Chapter 3

DESIGN CONSIDERATIONS AND CRITERIA

Introduction

The objective of highway design is to provide a safe, efficient, economical and environmentally sensitive highway system. When good judgment and application of design considerations and design criteria are adopted, the planned level of service is reached.

This chapter explains general guidelines and those elements of highway design which must be addressed to ensure that highway facilities safely accommodate current and projected traffic volumes. These guidelines are divided into the two broad categories of general requirements and geometric requirements. General requirements are based on functional classification and relate to features of the cross section that influence safety, level of service, comfort, and convenience. Geometric requirements are a function of the design speed and relate to features of the alignment that are controlled by the operating characteristics of motor vehicles and physical limitations of drivers.

In this and subsequent chapters, references are made to guidelines, criteria, design controls, and design elements. In this manual, the meanings of these terms are:

- Guidelines — procedures for design adopted by the NHDOT and the way they are implemented,
- Criteria — standards which influence design,
- Design Controls — constraints affecting the application of guidelines or criteria, and,
- Design Elements — identifiable segments of the design objective.

Considerations

The principal design considerations are safety, environmental sensitivity, economy, constructability, future maintenance, and consistency with the highway's function within the overall system.

<u>**Safety**</u>

Safety is the principal design consideration. All designs have maximum safety as their primary objective.

Emphasis on safety has also come from Congress, of the United States with passage of the Highway Safety Act of 1966 and continuing to current federal transportation funding legislation, from the Federal Highway Administration (FHWA) by their endorsement of the AASHTO *A Policy on Geometric Design of Highways and Streets* "Green Book" (1), *Roadside Design Guide* (2), *The Highway Safety Manual* (20) and from State and municipal government.

In addition to highway design, consistency is an important safety consideration. High traffic volumes and operating speeds require quick driver response. Driver expectancy is a term that relates the driver's anticipation to reaction time. If designs are consistent, there are no surprises to overload the driver's thought process, which may cause a crash. Reinforced expectancies help drivers respond quickly and correctly. Unusual situations that violate expectancies may cause longer response times, inappropriate responses, or errors of judgment.

Most design features are sufficiently similar, to create expectancies related to common geometric, operational, and route characteristics. For example, because most freeway interchanges have right-hand exits, drivers generally expect to exit to the right. This aids performance by enabling quick and correct responses when right exits are to be negotiated. There are, however, instances where expectancies are violated. For example, if an exit is on the left, then the right-hand exit expectancy is incorrect, and the decision sight distance may need to be lengthened to compensate for the additional reaction time.

Environmental Sensitivity

All highway improvement projects should strive to have no net impact upon their environment. The design should first seek to avoid impacts to natural or cultural resources. Unavoidable impacts should be minimized to the extent possible and mitigated when required to compensate for the impacts. The designer should work closely with the Environmental Manager assigned to the project. The Environmental Manager will gather information on the presence and sensitivity of natural and cultural resources within the project area and facilitate reviews with the appropriate State and Federal agencies.

The design of highway improvement projects and the evaluation of the resultant impacts on environmental resources, both natural and cultural, are subject to the requirements of numerous Federal and State laws. Some of the more prominent regulations include the following:

- National Environmental Policy Act (NEPA): A national policy established to promote the equal weight of environmental factors when compared with other design considerations for federally funded projects. Compliance with the NEPA guidelines is overseen by the Lead Federal Agency.
- Section 4(f) of the Department of Transportation Act: A special provision of the Act which stipulates that all USDOT agencies (e.g., FHWA, FAA, FRA, FTA, etc.) cannot approve the use of land from publicly owned parks, recreational areas, wildlife and waterfowl refuges, or public and private historical sites unless there is no feasible and prudent alternative and all impacts to the property are minimized. Compliance with the Section 4(f) guidelines is overseen by FHWA.
- Section 106 of the National Historic Preservation Act: A requirement that Federal agencies must consider the effects of projects on historic properties. Project review may include consulting parties and is overseen by the NH Division of Historical Resources (NHDHR).
- Sections 401 and 404 of the Clean Water Act: Section 401 requires an applicant for a federal license or permit to certify that any discharges will comply with the act, including water quality standards. Water quality permits are administered by the New Hampshire Department of Environmental Services (NHDES). Section 404 regulates the discharge of dredge and fill material into surface waters such as rivers, lakes, streams, and most wetlands. Permits for these activities are issued by the US Army Corps of Engineers (ACOE).

- Section 6(f) of the Land and Water Conservation Fund Act: Conversion of public recreational lands or facilities acquired with Land and Water Conservation Act funds must be coordinated with the US Department of the Interior.

Economy

An economical design meets all of the necessary objectives while minimizing costs. Consideration must be given to the initial engineering, right-of-way, environmental mitigation, and construction costs as well as the future maintenance expenses of a roadway design. A true assessment of the design benefits relative to public safety and the effects on regional economies will support the need for each project. A well-documented cost/benefit analysis will help identify a preferred alternative, assist in the environmental assessment process, and explain the decision process to the public.

Constructability

A designer must carefully consider the practical requirements and limitations of construction methods and materials. Key items to review include the following:

- Traffic control during construction must be taken into account early in the design process. For example, a temporary construction easement may be required for temporary road widening in order to maintain two-way traffic. All projects require a review by the Traffic Control Committee to determine project significance and to determine what level of Traffic Management Plan (TMP) is required.
- Care must be exercised to provide appropriate working space for the staging and operation of necessary equipment and required construction techniques. Alternatively, other methods may be investigated to achieve the same results in more confined spaces. Constrained construction areas will often increase both the cost of the project and the time needed to complete the work.
- Plans must be clear to avoid misrepresentation or misinterpretation.
- Sufficient information must be shown for the design to be constructed as intended.
- Small quantity bid items should be avoided when possible. Combine similar small-quantity items into a single item that will satisfy the requirements of both when appropriate.
- Cross-check the plans, sections, estimate, and proposal to avoid conflicting information.
- Coordinate with the District Construction Engineer to resolve specific construction related design issues.
- Coordinate with the District Engineer to identify any known issues.

Designers should become familiar with construction practices and use the *Standard Specifications for Road and Bridge Construction* (3) as a design reference.

Most roadway construction may be categorized as follows:

- Relocation: Construction of a new highway facility on new location. All facets of the guidelines shall be applicable with few exceptions. Projects of this nature generally have enough design latitude to avoid the need to compromise design standards.
- Reconstruction: Rebuilding an existing highway to higher design standards with a substantial portion of the existing facility replaced or expanded. This category includes all projects that provide for an increase in the number of traffic lanes. All facets of the design guidelines shall be applicable and deviations will be approved only if they substantially reduce costs or impacts without compromising safety.
- Rehabilitation: The improvement of an existing highway by retaining a major portion of it while correcting structural and functional deficiencies to bring most elements of the roadway and structure cross sections into conformance with the guidelines. All facets of the design guidelines shall be applicable except that substandard horizontal and vertical alignments may be retained if they do not compromise safety. Projects to provide truck climbing lanes are included in this category.
- Resurfacing: A preventative maintenance technique to extend the service of life of the existing pavement. Typically includes pavement inlay, leveling, and/or overlay, and occasional shoulder improvements. The design intent is to keep a highway open to traffic with a serviceable riding surface while avoiding the extensive work and cost associated with rehabilitation or reconstruction. This category of construction does not normally include pavement widening. The overlay may be placed over a continuous segment of roadway or intermittently as required by the condition of the existing pavement. The design guidelines are applicable to this type of construction as guides to aid in correcting deficiencies. When such corrections are necessary, the proposed improvements should comply with design guidelines and be consistent with the nature of the remainder of the roadway.

In addition to the above categories, there are many special projects that are constructed to fill specific needs including pedestrian and bicycle facilities, park and ride facilities, bridges and culverts, traffic signals, street lighting, signing, and landscaping.

No set of guidelines, however comprehensive, can replace sound engineering judgment and experience. Each construction project must be considered individually with respect to the factors controlling its design, as well as collectively with other projects comprising the overall improvement.

Future Maintenance

After a project has been completed, maintenance responsibilities of the Department begin immediately upon acceptance of the work. Insufficient or inappropriate design can lead to increased maintenance efforts or additional construction work to correct the design flaw. Early coordination with the District Engineer and maintenance foreman regarding the existing conditions and proposed improvements is essential to a successful project.

Problems arise from drifting snow created by highway appurtenances, inadequate snow storage, insufficient width for efficient snow removal, obstructions to snowplows, and inadequate measures to address snow melt on the roadway. Drifting snow will typically occur where the roadside area is higher than the road and has no obstructions to block the wind. Roadway cuts in open areas should be avoided if possible; otherwise properly located landscape screening or fencing can help reduce the amount of drifting snow.

Snow banks may melt during the day then refreeze on the road at night and cause icing problems. Shoulders on the outside of superelevated curves should be properly graded to prevent the melt water from flowing across the roadway. Snow storage on and adjacent to bridges should be carefully evaluated because bridge decks freeze before roadway pavement surfaces. Some roadway elements including curbs, signposts, mailboxes, guardrail, and other such appurtenances can make plowing more difficult. Such obstructions should be kept as far from the edge of pavement as practicable to allow adequate space for snow plowing and storage, as well as snow removal in urban areas.

Raised median islands should also be designed, where practicable, to contain or divert snowmelt and prevent water from flowing onto the roadway. (Refer to Sample Layouts in Volume 2.)

Proposed rights-of-way and easements should be provided to permit future routine maintenance operations, such as for drainage facilities and tree clearing, and should also provide reasonable access to the maintenance location if it is not directly accessible from the roadway (e.g. drainage structures behind guardrail). (This issue is further discussed in Chapter 10, "Right-of-Way.")

Highway Function

The relationship of function to administrative or legal classification is more fully explained in Chapter 2 but, for purposes of design, there are four main highway functional classifications:

- Local Roads and Streets — primarily serve as access to residences, businesses or other abutting properties. Also included are Special Purpose Roads, including recreational roads, resource development roads, and local service roads.
- Collector Roads and Streets (Rural and Urban) — collect traffic between local roads and arterial streets and provide access to abutting properties.
- Arterials (Rural and Urban) — provide a high speed, high volume network for travel.
- Freeways (Interstates and Turnpikes) — are not a functional class by themselves but rather are a subset of principal arterials and are defined as limited access expressways. Freeways are considered separately because of their unique design.

The "Green Book" has specific information and design criteria pertaining to each classification. It is the intent of this Manual to emphasize the more common design guidelines and provide reference to the "Green Book".

Designs vary between urban and rural highways and between highways with different functions. Rural highways are characterized by high-speed, low-density traffic with shoulders and open drainage channels as elements of the design. Urban highways are differentiated by having relatively low-speed, high-density traffic with curbs and underground drainage.

The distinction between rural and urban highways is quite clear when comparing a highway in open farmland to one in a business district. The difference is not quite so apparent, however, when a two-lane highway passes through the center of a relatively small community or a divided highway traverses the suburbs of a metropolitan area. For the purpose of applying the design guidelines, highways shall be considered as urban where it is desirable or necessary to construct or reconstruct an urban cross section.

Criteria

Recommended design values for critical dimensions are typically presented within a range of numbers and/or with a minimum threshold to meet or exceed. Design criteria should be selected with a balance of safety, mobility, and economic constraints along with consideration for environmental and right-of-way impacts. Flexibility in design may vary by project based on the roadway function and location. For example, it may be acceptable to retain substandard design elements on a roadway where there is no indication that the conditions have led to safety deficiencies. See Design Exception discussion on page 3-8.

Criteria are disseminated through publications, directives, or sometimes by verbal instructions. The basic design criteria used on a project are recorded as “Design Data” and indicated on the front sheet of most highway construction plans. The Design Report is prepared as the design progresses summarizing all major design criteria, decisions and assumptions. A Design Report template can be found on the Departments website.

Design Data

The design data table summarizes the general conditions and controls for a project and is shown in the upper right area of the front sheet of the plans usually in the format indicated in Figure 3-1.

Figure 3-1
DESIGN DATA

Roadway Classification	________________________	
Average Annual Daily Traffic (Year)______		(the year of construction)
Average Annual Daily Traffic (Year)______		(the projected year, normally 20 years)
Percent of Trucks	________	percent trucks in ADT
Design Speed	________	mi/hr
Length of Project	________	miles or feet

Guide Publications

In addition to this Manual, the NHDOT publishes several references frequently used in the design process. All published materials are available from the Department’s website.

- *Standard Specifications for Road and Bridge Construction* (7),
- *Manual on Drainage Design for Highways* (“Drainage Manual”) (4),
- *Policy for the Permitting Of Driveways and Other Accesses to the State Highway System* (the “Driveway Manual”) (5),

- *Utility Accommodation Manual* (6),
- *New Hampshire Statewide Bicycle and Pedestrian Plan* (7).
- *Positive Protection Guidance for Work Zones* (8)
- *Guidelines for Implementation of the Work Zone Safety and Mobility Policy* (9)

The FHWA *Federal-Aid Policy Guide* (10) contains FHWA policies affecting the NHDOT. The guide is online at https://www.fhwa.dot.gov/legsregs/directives/fapgtoc.htm.

An important FHWA publication which designers should be familiar with is the *Manual on Uniform Traffic Control Devices* (MUTCD) (11). This document includes standards for signs, pavement markings, traffic signals, and work zone traffic control, is online at https://mutcd.fhwa.dot.gov/.

The American Association of State Highway and Transportation Officials (AASHTO) produces numerous reference materials endorsed by both the NHDOT and the FHWA. The NHDOT closely follows the criteria provided by the AASHTO series, primarily the "Green Book" and the *Roadside Design Guide*. In some cases, the NHDOT criteria are higher than those suggested by AASHTO and will govern design. The FHWA publication *Flexibility in Highway Design* (12) provides guidance for design criteria adjustments to reduce costs, impacts, and construction delays without lowering safety standards

The National Cooperative Highway Research Program (NCHRP) Reports and other Transportation Research Board (TRB) reports cover the field of highway and traffic engineering, most notably the TRB *Highway Capacity Manual (6th Edition) – A Guide for Multimodal Mobility Analysis*, (13). The *NCHRP Report 672 – Roundabouts: An Informational Guide, Second Edition* (14) expands on the original FHWA first edition and provides an excellent resource for planning and designing roundabouts. Many of these publications are available in the Highway Design reference library or online.

Suppliers, manufacturers, and trade associations also distribute books, pamphlets, and sales information helpful to designers. Manufacturers of patented retaining walls, gabions, slope stabilizing products, drainage pipe and structures, and other proprietary applications employ sales engineers who can be helpful in developing designs that incorporate their product. Note that on all projects with proprietary items the Department requires Director approval for them to be used. See Chapter 13 for more information.

Finally, completed projects are an important reference to consult when seeking solutions to commonly encountered design situations. As-built or proposed construction plans may be accessed through the Records Section or from the Department's Project Viewer website.

Design Exceptions

Designers must balance all aspects of a roadway project with due consideration for safety, mobility, economic constraints, right-of-way, and environmental impacts. When a design cannot achieve this balance under strict adherence to the design criteria, there may be appropriate solutions that will permit the application of lower design values without affecting safety or operations. Design exceptions should be used as a last resort and will require the Assistant Commissioner's approval (and FHWA approval on Federal oversight projects).

The FHWA has identified *10 controlling criteria* (23 CFR 625.3) directly related to roadway operations and safety that should be given special consideration for all design decisions. The 10 criteria include:

1. Design speed (*);
2. Lane width;
3. Shoulder width;
4. Horizontal curve radius;
5. Superelevation rate;
6. Stopping sight distance (SSD);
7. Maximum grade;
8. Cross slope;
9. Vertical clearance; and
10. Design loading structural capacity (*).

Roadways on the National Highway System (NHS) that are Interstate highways, Freeways, or roadways with design speed ≥ 50 mph: All 10 controlling criteria apply. The SSD criterion applies to horizontal alignments and vertical alignments except for sag vertical curves.

Roadways on the NHS that are Non-freeways and Non-Interstates with design speed < 50 mph: On low-speed roadways*, only the design speed and design loading structural capacity controlling criteria apply (*).*

Deviations from Controlling Criteria on NHS roadways that require a design exception: Design exceptions on Federally exempt projects are reviewed and approved by the Assistant Commissioner. Design exceptions on Federal oversight Projects require approval from the Assistant Commissioner and from FHWA.

Deviations from other design criteria in the AASHTO Green Book, The Roadside Design Guide, or other standards the Department has adopted <u>or deviations from the controlling criteria on non-NHS roads</u>, do not require formal design exceptions but should be thoroughly documented, typically in the project's Design Report.

Design exception documentation should include the following information:

1. Specific design criteria that will not be met.
2. Existing roadway characteristics.
3. Alternatives considered.
4. Comparison of the safety and operational performance of the roadway and other impacts such as right-of-way, community, environmental, cost, and usability by all modes of transportation.
5. Proposed mitigation measures.
6. Compatibility with adjacent sections of roadway.

Two informative FHWA resources that should be consulted when evaluating design exceptions include *Flexibility in Design (12)* and *Mitigation Strategies for Design Exceptions.* Both are available on-line.

Design exceptions will be prepared by the lead designer (typically a CE IV or CE V) and reviewed for submission by the Section Chief. The Design exception Document will then be routed for signature in the following order:

- Geometrics SME
- Administrator of Highway Design & (Bridge Design for design criteria 10)
- Chief Project Manager or Project Manager
- Director of Project Development
- Assistant Commissioner

If the project is exempt from FHWA oversight then the signed document will be filed as a PDF in the project folder and on the Global drive in the Design Exception folder. The design exception is also sent to FHWA for their records.

If the project has FHWA oversight, internal filing remains the same but FHWA will need to approve the design exception and therefore a letter will need to be prepared to request this action.

Example of a design exception request is provided in Appendix 3-1.

Additionally, a design exception is required for any guardrail terminal unit that does not meet the requirements of The Manual for Assessing Safety Hardware (MASH). This process and a sample design exception can be found in Appendix 3-3.

All design exceptions shall be noted in the Front Office Project Information Sheet (FOPIS)

Basic Factors Influencing Design

Design is based on a number of factors, including the following:

- Traffic volumes
- Design elements
- Expected operating speed
- Highway capacity
- Highway system
- Access control
- Non-motorist usage
- Utility involvement
- Environmental considerations

The predominant factors of traffic volume, design elements, and environmental considerations are further explained.

Traffic Volume

Most of the criteria defining the geometric characteristics of highway cross section elements are related to traffic volumes and the highway functional class. Geometric criteria adopted for use are illustrated in Volume 2.

Design Elements

Traveled Lanes

The required number of lanes depends primarily on traffic volume and the design level of service. Usually, the number of lanes will be determined during the preliminary design phase. Designers will also determine whether auxiliary lanes are warranted.

The traveled way designated for vehicle operation (excluding shoulders) normally consists of two or more paved traffic lanes. The lane width depends primarily on traffic volumes and ranges from 10’ for minor local roads to 12’ for most major highways.

Shoulders

A shoulder is the portion of the roadway contiguous with the traveled way for accommodation of disabled vehicles, for emergency use, and for bypassing left turning vehicles, and is an important element of roadway safety. Shoulders accommodate bicycles and pedestrians in the absence of dedicated facilities. Shoulders also provide lateral support for the base course and pavement thus reducing deterioration of the edge of the traveled way.

Shoulder widths typically range from 4’ to 12’ on major facilities and may be less on minor local roads. The *Green Book* is typically referenced for minimum shoulder widths a starting point for the design. Typically a 5’ paved shoulder is the minimum when guardrail or curbing is present at the edge of pavement. All shoulders shall be paved unless otherwise approved.

On divided highways the median shoulder is typically 4’ and the right shoulder is 10’. On divided highways with six or more travel lanes, median shoulder width should be increased from 4’ to 10’. On divided highways with roadside barriers or where the directional design hourly volume for trucks exceeds 250, the shoulder width should be increased to 12’.

Medians on rural highways divide opposing traffic, reduce headlight glare from oncoming traffic, and assure safe operation of vehicles at intersections.

Median width is defined as the distance between the edges of the traveled ways of the separated roadways. The minimum desirable median width without a median barrier on rural multi-lane State highways is 50’. A greater separation of 90’ is desirable where independent grade lines are used for each roadway.

The median width of State and other controlled access multi-lane highways may be less than the above dimensions if a median barrier is used. The minimum median width for a four-lane facility is 14’ allowing for two 6’ shoulders and a 2’ barrier. For facilities with more than four travel lanes, the minimum median width is 26’ and consists of two 12’ shoulders and a 2’ barrier. Median widths on four-lane highways in urban areas with severe right-of-way constraints can be narrowed to 10’ including two 2’ shoulders and a 6’ curbed island with barrier. Any median barrier will impede wildlife crossings and impose maintenance and safety concerns, therefore, medians of sufficient width not requiring barrier are preferable.

Vertical Clearance

Vertical clearance is the minimum distance measured from overhead structures to the finished roadway surface or highest rail of a railroad crossing. The appropriate minimum clearance must be provided over the entire usable roadway width including shoulders. Figure 3-2 shows the established minimum vertical clearances with an additional 6" for consideration of future overlays. The designer shall coordinate with the Chief of Design Services to verify required clearances for all grade-separated railroad crossings.

Clearances must be shown on all profiles, both preliminary and final.

Requests for vertical clearance design exceptions on the Interstate System must be coordinated with the FHWA and the Surface Deployment and Distribution Command Transportation Engineering Agency (SDDCTEA). The SDDCTEA works with the Department of Defense (DOD) to improve the deployability of the U.S. armed forces and the transportability of military equipment. The SDDCTEA administers the Highways for National Defense (HND) program which included the development and update s to the Strategic Highway Corridor Network (STRAHNET). This program ensures our nation's public highway system serves the needs of military forces. see Appendix 3-2 for a process to follow and a map of the STRAHNET roads in NH.

Recommended Minimum Vertical Clearance

Roadway Functional Classification:

Interstate/Freeway

Rural: 16'-6"

Urban: 16'-6" *

* In highly developed urban areas, where attaining a 16'-6" clearance would be unreasonably costly, a minimum clearance of 14'-6" may be used if there is a freeway facility with the minimum 16'-6" clearance that serves as a reasonable alternative through route.

Arterial

Rural or Urban: 16'-6" (existing structures @ 14' may be retained)

Collector

Rural or Urban: 14'-6"

Collector road under Interstate highway with interchange: 16'-6"

Local

Rural or Urban: 14'-6"

Local road under Interstate highway with interchange: 16'-6"

- Clearances include a 6" allowance for future pavement overlays.
- Minimum clearance is required over the entire roadway, including shoulders.

- Vertical clearance to bicycle and pedestrian overpasses should be 1.0’ greater than the highway structure clearance.
- Vertical clearance to overhead sign structures: See Section 10.3.2 of the Bridge Design Manual.

<u>Vertical Clearance over Railroads:</u>

Railroad under all roads: 22’-6” (RSA 373:39 specifies 22’-0” minimum)

- Measured from top of high rail to bottom of low edge of bridge.
- If site conditions will not allow at least 22’-0” vertical clearance without considerable impacts, clearance may be reduced to 21’-0” (or less) with approval from the executive office. Lowering the footing elevations shall be investigated to allow for future lowering of the tracks to achieve the 22’-6” clearance.

<u>Lateral Offset to Obstruction</u>

Lateral offset refers to the clear distance between the edge of travel way or shoulder and a vertical roadside obstruction. Adequate clearance to obstructions will avoid affecting the driver’s speed or lane position. The recommended lateral offset for all road types is 1.5’ to protect mirrors on trucks and buses as well as provide space for parked vehicles to open doors.

<u>Clear Zone</u>

The clear zone represents the area needed for vehicles leaving the road to safely stop or recover and return to the road without obstruction, and is based upon traffic volume and design speed. In New Hampshire, the minimum clear zone from the traveled way for interstate highways and major arterials for the purpose of Tier 1 rehabilitation (4R) work is 30’. Consult the *Roadside Design Guide* for clear zone requirements. There may be instances where design constraints will require consideration of a lesser offset. For these instances the approval of the Highway Design Administrator is needed and the exceptions shall be documented in the Design Report.

Breakaway-type light poles and signposts are permitted in the clear zone. Roadside slopes in the clear zone should be as flat as practicable and not steeper than 4H:1V.

Lateral clearances for utility poles are listed in the NHDOT *Utility Accommodation Manual*.

In situations where guardrail is installed in areas that include roadside obstructions, the lateral clearance shall equal or exceed the full shoulder width plus the design deflection of the guardrail. (See the *Roadside Design Guide* for guardrail deflection.) The guardrail location should also consider the tendency of vehicles with high centers of gravity such as trucks and buses to tilt upon impacting a barrier. An additional clearance of at least 2’ should be provided behind the barrier to any hazards that could be struck by a leaning vehicle, such as bridge abutments, signposts, and exposed ledge.

<u>Bridge Width</u>

<u>New bridges (Relocation or Reconstruction):</u> Bridge width dimensions refer to the clear width between bridge rails. This width should not be less than the approach width, i.e. traveled way

plus paved shoulders. A reduction in this width can be made for brush curb that can be inset from the face of bridge rail up to 6”.

Existing bridges to remain (Reconstruction or Rehabilitation): The minimum clear width should not be less than the approach traveled way and in no case less than 24’ between curbs.

AASHTO provides minimum clear roadway widths based on functional classification of roadways. Compare proposed bridge widths with the “Green Book” standards to ensure compliance.

Each existing structure should be evaluated by the Bureau of Bridge Design if widening of the existing road is planned. The bridge’s condition and width, expected service life, compatibility with the new road width, and the roadway geometry approaching the bridge should be evaluated.

All sidewalks shall be designed in accordance with current Americans with Disabilities Act (ADA) guidelines. In no case shall bridges be designed with a raised sidewalk and curbs if sidewalks do not exist on the roadway approaches.

Right-of-Way Width

There is no fixed rule for setting right-of-way widths other than general guidelines found in the “Green Book”. Each situation must be evaluated individually based on the width requirements for the proposed roadway improvements, economic factors and consideration of the existing right-of-way layout. The procedures for acquiring right-of-way are discussed in Chapter 10.

Pavement and Shoulder Slopes

The pavement surface must be sloped sufficiently to ensure proper drainage, yet not so steeply as to adversely affect vehicle operation. Normally, the traveled way on tangent sections shall be crowned at 2%, and paved shoulders sloped at 5% without curbing and 2% with curbing.

Design Speed

As speed increases, the driver’s peripheral vision decreases and the visual field is narrowed, thereby lessening the time for the driver to perceive and react to highway conditions. Highways built to high design standards compensate for these limitations in several ways. Simplifying control and guidance activities, aiding drivers with appropriate information placed within the cone of clear vision and eliminating much of the need for peripheral vision, and simplifying the decisions required and spacing them further apart to decrease cognitive demands.

Design speed is the principal factor that must be correlated with the physical features of design to achieve a roadway that will accommodate the traffic safely for the planned use. Once a design speed is selected, all geometric features should be related to it to obtain a balanced design. Changes in terrain and other physical controls may dictate a change in design speed in certain sections. A decrease in design speed along the road should not be introduced abruptly, but extended over a sufficient distance to allow the driver to adjust and smoothly transition to the lower speed.

Design speed criteria are shown in Chapter 4, Alignment and Typical Sections, and Chapter 5, Geometrics.

Three considerations are directly related to the selected design speed:

1. Horizontal curvature and superelevation
2. Vertical curvature and grade
3. Sight distance

The minimum guideline values for these design considerations should always be provided regardless of traffic volumes, highway classification or any other factors influencing design. These design considerations are closely related to traffic safety and should not be compromised.

Horizontal Curvature and Superelevation

In the design of highway curves, it is necessary to establish the proper relation between design speed and curvature and also their joint relations with superelevation and side friction. Although these relations stem from laws of physics, the actual values for use in design depend on practical limits and factors determined empirically over the range of variables involved. These limits and factors are explained further in Chapter 3, Elements of Design*,* of the "Green Book".

The maximum permissible rate of superelevation is an example of practical limitations. Highways must serve vehicles traveling at a wide range of speeds. Slow-moving vehicles or stopped vehicles would be adversely affected by excessively steep superelevations, particularly in areas subject to ice and snow. The Department has adopted maximum superelevation rates of 8% for rural highways, 6% for ramps, and 4% for urban highways and for some rural intersections to minimize superelevation where traffic is turning to and from the roadway.

Refer to the "Green Book" for complete tables of superelevation rates for various combinations of design speed and curvature. As a general rule, less superelevation is needed for flat (large radius) curves. As the radius decreases and curvature increases, the rate of superelevation must increase. When the required superelevation reaches 8%, the minimum permissible radius is established for that particular design speed. Correspondingly, minimum radii are established for all design speeds.

Vertical Curvature and Grades

Establishment of criteria for grades is not as objective as for other geometric elements of highways. The "Green Book" has established recommended maximum grades based primarily on analysis of vehicle operating characteristics, design speeds, highway types, and common practice among highway agencies. Refer to the "Green Book" for tables of maximum allowable grades based on the highway functional class (freeway, arterial, collector, and local) in rural or urban areas. Additional guidance and criteria for proper vertical designs are presented in Chapter 4, Alignment and Typical Sections.

Sight Distance

Sight distance is the clear sight line necessary for the driver to either: (1) react and stop or avoid an obstacle in the travel way, or (2) select a safe gap at an intersection to enter or cross another roadway. Chapter 4, Alignment and Typical Section includes special considerations for stopping sight distance relating to horizontal and vertical alignment conditions, as well as guidance for both intersection and passing sight distance requirements.

Refer to the "Green Book" for detailed explanations of the concepts and procedures for determining required stopping sight distance. It is sufficient for this Manual to identify the sight distance requirements for various design speeds, and to recognize those conditions that should be thoroughly investigated to ensure adequate sight distance is provided.

Stopping Sight Distance

Stopping sight distance is computed as the sum of two distances: (1) the distance traversed by a vehicle from moment a driver recognizes an obstacle or hazard until the brakes are applied, and (2) the distance needed to decelerate the vehicle to a stop. Stopping sight distance on level terrain is computed by the following equation:

$$SSD = 1.47Vt + 1.075\frac{V^2}{a}$$

where:

SSD = stopping sight distance, ft

V = design speed, mph

t = brake reaction time, 2.5 s

a = deceleration rate, 11.2 ft/s^2

For non-level terrain, such as grades equal to or greater than 3%, the SSD equation is modified to adjust the amount of braking distance required.

$$SSD = 1.47Vt + \frac{V^2}{30\left[\left(\frac{a}{32.2}\right) \pm G\right]}$$

where:

G = grade, rise/run, ft/ft

Stopping sight distance is measured from the driver's eye of 3.5' to a 2' object in the road. Sometimes it is more appropriate to measure the sight distance to the road surface, a sign, signal head, or other object to allow greater perception time for the driver.

Decision Sight Distance

Decision sight distance provides a longer stopping distance by increasing the driver perception and reaction time. The typical stopping sight distance reaction time of 2.5 s may be insufficient for situations where a driver must make complex or instantaneous decision to either stop, change lanes, or avoid obstacles. The following are examples of critical locations where decision sight distance can be important: interchanges and intersections, changes in cross section such as toll plazas and lane drops, and areas of concentrated demand where there is apt to be "visual noise" (i.e. wherever sources of information compete, as those from roadway elements, traffic, traffic control devices, and roadside distractions).

Decision sight distances are given in the "Green Book" for various avoidance maneuvers and roadway types. In computing and measuring decision sight distances, the 3.5' driver's eye and 2' object heights used for stopping sight distance are typically used. Occasionally, other target object heights may be more appropriate, such as to a signal head. In these situations, the target height should be adjusted to reasonably represent the feature to be sighted. The designer should investigate the condition carefully at critical locations and use judgment in applying this criterion. Because decision sight distance offers drivers additional margin for error and affords them sufficient length to maneuver their vehicles at the same or reduced speed, the values can be substantially greater than stopping sight distance.

Intersection Sight Distance

Intersection sight distance is the clear sight line needed for a driver to safely enter or cross an intersecting roadway. The "Green Book" includes methods for determining intersection sight distance for various traffic controls methods including yield, stop, and signalized. The required intersection sight distances are given in the "Green Book" and are further discussed in Chapter 4 of this Manual.

Environmental Considerations

Environmental considerations play a major role in project development. The Department's Bureau of Environment evaluates the potential impacts of projects upon natural and cultural resources. These evaluations are conducted in accordance with pertinent Federal and State laws, including the National Environmental Policy Act (NEPA), the Clean Water Act, the National Historic Preservation Act, Section 4(f) of the Department of Transportation Act, and New Hampshire RSA 482-A regarding Dredge and Fill in Wetlands.

Once the preliminary design has begun and initial information on the range of alternatives and perceived constraints is available, a Request for Environmental Review ("green sheet") is submitted by the lead design Bureau to the Bureau of Environment. This form includes general information about the project and indicates the appropriate contact people for design data. It is normally accompanied by a project location map, as well as an existing detail plan, if available.

Throughout project development, a close working relationship is needed between the Environmental and Design staff assigned to each project to identify potential environmental impacts, seek alternatives to avoid those impacts, adjust the design to minimize impacts to the extent practicable, and develop appropriate mitigation measures, if necessary. Detailed design information is required to be included in the environmental documents and it is the responsibility of the design personnel to provide that information.

In preparing to advertise projects for bids, any environmental commitments that have been consented to during the preliminary review process need to be incorporated into the contract documents. The specific details of the commitments will be provided by the Bureau of Environment to the appropriate Design personnel who are responsible to incorporate this information as outlined in the Department's Environmental Commitments Procedure (ENV 1-11).

Public participation is an essential component of the project development process and of the environmental impact evaluation efforts in particular. To address this issue, the NHDOT has prepared a guide titled *"Public Involvement Procedures for New Hampshire Transportation*

Improvement Projects" (15) and a *NEPA Public Involvement Manual* (21). These guides include specific information about the environmental evaluation process, types of public involvement including virtual, media templates and more.

Traffic Operations

Level of Service (LOS) is a performance measure that represents the quality of service of a roadway based on operating conditions from a driver's perspective. The LOS is influenced by speed and travel time, traffic interruptions, freedom to maneuver, safety, driving comfort and convenience, and operating costs. General operating conditions for levels of service are defined as:

A — Free flow with low volumes and high speeds.

B — Stable flow but speeds starting to be restricted by traffic conditions.

C — Within stable flow zone but most drivers restricted in freedom to select their own speed.

D — Approaching unstable flow and drivers have little freedom to maneuver.

E — Flow is unstable and may experience short stoppages.

F — Flow is restricted and drivers experience excessive stopping with long periods of delay.

The functional concept is related to level of service and it is important to the designer. Even though many of the geometric standards could be determined without reference to the functional classification, the designer must keep in mind the overall purpose of the street or highway. This concept is consistent with a systematic approach to highway planning and design.

Arterials provide a higher degree of mobility for longer trips with higher operating speeds and improved levels of service. Since access to abutting property is not their major function, some degree of access control is desirable to enhance mobility. Collector roads serve a dual function in accommodating shorter trips and feeding the arterials. They must provide some degree of mobility but also provide access to abutting property. Thus, an intermediate design speed and level of service is appropriate. Local roads and streets have relatively short trip lengths, and because property access is their main function, there is no need for high flow rates or high operating speeds.

Selecting an appropriate level of service for the anticipated volume and composition of traffic provides an effective method for determining necessary design elements. For example, to achieve a satisfactory level of service at an intersection it may be critical to include an additional turn lane in the current design.

Appropriate levels of service are shown for various highway functional types and for various terrains, Figure 3-3.

Once a level of service has been selected, it is desirable that all elements of the roadway are consistently designed to this level. This consistency of design results in more uniform traffic movement and operating speed, and flow restrictions can be avoided.

The *Highway Capacity Manual* (HCM) supplies the analytical methods for design calculations and decisions, but the designer must use judgment to select the proper level of service.

Figure 3-3
GUIDE FOR SELECTION OF DESIGN LEVELS OF SERVICE

	Type of Area and appropriate Level of Service			
Highway Type	Rural Level	Rural Rolling	Rural Mountainous	Urban and Suburban
Freeway	B	B	B	C
Arterial	B	B	C	C
Collector	C	C	D	D
Local	D	D	D	D

Whether designing an intersection, an interchange, an arterial, or a freeway, the selection of the desired level of service must be carefully weighed, as the adequacy of the roadway is dependent on this choice.

Major Design Elements

The major design elements for which most criteria have been developed include pavement, typical section, horizontal and vertical alignment, lighting, traffic control and standard roadway items such as guardrail and drainage structures. These elements are more fully discussed in other chapters of the Manual.

Other Design Elements

Other design elements that must be considered and may affect the overall operating characteristics of the facility include pedestrian facilities, bicycle facilities, railroad crossings, drainage, utilities, airport clearances, and the avoidance or mitigation of environmental impacts.

Individual chapters are devoted to utility involvement and drainage, therefore, their description in this chapter is brief.

Pedestrian/Bicycle Facilities

All pedestrian facilities must comply with the requirements of the ADA. The designer should be particularly concerned with pedestrian conflicts on urban intersection projects. Safety should be the primary concern, with mobility secondary. Most conflicts occur at signalized high-volume intersections.

If it is decided to design special accommodations for pedestrians, refer to the "Green Book", *Highway Capacity Manual*, *Guide for Planning, Design, and Operation of Pedestrian Facilities* (16), and the *MUTCD*.

Sidewalks, when warranted, must be a minimum width of 5.5' from the front of curb to the back of the sidewalk. Narrow widths can be used if conditions warrant, however additional ADA elements may be needed and close coordination with the Departments Federal Compliance Officer is required. Conversely, a wider sidewalk may be warranted in urban areas to accommodate high pedestrian volumes, municipal standards or roadside appurtenances such as signs, hydrants, trees, street furniture, etc. When the right of way width is available, it is desirable to separate the sidewalk from the roadway for increased pedestrian safety. Safe and convenient movement of disabled persons, including those in wheelchairs, requires that accessible sidewalk ramps with tactile strips be provided at crosswalks, side roads and major driveways. A crosswalk is a marked crossing of a street or public way at the extension of a pathway used by pedestrians. For uniformity, the NHDOT standard for sidewalk ramps should be used unless a local standard acceptable to the FHWA is preferred by the municipality.

In establishing the location of the ramps, consideration should be given to drainage, access to pedestrian push buttons at signalized intersections, and utility appurtenances. Normally, the ramp should align with the sidewalk and crosswalk. If offset ramps are necessary, the need for a properly located and highly visible stop line as a safety device is increased. Visually impaired persons have difficulty in detecting ramps; therefore, it may be advisable to provide textured surfaces different from the sidewalk surface. The designer should confirm that current ADA requirements are met.

In order to ease pedestrian travel through curbed islands, certain modifications are normally required. In many cases, the crosswalk can be located directly in front of the island nose without special design provisions, or the island can be shortened sufficiently to permit such location without affecting turning vehicles. However, when an island does encroach on the location of a crosswalk, it is desirable to depress the island across the entire width of the crosswalk, rather than construct ramps, particularly if the island is less than 16’ wide.

In areas of high traffic volumes or high speeds, grade-separated pedestrian facilities (underpasses or overpasses) may be advisable and should be located and designed to ensure their use. Generally, pedestrians will avoid using steps or out-of-the-way ramps. Underpasses will be used if they are not too long and if they are maintained, lighted, and secure.

Other modifications that are beneficial for pedestrian access and safety include converting from two-way to one-way traffic flow, eliminating turns, providing exclusive signal phases for pedestrians, and eliminating crosswalks in unexpected, non-standard, or unsafe locations (e.g. mid-block crosswalks). Underpasses for livestock, snowmobiles, skiers, or bicycles require the Highway Design Administrator’s approval and, in most instances, the planning is prompted by users’ requests, right-of-way considerations, or socio-economic considerations.

Bicycle facilities (separate or shared use within shoulders) should be considered. The designer, however, should be cautious when combining vehicles and bicycles. The suggested references are the AASHTO *Guide for Development of Bicycle Facilities* (17), *Selecting Roadway Design Treatments to Accommodate Bicycles* (18), and the NHDOT Bureau of Rail and Transit *New Hampshire Statewide Pedestrian and Bicycle Plan, 2023* and the Statewide Regional Biking Maps which show the recommended bike routes in the State. Projects on roadways where bike travel is encouraged should be evaluated to accommodate bicycle travel, i.e., minimum 4 ft wide shoulders (5 ft. wide when adjacent to curb or guardrail).

See Chapter 11 for additional information on Pedestrian/Bicycle Facilities.

Railroad Grade Crossing

Projects involving a railroad crossing must be reviewed with the Chief of Design Services who will coordinate communication with the appropriate railroad company. Appropriate grade crossing protection devices, pavement markings, and warning signs should be installed at all railroad grade crossings. Details are shown in the *MUTCD* and *Railroad-Highway Grade Crossing Handbook* (19) and must be approved by the NHDOT Bureau of Rail and Transit.

Sight distance is a major consideration at railroad grade crossings. There should be sufficient sight distance along the road for the driver to recognize the crossing, perceive the train, stop if necessary, and depart from a stopped position. The sight distances given in the "Green Book" are recommended but not always attainable. When costs, right-of-way, or environmental considerations prohibit achieving the recommended sight distances, some form of crossing protection should be provided. Decision and stopping sight distances must be provided to ensure a safe crossing. Refer to the "Green Book" for more detailed information.

Crossings can be treated in various ways, including adequate signing, traffic signals, railroad signals with gates, or by grade separation. Judgment must be used to select the appropriate crossing treatment based on the volume and speed of traffic on both the road and railroad, the types of vehicles on the roadway, and the available sight distance. The roadway width at all railroad crossings should be the same as the width of the approach roadway, unless it is desirable to provide truck turnout lanes. If the crossing angle is less than approximately 45 degrees, consideration should be given to widening the outside lane, shoulder, or bicycle lane to allow bicyclists and/or motorcycles additional maneuvering width to cross the tracks at a more perpendicular angle. Additionally, compressible flangeway fillers can enhance bicycle and motorcycle crossing safety. In some cases, abandoned tracks can be removed or paved over.

Drainage

Drainage is a very important element for which criteria have been developed. The reference for drainage criteria is the NHDOT *Manual on Drainage Design for Highways* (the "Drainage Manual"). Chapter 6 of this Highway Design Manual provides additional drainage information.

Drainage items are estimated to cost 15% to 30% percent of the expenditure for highway construction and, from that viewpoint alone, drainage is an important design consideration.

Drainage facilities are provided through culverts, closed-system pipe, underdrain pipe, catch basins, and open ditches. For roadside safety, the designer should provide sufficient vehicle recovery area or protection from deep ditches and keep catch basin grates and culvert end sections flush with the ground.

One of the major considerations when designing highways (drainage in particular), is the extent to which land-use changes will affect the area during the design period. It may be more economical to oversize a drainage facility to allow for increased runoff in the future than to rebuild the system before the design life of the road has lapsed. The issue of a private developer's responsibility for impacts to the State highway drainage system is addressed in the "Driveway Manual".

Drainage considerations are usually divided into hydraulic and structural requirements. Hydraulic design, procedures, and criteria are covered generally in Chapter 6, and in detail in the Drainage Manual. Structural issues are covered in Chapter 7, "Highway Structures."

The designer should refer pertinent drainage questions for all major and "special" drainage designs to the Specialty Section of Highway Design. Design plans and well-organized, legible drainage computations must accompany all requests for review. Refer to Chapter 6 for procedures to follow.

Utilities

Although the geometric layout usually is unaffected by the utilities located within the project limits, utility relocation costs, although they are not typically borne by the project, can be significant and should be seriously considered especially when adjusting an alignment and designing the storm drainage system and other elements of the cross section. Time frames to relocate utilities (especially telephone — aerial or underground) can be substantial and commonly are a critical consideration in the construction schedule.

Utility adjustments are coordinated by the Utilities Engineer who arranges for all work to be done prior to or during construction. (The utility company may elect to perform the adjustment work with its own forces or to hire a contractor to do the work.)

The approved reference for utility issues is the NHDOT *Utility Accommodation Manual*. Refer also to Chapter 9, "Utilities", of this Highway Design Manual for additional information regarding utility coordination.

Design considerations include provisions for utilities; however, the designer should keep the following in mind:

- Survey plans or As-Built plans, if no survey is planned, of existing detail should be provided to the Utility Coordinator as soon as available for verification and to initiate utility coordination.
- The cost of utility adjustment, regardless of who pays for it, and the time required for utility adjustments may be substantial. Designers must consider the cost of and time required for utility adjustments as part of a comprehensive review of project economics.
- Protection of existing underground utilities is important. For example, decreasing cover over existing waterlines below acceptable limits may result in their freezing and bursting. Decreasing cover over electric power lines may violate the National Electric Safety Code and create a potentially damaging or hazardous situation. Sanitary sewer disruption caused by improperly designed protection can cause health problems and roadway damage. Substantially increasing the cover over utilities can make them difficult to access for repair.

Airports

For all projects near airports, the highway designer shall contact the Bureau of Aeronautics to determine whether the airport's proximity to a project will be a design factor, and whether coordination with the Federal Aviation Administration (FAA) is required. On Federally-funded projects, FHWA can act as intermediary in air-highway clearance approval negotiations with FAA.

Coordination with Federal Aviation Administration (FAA) could be required for any construction or alteration of height, permanent or temporary, within the airway slope extending outward and upward up to 20,000 feet horizontally from the nearest point of the nearest airport runway, or construction or alteration in an instrument approach area. The airway slope rate and distance from the nearest airport runway varies with the length of the longest runway. Airports, as referenced herein, include privately used and publicly used aircraft landing facilities as well as heliports, seaplane bases, and ice runways.

References

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3. New Hampshire Department of Transportation (NHDOT), *Standard Specifications for Road and Bridge Construction*, NHDOT, 7 Hazen Drive, Concord, NH, 2016

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5. New Hampshire Department of Transportation (NHDOT), *Policy for the Permitting of Driveways and Other Accesses to the State Highway System*, NHDOT, 7 Hazen Drive, Concord, NH, 2000

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16. American Association of State Highway Transportation Officials (AASHTO), *Guide for the Planning, Design, and Operation of Pedestrian Facilities,* AASHTO, 444 North Capital Street, NW, Suite 249, Washington, DC, 2004

17. American Association of State Highway and Transportation Officials, (AASHTO), *Guide for the Development of Bicycle Facilities,* AASHTO, 444 North Capitol Street, NW, Suite 249, Washington, DC, 2014

18. Center for Applied Research, Incorporated, *Selecting Roadway Design Treatments to Accommodate Bicycles*, Center for Applied Research, Incorporated, 10213 Forest Lake Drive, Great Falls, VA, 1994
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20. American Association of State Highway and Transportation Officials, (AASHTO), *Highway Safety Manual*, AASHTO, 444 North Capitol Street, NW, Suite 249, Washington, DC, 2014

21. New Hampshire Department of Transportation (NHDOT), *NEPA Public Involvement Manual*, NHDOT, 7 Hazen Drive, Concord, NH, 2021

APPENDIX LIST

3-1 Sample Design Exception
3-2 Vertical Clearance on the Interstate System
3-3 Process for the Determination of Roadside Safety Hardware Crashworthiness and MASH Hardware Design Exception

Appendix 3-1

STATE OF NEW HAMPSHIRE
INTRA-DEPARTMENT COMMUNICATION

DATE: January 30, 2017

FROM: Margarete Baldwin, P.E.
Chief of Roadway Section

AT (OFFICE): Department of Transportation
Bureau of Highway Design

THRU: ________________________
John Butler, P.E.
Geometric SME

SUBJECT: Project
Federal Number
Project Number

TO: Assistant Commissioner, P.E.
Assistant Commissioner

THRU:

____________________	______________________	________________________
James Marshall, P.E. Administrator Highway Design	Victoria Chase, P.E. Project Manager	Peter Stamnas, P.E. Director of Project Development

MEMORANDUM

I hereby request that a design exception be approved to allow the use of lanes and shoulders narrower than recommended by the AASHTO Policy on Geometric Design of Highways and Streets for the proposed reconstruction and expansion of NH 101. The attached Design Exception Report outlines the AASHTO design guidelines for this type of facility and my justification for modifying the recommended criteria. Because this project is exempt from Federal Highway Administration oversight, FHWA approval of this design exception is not required.

DESIGN APPROVED: ☐
NOT APPROVED: ☐

____
William J. Cass, P.E.
Assistant Commissioner

TLR/tlr
Attachments

S:\Global\B34-HighwayDesign\Manual\HWY-MAN\Volume 1\Chapter 3\2016 CHAP-03_Rewrite\design exception request.docx

NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION
DESIGN EXCEPTION REPORT

City: Bedford **Project No.:** 13953

Route: NH 101 **Federal No.:** X-A000(143)

I. Project Description

NH 101 – reconstruct and expand roadway to improve traffic operations and safety.

A. Type of Work Proposed

- ☒ Full Depth Reconstruction
- ☐ 3R/4R Rehabilitation
- ☐ New Construction
- ☒ Resurfacing/Box Widening
- ☐ Bridge Replacement/Rehabilitation
- ☐ Other:

B. Purpose of Project

- ☒ Safety Improvements
- ☒ Additional Capacity
- ☐ Maintenance
- ☐ Other:

II. Description of Facility

A. Functional Class

- ☐ Urban Freeway
- ☒ Urban Principal Arterial
- ☐ Urban Collector
- ☐ Urban Local
- ☐ Rural Freeway
- ☐ Rural Principal Arterial
- ☐ Rural Collector
- ☐ Rural Local
- ☒ NHS

B. Federal Highway Administration approval required?

- ☐ Yes
- ☒ No

Explanation: Exempt from FHWA oversight

C. Traffic Volume

ADT (2017) 29,000 – 36,000 vpd
ADT (2037) 35,000 – 44,000 vpd

D. Speed

Existing Posted Speed	Proposed Design Speed
50 mph	50 mph

E. Project Context

The project extends along NH 101 approximately two miles from its intersection with Wallace Road on the west to its intersection with NH 114 and Boynton Street on the east. Both of these intersections are signalized as are the intervening intersections with Nashua

SAMPLE

Road, Meetinghouse Road, and Old Bedford Road / Constitution Drive. NH 101 is a principal east-west commuter and commerce route and is subject to substantial recurring delays due to its high traffic volumes. The highway segments west of Nashua Road and near Old Bedford Road are heavily developed with retail and office establishments. Much of the rest of the project corridor is residential with access generally from the adjacent Town roads. In addition there are large wetland areas adjacent to the roadway.

III. Indicate Controlling Criteria Requiring A Design Exception

A. Roadway and Bridge Criteria *

- ☐ Design Speed
- ☒ Lane Width
- ☒ Shoulder Width
- ☐ Horizontal Curve Radius
- ☐ Superelevation Rate
- ☐ Stopping Sight Distance
- ☐ Maximum Grade
- ☐ Cross Slope

B. Bridge Only Criteria *

- ☐ Vertical Clearance
- ☐ Design Loading Structural Capacity

* See Federal Register (May 5, 2016) Docket No. FHWA-2015-0020. On NHS facilities with a design speed less than 50 mph, only Design Speed and Design Loading Structural Capacity require a design exception.

AASHTO Policy on Geometric Design of Highways and Streets (2011)
used to develop this report

	STANDARD	**PROPOSED**	**EXCEPTION?**
Design Speed			No
Lane Width	12’	11’	Yes
Shoulder Width	8’	2’ inner, 4’ outer (5’ with curb)	Yes
Horizontal Curve Radius			No
Superelevation Rate			No
Stopping Sight Distance			No
Maximum Grade			No
Cross Slope			No
Vertical Clearance			No
Design Loading Structural Capacity			No

SAMPLE

IV. Justification

The proposed cross section consists of a four-lane divided highway with 11' lanes, narrow shoulders, a landscaped median, and a curbed sidewalk on one side of the roadway. Median openings will be provided where appropriate for access. The proposed 'boulevard' design will allow the project to achieve the following goals:

- Traffic calming: High travel speeds are a common safety concern along this segment of NH 101. Narrowing the lanes by one foot is a proven, although modest, traffic calming measure. The proposed 4' shoulders (5' with curb) will provide adequate width for cyclists while keeping the shoulder width to a minimum as a further traffic calming measure.

- Access management: The proposed landscaped median will manage access along the corridor by providing limited openings at strategic locations, thus improving the safety and efficiency of the roadway. In addition the curbing and landscaping of the median will contribute to the traffic calming objective of the design.

- Natural resource impacts: The reduced width of the proposed cross section as compared to the AASHTO standards will minimize direct impacts to the extensive abutting wetlands, and will substantially reduce the potential increase in impervious surfaces thus helping to minimize the extent of required water quality treatment that must be constructed.

- Cost: The reduced width of the proposed cross section will reduce the cost of construction, ROW acquisition, and environmental mitigation. The cost savings have not been quantified.

SAMPLE

Appendix 3-2

Design Standards, Uniform Federal Accessibility Standards, and Bridges

Vertical Clearance on the Interstate System

A. It must be emphasized that the integrity of the Interstate System for national defense purposes be maintained to meet AASHTO Policy as stated in A Policy on Design Standards - Interstate System, incorporated by reference in 23 CFR 625. On Interstate sections in rural areas, the clear height of structures shall be not less than 4.9 meters (16 feet) over the entire roadway width, including the usable width of shoulder. On Interstate sections in urban areas, the 4.9-meter (16-foot) clearance shall apply to a single routing. On other Interstate urban routes, the clear height of structures shall be not less than 4.3 meters (14 feet). Design exceptions must be approved whenever these criteria are not met.

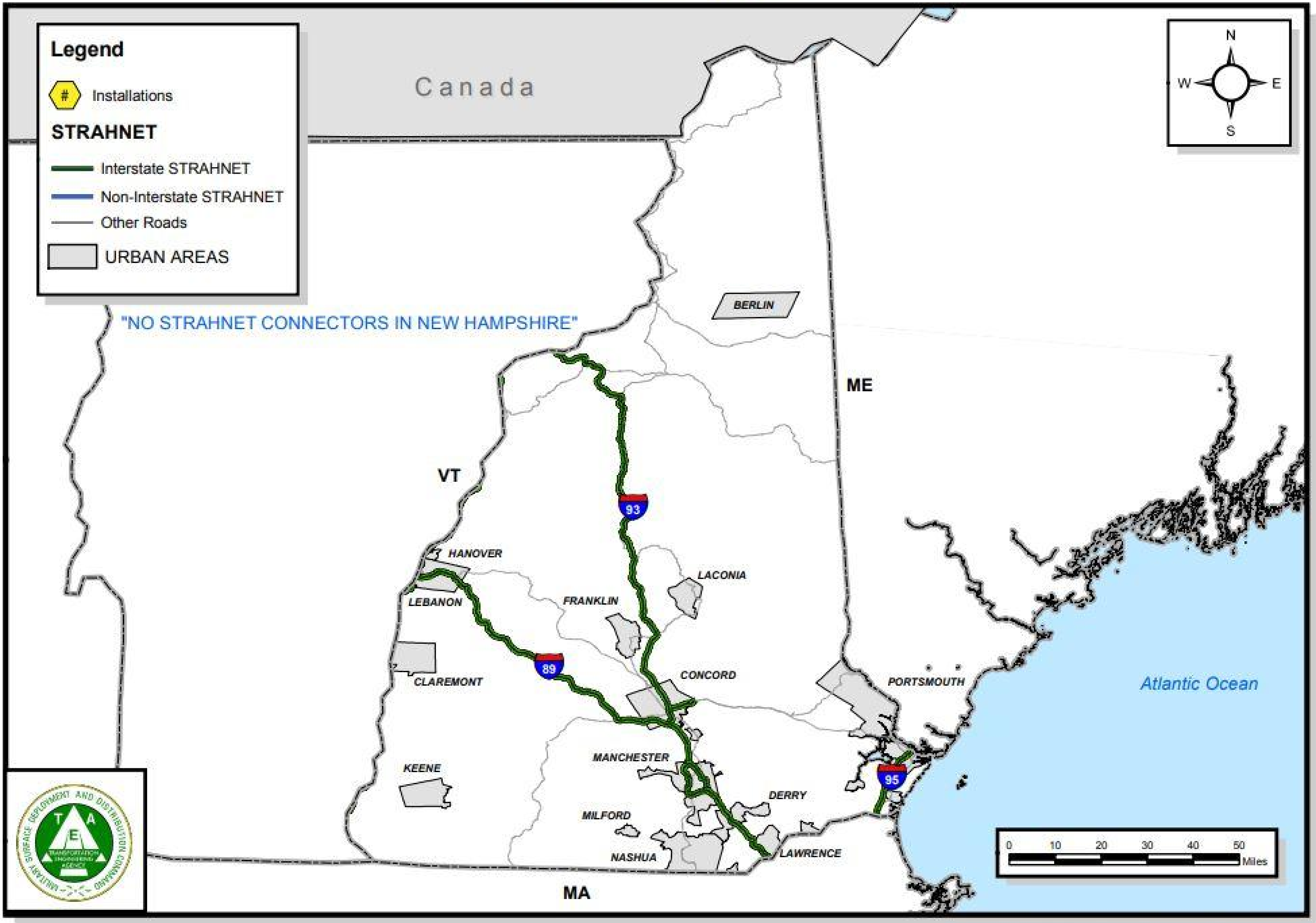
B. The FHWA has agreed that all exceptions to the 4.9-meter (16-foot) vertical clearance standard for the rural Interstate and the single routing in urban areas will be coordinated with the Surface Deployment and Distribution Command Transportation Engineering Agency (SDDCTEA) of the Department of Defense. This agreement applies whether it is a new construction project, a project that does not provide for correction of an existing substandard condition, or a project which creates a substandard condition at an existing structure. Furthermore, it applies to the full roadway width including shoulders for the through lanes, and to ramps and collector-distributor roadways in Interstate-to-Interstate interchanges.

C. A number of toll roads have been incorporated into the Interstate System under the former provisions of Section 129(b) of Title 23, United States Code. While the FHWA does not have any particular "leverage" on the toll authorities to comply with Federal standards on non-federally funded projects, it is expected that the SHA's have established appropriate procedures to assure that proposed changes or alterations of the toll road will meet applicable policies established for the Interstate System. The working relationship should ensure the needs of the military are considered and that necessary coordination occurs.

D. The approval action for Interstate design exceptions has been delegated to FHWA field offices and, in some cases, to the SHA. Whoever has responsibility for approving the design exception also is responsible for coordination with SDDCTEA. A request for coordination may be forwarded directly to the SDDCTEA at any time during project development but in all cases prior to taking any action on the design exception. It should include a time period of 10 working days (after receipt) for action on the request. The office initiating a request for coordination to the SDDCTEA can verify receipt of the request by telephone or fax. If the SDDCTEA does not respond within the time frame, it can be concluded that the SDDCTEA does not have any concerns with the proposed exception. If comments are forthcoming, the FHWA and/or SHA will consider mitigation to the extent feasible. A request for coordination should be addressed to:

Director, Surface Deployment and Distribution Command Transportation Engineering Agency (SDDCTEA)
ATTN: SDTE-SA
709 Ward Drive, Building 1990
Scott AFB, IL 62225
Telephone: 618-220-5229; Fax 618-220-5152

NEW HAMPSHIRE



Last Updated: June 12 2012

New Hampshire DOT Department of Transportation

THE STATE OF NEW HAMPSHIRE
DEPARTMENT OF TRANSPORTATION

Victoria F. Sheehan
Commissioner

William Cass, P.E.
Assistant Commissioner

Tel: 603.271.1484
Fax: 603.271.3914

Revised - Process for Determination of Roadside Safety Hardware Crashworthiness

February 27, 2020

Michelle Marshall
Safety and Area Engineer
Federal Highway Administration, NH Division
53 Pleasant St, Suite 2200
Concord, NH 03301

Dear Ms. Marshall,

Please find attached NHDOT's **revised** outlined process for determining crashworthiness of roadside safety hardware on the National Highway System (NHS). The attached revises the original process outline sent to your division office in June 2018.

It remains the goal of NHDOT to utilize roadside safety hardware that meets national crash test criteria. During our search for a new state standard for portable concrete barrier it became evident that there are many MASH compliant barrier options, some of which contractors have already purchased and put into use. We feel that this revised process best addresses future use of temporary work zone devices that are MASH compliant.

In the attached document, we separate the requirements for new hardware into two categories, permanent and temporary. We have identified that the need for detailed review of maintenance, installation, and in most cases regional climate, is not the same for temporary installations as it is for permanent installations of hardware. Proof of MASH testing compliance at an approved laboratory will need to be submitted for approval of temporary hardware. Temporary hardware would not require a federal letter of compliance, or require to be "Department Approved" hardware. Temporary hardware will still be reviewed for approval for use on a project by project basis. Regional climate impact on the hardware can be best assessed by project Construction personnel.

Thank you for the original guidance for determining this process. I trust the attached meets FHWA's expectations of an acceptable process, please let me know if otherwise.

Sincerely,

Peter Stamnas
Director of Project Development

Attachment
KOM

cc: J. Marshall/K. Cota

S:\Highway-Design\Specialty Section\Guardrail\Processes\Crashworthiness\Revision\Revised Crashworthy Process FHWA.doc

NHDOT Process for Determination of Roadside Safety Hardware Crashworthiness

February 27, 2020

New Permanent Roadside Safety Hardware

To determine crashworthiness of new permanent systems, NHDOT shall:

- Confirm the existence of a federal eligibility letter relative to AASHTO MASH criteria.
- Confirm that the crash testing was conducted by an ISO 17025 accredited laboratory
- Seek out manufacturer's data for installation, maintenance, and crash testing and determine if the system meets the NHDOT's needs, considering, at a minimum :
    - Climate effects on the system performance, longevity, etc.
    - Complication of installation requirements
    - maintenance needs
    - overall crash performance
- Documentation would be required, with signature of chief engineer, similar to controlling criteria design exception process.

Modifications to existing successfully MASH tested permanent roadside safety hardware

Proprietary Devices –

- Originally having a federal eligibility letter relative to AASHTO MASH criteria
- Confirmation that the crash testing was conducted by an ISO 17025 accredited laboratory
- Engineering analysis conducted by an ISO 17025 accredited laboratory that determines the modification does not affect the crashworthiness of the roadway safety hardware based on previous testing.
- Internal review to determine that the modification will still meet the NHDOT's need for a system using the same criteria as for a new system.
- Documentation would be required, with signature of chief engineer, similar to controlling criteria design exception process.

Generic Devices –

- An engineering analysis shall be conducted by NHDOT, or group approved by NHDOT. The other group could be another state or pooled fund, but NHDOT would need to review their report and videos.
- Crash testing may be warranted based on the results of the analysis.
- Documentation would be required, with signature of chief engineer, similar to controlling criteria design exception process.

Assurance of Proper Installation of Proprietary System, Through Contractor and Maintenance Forces

- Ensure proper installation through:
  - Required training of installer by manufacturer
  - Contractor completion of checklist (sign off), including:
    - Date
    - Location (Coordinates)
    - Type
- Encourage proper maintenance by providing manufacturer installation guides to maintenance forces.

Assessment of In-Service Performance

- NHDOT may perform periodic crash data assessments
  - Priority to examine new products over established products, 3-5 years after first installed
  - Sources that are most likely to contain relevant data for use:
    - Crashes occurring during construction of a project. (Those who understand the hardware are quite often witnesses to the event.)
    - Accident reports that come via re-imbursement sought though Bureau of Finance – where guardrail is impacted during a crash. (These are usually more detailed than typical police reports)
    - Other state's crash data, if available and detailed enough.
  - NHDOT will make determination from this review, whether the system is still meeting our expectations.

Exceptions to MASH Approved Hardware Requirement

There may be circumstances where requiring hardware that meets AASHTO MASH test criteria is very difficult. Approval for exceptions would be required, with signature of chief engineer.

Temporary Use Safety Hardware

To determine crashworthiness of temporary (construction workzone) systems, contractors shall:

Either,

- Use a pre-approved permanent hardware system being utilized for temporary use, that NHDOT approved via the system above (New Roadside Permanent Safety Hardware),

Or,

- Use a pre-approved system that NHDOT approved by:
    - Confirmation that the system has passed MASH testing
    - Confirmation that the tests took place at an ISO 17025 accredited laboratory
    - Determining from manufacturer's data for crash testing, that the system meets the NHDOT's needs for overall crash performance.

Or,

- Supply proof of successful MASH testing of a product for approval by the engineer. This method shall be outlined for contractors in item specifications and elsewhere within the Proposal.
    - For example: NHDOT will have a preferred and approved standard portable concrete barrier, but will allow use of other MASH systems, with approval, on a project by project basis.
    - Engineer will determine if the system meets the project's needs, considering:
        - Climate effects on the system performance, longevity, etc.
        - Overall crash performance

Drafted By: K. Mudgett
Noted By: J. Marshall, K. Cota, C. Spetelunas
Attachments: Cover Letter

STATE OF NEW HAMPSHIRE
INTRA-DEPARTMENT COMMUNICATION

DATE: March 8, 2023

FROM: [Name]
[Position Title]

AT (OFFICE): Department of Transportation
Bureau of Highway Design

THRU: [Project Manager's Name]
Project Manager

THRU: Kirk Mudgett, P.E.
Chief of Specialty Section

SUBJECT: Design Exception for Non-MASH Hardware on the NHS –
[Project Name & Number] – [Project Description]

TO: William J. Cass, P.E.
Assistant Commissioner

THRU:

____________________	____________________	____________________
James A. Marshall, P.E. Administrator Highway Design	William J. Oldenburg, P.E. Assistant Director of Project Development	Peter Stamnas, P.E. Director of Project Development

MEMORANDUM

In cooperation with the *NHDOT Process for Determination of Roadside Safety Hardware Crashworthiness* (with FHWA), and AASHTO, MASH compliance shall be met on NHS roadways. When compliance cannot be met due to unavailable resources, or other reasons, a design exception shall be obtained, through use of this memo.

Example Wording:

I hereby request that a design exception be approved to allow the use of a Controlled Release Terminal (CRT) on [Roadways, # of locations, Towns where units are proposed].

The CRT is a terminal, or treatment, of which we do not have a cost effective MASH approved option or design. The CRT is most often used when the hazard is interrupted abruptly by a driveway or side road, leaving no room for the length of need required for an energy absorbing guardrail terminal (EAGRT). The intention of the terminal is to close off the access to the hazard. It is comprised of breakaway posts which require a clear area behind the rail to retain the vehicle and a special anchor in many situations. It is limited to NHCRP 230 testing, low speed (40 mph and below), and low volume roadways. However, in some circumstances, it may be used at higher speeds (up to 55 mph).

Each of the [Number of Locations] locations have plans attached with the field observed hazard location sketched to indicate the inability of meeting length of need by extension of guardrail.

Elimination of the hazard is not considered feasible at each of these locations due to [Reason. ie: scope, filling in of wetlands, cost, other]. In addition, eliminating the break in the rail by moving the driveway is not considered feasible due to (right-of-way impacts beyond the scope of this project, cost, property frontage limitations, other)

DESIGN APPROVED: ☐
NOT APPROVED: ☐

____
William J. Cass, P.E.
Assistant Commissioner

[INITIALS of author/initials of checker]
Attachments - General Plans of Locations, CRT Detail, CRT Specification, photo of each location

S:\Highway-Design\Specialty Section\Guardrail\Design Exceptions\CRT Design Exception.docx