contacted by telephone to verify willingness to complete the survey and for the accuracy of e-mail contact information. The intention was to report the answers from two perspectives to help determine in their responses how proactively addressing design issues in a collaborative manner could result in improving the design exception process for the local agencies and deliver an appropriately contextual project.

The survey format was created as an online web application with the ability to collect and report all responses. The survey participants were sent an e-mail invitation identifying the scope of the survey and providing the web address for the survey completion. The survey was launched in March 2008 and a three-week time period was given to respond. To increase the number of responses, e-mail reminders were sent to those who had not completed the survey a week before the deadline. A second e-mail was sent after the deadline to those who had not completed the survey as a reminder with an extension to increase the number of respondents. The survey instrument is presented in Appendix A and the survey results are included in Appendix B (web-only: http://trb.org/news/blurb_detail.asp?id=10263).

The survey was structured in a way that provided information regarding (1) an overview of the agency's responsibility, (2) the need for design variances, (3) the design exception process and required documentation, (4) the agency's efforts to improve the process, and (5) identification of potential case studies. The results of the survey are presented organized in these areas.

A total of 39 agencies were identified and survey requests were e-mailed to all potential respondents.

Eighteen surveys from local agencies were returned and nine responses were received from large cities' DOTs yielding a response rate of 69%. Big city locations and agencies completing the survey are listed in Table 1, a full list of respondents is provided in Appendix C (web-only: http://trb.org/news/blurb_detail.asp?id=10263).

These agencies represent a reasonable geographic representation, as well as a mix of large- and medium-size urban centers, thus creating an illustrative sample of responses. Most local agency responses came from their departments of public works. State DOTs that responded are noted.

It should be noted that in the following sections the terms “local” or “city” agency refer only to these agencies, and their responses are examined separately from those of the state DOTs. The study sought similarities and differences in the practices between local agencies and state DOTs and the cases where these practices varied are presented. The emphasis was on the implication of design exceptions for the local agencies and thus greater emphasis was placed in the responses of these agencies for their use in understanding proactive approaches in a collaborative manner.

Survey Results

Agency Responsibility Overview

This section examines the areas of responsibility for the agencies regarding roadway design, construction, maintenance, and/or operations (see Appendix B for survey results). The objective of this section is to identify the extent of responsibility and involvement in the project development process, as well as the guidance and manuals used in the design process.

As anticipated, for most city agencies the primary responsibility lies with local roads and the agency is almost equally involved in all aspects of the project development phase (Figure 2). All responding agencies appear to be involved in the design phase of local roads indicating a significant involvement for such projects. A few agencies are involved in various aspects of the project development process for roads in the National Highway System and all are equally involved in all phases defined. A larger number of agencies are involved in state road projects and these agencies are mostly involved in the design and construction phases. Only one local agency noted that it is responsible for interstate projects and is equally involved in all project phases, which was the

Table 1 List of cities and agencies responding

State	City	Local Transportation Agency	State DOT
AZ	Phoenix	Engineering and Architectural Services Department and City Manager's Office	Roadway Engineering
CO	Denver	Department of Public Works	
DC	Washington	District Department of Transportation	DC DOT
FL	Jacksonville	Department of Public Works Division of Engineering and Construction Management	
FL	Miami	Department of Public Works	
GA	Atlanta	Public Works/Office of Transportation	Office of Urban Design
HI	Honolulu	Department of Transportation Services	Design Branch
MA	Boston	Boston Transportation Department	
MO	Kansas City	Department of Public Works	Design Division
NE	Omaha	Department of Public Works	Roadway Design Division, Department of Roads
OH	Columbus	Public Services/Transportation Division	Office of Roadway Engineering Services
OH	Cleveland	Department of Public Service	Office of Roadway Engineering Services
TX	Dallas	Department of Public Works and Transportation	
TX	Houston	Department of Public Works and Engineering	
VA	Virginia Beach	Department of Public Works	Location and Design Division
WA	Seattle	Department of Transportation—Division of Street Design and Office of the Director	Design Office

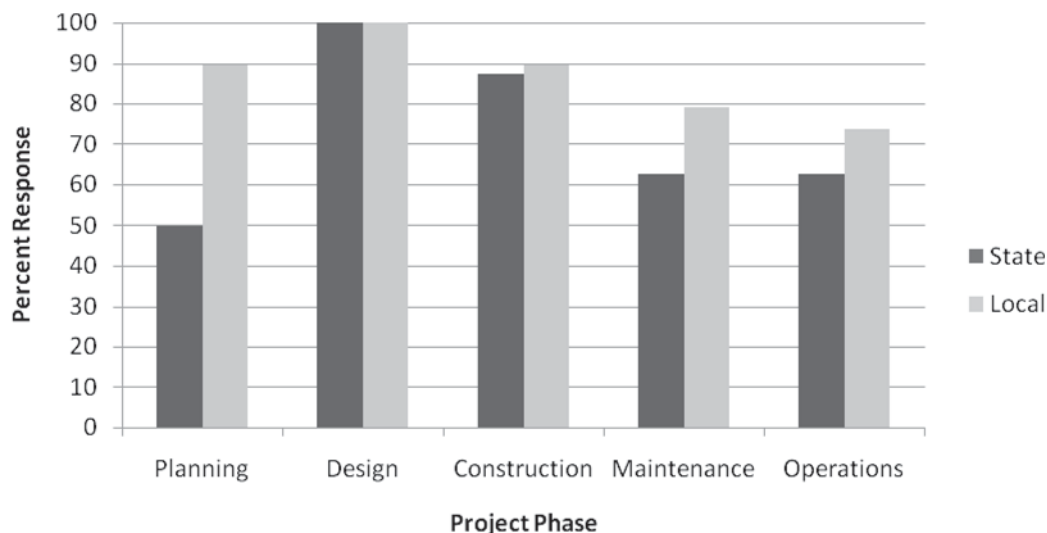


Figure 2 Level of responsibility by project phase and road class.

Washington D.C. DOT. Of the state DOTs responding only one, the Arizona DOT, noted that it was involved in the planning, design, and construction of local roadways.

City agencies are mainly dependent on consultants to complete their designs managed mainly by the agency (16 of those 17 responding). The remaining respondents indicated that design is completed either by the city agency or state DOT personnel. For designing roads, most responding agencies use design standards, whereas a few use design guidelines. It should be noted here that there is a difference between standards (mandatory practice) and guidelines (recommended practice but not mandatory) as they are applied in design and probably reflect the level of flexibility that agencies are inherently allowed. The remaining local agencies reported the use of a combination of other guidelines and standards without specifying the extent of each. In contrast, most of the responding state DOTs use design standards and fewer use design guidelines when designing urban roadways.

Most city agencies have developed their own design documents for urban streets that are based primarily on the *Green Book* and fewer other research and/or guidelines. Two agencies noted that they use the *Green Book*, and one indicated the use of the American Public Works Association (APWA) Specifications and Criteria. The majority of state DOT respondents noted that they use both state DOT and local agency guidelines or develop independent designs to fit the situation. Of interest here is also the

response to the question regarding the perceived level of flexibility provided with the design documents used by the agency. Most city agencies noted that there is enough flexibility within the document that will not require the agency to request a design exception. Moreover, a closer examination of those who responded as lacking flexibility had identified mainly the *Green Book* as their design guidance. These answers indicate that city agencies that have developed their own design guidance have considered the need for providing flexibility in design and thus allowed for in their documents, whereas those that use guidance from others (*Green Book* or APWA Specifications and Criteria) believe that there is little flexibility built into these documents. Of interest are the responses of the state DOTs where half noted that they use a combination of state and local guidelines and those are the state DOTs that work with local agencies that have developed their own design guidelines.

It was identified that city agencies dealing only with local street systems were more inclined to maintain their own guidelines or standards. Of the respondents who are responsible only for local roads, two did not have agency standards. However, of those agencies that participated in the planning, design, construction, maintenance, and/or operation of portions of the state, national highway, or Interstate system, almost half used the *Green Book*, state agency, or other standards. This may indicate that local agencies dealing with other agencies more often defer to those standards, whereas local agencies can adopt or

develop standards to better fit the needs of the local street system.

A review of various agency guidelines also indicated a wide breadth of information contained within the guidelines as well as the manner in which it was presented. The majority of design documents reviewed contained engineering details and specifications. However, geometric design details such as horizontal and vertical alignment, right-of-way widths, etc., were frequently absent. One agency, which identified itself as being involved in both local and state highway works, maintained comprehensive standard drawings; however, design limits were established in the local planning and zoning code. This could be indicative, however, of local policies driving local streets through subdivision and zoning review, whereas state roadways are handled by state agency criteria as noted previously. Based on survey responses, it was noted that the city of Virginia Beach, Virginia, which is only involved in local street systems, has a set of standards and guidelines approaching the breadth and depth as that of Washington, D.C., which designs and operates all roadways within their jurisdiction. Therefore, no discernible pattern was identified in the depth and breadth of the agency guidelines based on the roadways for which they have responsibility. Excerpts from select design guidelines and standards of responding agencies are provided in Appendix D (web-only: http://trb.org/news/blurb_detail.asp?id=10263).

Need for Design Variance

This section of the survey identified the design practices used by the agencies and the extent of innovation applied in designs. It focuses on determining where design exceptions are most often used and why, as well as identifying the most frequent design elements used in these exceptions. This will provide an understanding of the areas where possibly greater emphasis is needed in determining the levels of flexibility required as well as identifying areas of additional study to improve these practices. For the questions where an opinion was sought, a composite score was developed that allowed for determining the relative importance of the various choices. Respondents were asked to identify items based on their frequency of use and this guided the scores. A score of 3 was assigned for answering “Always,” 2 for “Frequently,” 1 for “Occasionally,” and 0 for “Never.” These composite scores were used to rank the various items and determine their relative importance.

The first focal area is the identification of the typical constraints within a project that could require flexibility (Figure 3). The responses indicated that the most frequent constraint (based on the composite score) was that of the right-of-way, followed closely by needs to accommodate pedestrians and bicyclists. One can also assume that often the need to accommodate pedestrian and bicycle needs and facilities may be related to right-of-way issues and thus this constraint becomes a very critical issue, especially

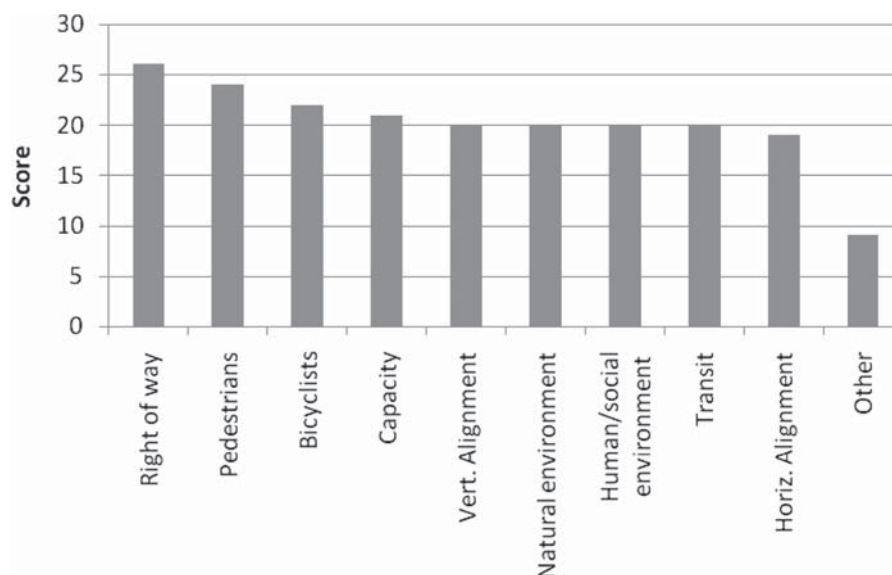


Figure 3 Scores for typical constraints.

for large urban areas. The data in Figure 3 indicate that most of the remaining constraints had close composite scores (all ranging between 21 and 19), indicating that these are the most frequent constraints that the agencies have to deal with and all are somewhat equally important when there is a need for flexibility to be considered.

Of interest is the comparison of local agency responses to those of the state DOTs. State DOT respondents only once identified a constraint as “Always” requiring a design exception, whereas six of the agency personnel observed a constraint as being frequent. This may be indicative of the increased constraints that must be dealt with by the agencies of built urban environments.

The reasons that may require design flexibility were also identified to allow for an understanding of the rationale for considering such an approach (Figure 4). Accommodations of pedestrians was the reason with the highest score (25 points) followed closely by cost (24 points). There were four reasons tied for the third position (22 points); safety, operational, right-of-way impacts, and bicycle accommodation. These reasons represent a mixture of design features, all of which have a significant impact in developing a project solution and may often require balancing to reach this solution. Therefore, it is reasonable to assume that all of these factors will be those with the highest scores: a point that was validated by the responses obtained.

The final element of this section dealt with the identification of the design elements that are most

frequently used when design flexibility is sought (Figure 5). The most frequent element is the lane width followed by grade and shoulder width. The presence of lane and shoulder width as the most frequent design elements is consistent with the previous answers where the right-of-way restrictions were the most frequent constraint. Moreover, the need for pedestrian accommodations as well as space for bicycles may be reflected in the need to consider flexibility for both lane and shoulder widths. The presence of the grade in the top three elements is somewhat surprising, given that agencies that have a hilly terrain within their jurisdiction did not score this highly. Most of the remaining design elements had similar scores and all were very close.

Design Exception Process

This section of the survey focused on identifying the design exception process followed by the agency, the required documentation for completing the process, and the means for addressing potential conflicts. The results from this section will allow for determining the amount of work required by the agency to complete the process and determine potential areas for improvement. The methods used for resolving conflicts will provide an insight on how the agency deals with potential problem areas and potentially identify efforts to avoid such conflicts.

All respondents that completed this section of the survey indicated that their agencies consider design exceptions when project elements do not conform to

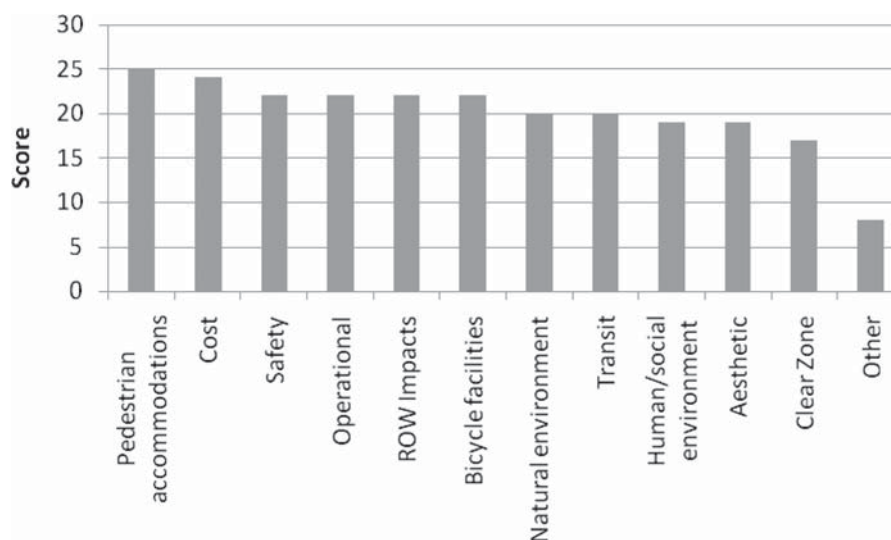


Figure 4 Scores for reasons requiring design flexibility.

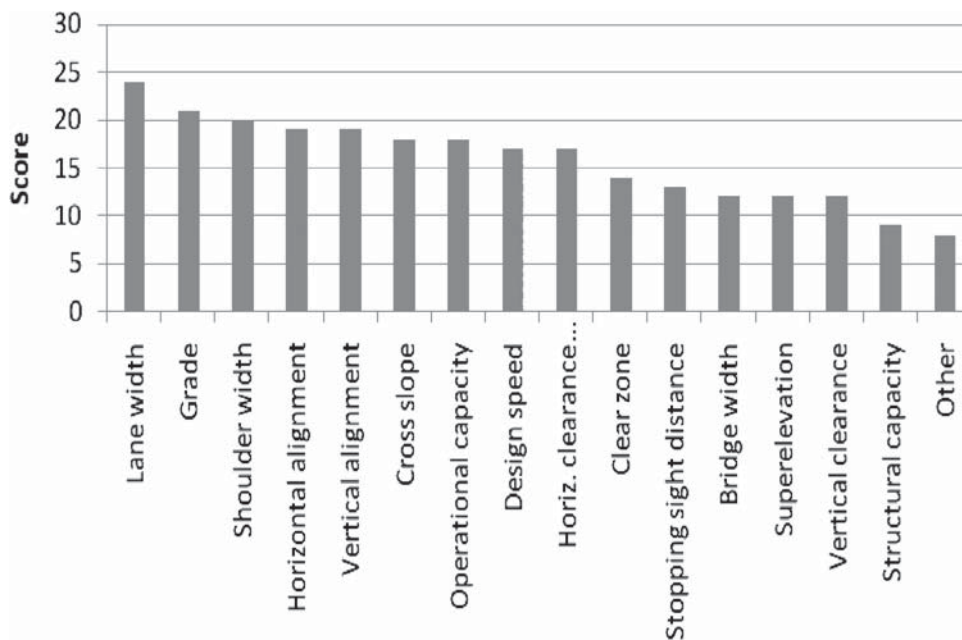


Figure 5 Scores for design elements requiring flexibility.

the applicable design guidelines/standards. This indicates that the design exception practice is widely considered and, by extension, used by various agencies. However, one-half of the respondents indicated that they consider design exceptions for all projects, whereas the others reported that there is a selection process on the types of projects where the design exception is used. This underscores the presence of institutional differences throughout the country on how policies and practices are applied.

The local agencies that noted that they do not apply design exceptions to all projects were queried to identify the types of projects that they do not consider design exceptions (Figure 6). All do not consider design exceptions for the following project types listed in the survey: intersection improvements, modifying design elements to address pedestrian issues, altering or lowering design speed, using traffic calming devices, and for preventive maintenance, and many do not consider modifying design elements to

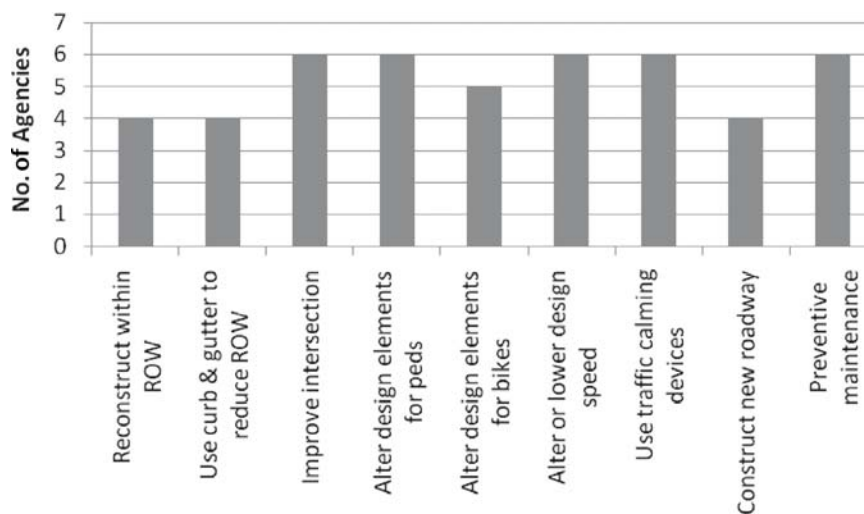


Figure 6 Number of agencies not considering design exceptions by project type.

address bicyclist access. Two agencies noted that they do not consider design exceptions for right-of-way restrictions and new roadway construction. Most local agencies that do not consider design exceptions for all project types have their own design guidelines. This finding could support the assumption that these agencies feel comfortable with the existing flexibility in their design documents and do not see the need for design exception in any but a few project types.

One-half of the agencies noted that they use only the 13 criteria provided by FHWA in their design exceptions. Of these agencies that used additional criteria for design exceptions, all identified operational capacity as a factor and five of the six identified clear zone. This indicates that the existing criteria cover adequately the spectrum of needs for design exceptions, but the consideration of the other two (operational capacity and clear zone) may be added in the list to provide the flexibility needed to these agencies. The question regarding the level of flexibility of the criteria as they compare with the values of the *Green Book* showed that most agencies believe that they are less strict or the same. This indicates that the processes that are in place adequately address flexibility.

The respondents were equally divided on the issue of how design exceptions are prepared. One-third noted that they are prepared by the local agency staff responsible for the design, another one-third indicated that agency staff supervising the design is responsible, and the remaining one-third noted that the consulting firm responsible for the design prepares

these documents. For most city agencies design exceptions are submitted in the design phase of the project development process, whereas the others submit them during the planning of the project. The project type and size will probably have an impact on the time required for the completion of the documentation of the design exception. However, the largest number of agencies estimate that the required time varies between one and two months, whereas one-fourth noted a short time for preparation (less than one month). An equal number of respondents noted longer periods (2 to 6 months and for more than 6 months).

There is a need for data to be collected by the agency when considering a design exception. The respondents were asked to identify the frequency with which they collect and use various data types for their design exception process (Figure 7). The results show that the most frequently used information are traffic volumes (score of 27) followed by cost estimates (score of 23) and prior examples (score of 20). The presence of traffic volumes and cost estimates as the most frequently used data items is not surprising, because both are integral to the project design. The use of prior examples appears surprising but may be indicative of the desire of the agencies to build a library of cases that could be used to justify future design exceptions.

The review process of design exceptions was also evaluated and indicated that for most agencies the review is completed in-house by the agency's design team or group. Four agencies noted that they also have a separate design exception committee and two

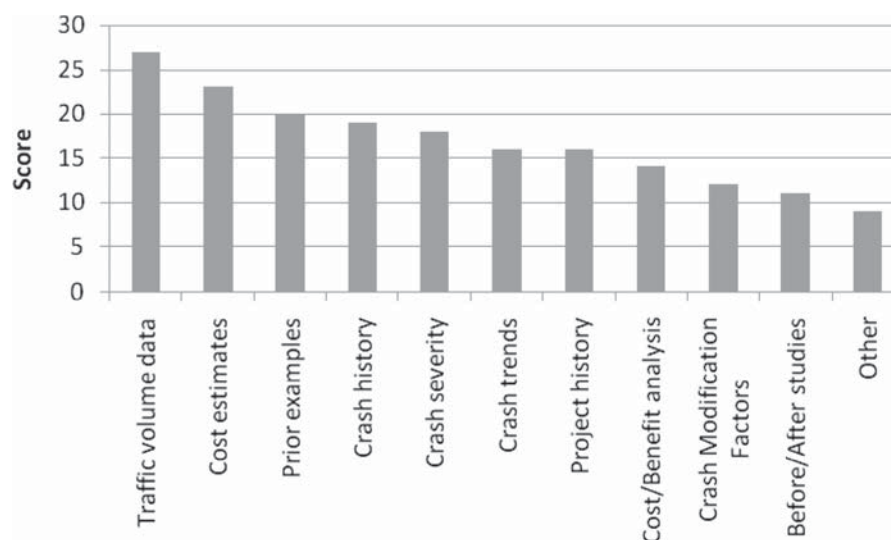


Figure 7 Scores for data used in design exceptions by agencies.

have only this as a review. The others use either the agency's legal office or the design team or group to review the exception. Among those agencies that conduct an in-house review, most rely exclusively on the agency's design team or group to complete the review. Those agencies that have a review conducted by their DOT use the DOT's design exception committee or the DOT's design team or group. Finally, one agency consults with its planning department and submits it to the city council for a resolution.

For one-half of the local agencies the review time is relatively short (under three months), whereas for another one-third the review is between three and six months. Of interest here is that the local agency that noted a long time for reviews (more than nine months) has reviews conducted by their DOT, whereas the other agency with a relatively long time for reviews (six to nine months) has an in-house process. It appears that an in-house process could result in short review times and longer if the review is conducted by other agencies, such as the state DOT. In contrast, all state DOT respondents indicated that review time is less than two months, with most indicating less than one month. This is reflective of the concept that design exceptions completed by a state DOT are reviewed internally and thus short times can be achieved with such internal reviews.

The review time could also be related to the number of design exceptions that a local agency typically completes within a year. One-half of the local agencies complete fewer than 5 design exceptions per year, whereas an equal number of the remaining agencies complete 11 to 20, 21 to 50, and more than 50 design exceptions per year. There appeared to be no correlation between the number of design exceptions and review time, with the only notable observation that the agency with the longest review time was also one of the two with more than 50 design exceptions per year.

The approval rate of design exceptions and the means to address non-approved design exceptions is also of interest to determine the level of rework that may be required by an agency. One-fourth of the agencies have an approval rate of more than 75%, whereas an equal percent of agencies has a very low approval rate (fewer than 25%). One-third of the remaining agencies have an approval rate between 51% and 75%. When design exceptions are not approved, most agencies redesign the project. One-fourth of the agencies negotiate a solution for the project and one agency resubmits the application (assuming the issues

are corrected). An examination of the approval rate and means to address non-approvals did not produce any notable relationships. For example, those agencies that negotiate a solution have varied percentages of approval (0% to 25% and 51% to 75%). The only notable trend was that those agencies that have fewer than five design exceptions per year were those that negotiate a solution when approval is not granted and the review was conducted in-house by the agency's design team.

Efforts to Improve

This section of the survey focused on identifying the efforts that a local agency has initiated to address potential issues with design exceptions as well as document any lessons learned from the practices applied. This will allow for determining those efforts that are notable and could be used by other agencies in improving their design exception process. This section also defines the perceived implications from design exceptions as documented by the respondents.

Although many local agencies review projects (as will be discussed later), most have not conducted a review of their design exception process. This is not surprising, because this is an additional activity that the agency needs to undertake and probably sees no benefit in completing. Among the agencies that have conducted a review of their processes, there are those that have fewer than five design exceptions per year and have no significant review time (three to six months) and one that has reasonable approval rate (51%–75%), whereas another has a low approval rate (under 25%). One agency that has more than 50 design exceptions per year has also completed a review of its design exceptions, whereas the other has not. Given these observations, there is no discernable pattern for when an agency needs to conduct such a review and what may be the elements that could trigger such a review.

The effect that design exceptions have on various aspects of the project delivery was also evaluated. It should be noted however that this is a subjective opinion rating and there was no effort to quantify the responses. Less than half of the agencies responding noted that the project delivery time was increased, whereas others reported that it remained the same or that it decreased. With regard to project costs, most agencies reported that they decreased, whereas others noted that they increased, and the remaining respondents stated that they remained the same. On the issue

of potential liability, most agencies believe that liability increased, whereas the rest believe that it remained the same. It may be that the agencies that have conducted a review of their design practices may have quantified these aspects and therefore an effort was undertaken to review these opinions for the agencies that had conducted such a review. There was no discernable pattern in responses among those agencies having conducted a review, indicating the subjectivity in the correlation of their responses. The only consistent trend was that a majority of responding agencies noted that project costs decreased.

Another aspect of design exceptions that was evaluated was the perception of their effect on the resulting safety level, operational performance, and modal choices. About one-third of the local agencies noted that safety improved; an equal amount noted that it remained the same; and the rest noted that it deteriorated. It should be noted that those local agencies that noted a safety improvement had conducted a safety analysis after the project completions, whereas among those that noted deterioration only one had completed such a study. One-third of the agencies responding stated that the operational performance improved, deteriorated, or remained the same. Finally, almost half of the agencies noted that modal choice either remained the same or that it was improved and none indicated that it deteriorated. These responses appear to indicate that design exceptions have, in general, a neutral to positive effect on the project performance regarding the aspects examined here.

In contrast, state DOT respondents indicated poorer performance through design exceptions. One-half indicated increased project delivery time, with half identifying no change, and two-thirds indicated an increase in liability exposure, with one-third no change.

Several of the agencies noted that they are involved in a variety of efforts to improve their design processes for timely resolution of potential issues. One-half indicated that they have initiated the development of improved guidance and the clarification of the controlling criteria. Training of personnel is another area that several agencies are targeting as a means for improving their process. Other efforts include development of a uniform document format and a checklist for documents to be included with the application, as well as meetings of the design exception committee and use of electronic format submittal. All of these efforts appear to indicate that there is a variety of efforts that could be undertaken

to improve the process and each agency should determine what may be the most appropriate approach for its operation. For example, one agency indicated that they use several of these methods, whereas another noted that the number of design exceptions they submit is too small to require a review of their policies and processes. Among the comments received regarding lessons learned and efforts to improve, the most common theme was development of checklists and clarification of the ranges for the criteria to be used.

Once design exceptions are granted and the project is completed, several agencies review the performance of the project with respect to safety and operational performance to determine the effect of the design exception. This appears to be a positive approach on determining the impact of design exceptions and a practice that should be recommended. Such evaluations could allow for the development of possible areas of success and create precedence for future applications. Even though most agencies reported that they do not use past design exceptions as a precedent, this evaluation could appear to provide the support needed to use them as documentation for developing a knowledge base for future applications.

A variety of lessons learned with a common theme were noted by the respondents: the need for dialogue and communication among the various agencies responsible for the project and the timely submission of the documentation. Respondents noted the limited involvement of other agencies that could have an impact on the project delivery or influence the final solution. The need to present design exceptions to the public was also noted and most agencies discuss them at public meetings. This allows the public to understand what may be the implications for the choices made and assist in the final decision. The timeliness and completeness of the submission of the design exception documents are also an important aspect and could have significant implications on the on-time delivery of the project and perhaps even cost. Early identification of elements that may require flexibility is required to avoid any time delays, and a clear understanding of the process and required documentation will reduce potential delays.

CASE STUDIES

To provide a context for the need and implementation of design exceptions, case studies for further analysis were identified through the survey

instrument. It should be noted that case studies where design exceptions were used were difficult to identify. The following case studies examine the Kuhio Avenue Improvement project in Honolulu, Hawaii, the Route 734 improvement project in Virginia, and the Dixie Highway Improvements Project in Park Hills, Kentucky. Each of these projects had to implement modifications to the minimum cross-section standards to meet the overall goals of the project.

An issue that should be noted here regarding case studies was the lack of any readily available documentation for any of these cases as well as others that were investigated. This points to the lack of documentation of past examples as well as the absence of any database that systematically catalogues and examines possible design exceptions. As was noted in the survey responses, very few agencies document their design exception efforts and this has resulted in providing such a small number of cases from the agencies that completed the survey.

Case 1: Kuhio Avenue Improvement Project

Project Purpose

Kuhio Avenue is a four-lane major collector in Waikiki Honolulu, Hawaii. As the avenue bisects downtown Waikiki, it has a posted speed limit of 25 mph. The Kuhio Avenue project extended approximately 1.2 miles from Kapahulu Avenue to Kalakaua Avenue. At the time of the initial study, Kuhio Avenue carried more than 21,600 vehicles per day. It is the main public transit corridor in Waikiki with six city bus routes that travel in both directions on the avenue. In addition, the avenue is used by automobiles, commercial (tour) buses, private buses, taxis, delivery vans and trucks, bicyclists, and is a major pedestrian corridor as well.

The Kuhio Avenue Improvement Project was undertaken as the result of recommendations made in the city's Waikiki Livable Community Project (WLCP). A key policy adopted by the WLCP study was a "pedestrian first" policy for Waikiki. The WLCP study documented a high level of pedestrian activity on Kuhio Avenue that included transit patrons, commercial tour bus passengers, taxis stopping for patrons, and truck drivers making deliveries to businesses, as well as pedestrians shopping or walking to the beach. It was observed that at times the public sidewalk would become so congested that people were spilling off the sidewalks and walking in the nearest travel lane to the sidewalk. The situa-

tion presented a pedestrian safety concern and the study concluded that certain sidewalk areas along the corridor needed to be widened.

The Kuhio Avenue Improvement Project attempted to address three main issues of the corridor.

1. Creation of a more pedestrian-friendly environment by widening and improving sidewalks.
2. Provision of beautification of the avenue through landscaping, including the planting of a significant number of trees and the creation of a landscaped median.
3. Installation of bus pull-outs to improve traffic flow and create a better transit environment.

Project Constraints

Owing to the mature nature of the corridor and its heavy use, the project experienced several constraints on the final design.

- **Traffic flow and circulation constraints.** Although the project was intended to narrow the right-of-way to accommodate sidewalk widening and beautification, traffic flow and circulation remained an important consideration.
- **Public transit constraints.** Proposed bus pull-outs along the avenue required careful consideration of sidewalk space. Often, certain transit stops along the avenue have significant numbers of riders waiting, affecting sidewalk space and pedestrian circulation.
- **Beautification constraints.** Proposed project landscaping and planting of trees required careful consideration of the location of the trees that would balance pedestrian shade while minimizing the amount of sidewalk space required.

Requested Variance

To accommodate the competing demands of the project, the design team requested narrowing the travel lanes on Kuhio Avenue from 12 ft to 10 ft whenever possible in limited locations. This reduction was necessary to widen the sidewalks in certain sections of the avenue and to implement bus pull-outs (see Figure 8). The narrowing was controversial because tour bus operators in Waikiki pointed out that tour buses from mirror to mirror are very close to 10 ft wide. Public transit vehicle drivers, large delivery truck drivers, and public and private refuse operators were also concerned about the travel lane width because of the width of their vehicles.



Figure 8 Before (*left*) and after (*right*) visualizations of Kuhio Avenue.

Lessons Learned

Based on the “Pedestrian-First” policy, which was adopted by the WLCP project, the project recommended that high priority be placed on pedestrian access and safety for Kuhio Avenue. The recommended improvements were part of an extended community-based process that was undertaken by the WLCP to receive extensive public input on making Waikiki more “livable.” This included public meetings, an extensive two-day public workshop, and neighborhood meetings.

Through the public process undertaken by the WLCP project, an administrative decision was made to implement improvements that would primarily benefit pedestrians and transit service. Although there were both internal and external debates on the trade-offs of narrower lanes versus wider sidewalks, it was ultimately believed that the improvements would benefit Waikiki as well as retail, hotel, and residential land uses along Kuhio Avenue.

Since the implementation of the Kuhio Avenue project, the department has had very few complaints about lane width and few accidents. Conversely, compliments have received from visitors, residents, and visitor industry executives on the “greening” of the avenue and making the public sidewalk space more pedestrian-friendly.

Case 2: Route 734 Improvement Project

This project is included here for two reasons. First, bridge replacements are a common project for several local agencies and dealing with existing right-of-way limitations is a common issue facing local agencies. Moreover, the need for bridge re-

placement as it has been documented by AASHTO is a high-priority area and, therefore, means (such as design exceptions) to increase the number of such replacements with limited funds are considered appropriate. Second, the bridge lies within the jurisdiction of the Pittsylvania County municipal authorities and there are several large cities (e.g., Los Angeles) that have such rural roadways within their responsibility.

Project Purpose

Route 734 is a two-lane local road in Pittsylvania County, Virginia. Route 734 has a 35 mph speed limit with an average daily traffic of 1,028. Traffic is primarily local and commuter traffic, with 12% truck traffic. Pedestrian or bicycle facilities are not provided on Route 734.

The purpose of this project was to reconstruct an existing bridge over Cane Creek as well as improve the bridge approaches to meet the improved structure. Total project length was 0.417 mile. The project was led by the Virginia DOT.

Project Constraints

The final design of the bridge reconstruction was constrained primarily by two factors. First, limited right-of-way existed for environmental and right-of-way impacts owing to the narrow width of the old bridge structure. Second, many environmental constraints existed as a result of the creek crossing. Existing shoulder widths on the roadway and bridge structure were less than current standards and widening to meet current standards would significantly impact both constraints.

Requested Design Exception

To minimize impacts and project costs, a design exception was requested to reduce shoulder widths to match existing conditions.

Lessons Learned

The project was successful in implementing the needed bridge improvements while minimizing right-of-way impacts and environmental impacts. The key to success was that driver expectations were not changed as the improvement was designed to meet existing conditions instead of being upgraded to meet standards. In the absence of an identified safety issue at the site, this solution provided an improved roadway and bridge with minimal impact and costs.

Case 3: Dixie Highway Access Improvements

Project Purpose

Dixie Highway (US-25) in Park Hills, Kentucky, is classified as an arterial in northern Kentucky providing north–south access to downtown Covington, Kentucky, and Cincinnati, Ohio. The highway parallels Interstate 75 and often serves as a diversion route during times of congestion and/or accidents. Through the project area, Dixie Highway is a four-lane undivided highway that serves as a transitional area into residential neighborhoods in the city (see Figure 9).

This project sought to provide access from Dixie Highway to a 200-unit residential development situated on the hillside overlooking the cities of Covington and Cincinnati. At issue with the project was the local planning commission requirement that full-length auxiliary turn lanes be provided on all arterial streets. Although Dixie Highway was classified as an arterial street, traffic volumes were observed to be considerably less on this section of the roadway than in other more commercial districts to the south.

This section of Dixie Highway was included in a 2006 multi-jurisdictional study, called *The Dixie Fix*, which examined improvements along the corridor (see Figure 10). The transitional area through the city of Park Hills was identified to be the subject of a “road diet,” which would reduce the northbound (downhill) lanes from two to one, provide two lanes coming up the hill (southbound), and provide a center two-way left-turn lane within the existing pavement limits.

Project Constraints

The primary constraint on the corridor was a limited right-of-way and severe topographic constraints owing to steep grade and hillside stability issues on both sides of the roadway.

Requested Variance

To reduce development costs, the developer requesting access also requested a variance of the local



Figure 9 Northbound (left) and southbound (right) views of Dixie Highway near the project.

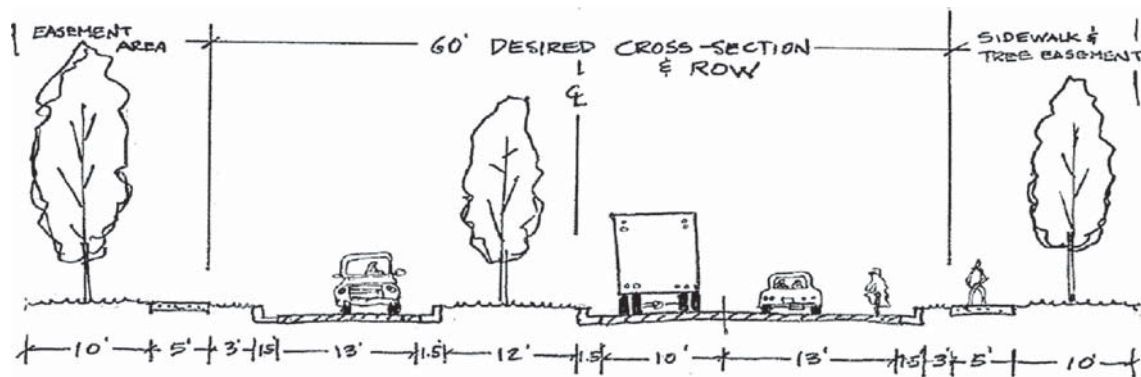


Figure 10 Proposed Dixie Highway cross section, *The Dixie Fix*, 2006.

regulations to waive the requirement for auxiliary left- and right-turn lanes into the development. Roadway widening to provide the required auxiliary turn lanes would have required considerable cost owing to the need for an expanded retaining wall on the west side of the highway. The initial waiver was denied and the project soon stalled.

To retain the proposed development and provide reasonable and safe access to and from Dixie Highway, a plan was developed that would retain the existing pavement width, but would begin to implement the lane configuration changes proposed under the corridor study. This flexible design approach proved to be acceptable to local and state agencies, as well as provided a reasonable access alternative to the developer of the project.

Lessons Learned

The regulations initially upheld by the local agencies while striving for improvements in the operations and safety of the local street system failed to provide the required flexibility for the situation. As such, the low traffic volumes of this section of Dixie Highway as well as the nature of the roadway context that served as a transition area to residential areas, were not taken into account and the roadway was treated the same as other sections where volumes were tripled and that served heavy industrial and commercial areas. If the regulations were to be followed it would have led to substantial cost as well as unneeded improvements and associated impacts.

The presence of a comprehensive corridor plan that took into account the special needs and context of each area proved invaluable in directing future improvements along the corridor. Providing the ability of detailed planning efforts and studies to be incor-

porated into or override existing general regulations will allow for a much more tailored and appropriate design.

Since this project, a memorandum of agreement has been signed by all local agencies, the Kentucky Transportation Cabinet, Ohio Kentucky Indiana Regional Council of Governments, and the Northern Kentucky Planning Commission that adopts all of the recommendations of *The Dixie Fix* to be used in directing future development.

CONCLUSIONS

Roadway designers are called on to balance several factors that require attention within the roadway environment and context. Mobility aspects, safety concerns, natural and human environment elements, cultural resources, and financial constraints often play an important role in determining the roadway context and in shaping the final design of the roadway. To address all of these issues, designers often have to provide a solution with design elements that may not conform to those typically used and therefore there is a need for deviating from these values. The approach for achieving this balance is documented through design exceptions or variances and this process has been used to address such departures from design standards and guidelines. The built urban environments may pose additional and more frequent constraints on roadway designs owing to the existing buildings and other structures where rights-of-way could be at a higher premium. Therefore, design exceptions for roadways in built urban environments may pose an additional problem as a result of their potential higher frequency for consideration as well as possible implications from their application.

This report addressed these issues through a nationwide survey of both city and state DOTs and concentrated on the following focus areas:

- Processes followed by agencies in developing and completing design exceptions, including responsibilities and documentation requirements;
- Magnitude of the issues to be addressed, such as frequency of revisions, number of applications, project delivery implications, and constraints requiring design exceptions;
- Level of required documentation dependent on contextual issues;
- Efforts for improving the process followed; and
- Documentation of successful and problematic design flexibility and variance requests.

The survey conducted for this report aimed at defining issues relative to the proactive use of design exceptions and identifying collaborative practices that could enhance this process and reduce potential conflicts between transportation agencies. The survey focused on examining how design exceptions are used by local transportation agencies in built urban environments, the documentation process followed, the time requirements for their completion, and the efforts undertaken to improve the practice. The findings of the survey are summarized here along with reported benefits, issues, and potential improvements to the process.

Agency Responsibility

Primary responsibility for local roads for large urban centers resides with local transportation agencies. These local agencies are often involved in all phases of the project development process. A smaller number of local agencies are involved with either state roads or roads in the National Highway System. These responses indicate that the role of these agencies is appropriate and within their purview. The delineation of such responsibilities and understanding of the boundaries of jurisdictions between local and state agencies is fundamental in defining the role and area of influence for each agency.

For designing roads, most local agencies use design standards, whereas a few use design guidelines. It should be noted here that there is a difference between standards (mandatory practice) and guidelines (recommended practice, but not mandatory) as they are applied in design and probably reflect the level of flexibility that agencies are inherently

allowed. The remaining agencies noted the use of a combination of other guidelines and standards without specifying the extent of each. The use of guidelines appears to also provide a greater flexibility to local agencies when design exceptions are considered as it was noted in the correlation of the frequency of design exception applications and design documents used. This may be a practice that local agencies need to review to improve their design exception process and allow for greater flexibility if needed. It should be also noted here that although the *Green Book* provides adequate flexibility for design, this flexibility may be inadequate when urban designs are considered as documented by the responses of a few agencies. The responses indicated that agencies that have developed their own design guidance have considered the need for providing flexibility in design and therefore have addressed the issue, whereas those that use guidance based on other design documents believe that there is little flexibility built in these documents. It therefore could be recommended that agencies need to review their documents to determine their level of flexibility, and they may consider developing their own.

Need for Variance

There are a number of constraints for which design flexibility may be needed for a project and understanding their influence is critical in determining the reasons for variance from the typical design. The survey respondents identified right-of-way restrictions or limitations as the primary reason for considering flexibility. The need to accommodate pedestrians and bicyclists also featured high in the reasons that may require design flexibility and thus underscores the potential influence that non-motorized users have on the design of urban streets. The limited right-of-way and the need to accommodate all users of the facility in urban areas may be the most critical aspects of roadway design and thus require significant flexibility and, often, innovative design. The reasons noted by the respondents as requiring flexibility included a mixture of design features, operational efficiency, financial constraints, and safety considerations all of which have a significant impact in developing a project solution and may often require balancing to reach this solution. The answers conform to a priori expectations, because all are factors that have to be considered.

Lane width is the design element for which design flexibility is sought most frequently. This was anticipated, because this is the primary element that could have a significant impact on right-of-way issues and the accommodations of bicyclists and pedestrians. Shoulder width was also among the top three elements, indicating its influence on right-of-way issues and accommodation of the other users. Therefore, agencies may need to revisit their design documents dealing with lane and shoulder widths if they desire to reduce the number and frequency of design exceptions and provide greater flexibility.

Design Exception Process

The design exception practice is widely used by local transportation agencies of built urban environments. Of interest was that one-half of the respondents indicated that they consider design exceptions for a select type of projects, whereas the others noted that they consider them for all project types. The agencies noting that they consider design exceptions for select types of projects have their own design guidelines. This finding could support the assumption that these agencies feel comfortable with the existing flexibility in their design documents and do not see the need for design exception in any but a few project types.

The 13 criteria provided by FHWA for use in design exceptions are adequate for most agencies. A few agencies reported the use of operational capacity and clear zone as additional criteria incorporated in their documentation process. Therefore, it can be assumed that the existing criteria adequately cover the spectrum of needs for design exceptions; however, the consideration of the other two (operational capacity and clear zone) may be added to the list to provide the flexibility needed to these agencies. The question regarding the level of flexibility of the criteria used as they compare with the values of the *Green Book* showed that all agencies but one believe that they are less strict or the same. This indicates that the processes that are in place adequately address flexibility.

The questions regarding the data to be collected for use in the design exceptions included the anticipated types; that is, traffic volumes and cost estimates, both of which are integral to the project design and solution. Of interest here is the prominence in the scores of the use of prior examples, because it could be viewed as an indication for compiling past prac-

tices and using them to support and justify future design exceptions. From this perspective, documentation and maintenance of past design exceptions is a positive aspect and a practice to be commended.

Design exceptions for local transportation agencies in built urban environments are mostly within the agency's staff supervision and responsibility even for agencies that rely on consultants to complete their design. Design exception applications are mostly submitted in the design phase of the project development process. This is probably a reasonable point in the project development process to address the need for flexibility and therefore there is no need for altering the practice. This approach will also provide a timely identification and resolution of possible problem areas and thus reduce any potential delays owing to the review of the application. The project type and size will probably have an impact on the time required for the completion of the documentation and approval of the design exception. Most of the respondents noted that the time required for the preparation of the documentation is short (less than two months), indicating that this is not a time-consuming process. The issue to be emphasized here is that there is timeliness for considering and submitting design exceptions and that this should be identified as early in the process as possible. The appropriate time for considering design exceptions will vary for each project and the project team needs to identify when design exception documentation should be submitted to avoid any potential delays and cost increases.

The review of design exceptions is completed by most local agencies in-house by the agency's design team or group even if it was prepared by the agency's staff. In this case, agencies noted that they have a separate design exception committee or that the documents are reviewed by the agency's legal office. A few agencies have a review conducted by their DOT (some using the state DOT's design exception committee and others the DOT's design team or group). A significant aspect of the review process is its timely completion for reducing any potential time delays for the project. For one-half of the local agencies the review time is relatively short (under three months), whereas for another one-third the review is between three to six months. It is reasonable to assume that an in-house process could result in short review times and longer if the review is conducted by other external agencies, such as the state DOT. The review time could also be related to the number of design exceptions that an agency typically

completes within a year; however, there appears to be no correlation between the number of design exceptions and review time.

Efforts to Improve

One can assume that efforts to improve a process start with a review of current practices and the identification of areas that need to be addressed. However, most agencies responded that they have not conducted a review of their design exception process. This could be either an indication of the lack of staff to complete this effort or the low number of design exception applications. The latter assumption was verified by two agencies that have not conducted a review because they have fewer than five design exceptions per year and short review time (three to six months). The responses provided did not allow for the identification of a pattern regarding when an agency needs to conduct a review of their practices and what may be the indications that could initiate the process.

The effect that design exceptions have on various aspects of the project delivery was also evaluated; however, the data provided did not allow for developing a pattern regarding their effect on project delivery time, costs, or potential exposure to liability. The liability issue was one that was noted in a few comments and it may be an area of concern for transportation agencies. Of interest here is that even though most agencies noted that the delivery time of the project was increased, they also noted that project costs were decreased. The survey results indicated that design exceptions may delay a project but have no increase on project costs. Another aspect of design exceptions that was evaluated was the perception of their effect on the resulting safety level, operational performance, and modal choices. The responses indicated that design exceptions have, in general, a positive effect on the project performance regarding the aspects examined here. Implications on safety are always a concern and most agencies noted that there was no deterioration of safety as a result of the application of the design exception.

Several of the agencies noted that they are involved in a variety of efforts to improve their design process for timely resolution of potential issues. These efforts include the development of improved guidance, clarification of the controlling criteria, and training of personnel. All of these efforts could pos-

itively affect both timely preparation and review of design exception applications. Moreover, this variety of approaches indicates that each agency should determine what may be the most appropriate approach to undertake to improve their design exception process. Among the comments received regarding lessons learned and efforts to improve, the most common theme was development of checklists and clarification of the ranges for the criteria to be used. The concept of establishing problem-solving sessions among the agencies involved was not specifically mentioned as an effort to improve. However, such meetings have the potential to resolve problem cases as they appear without creating time delays and cost increases.

A feedback loop that allows for the determination of lessons learned and identification of efforts to improve the process is important in every improvement effort. Several agencies indicated that they conduct a review of the project performance with respect to safety and operational performance to determine the effect of the design exception applied. This is a positive approach to determining the impact of design exceptions. Such evaluations could allow for the development of possible areas of success and create precedence for future applications. A variety of lessons learned were noted by the respondents with a common theme: the need for dialogue and communication among the various agencies responsible for the project and the timely submission of complete documentation. Respondents noted the limited involvement of other agencies that could have an impact on the project delivery or influence the final solution. The timeliness of the submission of the design exception documents is also an important aspect and could have significant implications on the on-time delivery of the project. Early identification of elements that may require flexibility is required to avoid any time delays as well as a clear understanding of the process and required documentation will reduce potential delays.

Future Study Needs

This report provided a review of the design exception practices for local transportation agencies in built urban environments. Even though a reasonable understanding of the state of practice as it exists could be gleaned from the findings of this study, there are additional topics of interest relative to this issue that

can only be addressed by additional research. The size, type, context, and number of projects that an agency deals with may partially explain the great variability noted in the responses of the agencies. However, the comments received could also indicate that the variability may be the result of knowledge gaps or documents used. Therefore, the following topics are recommended for future studies.

The survey noted that very few agencies have an understanding or have completed a study that documents the benefits of design exceptions. The respondents were divided on whether they will improve, deteriorate, or leave the same various aspects of the project. Therefore, a study that will develop a process for evaluating the benefits of preparing design exceptions by establishing performance measures and metrics is needed.

Another area of concern is the documents used for design and the lack of clarification of the impacts of the various elements used in design exception applications. The anticipated *Highway Safety Manual* (32) will provide some needed guidance on the safety implications of various design element choices and may facilitate clarification of the impacts of design choices. However, this manual will not address all aspects of roads in built urban environments that large city transportation agencies deal with such as “share the road” and “transit first” policies. Therefore, a critical review of these needs should be conducted to identify areas of potential needs.

Training was a consistent theme noted among the efforts to improve. Several agencies are currently involved in such efforts and identifying a model that is successful may be of interest to other agencies. Therefore, a study could be undertaken to identify these efforts and synthesize successful elements of various programs to develop a tool that could be used by other agencies.

An element that has not been explored adequately is the level of interaction between the state metropolitan planning organization and transportation agencies for large cities. Each agency has a specific role to fulfill; however, there is the potential for significant overlap when the transportation system for the cities is within the influence realm of the state metropolitan planning organization. Therefore, a study identifying these relationships might be undertaken to determine the means to improve them, if there is found to be such a need.

The issue of liability and exposure to it owing to the use of design exceptions is another aspect that respondents identified as an area of concern. There is no study that correlates tort claims to projects where design exceptions were applied. Therefore, a study could be initiated that will determine whether this is a true or perceived issue and then associate the agency’s potential exposure to risk and tort liability to various aspects of tort claims.

That several agencies have developed their own design documents could be an indication of the need for a document, new or to supplement to the *Green Book*, for addressing urban roadway designs. It may therefore be the time to critically evaluate the proposed roadway and street guidance provided in the *Green Book*. Such a study can determine whether it actually addresses the design of such roadways and streets and identify areas where additional research is needed.

This report attempted to identify the state of practice for local transportation agencies of built urban environments regarding their approach and issues with design exceptions. In general, the findings show a varied approach and no significant issues with the current practice. Agencies need to conduct an internal review to determine whether there are issues with the timely completion and review of such applications and reconsider the documents they use in their roadway design. The proposed studies noted previously will also assist in developing a more robust and streamlined process and help agencies determine when and how design exceptions should be completed. However, because urban areas have different requirements than rural environments and each project has a unique context may require varied approaches in design exception practices and efforts to streamline it could be unique to each agency.

REFERENCES

1. *A Policy on Geometric Design of Highways and Streets*, American Association of State Highway and Transportation Officials, Washington, D.C., 2001.
2. Mason, J. and K. Mahoney, *NCHRP Synthesis of Highway Practice 316: Design Exception Practices*, Transportation Research Board, National Research Council, Washington, D.C., 2003, 82 pp.
3. *Urban Sites BMP Manual*, Metropolitan Council, St. Paul, Minn., 2001.
4. *Street Design Manual 2002*, San Diego, Calif., 2002.
5. *Street Design Guidelines*, Stockton, Calif., 2003.

6. *When Main Street Is a State Highway*, Maryland Department of Transportation, Baltimore, 2003.
7. *Main Street: When a Highway Runs Through it: A Handbook for Oregon Communities*, Oregon Department of Transportation, Salem, 1999.
8. *Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities*, Institute of Transportation Engineers, Washington, D.C., 2006.
9. Morrish, W., C. Swenson, and F. Dock, *Design and Development Principles for Livable Suburban Arterials*, Research Project 99025, Center for Transportation Studies, University of Minnesota, Minneapolis, 2004.
10. Fitzpatrick, K. and M. Wooldridge, *NCHRP Synthesis of Highway Practice 299: Recent Geometric Design Research for Improved Safety and Operations*, Transportation Research Board, National Research Council, Washington, D.C., 2001, 134 pp.
11. Stamatiadis, N., K. Agent, and J. Pigman, *Safety Implications from Design Exceptions*, Paper 03-2185, presented at the 82nd Annual Meeting of the Transportation Research Board, Washington, D.C., Jan. 12–16, 2003.
12. *Flexibility in Highway Design*, Report FHWA-PD-97-062, Federal Highway Administration, Washington, D.C., 1997.
13. *A Guide for Achieving Flexibility in Highway Design*, American Association of State Highway and Transportation Officials, Washington, D.C., 2004.
14. Hauer, E., “Safety in Geometric Design Standards I and II,” in *Conference Proceedings of 2nd International Symposium on Highway Geometric Design*, Mainz, Germany, 2000.
15. Design Standards for Highways, Federal-Aid Policy Guide, 23 CFR 625.1, Federal Highway Administration, Washington, D.C., Oct. 1997.
16. Neuman, T., C. Zegeer, and K. Slack, *Design Risk Analysis, Volume I, Final Report*, Report FHWA-FLP-91-010/3A4A1092, Federal Highway Administration, Washington, D.C., 1991, 128 pp.
17. Martin, S., “Design Exceptions: Legal Aspects,” *Transportation Research Record 1445*, Transportation Research Board, National Research Council, Washington, D.C., 1994, pp. 156–160.
18. Krammes, R., “Design Speed and Operating Speed in Rural Highway Alignment Design,” *Transportation Research Record: Journal of the Transportation Research Board*, No. 1701, Transportation Research Board, National Research Council, Washington, D.C., 2000, pp. 68–75.
19. Fitzpatrick, K., P. Carlson, M. Brewer, M. Wooldridge, and S. Miaou, *NCHRP Report 504: Design Speed, Operating Speed, and Posted Speed Practices*, Transportation Research Board, National Research Council, Washington, D.C., 2003.
20. Krammes, R.A., et al., *Horizontal Alignment Design Consistency for Rural Two-Lane Highways*, Report FHWA-RD-94-034, Federal Highway Administration, Washington, D.C., 1994, 137 pp.
21. *Designing Safer Roads; Practices for Resurfacing, Restoration, and Rehabilitation*, Special Report 214, Transportation Research Board, National Research Council, Washington, D.C., 1987, 319 pp.
22. Poe, C.M., J.M. Tarris, and J.M. Mason, *Relationship of Operating Speeds to Roadway Geometric Design Speeds*, PTI Report 9606, Pennsylvania Transportation Institute, State College, Pa., 1996, 268 pp.
23. Stamatiadis, N., et al., *International Scanning Tour on Highway Geometric Design*, FHWA-PL-01-026, Federal Highway Administration, Washington, D.C., 2000, 46 pp.
24. *Roundabouts: An Informational Guide*, FHWA-RD-00-067, Federal Highway Administration, Washington, D.C., 2000.
25. Elvik, R., “Effects on Road Safety of Converting Intersections to Roundabouts,” *Transportation Research Record: Journal of the Transportation Research Board*, No. 1847, Transportation Research Board of the National Academies, Washington, D.C., 2003, pp. 1–10.
26. Harwood, D., *NCHRP Report 330: Effective Utilization of Street Width*, Transportation Research Board, National Research Council, Washington, D.C., 1990, 55 pp.
27. Neuman, T., M. Schwartz, L. Clark, and J. Bednar, *NCHRP Report 480: A Guide to Best Practices for Achieving Context Sensitive Solutions*, Transportation Research Board, National Research Council, Washington, D.C., 2002, 138 pp.
28. Fambro, D., K. Fitzpatrick, and R. Koppa, *NCHRP Report 400: Determination of Stopping Sight Distances*, Transportation Research Board, National Research Council, Washington, D.C., 1997, 107 pp.
29. Gladwell, M., *The Tipping Point: How Little Things Can Make a Big Difference*, Little, Brown and Company, 2000, 304 pp.
30. Stamatiadis, N., J. Pigman, and D. Hartman, *Safety Consequences from Flexibility in Highway Design*, Final Draft Report, NCHRP Project 15-22, Transportation Research Board, National Research Council, Washington, D.C., 2004.
31. Stein, W. and T. Neuman, *Mitigation Strategies for Design Exceptions*, FHWA-SA-07-011, Federal Highway Administration, Washington, D.C., 2007.
32. Hughes, W., K. Eccles, D. Harwood, I. Potts, and E. Hauer, *Highway Safety Manual, NCHRP Web Document 62*, Transportation Research Board, National Research Council, Washington, D.C., 2004, 303 pp.

APPENDICES A THROUGH D

Appendices A through D as submitted by the consultant are not published herein. These appendices are available as part of web version of this document at: http://trb.org/news/blurp_detail.asp?id=10263. The titles of the appendices are as follows:

Appendix A	Agency Survey
Appendix B	Survey Results
Appendix C	Respondents
Appendix D	Standards/Guideline Excerpts



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