FDM 11-15-1 Design Guidance for Highways

February 15, 2024

1.0 Introduction

This section contains design guidance for rural roadway projects. These include State Trunk Highways (STH), Non-STHs (Local Roads), Expressways, non-Interstate Freeways, and Interstate Highways.

1.1 Overview and Scope of Projects

Projects are intended to reconstruct or newly construct highway pavement structures, geometric, and cross-sectional features to meet service life cycles. A practical minimum design analysis period for projects is 20 years with many projects meeting a project service life cycle of more than 20 years.

Design of projects shall be in accordance with the Facilities Development Process described in Chapter 3 of the Facilities Development Manual (FDM Chapter 3).

1.1.1 Definitions

The purpose and need for projects should provide pavement structures, geometric, and cross-sectional features that will adequately meet the pavement, safety, and operational needs for full service life cycles of 20 or more years.

FDM 3-5-1 contains definitions for Highway Improvement work types, as well as other criteria, examples, and requirements.

WI Administrative Code Trans 209, Highway and Bridge Project Selection Process, is the basis for the definitions in FDM 3-5-1.

1.2 Safety and Traffic Operations

Safety and traffic operations, in addition to pavement structure, are equally important considerations to design for within the project service life cycle time frames. Safety and traffic operations will be addressed on these projects by applying the appropriate safety and operational analyses per the WisDOT Safety Certification Process (SCP) or Operations Certification Process (OCP) and associated Safety and Operations Certification Document (SOCD). See FDM 11-38 and FDM 11-52-15. If the project is a Modernization strategy, safety and operations will be addressed using design criteria per FDM 11-15-1.3.2, below. The SOCD, along with Design Justifications (DJs) in the Design Study Reports (DSRs) (see FDM 11-1-20 and FDM 11-4-10.4), when needed, are the mechanisms available to justify, document and approve the retention of existing geometric and cross-sectional features or to introduce new geometric or cross-sectional features outside of existing or new design criteria values when needed for situations in which reducing environmental impacts or excessive costs is justified. This FDM chapter will define the WisDOT policy on the proper application of these criteria and processes.

1.3 Design Criteria Application

Geometric and cross -sectional design criteria have been developed for improvement projects based on the following sources:

1. Interstate Highways - A Policy on Design Standards - Interstate System, 2016, AASHTO (see FHWA website, “Interstate System”, https://www.fhwa.dot.gov/programadmin/interstate.cfm, under “Interstate Design Standards”)
2. Non-Interstate Highways - A Policy on Geometric Design of Highways and Streets, 7th edition, AASHTO 2018 (see FHWA website, “Geometric Design”, http://www.fhwa.dot.gov/programadmin/standards.cfm, under “Information”)

Projects will use these nationally recognized criteria and the derived FDM 11-15 Attachments 1.1 to 1.17 as the references for design criteria values for geometric and cross-sectional feature improvements. The Safety Certification Process will be used in conjunction with this guidance to allow for the evaluation and potential utilization of existing geometric and cross-sectional features. Existing features not contributing to safety issues justify improvements using the lower end of the design criteria ranges and may with the addition of other factors (environmental, public involvement, significant costs, etc.) justify the use of existing feature values outside of the range of design criteria. The applications that WisDOT will use to apply these design criteria will be the defined guidance described below as S-2 and S-3 Applications. These applications will apply to both Federal-aid and State funded projects. See FDM 11-38 for Safety Certification Process (SCP) guidance. See FDM 11-1-10 for additional information regarding S-2 and S-3 Applications.

1.3.1 S-2 Application

S-2 will be applied to reconstruction-type projects in the following ways:

1. Where the SOCD shows either that projects or project segments/locations have no discernible safety issues or where existing cross sectional, or geometric features are not contributing to safety issues, existing feature values within the range of design criteria may be retained and existing features outside of the range of design criteria may be considered when evaluated with other factors (such as environmental, public involvement, significant cost implications, etc.) and justified in a Design Study Report (DSR) Design Justification (DJ).
2. Where the SOCD shows that existing cross sectional or geometric features are contributing to safety issues, then utilize the lowest design criteria values to acceptably meet the project purpose and need. The application of cross sectional and geometric feature improvements will begin with the use of the lower design criteria in design alternatives development. The final design criteria values chosen will be based on predictive safety benefit/cost analyses results in conjunction with the natural and societal environmental impact evaluations completed as part of the environmental process described in FDM Chapter 20.
3. Design Justifications (DJs) can also be used when needed to justify, document and approve the use of values outside of design criteria in which the SCP has identified existing cross sectional or geometric features as contributing to safety issues and in which environmental or other project impact evaluations have determined that existing or less than existing design criteria values are justified. See FDM 11-1-20 and FDM 11-4-10.4 for information and guidance on developing DSR DJs.

1.3.2 S-3 Application

S-3 will be applied to new construction, reconstruction of an existing roadway with additional through lanes (expansion), or new bridge construction -type projects in the following ways:

1. The SCP cannot be applied to new construction-type projects or project segments/locations on new alignment because no cross sectional or geometric roadway features nor crash histories exist in which to evaluate safety performance.
2. These projects, or segments/locations of projects, will typically begin with the application of higher design criteria values in the development of design alternatives aimed at meeting the purpose and need of the project. The final design values chosen should be based on appropriate predictive safety benefit/cost analyses in conjunction with the natural and societal environmental impact evaluations completed as part of the environmental process described in FDM Chapter 20.
3. DJs can also be used to justify, document, and approve the introduction of values outside of design criteria that can be justified, documented, and approved based on other considerations besides just safety, such as environmental impacts, unacceptable costs, etc. See FDM 11-1-2 and FDM 11-4-10.4 for information and guidance on developing DJs.

1.4 Lanes and Shoulders

1.4.1 State Trunk Highways (STH), Non-STHs (Locals Roads), Non-Interstate Expressways, and Freeway Highways

Design criteria for various rural highway systems are given in this procedure. Attachment 1.1, 1.2 and 1.3 are for rural state trunk highways classified as arterials, collectors and locals respectively, and they provide separate design criteria for highways in level terrain and rolling terrain. Level terrain is the most prominent topography in Wisconsin and as such most projects will be designed using the level terrain criteria. Attachment 1.4 applies to town roads. Attachment 1.15, 1.16 and 1.17 are for rural county trunk highways classified as arterials, collectors and locals, respectively.

1.4.2 Interstate Highways

Interstate Reconstruction and New Construction projects are part of the 4R (Resurfacing, Restoration, Rehabilitation and Reconstruction) program which is a continuing post Interstate highway program established by Congress through a series of Federal Legislation [1] [2] [3] [4] [5]. The basic objective of this program is to preserve the integrity and operational effectiveness of the existing Interstate highway system.

This objective will be accomplished by appropriate work in three broad areas of activity:

1. The useful life of various elements of the system may be substantially extended through various resurfacing, restoration, and rehabilitation (or Preventative Maintenance and Perpetuation) efforts.
2. When such efforts would not be cost effective, it would be appropriate for the elements to be completely reconstructed or newly constructed (or modernized).
3. Finally, the program can respond to the need for improved functional effectiveness to reflect changed conditions. Consequently, where justified, these funds can be used to reconstruct (or modernize) facilities such as interchanges and overpasses and provide for safety upgrading. In addition, these funds can be used for other items of work which have been determined to be beyond that necessary "to provide a minimum level of acceptable service." Such items include rest area construction; new interchanges and added grade separations.

Interstate funds may also be used to construct new High Occupancy Vehicle (HOV) lanes but cannot be used to construct new travel lanes. Other Federal aid funds, such as National Highway System (NHS) or Surface Transportation Program (STP) funds may be used to add new travel lanes.

The definition of Interstate Reconstruction is work required to effect substantial upgrading of major highway features to increase the serviceability and safety of operations for a design life of 20 years or more. This class of work may require acquisition of additional right-of-way. Examples of this type of work are the following:

1. widening of roadways and bridge decks to add lanes;
2. bridge work beyond replacement of decks including work to increase vertical clearance under grade separations;
3. major grading to improve drainage and alignments;
4. addition of ramps and through lanes on crossroads at interchanges.

Note: This is a federal definition and is not meant for project programming purposes. For programming purposes use the definitions in the Program Management Manual (PMM) 5-10-5* pages 7 and 8 (*Only WisDOT employees have access to this hyperlink).

See Attachment 1.18 for Interstate Freeway Design Criteria.

Interstate highway segments being constructed on new right-of-way and segments undergoing complete reconstruction along existing right-of-way shall conform to current design criteria.[6]

Requests for design justifications (DJs) involving FHWA's controlling criteria on reconstruction and new construction-type interstate projects shall be prepared and processed in accordance with FDM 11-38 and FDM 11-1-20 for the appropriate situations. DJs, when needed, are approved by the Chief of the Design Standards and Oversight Section and, when required, by FHWA. DJs will only be acceptable if adequately supported and are not shown to lead to an identifiable loss in the safety features of highway designs.

1.5 Railroad Crossings

Avoid designing projects to start or end at railroad grade crossings. Either extend lane widths, shoulder widths, or cross section changes through the grade crossings, or stop the changes well short of the crossings (more than 1000-feet). See FDM Chapter 17. Review project termini with the Region Railroad Coordinator.

[1] Federal-aid Highway Acts of 1976

[2] Federal-aid Highway Act of 1981

[3] The Highway Improvement Act of 1982

[4] The Intermodal Surface Transportation Act of 1991 (ISTEA)

[5] The Transportation Equity Act of 1998 (TEA 21)

[6] A Policy on Design Standards Interstate System, AASHTO 2016

1.6 Cross Slopes

The normal cross slopes of all pavement types are 2%.

For Interstate Highways, pavement cross slopes should be 2% on tangent sections.

1.7 Shoulders

Shoulders should have adequate strength and stability to support occasional vehicle tire loads under all weather conditions without rutting or other surface variations.

- On tangent sections and crown runoff sections, shoulders typically slope 4% downward from the adjacent pavement edges.
- In super-elevated sections, the shoulder slopes should be designed in accordance with 2018 GDHS Figure 4-2, Cases A, A (Alternate), B, C, or C (Alternate). (GDHS hyperlink is only available to WisDOT staff.)
- See Attachment 1.19 - Design Considerations for Various Shoulder Treatment Options in Areas of High Side Superelevation to determine appropriate option for specific projects.

However, when the shoulders of two-lane highways are paved as integral parts of the travel lanes and the paved portions are 6 feet or less in width, the paved shoulder cross slopes should typically match the cross slope of the travel lanes for newly constructed or reconstructed pavement, or match the existing cross slope for resurfacing, reconditioning projects, or pavement replacement projects consisting of a structural overlay. The remaining unpaved portions of the shoulders are typically sloped 4%, except as previously noted for super-elevated sections.

Non-interstate width design criteria values for paved shoulders are shown in Attachment 1.5.

1.7.1 Shoulder Paving Policy

1. The shoulder paving policies are described as follows:

   a. For STH's with asphalt roadways where the application of existing or design classification shoulder values show total finished shoulder widths of 6 feet or more, provide paved shoulders in accordance with Attachment 1.5 of this procedure.

      Note - STH Design Classifications C2 and L3 with current ADTs of 750 or more, 12-foot lanes, and having 6-foot or more total shoulder widths, provide 5-foot paved shoulders. Where the total shoulder widths are 3-foot or more, and less than 6-foot, provide minimum 3-foot paved shoulders.

   b. For County Trunk Highways (CTH), and other local highways with total shoulder widths of 3-foot or more and having construction year traffic volumes of 750 AADT or more, provide 3-foot paved shoulders.

      Note - reconstruction and new construction-type projects on local roadways receiving state or federal funding with construction year AADTs of 750 or more are required to include the installation of 3-foot minimum paved shoulders. See FDM 11-46-15.4 for conditions where wider than a 3-foot paved shoulders are required. For local roadways having construction year traffic volumes less than 750 AADT, paved shoulders are at the discretion of the local officials.

      See Trans 204 and Trans 205.

   c. For Interstate highways, typical lowest width requirements for paved shoulders should be 10-foot on all right shoulders and for left shoulders 10-foot on highways with 6 or more lanes and 4-foot on 4-lane highways. Consider the use of 12-foot paved shoulders (left and right) on 6-lane freeways if truck traffic > 250 DHV or if the facility experiences a high degree of congestion and incidents. The roadway widths and clear roadway widths on bridges are increased accordingly.

   Regions may decide to pave more shoulder widths than the policy widths. There may be design justifications (DJs) for finished shoulder widths on some projects with high cuts, or fills, or adverse environmental factors. When DJs are granted that will reduce the finished shoulders to less than 6 feet, then 5-foot paved shoulders may also qualify for DJs to the design criteria.

2. When the pavement structures are PC concrete and the construction year AADTs are greater than 750;

   a. two-lane, two-way highways constructed with a PC concrete shoulder 3 feet or greater in width are tied. PC concrete shoulders less than 3 feet should be paved monolithically with the PC concrete pavement.

b. multi-lane divided highways should typically be constructed with 2-foot monolithic shoulders on the right.

Total paved shoulder widths should typically be as shown in Attachment 1.5 of this procedure and as shown in the SDD for Doweled Non-Reinforced Concrete Pavements, Section A-A.

3. Shoulders may be paved full width along highways in suburban areas where closely spaced driveways and frequent turning movements cause unpaved shoulders to require excessive maintenance.
4. Continuity of shoulder paving between logical termini is desirable. Try not to leave gaps of unpaved shoulders.
5. Provide a thickness of shoulder paving based on the usual design considerations appropriate for each situation (see FDM 14-10-20).

1.8 Rumble Strip Introduction and Definitions

Rumble strips are an engineering treatment designed to alert drivers of a lane departure through vibration and noise created when a vehicle's tires contact the rumble strips. Rumble strips may be placed on the shoulders, between opposing travel lanes (centerline), or across the travel lanes (transverse).

WisDOT specifies milled-in rumbles on concrete and asphalt shoulders on divided highways and on shoulders (or edge lines) and centerlines on undivided highways. Rumble strips are typically installed on rural roadway segments that have minimal residential or commercial development, with little or no further development anticipated in the future.

There are two milling types for rumble strip corrugations:

- **Conventional -** Conventional milled rumble strips refer to individual rectangular concave grooves cut intermittently in the pavement surface. These are the typical rumble strips currently in use at WisDOT.
- **Sinusoidal -** Sinusoidal milled rumble strips, sometimes referred to as mumble strips, use a continuous groove that changes depth following a sine wave pattern. The design reduces the external noise generated from vehicles traveling across them.

Rumble strips are further broken down by location on the roadway:

- **Centerline Rumble Strips** - are placed along the road centerline with the pavement markings placed partially or completely over them. Centerline rumble strips help keep vehicles in their lanes and are effective at reducing head-on collisions and opposite-direction sideswipes. They are primarily used to alert drivers on two-way, two-lane roadways.
- **Shoulder Rumble Strips** – are placed on the roadway shoulder. They are primarily used to warn drivers when they have drifted from their lane.
- **Edge Line Rumble Strips –** are a variation of shoulder rumble strips where the rumble strip is placed at the edge line of the lane with the pavement marking on top. Edge line rumble strips are generally placed on roads with narrow shoulders where safety considerations justify installation. These are sometimes referred to as shoulder rumble stripes.
- **Transverse Rumble Strips** – on a given approach, these are placed across a travel lane to alert drivers of a need to slow down, stop, or alert them to other upcoming changes that may not be anticipated (typically at intersections).

Shoulder and centerline rumble strips are especially helpful during bad weather such as rain, snow, or fog when visibility of the edge line or centerline pavement markings are substantially reduced. Rumble strips also help to reduce inattentive driving crashes. Driver inattention comes in many forms, including fatigue, drowsiness, daydreaming, cell phone use, texting, visual distractions, alcohol, and drug impairment to mention a few.

Run-off-the-road (ROR) crashes account for over one-third of fatal and injury crashes each year, with 90% taking place on rural Wisconsin highways. Rumble strips will not eliminate all ROR crashes especially those caused by excessive speed, sudden turns to avoid on-road collisions, or high-angle encroachments.

Although conventional rumble strips are a low-cost safety measure to reduce head-on, sideswipe and ROR crashes, sometimes they are not installed due to exterior noise concerns. Residents living adjacent to highways with conventional rumble strips often complain about the noise generated from conventional rumble strips.

A potential solution to noise issues associated with conventional rumble strips is the sinusoidal rumble strip design. Following research by other states, the Minnesota Department of Transportation (MnDOT) conducted a study in 2016 that compared various types of sinusoidal rumble strip patterns to determine the design pattern that provides a reduction in exterior noise, while maintaining an adequate level of interior vehicle noise and vibration. The study included various sinusoidal designs from other states along with their standard conventional rumble strip for comparison. The study recommended the sinusoidal design with a 14-inch-long wavelength that oscillates between 1/16” and 1/2” below the pavement surface.

WisDOT has adopted MnDOT’s recommended design. This design reduces the exterior noise (creating an exterior sound that’s less harsh and slightly louder than the vehicle on pavement) while generating an internal noise at or above the minimum levels recommended in NCHRP Report 641. While the sinusoidal rumble strip design’s interior feedback performed well with passenger cars and SUVs, and were acceptable in pick-up trucks, the evidence suggests that more studies are necessary to determine their effectiveness with large trucks.

For additional information on rumble strips, refer to FHWA web site:

https://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips/

The web site contains links to; FHWA Technical Advisory T5040 39: Shoulder and Edge Line Rumble Strips, FHWA Technical Advisory T5040 40: Centerline Rumble Strips, NCHRP Report 641 - Guidance for the Design and Application of Shoulder and Centerline Rumble Strips, MnDOT’s - Rumble Strip Noise Evaluation report along with other information.

1.8.1 WisDOT Rumble Strip Policy and Design Criteria

A systemic approach is taken to rumble strip installation based on national evidence that rumbles strips reduce crashes and increase safety on divided and undivided roadways. WisDOT policy for each installation is described in the sections below.

Careful consideration was given for noise generation in development of the rumble strips policy. The design and horizontal locations/offsets of the rumbles, along with the option to place sinusoidal rumble strips on some roadways, should minimize noise generation. The safety benefits of rumbles outweigh the impacts of the noise generated most of the time. Therefore, it is appropriate to take a systemic approach to the implementation of rumbles. However, there may be situations where noise generation factors into the decision to either install or gap installations of rumble strips. These situations may include where current high speed (≥50 mph) facilities are likely to have posted speeds reduced in the future because of increased traffic or congestion, or future land uses allow for adjacent developments where noise may be an issue.

Decisions to either gap or not install rumble strips will be kept to a minimum. Document these decisions with a design justification in Section 4.3.2 (Non-Controlling Design Criteria) of the design study report.

The designs in terms of depths, widths, lengths, spacings as well as start/stop locations for typical roadway features will vary between divided and undivided highways and are identified below and on the Standard Detail Drawings (SDDs).

Contact Bureau of Technical Services Materials unit when considering retrofitting rumble strips onto existing highways.

1.8.1.1 Divided Highways

On rural divided freeways and interstates install conventional rumble strips on both the right and left shoulders including parallel entrance ramp shoulders, and the last 600 feet on the right shoulders of tapered entrance ramps. Do not install rumbles on bridge approaches or bridge decks. Sinusoidal rumble strips shall not be installed on divided highways. Refer to SDD 13A5 for design and location details.

On rural multi-lane divided, high speed (≥50 mph) roadways install conventional rumble strips on both the right and left side shoulders, except they shall not be constructed on tapers to right or left turn lanes, along turn lanes, across side road intersections, across commercial and private driveways, within 25’ of bridge approaches or bridge decks, and 100 feet in advance of railroad crossings. There may be locations along rural multi-lane divided, high speed, roadways near urbanized areas where rumbles may not be appropriate. See SDD 13A5 (Shoulder Rumble Strips, Divided Roadway) for rumble design and location details.

There may be locations on freeways and multi-lane divided, high speed, roadways in urbanized areas where shoulder rumble strips may not be appropriate. These locations may include residential areas or other areas where road noise from rumble strips is undesirable. In other situations, shoulder rumble strips may not be desirable because traffic needs to use the shoulders on a recurring basis to get around mainline blockages, or the shoulders are frequently used for incident management, law enforcement or other purposes.

1.8.1.2 Undivided Highways

Install centerline and shoulder conventional or sinusoidal rumble strips on concrete and asphalt two-lane, rural, undivided, high speed (≥50 mph) roadways. These projects shall be greater than one-half mile long and meet the criteria listed in the following subsections.

Conventional rumble strips are a proven safety countermeasure. Sinusoidal rumble strips are a newer alternative to conventional rumble strips, and the safety benefits are not known at this time. Designers shall install conventional rumble strips whenever possible and only install sinusoidal rumble strips when justified by receptor location, noise, or other concerns.

Mixing conventional and sinusoidal rumble strips on the same project should be minimized. For instance, do not switch between conventional and sinusoidal centerline rumble strips every 1,200 feet within a 5-mile project.

Work with BPD Region Design Oversight Engineer when considering sinusoidal rumble strips.

Table 1.1 is a summary of combinations for conventional and sinusoidal rumble strip placement on asphalt and concrete pavements for undivided highways, subject to the design criteria in the following subsections.

Table 1.1 Summary of Rumble Strip Milling and Pavement Type vs. Allowable Location

	Rumble Strip Milling and Pavement Type			
	Conventional		***Sinusoidal***	
Rumble Strip Location	***Asphalt***	***Concrete***	***Asphalt***	***Concrete***
Centerline Rumble Strip	Yes	Yes	Yes	No
Shoulder Rumble Strip	Yes	Yes	Yes	Yes
Edge Line Rumble Strip	Yes	Yes	No	No

Consideration should be given to project types, lane widths, finished shoulder widths, paved shoulder widths, horse and buggy travel, bicyclists, roadside noises, steepness and length of downhill grades and beam guard or barrier wall installations, as described in the following subsections.

1.8.1.2.1 Centerline Rumble Strips

On projects that are rural, two-lane, undivided, high speed (≥50 mph) highways having 12-foot lane widths, install centerline rumble strips with conventional or sinusoidal corrugations.

Do not install warning signs for centerline rumble strips per the Traffic Engineering Operations and Safety Manual TEOpS 2-3-65.

See SDD 13A11 for more detailed design and installation location information.

1.8.1.2.2 Shoulder Rumble Strips

On projects that are rural, two-lane, undivided, high speed (≥50 mph) highways having 12-foot lane widths and a minimum 5-foot paved shoulder, install shoulder rumble strips (formerly Type 1 rumble strips) with conventional or sinusoidal corrugations.

A 5-foot paved shoulder provides 4 feet of paved shoulder outside of the rumble strips as a clear zone to accommodate bicyclists and allows oversized-overweight (OSOW) vehicles to straddle the rumbles.

If the outside edge of shoulder is adjacent to beam guard or barrier wall, provide 5 feet of clear area between back of rumble strip and face of beam guard or barrier wall. If 5 feet of clear area cannot be obtained, consider gapping shoulder rumble strips.

Shoulder rumble strips should not be installed on roadways that experience recurring horse and buggy travel unless a run-off-the-road crash history exists. When a correctable crash history does exist, consider using rumble strips and widening the shoulder width to accommodate both.

Contact the Regional Bicycle and Pedestrian Coordinators to discuss locations of known high bike traffic, designated bike routes on local, county or state plans and installation appropriateness near recreational and resort areas with likely bike and pedestrian traffic.

Shoulder rumble strips are the most common type of rumble strip installed in the shoulder area. The standard detail shows the installation location adjacent to the edge of traveled way and the edge lines. Shoulder rumble strips shall not be installed through intersections, marked crosswalks, non-motorized path crossings, concrete pavement joints (transverse and longitudinal) and as shown on SDD 13A10 (Shoulder and Edge Line Rumble Strips).

1.8.1.2.3 Edge Line Rumble Strips

Edge line rumble strips (formerly Type 2 rumble strips) can be installed on new construction or improvement projects that are rural, two-lane, undivided, high speed (≥50 mph) highways having 12-foot lane widths. However, they are not installed systemically like shoulder rumble strips. Edge line rumble strips should be installed when there are known high run-off-the-road (ROR) crash issues with logical termini, not short spot locations. Edge line rumble strips may be used when the paved shoulders are at least 3 feet wide and less than 5 feet wide. Recommendations to install edge line rumble strips should be coordinated with the Region Traffic Safety Engineer. In addition, contact Bureau of Traffic Operations (BTO) - Traffic Design Pavement Marking Unit to discuss proposed edge line rumble strip installation locations. Edge line rumble strips are likely to generate more noise from nuisance hits than shoulder rumble strips because they are closer to the edges of the travel lanes. For edge line rumble strips only conventional corrugations in asphalt or concrete pavements are allowed.

If safety considerations require the consideration of edge line rumble strips on projects with less than 3-foot paved shoulders, work with Region Safety Engineer and contact BTO Safety Engineer, BPD Standards Engineer and DTIM Bicycle and Pedestrian Coordinator to discuss.

Edge line rumble strip installation information is the same as the shoulder rumble strip installation location information found above and on SDD 13A10 (Shoulder and Edge Line Rumble Strips).

1.8.2 Transverse Rumbles

Transverse rumble strips (formerly travel lane rumbles) are typically used for intersection approaches. Transverse rumbles must be used in combination with other traffic control devices such as advance-warning signs and are often installed in advance of stop-controlled conditions. Several scenarios where transverse rumbles may be installed:

1. At the intersections of two highways that have similar functional classifications or where the AADT volumes are similar. This could be at the intersections of two STHs or the intersections of STHs and CTHs having similar traffic volumes, or where driver expectancies are that the facility they are driving on would not have a stop-control condition.
2. There are perceived or demonstrated crash issues when drivers are unaware that they are supposed to stop for crossing traffic or where the geometrics of the roadways may prevent the drivers from seeing the approaching intersections such as at vertical crest curves or horizontal curves.

Noise generation is a primary concern with these types of rumble installations for people at residential or other properties close to the installations. It is important to communicate with and coordinate with affected property owners prior to installations. It is important to not overuse these treatments as to become common place so that drivers are desensitized to the noises and vibrations generated by the rumbles.

See SDD 13A8 and SDD 13A9 for more detailed information on the rumble installations and rumble locations prior to intersections.

1.9 Auxiliary Lanes

For a definition of auxiliary lanes see FDM 11-25-35.

On PCC pavement projects, auxiliary lanes longer than 800-feet, including tapers, shall have a construction joints at the proposed pavement marking locations. See FDM 14-10-10 for more information.

1.10 Subgrade Side Slopes and Widths

Establish subgrade widths by maintaining constant side slopes between the finished shoulder points and the subgrade shoulder points on both the left and right sides of the cross sections. See Attachment 1.6 and Attachment 1.7 for typical cross sections depicting rural roadway design classes. By maintaining constant side slopes, the subgrade widths will vary throughout super-elevation transitions. The subgrade widths will be constant throughout full super-elevations but will have different subgrade shoulder point offsets (i.e. distances left and right of roadway centerlines) versus normal crowns.

Assess impacts and right-of-way needs when widening existing subgrades for roadway or shoulder improvements (e.g. adding passing lanes). Widened subgrades may also be necessary to accommodate barrier systems or other needs.

1.11 Side Slopes

Flatten and round side slopes to fit the topography consistent with site conditions, traffic safety, and cost effectiveness of design. Gradual transitions from cut to fill slopes, or within cut or fill slopes, will avoid unattractive bulges and sharp depressions. Do not vary fill slopes of adjacent full stations by more than 1:1, except under unusual conditions.

Interstate highway fore-slopes should be either recoverable (4:1 or flatter), or traversable (3:1 MAX) with adequate recovery areas to meet the clear zone criteria of FDM 11-15 Attachment 1.9. If not obtainable, install barriers as warranted in accordance with current design criteria.

Design guide values for rock slopes are shown on Attachment 1.8. Selection of rock slopes should be determined in consultation with the Region Chief Materials Engineer. (See Page 4-31, 2018 GDHS).

For side slope criteria in clear zones, see "Clear Zones and Side Slopes" below.

1.12 Side Ditches

Typical side ditch configurations are shown in Attachment 1.6 and Attachment 1.7. Greater ditch widths may be used in earth cuts as necessary to provide increased drainage capacity or more space for snow storage and falling rocks from unstable cut slopes. The minimum depths of ditches should be 1 foot below the sub-grade shoulder points to ensure positive drainage of the sub-grades. The flattest gradients for side ditches should be 0.5 percent. Avoid using flatter ditch gradients when excessive vegetation or debris may restrict drainage. Use criteria in Chapter 13 when designing ditch cross sections.

All cross-drain culvert ends, and cattle passes should be marked with Marker Post, Flexible, for Culvert Ends. This includes single and multiple culvert ends and cattle passes in shielded and unshielded locations either inside or outside the clear zones on the public right-of-way. Do not mark driveway culvert ends, field entrances, or underdrain outfalls.

1.13 Clear Zones, Horizontal Clearances, and Clear Roadway Widths of Bridges

Clear zones, horizontal clearances, and clear roadway widths of bridges are not the same, and the terms cannot be used interchangeably. A quick distinction is that clear zone is for the benefit of vehicles that errantly leave the roadway; horizontal clearance is for the benefit of vehicles on the roadway, and clear roadway width of bridges applies only to structures.

The following are definitions and guidance for each of these terms:

1.13.1 Clear Zone [7]

Clear zone is defined as that roadside border area which is made available for safe use by errant vehicles. Clear zones start at the edges of the traveled ways and consist of the shoulders, auxiliary lanes, recoverable slopes, and any traversable but non-recoverable slopes with clear run-out areas at the toes of the slopes. Clear zones should not contain critical, i.e. non-traversable, slopes.

See FDM 11-45-15.1.3 for preferred roadside hazard treatment sequence.

The extent of clear zones depends on the design speeds and the probability of vehicles leaving the roadways.

Clear zone is not one of the Controlling Criteria for geometric design. However, they establish the "Zones" in which obstructions or steep slopes warrant evaluation. These "Zones" include any required clear runout areas. Therefore, the proposed clear zones and the basis for their selections should be justified in the SOCDs or Design Study Reports (DSRs). If less-than-typical design criteria clear zone widths are proposed for projects, the reasons should be justified in the SOCD or the DSR. Approval of the SOCD or the DSR establish design variances for not meeting WisDOT's clear zone policy.

Clear zones are key considerations when analyzing roadside hazards. There are no definitive amounts of clear zone required. The intent is to provide as much clear, traversable recovery areas as practical. Attachment 1.9 lists clear zone widths for various combinations of design speeds, AADTs and side slopes. The attachment is from the 2011 AASHTO Roadside Design Guide. The values in Attachment 1.9 are based on limited empirical data that was extrapolated to provide information for a wide range of conditions. These widths represent only the approximate center of ranges to be explored and not precise distances to be held as absolute. These widths may be modified, within reason, in consideration of site-specific conditions, and are consistent with the roadway classifications, traffic volumes, roadway geometry, crash history, design speeds, available resources, available right-of-way, and good engineering judgment.

Reduced clear zone widths may be warranted to avoid extensive right of way taking, excessive property or environmental impacts or on relatively short projects to provide cross sections compatible with abutting sections of the highways.

See Attachment 1.20 for clear zone recommendations for roads with posted speeds of 70 mph.

Consider providing wider clear zones on the outsides of horizontal curves for roadways and structures (see

[7] *AASHTO (2011). Roadside Design Guide. Pages 2-2, 3-3 to 3-12, 3-14 to 3-16, 4-1, 5-6, 5-9, 5-40 to 5-48, 6-12 to 6-13, 10-2 to 10-3, 10-15 to 10-18. Washington, DC.*

Attachment 1.10 for adjustment factors). Clear zone widths should be evaluated at all roadside locations where warranted because of crash history.

Clear zone widths shall be increased where necessary to include the roadside ditches. Roadside ditches shall be traversable (see Attachment 1.11 for preferred ditch sections). Utility poles or other non-breakaway hazards should not be located in or near ditch bottoms.

1.13.1.1 Clear Zones and Driveways, Side Roads and Median Crossovers

Embankment slopes created by driveways, intersection side roads, and median crossovers will be impacted at right angles by errant vehicles leaving the roadways. Flatter slopes are desirable at these locations because steeper slopes can cause vehicle bumpers to dig in, or cause vehicles to vault.

Review FDM 11-45-30 for guidance on acceptable slopes and roadside design options.

Place driveway, side road, and median crossover culvert pipes as far from the main roadways as practicable.

1.13.1.2 Clear Zones and Side Slopes[7]

Side slopes parallel to the flow of traffic can be characterized in one of three ways:

1. recoverable
2. non-recoverable, but traversable
3. critical

A recoverable slope is one on which most motorists can generally stop their vehicle on the slope or slow them enough to return to the roadway safely. Fill slopes of 4:1 or flatter and cut slopes of 3:1 or flatter are considered recoverable if they are also relatively smooth and traversable. Provide recoverable slopes within the clear zones if at all feasible.

A non-recoverable slope is one on which most motorists will be unable to stop or return to the roadway easily, but one that will not cause a vehicle to overturn. Traversable fill slopes between 3:1 and 4:1 are generally non-recoverable. On slopes between 3:1 and 4:1 many vehicles will continue to the bottom. Because of this, try to provide clear runout areas at least 10 feet wide beyond the toes of non-recoverable slopes. See Attachment 1.9 for an explanation and illustration of how recovery areas are computed.

A critical slope is one on which a vehicle is likely to overturn. Fill and cut slopes steeper than 3:1 are considered critical. If slopes steeper than 3:1 begin closer to the traveled ways than the suggested clear zone widths, then barriers may be warranted.

Clear zones with variable side slopes ranging from essentially flat to 4:1 may be averaged to produce composite clear zones. Slopes that change from negative to positive cannot be averaged and are treated as ditch sections and analyzed for traverse-ability using Attachment 1.11.

1.13.1.3 Interstate Clear Zones and Side Slopes

Attachment 1.9 and the 2011 AASHTO Roadside Design Guide should be used for guidance regarding warranted clear zone widths. Any fixed objects within clear zone limits should be removed, made breakaway, or made safe through shielding by roadside barriers or crash cushions or a combination of the two.

1. **Curbs or Curb and Gutters**

   Barrier curbs should not be used.

   Sloped curbs, when used, should be located at the outer edges of the shoulders. Also, where guardrails are used, design the faces of the curbs to be flush with the faces of guardrails or placed behind them. See FDM 11-20 for information on sloped curbs.

2. **Cross-drain Culvert End Sections and Headwalls**

   Refer to FDM 11-45-30 for the definition of hazardous cross drains or cattle passes, treatment options, and warrants for various treatment options.

3. **Median Inlets and Ditch Checks**

   Median inlets should have 6:1 or flatter traversable grates, and 10:1 or flatter ditch checks.

1.13.2 Horizontal Clearance [8] [9]

Horizontal clearance refers to:

- Minimum lateral under-clearance to structure
- Minimum lateral clearance.

1.13.2.1 Horizontal Clearance - Lateral Underclearance to Structure [8]

Lateral underclearance to Structure is defined and design criteria for roadways is shown in FDM 11-35-1. Minimum lateral underclearance to Structure for railroads is also defined in FDM 11-35-1.

1.13.2.2 Horizontal Clearance - Lateral Clearance [10]

Lateral clearance is defined as an obstruction free area beginning at the edge of driving lane and extending a minimum distance so as not to interfere with the operation of the roadway.

These areas should contain no fixed objects, including, but not limited to, light poles, sign posts, sign faces, beam guard, barriers, trees, shielded objects or break away objects (moving vehicles, parked vehicles, and pedestrians are not considered fixed objects). Lateral clearance design criteria apply to all roadways.

1.13.2.3 Lateral Clearance for Rural (Shoulder) Roadways

On roadways without roadside barriers, typically provide lateral clearance from the edges of driving lanes to at least a minimum distance outside the edges of the finished shoulders (see Table 1.2 and Attachment 1.15). On roadways with narrow shoulders, offsets from the driving lanes may extend farther beyond the edges of the finished shoulders than the minimum offset outside the edges of finished shoulders.

On roadways with roadside barriers, provide the required lateral clearance between the edges of the driving lanes and the faces of the barriers. See Table 1.2 and Attachment 1.15.

[8] U.S. Department of Transportation Federal Highway Administration. Office of Engineering. Bridge Division. Bridge Management Branch. (1995). Recording and Coding Guide for the Structure Inventory and Appraisal of The Nation's Bridges. "Item 47 - Inventory Route, Total Horizontal Clearance; Item 51 - Bridge Roadway Width, Curb-to-Curb; Item 55 - Minimum Lateral Underclearance on Right; Item 56 - Minimum Lateral Underclearance on Left; Item 68 - Deck Geometry; Item 69 - Underclearances, Vertical and Horizontal". (Report No. FHWA-PD-96-001). Washington, DC.

[9] U.S. Department of Transportation Federal Highway Administration (1996). Federal Lands Highway Project Development and Design Manual. "Chapter 9 – Highway Design, Section 9.1.B.2 – Design Standards – Design Exceptions". (Publication No: FHWA-DF-88-003)

[10] A Policy on Geometric Design of Highways and Streets. 7th edition, AASHTO, 2018. Pages 3-112, 3-113, 3-144, 4-9, 4-35, 7-17, 8-5, and 9-92.

Table 1.2 Required Clearances from Edges of Driving Lanes for Rural Highways [1]

ROAD TYPE	WITHOUT roadside barriers[2]	WITH roadside barriers[2]
	New Construction and Re-construction	**New Construction and Re-construction**
All STH's Arterials non-STH Collector and Local Roads (i.e., non-arterials) with Design Year AADT ≥ 1500	**The GREATER of 6 feet** **OR** **finished shoulder width[4] + 2 feet**	**The GREATER of 6 feet** **OR** **finished shoulder width[4]** (Minimum) (The GREATER of 4 feet OR finished shoulder width[4])
non-STH Collector and Local Roads (i.e., non-arterials) with Design Year AADT < 1500	**The GREATER of 6 feet** **OR** **finished shoulder width[4] + 2 feet** (Minimum) (The GREATER of 2 feet OR finished shoulder width[4] + 2 feet)	**The GREATER of 4 feet** **OR** **finished shoulder width[4]** (Minimum) (The GREATER of 2 feet OR finished shoulder width[4])

[1] Applies to all fixed objects other than mailboxes. Clearances to mailboxes are based on the guidelines from Chapter 11 of the 2011 AASHTO Roadside Design Guide, titled “Erecting Mailboxes on Streets and Highways.”

[2] Lateral Clearance extends beyond the edges of the finished shoulders. Also, additional clearances may be needed at some locations - particularly at intersections - to compensate for off-tracking.

[3] Lateral Clearance should be provided to the faces of the barriers, but do not extend behind them. Other offsets behind the barriers or beyond the edges of the finished shoulders may apply. Also, consider the potential deflections of the roadside barriers (see FDM 11-45). Also, additional clearances may be needed at some locations - particularly at intersections - to compensate for off-tracking.

[4] See Attachment 1.1 - 1.4 and Attachment 1.17 - 1.19 for guidance on finished shoulder widths for new construction and reconstruction.

1.13.2.4 Lateral Clearances vs. Other Required Offsets

In addition to lateral clearance design criteria, there may be other required minimum offsets from the edges of travel lanes, edges of shoulders or faces of curbs, e.g.

- Wisconsin Manual on Uniform Traffic Control Devices (https://wisconsindot.gov/Pages/doing-bus/local-gov/traffic-ops/manuals-and-standards/wmutcd/wmutcd.aspx) criteria for sign placement
- Traffic Engineering Operations and Safety Manual (TEOpS), Chapter 11 criteria for the placement of light poles (TEOpS 11).
- Traffic Signal Design Manual, TSDM 6-1-3 guidance on offsets for traffic signal supports.

If the lateral clearances exceed any other design criteria offsets, use the lateral clearances, otherwise use the other offsets.

1.13.2.5 Lateral Clearance and Mailboxes

Make sure that lateral clearances to mailboxes meet the guidelines contained in Chapter 11 of the 2011 AASHTO Roadside Design Guide,” except that the shoulders or turnout widths at mailboxes cannot be less than the finished shoulder widths for the roadways. Mailbox installations not meeting these guidelines can be considered hazardous (see "Hazardous Mailboxes" below). If possible, offset the roadside faces of mailboxes no closer to the driving lanes than are required for other fixed objects.

1.13.3 Clear Roadway Widths of Bridges [8]

Clear roadway width of bridges is defined as the most restrictive minimum distance between curbs or rails on a structure. This measurement is exclusive of flared areas for ramps.

Clear roadway width of bridge design criteria is shown in Attachment 1.1 - 1.4 and Attachment 1.17 - 1.19 along with FDM 11-35-1.

For interstates, widening of existing structures are high cost improvements which should be decided on a case by case basis with consideration given to site specific crash history, traffic characteristics, and the potential for crashes as traffic volumes increase. Bridges that warrant widening, except major long span structures, shall be widened to full approach roadway widths. Major long span structures shall provide for minimum offsets from the edges of the traffic lanes to the parapets of at least 4 feet. However, consideration should be given as to traffic control and snow storage needs when evaluating shoulder widths.

Bridge widths may be increased to accommodate high traffic demand during construction and to reduce user delays in work zones on rural Corridors 2030 Backbone facilities. See FDM 11-35-10 for additional information and warranting criteria.

Interstate Bridges to remain in place must have 12-foot wide traffic lanes, 10-foot wide shoulders on the right, and 3.5-foot wide shoulders on the left. On major long span bridges, minimum shoulder widths may be 3.5 feet for both left and right shoulders. However, consideration should be given as to traffic control and snow storage needs when evaluating shoulder widths.

1.14 Median

A median is the portion of the highway separating opposing directions of the traveled way. Medians may be depressed, raised, or flush. Medians on rural highways are typically depressed, i.e. ditched.

Medians perform the following functions.

- Separate opposing streams of traffic to minimize the risk of head on collisions,
- Provide recovery areas for out-of-control vehicles,
- Provide stopping areas in cases of emergencies,
- Allow space for speed changes and storage of left-turning and U-turning vehicles,
- Minimize headlight glare and gawking,
- Provide widths for future lanes,
- Provide refuge areas for wildlife, and
- Control access.

See Pages 4-38 thru 4-41, 7-17 thru 7-18, 8-9 thru 8-11, 2018 GDHS.

1.14.1 Median Widths for Rural Highways

Median width is expressed as the dimension between the edges of traveled ways and includes the left shoulders. The lowest median widths shall be 60 feet on Design Class A3 freeways. The lowest median widths shall be 60 feet on Design Class A3 expressways with posted speeds greater than 55 mph, and 50 feet on Design Class A3 expressways with posted speeds of 50 or 55 mph.

1.14.2 Intersections

Widen medians at median openings for un-signalized intersections on expressways if necessary to accommodate the design vehicles for those intersections. This is especially critical at locations that must handle large trucks, long school busses or combinations of farm machinery. In these situations, the median widths should typically be about 100 feet.

WisDOT crash analysis indicates that high-speed expressways with at-grade intersections on curves are problematic. See FDM 11-25-1 for more information on at-grade intersections.

1.14.3 Median Ditches

Median ditches must:

- Have sufficient depths to provide positive drainage of the adjacent sub-grades. Normally this requires median depths of at least 1-foot below the sub-grade shoulder points.
- Have ditch cross-sections within the clear zones that are within the "preferred channel cross section"

area of Attachment 1.11 to prevent vehicles from "tripping."

- Have recoverable side slopes within the clear zones, per Attachment 1.9, to facilitate the recovery of out-of-control vehicles. Typically, the ditches are based on a 6:1 maximum slope from both sub-grade shoulders. For medians between widely separated roadways, the side slopes of normal cut and fill sections are typically used.
- Have sufficient longitudinal gradients to ensure good drainage. The typical flattest longitudinal gradients of median ditches are at least 0.5 percent.
- Have sufficient hydraulic capacities to handle the expected design flows (see FDM 13-10-1).

1.14.4 Median Maintenance Crossovers for Freeways

Install median maintenance crossovers to avoid extreme adverse travel for emergency, law enforcement, and maintenance vehicles on rural freeways. They are typically provided where interchange spacings exceed 5 miles, depending on needs for snow removal equipment and other locations to facilitate maintenance operations. Median maintenance crossovers are located according to need after considering the number and spacing of interchanges and coordination with the Bureau of Highway Maintenance, State Patrol, and Emergency Management. In general, these crossovers should not be located closer than 1,500 feet from the ends of entrance or exit ramps or to any structures. Crossovers should typically be located having decision sight distances, or at least stopping sight distances.

Other factors to consider are drainage, profile differences between the divided roadways, and not to install crossovers on super-elevated sections.

In all cases, minimize the number of median crossovers, and design them to be as inconspicuous as possible. The crossover profiles are preferably sags between the opposing edges of shoulders. See SDD 11a1 titled "Maintenance Crossover for Freeways" for design details.

Median maintenance crossovers are not generally warranted on urban freeways due to the close spacings of interchange facilities. Only in rare situations would crossovers in urban areas be warranted and then only after appropriate installation of roadside design features are coordinated with the Bureau of Project Development.

For interstates, median maintenance crossovers should be eliminated if not providing a needed function or reconstructed to have 10:1 or flatter side slopes.

1.14.5 Median Construction Crossovers for Freeways

See FDM 11-50-20.4 for design information. Median construction crossovers are installed to allow traffic from one side of the divided highways to cross to the other side at high speeds (typically 50mph or greater). These are typically in work zones where two-way traffic is maintained on one roadway while the opposite direction roadway is closed.

Interstate construction crossovers should be removed after project completion unless they are planned to be used for subsequent maintenance or other traffic control operations. Construction crossovers left-in-place should have 10:1 or flatter side slopes and appropriate safety devices installed along their lengths to minimize the potential for median-crossing crashes or unauthorized U-turns. See FDM 11-50-20.4 for additional guidance.

1.14.6 Median Barriers

See FDM 11-45-30.

1.15 Transition from Divided to Two-Way Roadways

Transitions between divided and single roadways generally are made on tangent sections and never at locations with horizontal or vertical sight restrictions.

The entire transition needs to be visible to the drivers of vehicles approaching the divided sections to prevent indecision, error, or wrong-way entries. Do not change horizontal alignments of lane(s) carrying traffic onto the divided facilities from that of the approaching two-lane roadways until reaching points beyond the beginning of the median dividers. The design criteria of the superior facilities are carried through the transitions to the extent feasible rather than confront the drivers with abrupt changes in geometrics (see Attachment 1.12).

Complete lane drop transitions far enough in advance of railroad grade crossings to allow drivers to see and react to crossing warning devices. Place transitions to provide the stopping sight distances shown in FDM 17-25 Attachment 1.2. This applies to both permanent lane drops and temporary lane drops for traffic control purposes.

1.16 Marsh Section

As a rule, do not specify the use of geotextiles in lieu of marsh excavation. Many of the shallow marshes are not problems to excavate. Excavation does bring up the need for hauling and disposal, and the accompanying DNR and environmental concerns, but these considerations do not justify improper designs.

Geotextiles have many appropriate uses, in which they satisfy need and function very well. However, roadway fills placed on geotextiles over marshes will eventually settle, as the underlying marsh becomes consolidated. Geotextiles will tend to provide more uniform settlement but will not prevent consolidation.

When designers are considering the use of geotextiles in lieu of marsh excavations, the concurrence of the Central Office Soils Unit is required. The designers will continue to be responsible for the necessary project design activities, and the Central Office Soils Unit must be contacted and provided the opportunity to review and concur in both the geotextiles specified and the intended uses.

The designs for marsh removals and backfills will be influenced by several factors, including marsh, fill heights, marsh bottom slopes, marsh material qualities, backfill material qualities, and water table locations. Because of these many variables, a standard detail drawing for marsh excavation is not practical. Attachment 1.13 is a typical marsh section that may be used as a guide when designing marsh excavation details for specific projects. Consult the Region Soils Supervisor to ensure adequate treatment of marsh areas is implemented.

The following general guidelines should be considered:

1. Avoid locating earthwork balance points in marsh excavation areas. Excavations and backfills should progress across the marsh from one end to the other.
2. Marsh excavation is usually feasible to upper depths of 20 feet. With rolling surcharges and excavations, marsh removals to depths of 40 feet in peat are usually possible, but the chance of total removal decreases with depth. In organic silts, successful displacements depend on strengths of the silts, and individual studies will be necessary to evaluate these.
3. Care must be exercised when using surcharges in order that loads do not exceed the shearing strengths of the marshes and cause failures of the fills and excessive settlements.
4. Clays or silty clays ordinarily will not displace satisfactorily; therefore, other methods will be required in such soils.
5. Provide for disposal areas in the immediate vicinities of the excavations.

1.17 Local Service

Local service roads (frontage roads) are most often used adjacent to freeways, where their primary functions are to serve abutting developments and to collect and distribute traffic between local streets and roads and the freeway interchanges. Local service roads are also used to control access to arterials, including freeways.

Normally, provide two-way service roads in rural areas to avoid the inconveniences and added travel distances to local traffic often required by one-way service road systems.

Local service roads do not necessarily have to parallel, abut, or front on and along the main highways, but may be located some distance away from the highways on separate, non-contiguous right-of-way.

Local service roads normally become part of local road systems, i.e., town roads, county trunk highways, or city streets, and are typically designed in accordance with the appropriate design criteria for those road systems.

1.18 Rural Driveways and Entrances

Refer to FDM 11-20-10 for information on rural and urban driveways.

1.19 Traffic Control Devices/Signing on Interstate Highways

All traffic control devices shall be in conformance with the current Manual on Uniform Traffic Control Devices (MUTCD) and the Wisconsin Manual on Uniform Traffic Control Devices (WMUTCD).

1.20 Access Control on Interstate Highways

Right-of-way fencing, or other appropriate measures, shall be incorporated into all Interstate projects to address any access control issues within the proposed project limits.

LIST OF ATTACHMENTS

Attachment 1.1	Design Criteria for Rural State Trunk Highways Functionally Classified as Arterials
Attachment 1.2	Design Criteria for Rural State Trunk Highways Functionally Classified as Collectors
Attachment 1.3	Design Criteria for Rural State Trunk Highways Functionally Classified as Local Roads

Attachment 1.4	Design Criteria for Town Roads (New Construction Only)
Attachment 1.5	Rural State Trunk Highway Paved Shoulder Width Criteria
Attachment 1.6	Typical Cross Sections for Rural 2-Lane Highways
Attachment 1.7	Typical Cross Sections for Divided Highways and 1-Lane Ramps
Attachment 1.8	Roadway Sections in Rock Cut
Attachment 1.9	Clear Zone Distance Tables and Recovery Area Width Determination
Attachment 1.10	Horizontal Curve Correction Factors
Attachment 1.11	Ditch Traverseability Evaluation Charts
Attachment 1.12	Typical 2- to 4-Lane Transition
Attachment 1.13	Typical Marsh Sections
Attachment 1.14	Lateral Clearance on Rural Roadway
Attachment 1.15	Design Criteria for County Trunk Highways Functionally Classified as Arterials
Attachment 1.16	Design Criteria for County Trunk Highways Functionally Classified as Collectors
Attachment 1.17	Design Criteria for County Trunk Highways Functionally Classified as Local Roads
Attachment 1.18	Design Criteria for Interstate Highways
Attachment 1.19	Design Considerations for Various Shoulder Treatment Options in Areas of High Side Superelevation
Attachment 1.20	Extended Clear Zone for Roadways Posted at 70 MPH

FDM 11-15-5 Design Criteria for the Great River Road *February 15, 2024*

5.1 Introduction

The Great River Road (GRR) is a national scenic highway located along the Mississippi River that is routed along the existing road systems of ten states. The designated GRR route in Wisconsin is along STH 35 between Prescott and Prairie du Chien and then along STH 133 and USH 61 to the state line at E. Dubuque, Illinois. See Attachment 5.1. The GRR serves local traffic but is primarily a tourist route that provides travelers the opportunity to enjoy the scenic beauty of the Mississippi River corridor and to learn about its history.

The special character of tourist traffic using the GRR warrants the use of modified design criteria for improvement projects on this road. Because people using the road are viewing the scenery, they tend to drive slower and pull onto the shoulders more often than is the case on typical state trunk highways. Also, the traffic mix during tourist seasons include an unusually high number of recreational type vehicles and bicycles.

5.2 Design Criteria

The GRR should be designed to the extent practicable as a parkway including scenic overlooks, waysides, special signing and, where warranted, wider shoulders and shoulder pavements. The design criteria for rural highways in FDM 11-15-1 for reconstruction and new construction, and in FDM 11-40-1 for Perpetuation and Rehabilitation improvements should be used for GRR projects except wider shoulders may be warranted.

5.3 Shoulder Width

Determination of shoulder widths and especially paved shoulder widths on the GRR should consider shoulder use by motorists and bicyclists, traffic safety, construction and maintenance costs, aesthetics and environmental impacts. Motorists frequently stop along the shoulders of the GRR, particularly where the scenery is attractive and there are no nearby scenic overlooks or waysides. This practice can result in traffic hazards where there are large numbers of vehicles entering and leaving the shoulder areas or where the parked vehicles obstruct driver vision.

Warning signs and advisory speed signs should be evaluated for use where the excessive use of the shoulders is an identified safety concern. Regulations prohibiting parking on the shoulders are generally not practicable because they are difficult to enforce, and the signs are unsightly. Frequent use of the shoulders occurs most often on the segments of the GRR identified on Attachment 5.1 as the closest roads to the Mississippi River. The following design criteria and guidance apply to shoulder widths and shoulder paving on those segments of the GRR:

5.3.1 Graded Width of Shoulder

The design widths of the graded shoulders may be increased to a maximum of ten feet where needs exist, and the cost of the extra widths add less than ten percent to the cost of typical-width shoulders. The use of wider shoulders should be evaluated for those sections of the GRR where there is frequent use of the shoulders by motorists and possibly bicyclists and this has caused or potentially could cause safety hazards.

5.3.2 Paved Shoulder Width

The paved shoulder widths shall be a minimum of 5-feet where the road has current traffic volumes over 1000 ADT. Full width paved shoulders should be evaluated to reduce maintenance requirements where barriers will be installed along the shoulders. Note: Bicycle traffic is not a warrant for full width paved shoulders. Refer to FDM 11-15-1.8 for rumble strips policy.

5.4 Special Design Features

To provide a parkway appearance to the road, the seeding and fertilizing of the roadway fore-slopes should be extended to the edges of the shoulder pavements.

5.5 Application of Design Criteria

This design criteria should be applied to future projects and projects now being designed for the GRR. Projects of limited scope to simply widen the shoulders of existing sections of the GRR to comply with these criteria are not intended.

LIST OF ATTACHMENTS

Attachment 5.1	Great River Road Map

FDM 11-15-10 Passing Lanes and Climbing Lanes — *February 15, 2024*

10.1 Passing Lanes

A passing lane is an added lane constructed alongside a two-way, two-lane rural highway to provide the desired frequency of safe passing zones. Passing lanes are particularly advantageous where passing opportunities are limited because of traffic volumes, roadway alignments or high proportions of slower vehicles. Passing lanes differ from truck climbing lanes in that passing lanes are provided regardless of topography. Truck climbing lanes are provided specifically on hills to allow faster moving traffic an opportunity to pass safely. However, newly constructed truck climbing lanes should meet the same design criteria entrance/merge taper lengths, lane widths, shoulder widths and pavement markings as newly constructed passing lanes. Refer to Truck Climbing Lanes in this procedure for guidance pertaining to truck climbing lanes.

Design criteria were selected from various published studies about passing lanes which can be used for background information and guidance. [11] [12] [13]

10.1.1 Application Criteria

Use the following criteria to determine if passing lanes are appropriate for the corridors in question.

10.1.1.1 Access Control

Passing lane areas should be access controlled early in the process to protect the corridors from potential conflicts.

10.1.1.2 Passing Lane Corridors

Corridor lengths of 15 to 50 miles are appropriate for planning and design purposes. Designers must also consider logical termini and abutting projects, such as Corridors 2030. Some sections of the corridors may not warrant passing lanes at the same time or with the same urgency as others, however the entire corridor should be reviewed.

See Attachment 10.1 for a state-wide map illustrating potential passing lane corridors. This map is based on 20-

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[11] "Low-Cost Methods for Improving Traffic Operations On Two-Lane Roads" by D. W. Harwood and C. J. Hoban, January 1987;
[12] Transportation Research Record (TRR) 1303 "Warrants For Passing Lanes" and "Traffic Performance and Design of Passing Lanes"; TRR 1512 "Relationship Between Operational and Safety Considerations in Geometric Design Improvements"; TRR 1628 "Drivers' Attitudes, Understanding, and Acceptance of Passing Lanes in Kansas";
[13] Ministry of Transportation, Ontario, Canada, "Operational Safety Review of Passing Lane Sites".

year traffic projections or for year 2030. Each region has participated in the development of this map and has concurred in the initial locations of the passing lane corridors. This map does not identify county trunk highways, however, there may be situations where the use of passing lanes on county trunk highways would be appropriate and should be considered.

10.1.1.3 Location

The general guidelines for selecting appropriate locations for passing lane segments are given below:

1. Passing lanes should be constructed in segments of highways which have minimal numbers of entrances and preferably no side roads. For some passing lane segments, it may be necessary to include side roads. When selecting sites for passing lane facilities avoid side roads with 500 ADT and over. Driveways and field entrances should be avoided in the merge taper area on either side of the highways. The merge areas extend from the W4-2R signs (lane reduction transitions) to the ends of the tapers, or 1,200 feet. See SDD 15C35, sheets b and c. No driveways or intersections should be located closer than 500 feet from the end of the downstream taper. Designers should consider relocating field entrances and driveways in the merge areas. Commercial driveways may be more problematic than side roads, depending on peak hour usage and traffic mix.
2. Widened segments of roadways, with protected left turn lanes, may be constructed in passing lane sections to provide for left turning traffic when left turn volumes are significant. See FDM 11-25-5 and FDM 11-25-10 for more detailed information on turn lanes. In those limited areas where 4-lane undivided passing lane sections are required, crossing intersections are not permitted and tee intersections are not desirable.
3. If the comparative costs for construction of passing lanes in rolling and level terrains are nearly the same, it may be desirable to construct them in the rolling terrain at locations where passing sight distances are unavailable, leaving flat sections for normal passing during the off-peak periods. Avoid passing lanes on horizontal curves greater than 3 degrees, if possible.

10.1.1.4 Traffic Volumes

Determine current and design year (projected 20 year) Average Annual Daily Traffic (AADT) and two-way Design Hour Volumes (DHVs). Use the 100th highest hour (K100) when determining the DHVs. On most rural two-way highways, the DHVs range from 10% to 15% of the AADTs. Recreational routes, however, can have significantly higher percentages of traffic in the DHVs. Regions should consult with their Systems Planning and Operations sections to get site specific hourly counts for recreational routes (including weekends) in order to gain a more realistic understanding of the situations.

To obtain traffic projections submit TRAFFIC FORECAST REQUEST (see FDM 11-5-2).

Generally, if the 20-year traffic projections exceed 12,000 AADT or exceed 1,400 two-way DHVs it may be appropriate to consider expanding the facilities to 4-lanes. The regions will consider the priority and funding of all projects, then determine whether passing lanes or other treatments are most appropriate.

When the 20-year projected, two-way DHVs fall between 200 and 1,400 use the nomograph provided in Attachment 10.2 and the DHVs from the Traffic Forecasts to see if passing lanes should be considered further. Note, this nomograph is from the Washington State DOT design manual so “rolling” implies a high degree of elevation variation.

Higher priority highways will generally have design year AADTs > 3,500 and <12,000; two-way DHVs greater than 400 and less than 1,400; passing opportunities less than 61%; trucks and RV’s greater than 4%.

10.1.2 Design Criteria

10.1.2.1 Lane Widths and Shoulder Widths

1. Passing lane widths are typically 12 feet for projects.
2. Shoulders should be full width, similar to the adjacent two-lane highway sections, for the classifications and ADTs of the facilities. Shoulders should be paved similar to the adjacent two-lane facilities.

   Designers may consider providing less than typical design criteria shoulder widths in certain areas where excessive cuts and fills would substantially increase the construction costs. In such cases the designer must request DJs to design criteria as specified in FDM 11-1-20 and FDM 11-1-4.10.
3. Minimize the occurrences of 4-lane sections of undivided highways (overlapping passing lane areas).
4. It is important, where possible, to provide advancing traffic with the experience of the passing lanes prior to seeing them in the opposing lanes.

10.1.2.2 Clear Zones

The clear zones on newly constructed passing lane sections, independent of project types, should be computed from the outer most lanes, outside edges of traveled ways.

Clear zones should meet design criteria per FDM 11-15-1. Justifications for not meeting/exceeding the design criteria shall be provided in the DSR.

10.1.2.3 Passing Lane Lengths

The optimal passing lane lengths, excluding tapers, is provided in the following table, and is based on design year two-way Design Hour Volumes (DHVs).

Table 10.1 Optimal Passing Lane Length

Two-Way Total DHV	Length of Passing Lane (Miles)
Less than 600	0.50 - 1.0
600 - 1,000	0.75 - 1.50
1,000 - 1,400	1.0 - 2.0

10.1.2.4 Spacing Between Passing Lane Sections

Provide 3-8-mile spacings between passing lanes in the same direction of traffic. These spacings depend on traffic volumes and passing opportunities outside of the actual passing lane locations. The spacings must be flexible to permit selection of suitable and inexpensive passing lane locations.

10.1.2.5 Taper Lengths, Locations and Signal Locations

1. Passing lane approach and merge taper lengths should be 700 feet.
2. Passing lanes should be designed with good visibility at the ends of merge tapers. Do not end merge tapers at or near crests of hills. The ends of the tapers should be physically visible from the W4-2R signs (lane reduction transitions).
3. Access is undesirable on either side of highways in merge taper areas. Do not end merge tapers immediately prior to intersections. Provide at least 500 feet of space downstream from the ends of the tapers to the nearest access points.
4. Signals downstream from passing lanes should be at least 1 mile from the closest merging taper ends.
5. Merge taper shoulders may include rumble strips or raised pavement markers.

10.1.2.6 Signing and Pavement Marking

Drivers may not know if the extra lanes they encounter are passing lanes or truck climbing lanes. For driver expectancies and design consistency similar design criteria should apply where practical. See SDD 15C35, sheets b and c for pavement marking and signing information.

10.1.2.6.1 Pavement Marking

1. Provide diagonal skip-dash pavement markings at entrance tapers to guide traffic to the right when the shoulder widths and construction is the same as the adjacent two-lane facilities. Do not install the skip-dash pavement markings when the shoulder widths are less than design criteria for the facilities.
2. Allow passing by opposing lanes of traffic if passing sight distances are available. This is allowed in accordance with the MUTCD[14] and Highway Capacity Manual[15]. Studies have found no adverse problems with this procedure. Regions should consider side roads, commercial driveways or other situations when it may be desirable to provide double yellows at the center lines.

10.2 Climbing Lanes

Climbing lanes should be provided to assure uniform levels of service rather than as necessities to avoid extreme congestion and disruption of traffic flows. Climbing lanes are warranted when the upgrades are so

[14] *Manual on Uniform Traffic Control Devices, 1988 Edition*

[15] *Highway Capacity Manual, 7th Edition*

steep and long that loaded trucks experience speed reductions of ten miles per hour or more and when the DHVs exceed levels of service 'D' (5.00). Other factors to consider, on the upgrades, are the amount and location of left or right turns at intersections or driveways within the segments. Refer to 2018 GDHS, pages 3-137 thru 3-142 (GDHS hyperlink is only available for WisDOT staff), for guidance in determining the lengths of grade for climbing lanes.

10.2.1 Design Criteria

10.2.1.1 Lane Widths and Shoulder Widths

1. Climbing lane widths are typically 12 feet independent of project types.
2. Newly constructed climbing lanes should include full width shoulders for the classifications and ADTs of the facilities. These are independent of project types. Shoulders should be paved similar to adjacent two-lane facilities. When beam guard is present it may be desirable to extend the paved shoulders to the post locations.
3. Designers may consider providing less than typical shoulder widths in certain areas where excessive cuts and fills would substantially increase the construction costs. In such cases the designers must request design justifications as specified in FDM 11-1-20 and FDM 11-1-4.10.
4. For existing climbing lane shoulders on Perpetuation and Rehabilitation (formerly referred to as 3R) projects refer to FDM 11-40-1.

10.2.1.2 Clear Zones

Clear zones on climbing lane sections, independent of project types, shall be computed from the outer most lanes, outside edges of traveled ways.

Clear zones should meet design criteria per FDM 11-15-1. Justifications for not meeting/exceeding the design criteria shall be documented in the DSR.

10.2.1.3 Taper Lengths and Locations

1. Climbing lane approach and merge taper lengths should be 700 feet.
2. Climbing lane merge tapers should be physically visible from the W4-2R sign(s) (lane reduction transitions). Climbing lanes should be carried well beyond the crests to points where trucks are able to regain speeds within 10 mph of the speeds of other vehicles.
3. Access is undesirable on either side of highways in merge taper areas. Do not end merge tapers immediately prior to intersections. Provide at least 500 feet of space downstream from the ends of the tapers to the nearest access points.

10.2.1.4 Signing and Pavement Marking

Drivers may not know if the extra lanes they encounter are passing lanes or truck climbing lanes. For driver expectancies and design consistency similar design criteria should apply where practical. See SDD 15C35, sheets b and c for pavement marking and signing information.

10.2.1.4.1 Pavement Marking

1. Provide diagonal skip-dash pavement markings at the entrance tapers to guide traffic to the right when the shoulder widths are the same as the adjacent two-lane facilities. Do not install the skip-dash pavement markings when the shoulder widths are less than the design criteria for the facilities.
2. Allow passing by opposing lanes of traffic if passing sight distances are available. Studies have found no adverse problems with this procedure. Regions should consider side roads, commercial driveways, or other situations when it may be desirable to provide double yellows at the center lines.

<u>LIST OF ATTACHMENTS</u>

Attachment 10.1	Rural STH Passing Lane Corridors
Attachment 10.2	Warrant for Considering Passing Lanes