Road Design Standards: Final Report

August 2016

Prepared by:

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Contents

Legislative Request

This report is issued to comply with 2015 Laws of Minnesota, Chapter 75, Article 2, Section 57.

Sec. 57. Road Design Standards. By August 15, 2016, the commissioner of transportation shall, in collaboration with city and county engineers, establish and adopt design standards and guidelines to be applied consistently to trunk highways, county state-aid highways, and municipal state-aid streets with similar characteristics. The standards and guidelines must align the state-aid standards with the Department of Transportation trunk highway standards and technical memoranda as appropriate. The commissioner shall report the adopted standards and guidelines to the chairs and ranking minority members of the senate and house of representatives committees with jurisdiction over transportation policy by August 15, 2016, and present an interim report by March 15, 2016.

The cost of preparing this final report is $88,000.

Introduction

Consistency in roadway design in the United States is achieved through design standards adopted at the local, state and federal levels. In Minnesota, the Minnesota Department of Transportation developed the MnDOT "Road Design Manual" and technical memos, which draw from the American Association of State Highway and Transportation Officials guidelines, but is tailored to address the physical and weather conditions found in Minnesota for the state's trunk highway system. The guidelines in the manual and technical memos provide a range of flexibility, allowing MnDOT engineers the opportunity to tailor roadway designs to the specific context of the roadway using their professional engineering judgement.

State Aid system roadways (county and city) follow more specific standards codified in Minnesota Rules (State-Aid Route Standards, State-Aid Operations Rules Chapter 8820), which provide minimum design standards addressing many different roadway functions and characteristics, including the following:

- Geometrics for travel lanes
- Bicycle facilities
- Parking dimensions
- Curb reaction distance
- Other elements of the roadway system

These rules were first adopted in 1957, but were amended, as needed, to address changing transportation needs and evolving engineering practice. Given the number of local agencies building roadways under this program, and the sometimes limited professional resources available to some agencies, part of the intent of these rules was to ensure the quality of roadways built with state aid funds had consistent roadway design properties across local jurisdictions.

To examine how the flexible approach of the MnDOT Road Design Manual and technical memos could be incorporated into the more specific design standards included in the state aid rules, the width standards (e.g., vehicle lanes, shoulders, bicycle lanes, parking lanes) were examined for the trunk highway and state aid systems. This statewide, planning-level review included an examination of the national standards and provided alternatives and recommendations on where the standards can be appropriately aligned.

To complete this task, MnDOT hired SRF Consulting Group, Inc. to facilitate the development of recommendations for the state aid standards to align with trunk highway standards by coordinating with a Transportation System Users Steering Committee and Technical Working Group. The TSUSC is comprised of pedestrian, bicycle and health advocates who support greater flexibility in design standards that would result in more opportunities for improved pedestrian and bicycle facilities throughout the state aid system. The TWG is made up of MnDOT staff and city and county engineers experienced with implementing design and construction projects in their local communities using the MnDOT "Road Design Manual", technical memos, and Chapter 8820 of Minnesota Rules.

Fulfilling the tasks outlined by the Legislature resulted in recommendations for changes to the following Minnesota Rules:

- Minn. Rules 8820.0200 Definitions
- Minn. Rules 8820.9920 Minimum Design Standards; Rural and Suburban Undivided; New or Reconstruction Projects.
- Minn. Rules 8820.9936 Minimum Design Standards; Urban; New or Reconstruction Projects.
- Minn. Rules 8820.9941 Minimum Design Standards: On-Road Bicycle Facilities for Urban; New or Reconstruction Projects.
- Minn. Rules 8820.9946 Minimum Design Standards, Urban; Reconditioning Projects.
- Minn. Rules 8820.9951 Minimum Design Standards, On-Road Bicycle Facilities for Urban; Reconditioning Projects.

The recommended changes reflect standards in the following guidance documents:

- MnDOT Road Design Manual
- MnDOT Bikeway Facility Design Manual
- MnDOT Technical Memorandum No. 12-12-TS-06: Shoulder Width Standards for State Highways (2012)
- MnDOT Technical Memorandum No. 13-18-TS-07: Traveled Lane Width Standards for State Highways (2013)

Stakeholders

MnDOT addressed the legislative request by engaging two committees to review the state aid standards and MnDOT design standards, identify differences and provide recommendations for potential changes to the standards.

Transportation System Users Steering Committee

The role of the TSUSC was to identify common concerns advocates recognized in the state aid standards. TSUSC representatives were tasked with evaluating recommended design standards to ensure the concerns and needs of pedestrians and bicyclists were understood and considered thoroughly throughout the process.

The TSUSC group had eight members who work with bicycle and pedestrian facilities and advocates from various organizations. The TSUSC group was comprised of the following individuals:

- Craig Churchward – Michael Baker International
- Ethan Fawley – Minneapolis Bicycle Coalition
- Dorian Grilley – Bicycle Alliance of Minnesota
- Tony Hull – Nonmotorized Transportation Consultant
- Sam Rockwell – Blue Cross and Blue Shield of Minnesota: Center for Preservation
- Fay Simer – Stantec
- Jessica Treat – Transit for Livable Communities
- Kelley Yemen – Hennepin County

The TSUSC identified the following goals:

- Address State Aid standards that limit bicycle and pedestrian facilities on all roadways
- Provide pedestrian and bicycle facilities that address mobility demands of all age ranges
- Provide flexibility in design standards to allow for engineering judgement
- Present the standards to provide clarity for local communities
- Review the State Aid standards variance process to alleviate project delays

Technical Working Group

The role of the TWG was to review and evaluate the technical aspects of the state aid standards. This was done by analyzing the differences between the state aid and MnDOT design standards based on best practices, practical experiences and safety. The TWG then recommended appropriate changes to the rules. The goals previously identified by the TSUSC set the foundation for the technical analysis.

The TWG was made up of the following seven city, county and state engineers:

- Gregory Isakson – Goodhue County
- Mel Odens – Kandiyohi County
- Wayne Sandberg – Washington County
- Shelly Hanson (Pederson) – City of Bloomington
- Cindy Voigt – City of Duluth
- Jim Rosenow – MnDOT
- Paul Stine – MnDOT

The TWG considered the following when developing its recommendations:

- There is a broad range of roadway functions (arterials, collectors, etc.), conditions (average daily traffic volumes, speed limit, etc.), and users (transit, farm equipment, freight, etc.) on the state aid system.
- State Aid standards address a wide range of urban and rural roadways.
- In comparison to MnDOT staff resources, many Minnesota cities and counties have a single, professional (i.e., licensed) engineer on staff who has many responsibilities. The state aid standards assist these staff and their elected officials to make good design decisions knowing that the standards have been fully vetted and provide for improved safety on their roadway systems.
- There is concern that the current state aid variance process is too restrictive and time-consuming for local project development decisions.

Approach

Project Process & Timeline

The focus of updating the State Aid standards was driven by the TWG and TSUSC meetings throughout the review process to make recommendations and discuss potential issues.

The TSUSC met twice individually on Dec. 8, 2015 and Feb. 26, 2016. At these two meetings, the TSUSC identified goals and objectives to inform the alignment process. Overall, the committee was interested in providing flexibility for the State Aid standards, processes, and decisions. These themes were used as the basis for the recommendations for potential changes to the state aid standards.

The TWG met seven times on Dec. 17, 2015; Jan. 14, 2016; Feb. 1, 2016; March 17, 2016; April 4, 2016; April 22, 2016; and May 23, 2016. Each of these meetings was used to compare and evaluate the identified differences between the state aid and MnDOT design standards. During the evaluation process, the TWG worked to develop recommendations for changes to state aid design standards to accommodate all modes of transportation in a uniform manner across Minnesota's transportation systems.

The TSUSC and the TWG met twice together on May 6, 2016 and June 24, 2016 to discuss the TWG's recommendations. These two meetings provided both groups an opportunity to openly discuss the changes and provide clarity with questions, comments and concerns. The June 24, 2016 meeting was considered a final meeting for both committees. Final recommendations were identified and agreed upon by both committees.

Literature Review

The initial meetings of the TSUSC and TWG included a discussion about the current guidance in engineering practice regarding design standards and about the current research of the safety of narrower travel lanes. Through these discussions, a variety of safety literature, national design guidelines and research reports were reviewed to determine how a facility is affected by roadway widths.

Literature and research were collected from the following sources and shared with the TSUSC and the TWG:

- Minnesota Department of Transportation
- American Association of State Highway and Transportation Officials
- Federal Highway Administration
- Transportation Research Board
- National Association of City Transportation Officials
- Institute of Transportation Engineers
- Minnesota Local Road Research Board
- Florida Department of Transportation

Design Guidance Key Findings

The state aid review process looked at national, state and local design guidance to help inform recommendations. These design guidance documents were intended to inform recommendations based on research and best practices.

Research Studies Key Findings

The literature review found three research studies that looked specifically at the safety impacts of narrower vehicle lanes. The general conclusions from each of these studies were that narrower lanes did not necessarily equate to decreased safety, specifically in lower volume, urban areas. However, there were some specific scenarios where there could be decreased safety with narrower lanes, which included the following:

- Rural roadways (minimum 11-foot lanes)
- Four-lane undivided roadways (minimum 11-foot lanes)
- Transit routes (recommended 11-12 foot lanes)

Because the number of research studies was limited, the TWG kept this information in mind and focused its efforts on best practices and experiences to develop the recommendations.

A formal literature review was produced for the state aid standards review and can be found at the end of this report in Attachment B.

Final Recommendations

The project team established recommendations for changes to Minn. Rules 8820.9920, Minn. Rules 8820.9936, Minn. Rules 8820.9941, Minn. Rules 8820.9946 and Minn. Rules 8820.9951 to be adopted and applied consistently on county state aid highways and municipal state aid streets. The TWG finalized the draft of recommended design standards. These recommendations were verified to meet the requirements of the legislation with the TSUSC and considered final after the June 24, 2016 joint meeting.

The following outlines the final recommendations for revisions to the state aid standards to be brought through the formal rules adoption process.

Minn. Rules 8820.9920 Minimum Design Standards; Rural and Suburban Undivided; New or Reconstruction Projects.

This table is used for rural areas where no curb and gutter are present, a bicycle facility may be located on the roadway, and the roadway is a new or reconstruction project. The recommended changes for the Minn. Rules 8820.9920 table address lane widths. Below is a high level summary of the recommendations.

Lane width – Changing the lane width values to between 11 to 12-feet, based on average daily traffic and design speed. Also add a footnote to all lane width values that reads, "Lane widths towards the wider end of the range are desirable. However, lane widths of 10 feet may be considered on roads classified as local or collector, where truck and bus volumes are relatively low and design speeds are 35 mph or lower, and ADT is less than 1,500, as well as in more constrained circumstances. District state aid engineer approval is required."

Minn. Rules 8820.9936 Minimum Design Standards; Urban; New or Reconstruction Projects.

This table is used for urban areas where curb and gutter are present and the roadway is a new or reconstruction project without a designated bicycle facility. The recommended changes for the Minn. Rules 8820.9936 table address the following: lane width, curb reaction distance and parking lane width. Below is a high level summary of the recommendations.

Lane width – Changing the lane width values to between 10 to 12-feet, based on functional classification, ADT and design speed. Also add a footnote to all lane width values that reads, "10 feet may be considered where truck and bus volumes are relatively low and design speeds are 35 mph or lower, as well as in more constrained circumstances. 11 feet minimum on four-lane undivided facilities. 12 feet should be considered in industrial areas."

Curb reaction distance – Changing the curb reaction distance values to between 1 to 4-feet, based on functional classification, ADT and design speed. Also add a footnote to low speed (30-35 mph) values that reads, "Zero foot curb reaction distance may be considered. District state aid engineer approval is required."

Parking lane width – Changing the parking lane width values to between 7 to 10-feet or not allowed, based on functional classification, ADT and design speed. Also add a footnote to all parking lane width values that reads, "In determining parking lane width, the roadway ADT and the vehicle mix shall be taken into consideration. In commercial or industrial areas, the minimum parking lane width is 8 feet."

Minn. Rules 8820.9941 Minimum Design Standards: On-Road Bicycle Facility for Urban; New or Reconstruction Projects.

This table is used for urban areas where curb and gutter are present, a designated bicycle facility is located on the roadway and the roadway is new or reconstruction. The recommended changes for the Minn. Rules 8820.9941 table address the following: lane width, curb reaction distance, parking lane width and bikeway design. Below is a high level summary of the recommendations.

Lane width – Changing the lane width values to between 10 to 12-feet, based on functional classification, ADT and design speed. For these changes, two footnotes would be added. First for the areas within the table for low speed (30-45 mph), low volume (<10,000 ADT) lane widths and also for low speed (30-25 mph), high volume (>10,000 ADT) lane width that reads, "A combination of all minimum widths for the driving lane, on-road bicycle lane and parking lane is only permissible with a variance." The second footnote would address all lane width values and would read, "10 feet may be considered where truck and bus volumes are relatively low and design speeds are 35 mph or less and in more constrained circumstances. 11 feet minimum on four-lane undivided facilities. 12 feet should be considered in industrial areas."

Curb reaction distance – Changing the curb reaction distance values to between 1 to 4-feet, based on functional classification, ADT and design speed. Also add a footnote for low speed (30-35 mph) values that reads, "Zero foot curb reaction distance may be considered. District State Aid Engineer approval is required."

Parking lane width – Changing the parking lane width values to between 7 to 10-feet or not allowed, based on functional classification, ADT and design speed. Also add a footnote to all parking lane width values that reads, "In determining parking lane width, the roadway ADT and the vehicle mix shall be taken into consideration. In commercial or industrial areas, the minimum parking lane width is 8 feet."

Bikeway design – Changing the bikeway design to align closer with the MnDOT bikeway facility manual design criteria, based on functional classification, ADT and design speed. Additionally, language was added to the table's introduction text to provide information for accommodating on-road bicycle facilities. The new introductory text reads, "There are many appropriate bikeway design options when choosing a design for a specific project. The standards listed in the table below depict design minimums. New and emerging practices are constantly evolving in bicycle accommodation design. Engineering judgment should be used when considering on-road bicycle facilities."

Minn. Rules 8820.9946 Minimum Design Standards, Urban; Reconditioning Projects.

This table is used for urban areas where curb and gutter are present, and the roadway is part of a reconditioning project (where the curb-to-curb width is not changed) without a designated bicycle facility. The recommended changes for the Minn. Rules 8820.9946 table address the total cross section width.

Total cross section width – Updating design standard values to align with recommendations from Minn. Rules 8820.9936 table updates.

Minn. Rules 8820.9951 Minimum Design Standards, On-Road Bicycle Facility for Urban; Reconditioning Projects.

This table is used for urban areas where curb and gutter are present, a designated bicycle facility is proposed to be located on the roadway, and the roadway is part of a reconditioning project (where the curb-to-curb width is not changed). The recommended changes for the Minn. Rules 8820.9951 table address the following: lane width, parking lane width and bikeway design. Below is a high level summary of the recommendations.

Lane width – Changing the lane width values to between 10 to 12-feet, based on functional classification, ADT and design speed. For these changes, two footnotes would be added. First for the areas within the table for low speed (30-45 mph), low volume (<10,000 ADT) lane widths and also for ow speed (30-25 mph) high volume (>10,000 ADT) lane width that reads, "A combination of all minimum widths for the driving lane, on-road bicycle lane and parking lane is only permissible with a variance." The second footnote would address all lane width values and would read, "10 feet may be considered where truck and bus volumes are relatively low and design speeds are 35 mph or less, and in more constrained circumstances. 11 feet minimum on four-lane undivided facilities. 12 feet should be considered in industrial areas."

Parking lane width – Changing the parking lane width values to between 7 to 10-feet or not allowed, based on functional classification, ADT and design speed. Also add a footnote to all parking lane width values that reads, "In determining parking lane width, the roadway ADT and the vehicle mix shall be taken into consideration. In commercial or industrial areas, the minimum parking lane width is 8 feet."

Bikeway design – Changing the bikeway design to align closer with the MnDOT bikeway facility manual design criteria, based on functional classification, ADT and design speed. Additionally, language was added to the table's introduction text to provide information for accommodating on-road bicycle facilities. The new introductory text reads, "There are many appropriate bikeway design options when choosing a design for a specific project. The standards listed in the table below depict design minimums. New and emerging practices are constantly evolving in bicycle accommodation design. Engineering judgement should be used when considering on-road bicycle facilities."

Minn. Rules 8820.3300 Variance.

Any project that does not meet the standards included in the state aid rules must submit a variance request to MnDOT. The request is reviewed by a committee of county and city engineers and elected officials (five committee members in total) who provide a recommendation to the commissioner of transportation. There was discussion with the TSUSC and TWG regarding the variance process. Some of the concerns discussed were that the variance committee did not meet frequently enough. The infrequent meetings could slow a variance request that could potentially lead to project delays. Another concern was that the variance process was considered intimidating procedure that made local agencies avoid seeking a variance altogether. Lastly, there was concern that there was not enough flexibility in the standards, so the variance process was the only way to meet community needs.

After examining the variance language in the rules more closely, none of the issues discussed surrounding the variance process required a change to the rules. Any changes could be addressed administratively by MnDOT.

With the proposed recommendations to the standards, it is anticipated that engineers will have greater flexibility to design state aid roadways that meet the standards laid out in the rules, while requesting fewer variances. MnDOT will examine the need to have the variance committee meet more frequently after these recommendations are adopted and put into practice.

Minn. Rules 8820.0200 Definitions.

Throughout the state aid standards review process, it was necessary to propose new words to the definitions section such as, rural, urban and curb reaction distance.

The recommended definitions for each of the proposed new words are, as follows:

Rural – A roadway including ditches, located in an area which is not presently, nor will be in the foreseeable future, sufficiently developed to warrant the use of a municipal design.

Urban – A roadway including curb and gutter, located in an area that is or will be in the foreseeable future, sufficiently developed.

Curb reaction distance – The distance measured from the edge of the outside through-traffic lane to the adjacent face of curb.

Conclusion

The review and update of the state aid standards for road design allowed for an open and engaged dialogue about the standards and how best to align them with the trunk highway standards. The process involved engineers from many levels of government, who are responsible for implementing safe, efficient, and effective roadway design and construction projects in their communities. These projects often involve pedestrian and bicycle facilities that effect, health advocates who promote multi-modal transportation systems and healthy living. This review resulted in an iterative process to develop the final recommendations supported by TSUSC and the TWG and included in this report.

In addition to the recommendations made in this report, during the review process there were other ideas to align the state aid standards with the MnDOT trunk highway standards identified. These ideas included the following: the possible removal of tables, the reconfiguration of tables, the need for specific bicycle standards included in the state aid rules and the overall need for state aid standards. These items were not addressed in this review process but may require attention in the future.

The TSUSC and TWG believe these final recommendations meet the legislative intent to align the state aid standards with the trunk highway standards, as appropriate.

Because the standards are codified in law, in order to be fully adopted, these recommendations must be brought through the formal rules adoption process as defined in Minn. Statute 162.152, Minn. Statute 162.155, and Minn. Statute 14.386. It is anticipated that this process will take six months to complete.

"As county and city engineers, we build and maintain state aid roads for a wide variety of users and circumstances - rural roads with long distance recreational bicyclists and farm equipment, suburban areas with high traffic volumes and teenagers biking to school, narrow urban streets with bike commuters. This process provided the opportunity to talk with bike and pedestrian experts about how best to align road standards to safely accommodate competing corridor use."

- Technical Working Group

"As the public advocates in this process, we believe that this report not only documents the effort of the Commissioner and his staff to align State Aid Standards with those used to design Minnesota's Trunk Highways, it is a testament to a cooperative approach and a willingness to solve the issue identified by the Minnesota State Legislature. We believe that the alignment of the standards has been successful and recommend the acceptance of this report and the adoption of the standards it suggests." *See Attachment A for full TSUSC letter of support.*

- Transportation System Users Steering Committee

Attachment A – TSUSC Letter of Support

July 20, 2016

Mr. Ted Schoenecker
Deputy State Aid Engineer
Minnesota Department of Transportation
395 John Ireland Blvd
St Paul, MN 55155

Dear Mr. Schoenecker:
In 2015, the Minnesota State Legislature asked that the Commissioner of Transportation align the design standards being used to construct State Aid roadways with those that were used to construct our state's trunk highway system. This report documents the success of that effort. The ability of counties and municipalities to design roadways that fit the needs and desires of their communities will be greatly enhanced by the alignment suggested in this report. By providing a greater range of geometric design options, State-Aid roadways can be better integrated into their surroundings while improving the multimodal opportunities we ask of our state's transportation network. This new flexibility will allow us to be more economical, spreading our tax dollars further, improving more miles of roadways with the same level of funding. It will enhance safety for all travelers on all roads, including bicyclists, pedestrians, transit users, and motorists. It will make routes more efficient and our economy more productive. And it will make traveling throughout our state more enjoyable.

As the public advocates in this process, we believe that this report not only documents the effort of the Commissioner and his staff to align State Aid Standards with those used to design Minnesota's Trunk Highways, it is a testament to a cooperative approach and a willingness to solve the issue identified by the Minnesota State Legislature. We believe that the alignment of the standards has been successful and recommend the acceptance of this report and the adoption of the standards it suggests.

This alignment of standards, however, is only a beginning. Fully integrating pedestrians, bicycles, and transit into the planning and design of our state's transportation network will require much additional effort. We look forward to continuing our dialog with the Minnesota Department of Transportation and the State Legislature to create a practical and efficient multimodal transportation system that truly provides safe, healthy, affordable and convenient mobility and access for all Minnesotans.

Sincerely,
Transportation System Users Steering Committee:
Craig Churchward, Avenue Design Partners
Ethan Fawley, Minneapolis Bicycle Coalition
Dorian Grilley, Bicycle Alliance of Minnesota
Tony Hull, Civil Street
Sam Rockwell, Blue Cross and Blue Shield of Minnesota
Fay Simer, Stantec
Jessica Treat, Transit for Livable Communities
Kelley Yemen, Hennepin County

Attachment B – Literature Review

Introduction

A number of manuals, policies, procedures and standards have been adopted for the state of Minnesota. These tools provide guidance and direction on how state aid roadways should be designed. More importantly, these documents provide the direction necessary for achieving a cohesive transportation network throughout the state.

These tools are used by various stakeholders (e.g., state, county and local agencies). In that respect, this literature review serves as a clearinghouse for various design tools. The literature review provides the user with a brief summary and guidance on how to interpret each of the design tools. A web-link to each document is provided allowing the user to access the most recent complete version of the manual, policy, procedure or standard.

The literature is organized into six categories. These categories provide an overview on the specific manual, policies, procedures and standards captured within this literature review. The categories are separated by publishing agency. Note that this literature review does not encompass every design manual, policy, procedure and standard. The literature review includes some of the manuals policies, procedures and standards from the following agencies: MnDOT Manuals, AASHTO, FHWA, TRB, NACTO and ITE.

Minnesota Department of Transportation Manuals

MnDOT is a cabinet level agency, focusing on six core values including safety, excellence, service, integrity, accountability and diversity and inclusion. These values work to support MnDOT's mission of planning, building, operating and maintaining a safe, accessible, efficient and reliable multimodal transportation system that connects people to destinations and markets throughout the state, regionally and around the world. The "Bikeway Facility Design Manual", "Road Design Manual", "State Aid Manual" and active technical memos have been provided to a cohesive network by encouraging collaboration and efficient use of transportation resources.

American Association of State Highway and Transportation Officials

AASHTO is a nonprofit, which seeks to educate and serve as a liaison for state departments of transportation and the federal government. AASHTO seeks to educate local officials and the public on the importance transportation plays in maintaining the quality of life. "A Policy in Geometric Design on Highways and Streets" (2011) (i.e., "Green Book") provides design guidelines for highway engineers on freeways, arterials, collectors and local roadways within urban and suburban areas.

Federal Highway Administration

FHWA is an agency within the U.S. Department of Transportation, which seeks to provide assistance for the maintenance and construction of the nation's highway system. The "Flexibility in Highway Design" guidebook provides additional design guidance in addition to those provided in the "Green Book." This guidebook recognizes the uniqueness of each project and seeks to provide additional design considerations, such as safety, mobility, aesthetic, history and scenic values while preserving the natural and built environment.

Transportation Research Board

TRB was formed to conduct ongoing research programs and exchange information. TRB's mission is to promote innovation and progress in transportation through research. The "NCHRP Report 783, Evaluation of the 13 Controlling Criteria for Geometric Design" sought to define the key design elements needed for federally assisted highway construction and reconstruction projects.

National Association of City Transportation Officials

NACTO is a nonprofit, which facilitates the collaboration of transportation experiences, ideas and best practices between agencies. NACTO sees the value and coordination required for local, regional and national transportation efforts. The "Urban Bikeway Design Guide and Urban Street Design Guide" seeks to establish best practices and address key issues facing agencies.

Institute of Transportation Engineers

ITE is an international educational and scientific association, which supports the application of technology and principals to meet mobility and safety needs. ITE promotes public awareness and collaboration by encouraging ongoing education and research opportunities. "Designing Walkable Urban Thoroughfares" works to increase mobility and community cohesion through walkable design practices.

1.0 Minnesota Department of Transportation Manuals

1.1 Bikeway Facility Design Manual

Guidance - The "Bikeway Facility Design Manual" is intended to serve as a guide and tool for making bicycle transportation decisions that align with MnDOT's vision. MnDOT's vision for bicycle transportation is to create a place where bicycling (i.e., commuting and casual trips) is a safe and attractive option for every community. The manual offers guidance and direction for elected leaders, citizens, economic interests and key stakeholders to achieve a shared vision for an integrated multimodal transportation system. Decisions concerning the future bicycle transportation network should seek to maintain standards outlined within the in the manual.

Summary - The manual focuses on six key bicycle design elements (i.e., on-road bikeways; shared use paths; bridges, over/underpass, rest areas and shuttle sites; traffic control; bicycle parking; and maintenance). Each of these design elements guide engineers, planners, and other affected agencies to promote bicycle safety, mobility and efficiency. These six design elements are highlighted below.

On-Road Bikeways

The on-road bikeways chapter provides standards and regulations to be considered for bicycle lanes, paved shoulders, traffic barrier-protected shoulder, bus/bicycle lanes, shared lanes and wide outside lanes. Recommendations are also provided for developing the most appropriate design based on various geometric and operational factors. This information provides guidance for future on-road facility system needs and compatibility.

Shared Use Paths

The shared use path chapter provides guidelines for the design of facilities separated from the roadway. These facilities must be designated as "shared use" to accommodate bicycles, pedestrians, roller skaters, wheel chairs, walkers, runners and others. Standards and recommendations are provided for shared use paths located within an exclusive right of way or within a road right of way. These guidelines serve to enhance the transportation network for bicycle and non-motorized use.

Bridges, Over/Underpass, Rest Areas and Shuttle Sites

Bridges often serve as the essential linkage connecting two points. These linkages are not only essential to vehicle travel but also non-motorized travel. Each location should be evaluated on a case-by-case basis to determine where future bicycle and pedestrian demand is anticipated. Each bridge, overpass, and underpass should be evaluated and designed carefully to ensure connectivity and safety are adequately maintained. Standards and guidelines are provided for accommodating non-motorized transportation on new and existing facilities.

Traffic Control

Traffic signs, signals, pavement markings and object markings are important to ensure all motorized and non-motorized traffic move in an orderly and predictable manner. Guidelines for coordinated controls, design, materials and placement are provided to ensure the effectiveness of area traffic controls. Additional recommendations are provided for the operation and maintenance of each traffic control.

Bicycle Parking

Bicycle parking facilities are essential elements for bicycle transportation. Every bicycle trip begins and ends with the need for a safe and secure place to park one's bike. A lack of adequate and secure parking will discourage people from biking. Bicycle parking should be provided at trip origin and destination points and offer protection from theft and damage. Local zoning, licensing and permit processes may designate the types and numbers of bicycle parking required.

Maintenance

The maintenance of bikeways is closely linked to bicyclists' safety and the preservation of the bikeway function and investment. Accumulation of sand, gravel, broken glass, branches, or the development of potholes, corrugations and other rough surface conditions are all signs of poor maintenance. Poor maintenance can potentially cause bicyclists to avoid certain bikeways and choose an alternative route that may not be suitable or safe. Maintenance should be regarded as an investment in the bikeway.

1.2 Road Design Manual

Guidance – The Road Design Manual establishes uniform policies and procedures for MnDOT. The design criteria may also be applicable on the broader highway and street system within the state, yet subject to the judgment of local jurisdictions. The policy and criteria in this manual are largely adapted from the AASHTO publication, "A Policy on Geometric Design of Highways and Streets," which has been adopted as the design standard by the FHWA. This manual is not intended as a legal standard, but, it presents vital engineering information normally required in the design of a new or reconstructed facility. It must be integrated with engineering judgement and balanced with social, economic and environmental factors.

Summary – The manual focuses on five key roadway design elements (i.e., highway design standards, cross sections, pavement design, bridges and other structures, and special designs). Each of these design elements help engineers, planners and other affected agencies promote roadway safety, mobility and efficiency. These five design elements are highlighted below.

Highway Design Standards

Many factors are incorporated into the design criteria used by highway engineers. These factors are based on the physical characteristics of vehicles and topography, the psychological characteristics of drivers, the safety and operating characteristics of the traffic stream, the desire to provide a level of service acceptable to the traveling public, the desire to integrate community and environmental values, the natural and cultural characteristics of setting and context and the fiscal resources of the highway agency. Some of the key points highlighted throughout the chapters on highway design standards include design flexibility, design controls, design parameters, design standards and design procedures.

Cross Sections

Six key elements need to be considered when discussing cross sections, including: subgrade, travel lanes, shoulders and curbs, medians, roadside elements and right of way.

Lane and shoulder widths greatly impact traffic operations and safety. Cross slopes facilitate drainage. Median types are selected based on many factors, including: drainage, right of way availability, snow and ice impacts, urban or rural, type of roadway, traffic composition and one or two stage design. Roadside elements are an important part of a highway facility and can greatly affect cost and integrity. The basic elements that must be evaluated and included in the cross section are side slopes, ditches and clear zones. These elements help with safety, construction and maintenance costs, right of way impacts, drainage and drifting snow. Finally, right of way widths need to accommodate all cross section elements and any future travel lanes, sidewalks or paths. The availability and cost of right of way may dictate the width of cross section elements that are provided.

Pavement Design

Roadway design relies heavily on pavement design for the success of the roadway. Pavement design can be divided into three crucial parts: rigid pavement design, flexible pavement design and shoulder structural design.

Bridges and Other Structures

This chapter addresses the basic geometric and design requirements for bridges, retaining walls, large drainage structures and other structures referred to the MnDOT Bridge Office for design. A more detailed treatment of design requirements for bridges and other structures is contained in the "MnDOT Load and Resistance Factor Design Bridge Design Manual."

Special Designs

These are design elements that have special significance in the design process, but may not be applicable to every project. The importance of these design elements should be integrated into the design process so they become an automatic part of the project development.

Pedestrian facilities cover a wide variety of pedestrian travel including people who use walkers, wheelchairs or push strollers. Designers must develop pedestrian facilities for all pedestrians. Consideration for the following design elements must be accounted for when designing for pedestrians: walkways, walkway widths, grade and cross slopes, crossings, curb extensions and radii, grade separated crossings, on-street parking, school and work zones and pedestrian safety.

1.3 State Aid Manual

Guidance – The purpose of the "State Aid Manual" is to provide resources to local governments. The Office of State Aid for Local Transportation serves as the liaison between MnDOT and county and city engineers. The strong support of these two groups is key to the success of the state aid system.

Summary – This document outlines three main themes that highlight roadway design standards for municipal and county state aid streets and highways. These standards help guide local governments to regulate and implement safe and productive roadway design. See below for highlights to municipal state aid streets, county state aid highways and design standards.

Municipal State Aid Streets

The 1957 legislature authorized the establishment of Municipal State Aid Streets system in all Minnesota cities with a population of 5,000 or greater. Allocation of state aid money to the state aid municipalities is made on the basis of a legislative formula, as follows: 50 percent is allocated according to a needs study and50 percent is allocated based on population from the most recent U.S. Census or State Demographer's estimate.

County State Aid Highways

The 1957 legislature authorized the establishment of a County State Aid Highway system. Any change to the CSAH system must first be presented to the MnDOT district state aid engineer for review and comment, and then the request is forwarded to the MnDOT State Aid Division for preliminary approval, if appropriate. Allocation of state aid money to the counties is made on the basis of a legislative formula, as follows: 50 percent is allocated according to a needs study and 50 percent is divided according to another legislative formula, which is 10 percent equally to every county, 10 percent based on vehicle registration and 30 percent based on CSAH miles.

Project Delivery: Plans and Proposals, Design Standards

The purpose of the MnDOT's State Aid Division is to provide guidance, assistance and oversight to counties and cities for their projects. Functional services provided include the following: funding sources and financial management for projects, agency agreements, environmental, pre-design, final design, right of way, bridge and construction. These services are provided to ensure that projects are developed and built according to laws, rules, regulations and current engineering and financial practices.

Every project that uses state aid or federal aid money in the financing of the project must prepare plans while referencing the "State Aid Manual" in addition to the appropriate MnDOT manuals for guidance. Projects can be approved for construction only after suitable plans are submitted with the required documentation and are reviewed by the DSAE.

Geometric design standards, as adopted in the state aid rules, apply on state aid and federal aid construction projects. Where the state aid rules or "State Aid Manual" does not contain specific requirements for a particular roadway feature, the "MnDOT Road Design Manual" should be used.

1.4 MnDOT Active Tech Memos

Guidance – These technical memorandums are meant to serve as updates to the "MnDOT Roadway Design Guide." The design guidance contained in these technical memorandums are effective immediately for projects in the early stages of preliminary design phase, and may be incorporated into projects in a more advanced design phase at the time of implementation. Each technical memorandum has an expiration date.

Summary – For the purpose of updating the state aid roadway design standards, the two technical memorandums that were the focus of the review include the following: Technical Memorandum No. 12-12-TS-06: Shoulder Width Standards for State Highways and Technical Memorandum No.

13-18-TS-07: Traveled Lane Width Standards for State Highways. These technical memorandums are summarized below.

Technical Memorandum No. 12-12-TS-06: Shoulder Width Standards for State Highways

MnDOT shoulder width standards were reviewed in comparison to current AASHTO standards and guidance and the experiences of department staff related to successful projects where the principles of context-sensitive solutions are practiced. The new design criteria presented within this technical memorandum represents a design process change in the determination of shoulder width. Designers are given leeway in selecting the most appropriate standard because a multitude of design considerations are incorporated into any decision. Due to the flexibility these standards allow, detailed decision documentation is required. Roadway shoulders have a profound impact on overall roadway operations, safety, maintenance and multimodal users. Shoulder width selection is a key decision on any roadway and due consideration is necessary.

Technical Memorandum No. 13-18-TS-07: Traveled Lane Width Standards for State Highways

MnDOT travel lane width standards were reviewed in comparison to current AASHTO standards and guidance and the experiences of department staff related to successful projects where the principles of context-sensitive solutions are practiced. The purpose of this technical memorandum is to update the MnDOT travel lane width design criteria. This update will provide more design flexibility when selecting a traveled lane width. Lane width influences the comfort, operational characteristics and likelihood of crashes for all users of the traveled lane. Design of traveled lane width must balance operational performance with physical, contextual, environmental and economic considerations. Non-standard design values outside the recommended ranges may occasionally be necessary to realize balance and contextual fit.

2.0 American Association of State Highway and Transportation Officials Guidelines

2.1 A Policy in Geometric Design of Highways and Streets

Guidance – "A Policy on Geometric Design of Highways and Streets" provides guidance based on established practices that are supplemented by recent research. This document is also intended as a comprehensive reference manual to assist in administrative, planning and educational efforts pertaining to design.

Summary – The intent for this policy is to provide guidance to the designer by referencing a recommended range of values for design dimensions. Good highway design involves balancing safety, mobility and preservation. Flexibility in this policy is intended to encourage independent designs tailored to particular situations. This policy is not intended to be a detailed design manual that could outweigh sound principles by knowledgeable design professionals. See the additional information below regarding AASHTO standards for highway functions, design controls and criteria, elements of design, local roads and streets, and rural and urban arterials.

Highway Functions

Classifying highways into different operational systems, functional classes, or geometric types helps facilitate various classification schemes for distinct purposes in different rural and urban regions. Classification of highways into design types is the most helpful approach for highway location and design procedures. Classification by route number is the most helpful approach for traffic operations. And finally, functional classification, by character of service, was developed for transportation planning purposes.

Design Controls and Criteria

This section is about the characteristics of vehicles, pedestrians and traffic that are the criteria that optimize and improve the design of the various highway and street functional classes. It is appropriate to examine all vehicle types, establish general class groupings and select vehicles of representative sizes within each class for design use. The design of a highway and its features should consider traffic volumes, traffic characteristics and all other information jointly. Design speed and average daily traffic are fundamental parts to consider when recommending design controls and criteria. In addition to vehicle operations, pedestrians are also a key component to design controls and criteria. Interactions of pedestrians with traffic are a major consideration in highway planning and design. And the final element AASHTO highlights throughout this section is safety. Designing roadways to reduce crashes and increase safety measures helps to facilitate proper highway design.

Elements of Design

The alignment of a highway or street has a great impact on the environment, the community and the highway user. The alignment consists of a variety of design elements that combine to create a facility that serves traffic safely and efficiently, consistent with the facility's intended function. This section highlights several elements of design, such as sight distance, superelevation, width of the road, grades, horizontal and vertical alignments and other elements of geometric design.

Local Roads and Streets

A local road or street serves primarily to provide access to farms, residences, businesses, or other abutting properties. These roadways constitute a high proportion of the roadway mileage in the United States. However, because of the relatively low traffic volumes and the extensive roadway mileage, design criteria for local roads and streets are of a comparatively low priority as a matter of practicality. These roadways should be planned, located, and designed to be suitable for predictable traffic operations and should be consistent with the development and culture abutting the right-of-way.

Collector Roads and Streets

The collector street is a public highway, usually serving moderate traffic volumes. The function of a collector combines aspects of arterials and local streets so, collectors serve dual functions by collecting traffic for movement between arterial streets and local roads, and providing access to abutting properties. General design considerations outlined in this section for urban and rural collectors include: design speed, traffic volumes, level of service, alignment, grades, cross slope, superelevation, sight distance, width of roadways, number of lanes, parking lanes, medians, right of way width, curbs and bicycle/pedestrian facilities.

Rural and Urban Arterials

The principal and minor arterial road systems provide a high-volume, higher speed network for travel between major points in both rural and urban areas. This section provides the general information needed to establish the basis of basic design for arterial roadways. The design of arterials covers a broad range of roadways, from two-lane to multilane. It is the most difficult class of roadway design because of the need to provide safe and efficient operations, allow varying degrees of accessibility, serve pedestrian and bicyclists and motor vehicles, and perform effectively under sometimes unusual or constrained conditions. Much like collector roads and streets, this section highlights important design elements and design considerations for rural and urban arterials, including: design speed, traffic volumes, level of service, sight distance, alignment, grades, cross slope, superelevation, width of roadway, number of lanes and cross section and right of way.

3.0 Federal Highway Administration

3.1 Flexibility in Highway Design

Guidance – This guide illustrates the flexibility already available to designers within adopted state standards. These standards allow designers to tailor their designs to the particular situations encountered in each highway project. These standards often provide enough flexibility to achieve a design that meets the objectives of the project and recognizes the surrounding environment. These options give designers the flexibility to use their expertise and judgment in designing roads that fit into the natural and human environments, while functioning efficiently and operating safely.

Summary – This guide outlines a variety of design guidelines suitable to proper highway design. Two key chapters worth noting include the design process and the design guidelines. See below for additional information on both of these chapter elements.

The Design Process

Design is only one part in the overall highway development process and many times the design element is dictated by the previous planning stages that can limit the flexibility available for highway design. The design process helps link the planning phase with the project development phase. These are distinctly different activities, but there is considerable overlap in terms of coordination among the various disciplines involved in each of these phases.

It is important to look ahead during the planning stage and consider the potential impact that a proposed facility or improvement may have while the project is still in early stages of development. During planning, there are decisions that may affect and limit the kinds of design features in subsequent phases.

Design Guidelines

The "Flexibility in Highway Design" guide references the AASHTO "Green Book, A Policy on the Geometric Design of Highways and Streets." The "Green Book" is not a design manual. It provides guidance on the geometric dimensions of the roadway, but it does not address a number of key aspects, such as: design within the appropriate context, determination of the appropriate functional requirements (capacity and level of service), and roadside development. A number of local governments developed their own geometric guidelines to allow for expanded design flexibility on local roads.

Important factors to consider when developing design elements for a cross-section include: volume and vehicle composition, pedestrian and bicycle use, climatic conditions, natural or human-made obstructions adjacent the roadway, type and intensity of development along the highway, and safety of the users. The design for a highway improvement should have the design elements balance the needs of all users within the physical constraints of the corridor.

4.0 Transportation Research Board

4.1 National Cooperative Highway Research Program Report 783, Evaluation of the 13 Controlling Criteria for Geometric Design

Guidance – This report describes the impact of the controlling roadway design criteria on safety and operations for urban and rural roads. This information will be useful to geometric designers and those responsible for reviewing designs.

Summary – In 1985, the FHWA designated 13 specific design elements as controlling criteria for roadway design. Highway construction and reconstruction projects that receive federal assistance must meet the established design criteria for these elements, or a formal design exception must be prepared and approved. These design criteria elements include the following:

- Design Speed
- Lane Width
- Shoulder Width
- Bridge Width
- Structural Capacity
- Horizontal Alignment
- Vertical Alignment
- Grade
- Stopping Sight Distance
- Cross Slope
- Superelevation
- Vertical Clearance
- Horizontal Clearance

Design Criteria, Traffic Operational and Safety Effects, and Mitigation Strategies for 13 Controlling Criteria

Design criteria are based primarily on the 2004 and 2011 editions of the AASHTO "Green Book," unless otherwise noted. Below is a brief summary of each of the 13 controlling criteria elements.

Design Speed – This element is unique in the fact that it has no direct effect on the design of the roadway, but instead only influences the values and ranges of other controlling criteria. Design speeds should reflect the speeds that drivers expect to travel.

Lane Width – This element determines the area where a vehicle can maneuver without encroaching into the path of another vehicle or shoulder. According to AASHTO, lane width recommendations vary between 9 to 12 feet depending on the functional classification of the given roadway.

Shoulder Width – This element affects capacity and safety on roadways. Shoulders can reduce the likelihood of crashes in several ways, including: providing a location for emergency stops, a space for drivers to make steering corrections and a space for evasive maneuvers. In addition to enforcement and maintenance activities and bicycle accommodations. AASHTO shoulder width recommendations vary between 1 and 12 feet depending on the functional classification of the given roadway.

Bridge Width – This element combines the total width of all lanes and shoulders on a bridge. Bridge width standards are met when a bridge is designed to maintain the minimum acceptable lane and shoulder width for the design condition's functional class, design speed and traffic volume.

Structural Capacity – This element has no effect on traffic operations, and its effect on safety is only related to the probability of a structural failure.

Horizontal Alignment – This element involves design of the horizontal curves along a roadway section. AASHTO recommends minimum curve radius based on design speed, but there are many possible recommendations as outlined in the "Green Book" Table 3-7.

Vertical Alignment – This element generally consists of two conditions, grades and vertical curves. Two types of vertical curves that each has their own recommendations are crest and sag vertical curves.

Grade – This element outlines the rate of change between vertical elevations along a roadway. The controlling criterion for grade includes maximum and minimum grades based on roadway types and functional classes.

Stopping Site Distance – This element is defined as the distance required for a driver to perceive or recognize a need to stop, react to that perception and then decelerate to a stop. Horizontal and vertical curves limit available sight distance for drivers, requiring a careful analysis of stopping sight distance during the design process.

Cross Slope – This element addresses the traverse slope of the pavement surface on tangent sections. This criterion is important because cross slope facilitates runoff of water from rain, snow, or ice from the pavement surface. In general the more cross slope a roadway has the more efficiently water flows to the edge. Flat cross slopes can lead to water ponding on the lanes.

Superelevation – This element is determined by equations provided in the "Green Book" to assess the appropriate superelevation rate for specific horizontal curves based on the design speed, curve radius and assumed maximum values of superelevation rate and friction demand.

Vertical Clearance – This element, in general, does not affect operations on the roadway other than for those vehicles that are taller than the available vertical clearance. Alternative routes must be used, which may increase travel time. Recommended vertical clearance is between 14 and 17 feet based on roadway type and location.

Horizontal Clearance – This element is referred to as the lateral offset in the AASHTO 2011 "Green Book". This deals with the distance from the edge of the traveled way to a vertical roadside element or obstruction. The 2004 "Green Book" recommends a 1.5 foot lateral offset while the 2011 edition says to reference the AASHTO "Roadside Design Guide."

4.2 Relationship of Lane Width to Safety for Urban and Suburban Arterials

Summary – This research investigates the relationship between lane width, safety for roadway segments and intersection approaches on urban and suburban arterials. Conclusions from the research are that use of lanes narrower than 12 feet on urban and suburban arterials generally does not increase crash frequencies and geometric design policies should provide flexibility for use of lane widths narrower than 12 feet. Additional information on the conclusions and recommendations from this research is outlined below.

Conclusions and Recommendations

Safety evaluations of lane widths for arterial roadway segments found no indication, except in limited cases, that the use of narrower lanes increases crash frequencies. It was found that crash frequency was higher for 10 foot lanes than for 11 and 12 foot lanes on four-lane undivided arterials and was higher for 10 foot lanes on four-lane divided arterials. These findings support the AASHTO "Green Book" recommendation of providing flexibility for use of lane widths narrower than 12 feet on urban and suburban arterials.

The potential benefits of using narrower lanes are shorter pedestrian crossing distances, space for additional through lanes, auxiliary and turning lanes, bicycle lanes, buffer areas between travel lanes and sidewalks and placement of roadside hardware.

5.0 National Association of City Transportation Officials

5.1 Urban Bikeway Design Guide

Guidance – The purpose of this guide is to provide cities with best practice solutions that can help create complete streets that are safe and enjoyable for bicyclists. To create the guide, the authors have conducted an extensive worldwide literature search from design guidelines and real life experience.

Summary – This guide outlines the following three levels of guidance: required (elements for which there is a strong consensus that the treatment cannot be implemented without), recommended (elements for which there is a strong consensus of added value), and optional (elements that vary across cities and may add value depending on the situation). It should also be noted that many urban situations are complex and treatments must be tailored to the individual situation.

Bike Lanes

According to the "Urban Bikeway Design Guide," a bike lane is defined as a portion of the roadway designated by striping, signage and pavement markings for the preferential or exclusive use of bicyclists. The creation of a bike lane requires a thorough consideration of existing traffic levels and behaviors, adequate safety buffers to protect bicyclists from parking and moving vehicles, and enforcement to prohibit motorized vehicle encroachment and double parking. These facilities may be distinguished using color, lane markings, signage and intersection treatments.

Cycle Tracks

According to the "Urban Bikeway Design Guide," a cycle track is defined as an exclusive bike facility that combines the user experience of a separated path with the on-street infrastructure of a conventional bike lane. A cycle track is physically separated from motor traffic and distinct from the sidewalk. By separating cyclists from motor traffic, cycle tracks can offer a higher level of security than bike lanes and are attractive to a wider spectrum of the public.

Intersection Treatments

Incorporating design elements for intersections with bicycle facilities should reduce conflicts between bicyclists, pedestrians and vehicles by heightening the level of visibility, marking a clear right of way, and facilitating eye contact and awareness with competing modes. The configuration of the intersection treatments can include: color, signage, medians, signal detection and pavement markings.

Bicycle Signals

These elements help to facilitate bicyclists' crossings of roadways. Bicycle signals clarify when to enter an intersection by restricting conflicting vehicle movements. Factors to consider when implementing a bicycle signal are speed limits, average daily traffic, anticipated bicycle crossing traffic and the configuration of planned or existing bicycle facilities.

Bikeway Signing & Marking

According to the "Urban Bikeway Design Guide," bikeway signing and marking is any treatment, such as pavement markings, or a piece of infrastructure, such as a sign, whose primary purpose is to indicate the presence of a bicycle facility or to distinguish that facility for bicyclists, motorists and pedestrians. When adding bikeway signing or markings, the goal is generally to achieve a high level of visibility and instant identification. Motorist and bicyclist movements are taken into account in relation to the marking placement.

Bicycle Boulevards

Bicycle boulevards are streets with low motorized traffic volumes and speeds and designated to give bicycle travel priority. These measures outline the feasibility of designing a successful bicycle boulevard that can include: route planning, signs and pavement markings, speed management, volume management, minor street crossings, major street crossings, offset crossings and green infrastructure.

5.2 Urban Street Design Guide

Guidance – The "Urban Street Design Guide" outlines the principles and practices of the nation's leading engineers, planners and designers working in cities today.

Summary – According to the "Urban Street Design Guide" this guide serves as a blueprint for designing 21st century streets and reveals the tools and tactics cities use to make streets safer, more livable and more economically vibrant.

Streets

Streets account for more than 80 percent of all public space in cities and have the potential to accommodate business activity, serve as a front yard for residents, and provide a safe place for people to get around using all kinds of transportation modes (i.e. foot, bicycle, car, or transit).

Street Design Elements

This section outlines the various elements that make a street a beneficial place for all transportation modes. These elements include lane width, sidewalks, curb extensions, vertical speed control elements, transit streets and stormwater management.

Interim Design Strategies

These design strategies are tools and tactics that cities use to improve their roadways and public spaces in the near-term. The strategies include low-cost, interim materials, new public amenities and creative partnerships with local stakeholders. Some examples of interim design strategies include moving the curb, temporary street closures and interim public plazas.

Intersections

Well-designed intersections use street space to bring people together while making traffic more intuitive, seamless and predictable for all users. This section of the guide outlines intersection design principles for major and minor intersections including raised intersections, mini roundabouts and complex intersections.

Intersection Design Elements

This section investigates each intersection design element as it relates to goals for safety, mobility, and more vibrant, accessible public spaces. Intersections are a very important element of street design, because they are the point where all transportation modes and movements come together. Successful intersection design incorporates these elements: crosswalks and crossings, corner radii and traffic signals.

Design Controls

This section is characterized by the difference between passive and proactive design. For many years street design took a passive approach. The passive approach in street design promoted high speeds because of the use of overdesigned buffers, clear zones and setbacks. A proactive approach to street design creates streets using physical and environmental cues to guide user behavior. Design control elements include design speed, design vehicle, design hour, design year, performance measures and functional classification.

6.0 Institute of Transportation Engineers

6.1 Designing Walkable Urban Thoroughfares: A Context Sensitive Approach

Guidance – The "Designing Walkable Urban Thoroughfares" report provides guidance for the design of walkable urban corridors. The guidance can be used for communities that have some walking infrastructure and communities that want to provide the infrastructure in the future.

Summary – This report was developed in response to widespread interest in improving mobility choices and community character through a commitment to creating and enhancing walkable communities. This report is also intended to facilitate the restoration of the complex multiple functions of urban streets.

Planning

This section of the report provides an overview of the transportation planning and project development process and how context sensitive solutions are applied within these processes. There is also an overview of thoroughfare network types, characteristics of successful networks, network design guidelines, an overview of the corridor planning process and the role of context sensitive solutions. Finally, this section is an introduction into the design framework. The design framework for context sensitive thoroughfare design includes: context zones, their characteristics, the features that create context, a description of thoroughfare types, the relationships with functional classifications, compatibility with context zones and general design parameters.

Design

The thoroughfare design process uses this report to design thoroughfares that are within constrained rights of way and thoroughfares with flexibility in the application of design criteria. The section on design controls outlines the engineering controls and level of flexibility critical in context sensitive design, including design vehicle, roadway geometrics and design speed. The final section of the design chapter guides general principles, design considerations, and detailed guidance about the elements that comprise the streetside, traveled way and multimodal intersections.

7.0 Minnesota Local Road Research Boards

7.1 Implications of Modifying State Aid Standards: Urban Construction or Reconstruction to Accommodate Various Roadway Users

Guidance – This research focuses on developing guidance for design decisions to best balance the competing needs and accommodate all expected roadway users. The study primarily focused on evaluating changes in safety and operations between the periods before and after implementation of complete streets and design elements for multimodal corridors.

Summary – To accommodate a variety of users, context-sensitive solutions are used when a design call for sharing of right of way by multiple user groups with different and often competing demands.

Non-standard design solutions, often associated with complete streets, were investigated in two major contexts. The first involves a comprehensive review of the current practice in design standards, complete streets and legislation in Minnesota and nationally. Second, a detailed analysis of 11 'complete street' study sites was conducted. Research suggests that changes made to the 11 study sites did not result in adverse safety or operational impacts. The changes helped provide flexibility and modification to the state aid design standards in the context of complete streets and conditions specified in this research appears to be a reasonable consideration.

Summary and Conclusions

The differences in the characteristics of the study sites and varying degrees of changes and improvements used at each specific location created difficulties in quantifying the implications of complete street improvements in an aggregate manner. Even though some sites had similar characteristics in terms of lanes, functional classification, traffic volume, etc., other differences in the type of surrounding area, roadside environment and construction improvements made direct comparison difficult. Identifying distinct criteria (e.g. traffic volume and functional classification) to provide guidance for future candidate locations for complete street improvements is not possible.

Overall, the complete street improvements implemented at the study sites did not create any significant safety issues after reconstruction, and in general, safety was improved. The results seem to suggest that flexibility in state aid design standards, in the context of complete streets, did not lead to adverse outcomes. Although qualitative analysis of traffic operations was not possible, primarily due to data limitations, anecdotal review of each study site and comments from local officials suggest that no significant operational impacts were experienced with any of the projects evaluated.

8.0 Florida Department of Transportation – Transit Office

8.1 Integrating Transit into Traditional Neighborhood Design Policies – The Influence of Lane Width on Bus Safety

Guidance – This project was initiated by the Transit Office of the Florida Department of Transportation to determine the influence of lane width on the overall safety of transit vehicles.

Summary – The research employed five methods to investigate whether there is a significant relationship between lane widths and bus vehicle safety. The five methods employed were:

- Questionnaire Survey
- Statewide Bus Crash Analysis
- Transit Agencies Incident Reporting Analysis
- Field Observational Study
- Physical Constraints Analysis

All five study methods consistently suggest a strong relationship between lane width and bus vehicle safety. The results suggest that the narrower the lane width, the higher the likelihood of having bus sideswipe and mirror crashes. The results also indicate that narrow lane width, especially lane widths of 10 feet and narrower are over-represented in the occurrences of bus sideswipe crashes. Based on the results of this study, it is recommended that 12-foot wide lanes be provided, when possible, for roadways located on transit routes.

Conclusions and Recommendations

The results from each of the five research methods employed are summarized below.

Questionnaire Survey – This survey revealed that most bus collisions occur on roadways with lane widths of 11 feet or less.

Statewide Bus Crash Analysis – Nine out of 10 segments in the list of the top 10 segments with the highest frequency of sideswipe crashes had lane widths ranging from 9 to 11 feet. Seven out of 10 were found to be 10 feet wide or narrower.

Transit Agencies Incident Reporting Analysis – The average width of the roadways that had sideswipe and mirror collisions was found to be 10.55 feet. The results strongly suggest that sideswipe and mirror crashes occur predominantly on narrow roadways.

Field Observational Study – The field observational study found that narrower lanes make it difficult for bus drivers attempting these maneuvers: to position their vehicle completely within the lane, to maintain their lanes when maneuvering tight horizontal curves on narrow lanes, to perform the passing maneuver between two opposing buses on 10-foot, two-way, two-lane roadways, and to perform right turning maneuvers onto a street with narrower lanes without encroaching an adjacent lane.

Physical Constraints Analysis – This analysis assumed that streets will be designed using complete streets design principles. There were two main requirements considered: adhering to a 3-foot clearance for bicyclists, and maintaining the bus, including its mirrors, in the same lane without encroaching into the adjacent lane. The results of this analysis indicate that a minimum of 11.25 feet and 11.75 feet for outside lanes is required for curbed roadways and roadways without curb and gutter, respectively, to meet these requirements. However, a 12-foot wide outside lane is recommended for all bus routes.