S-2 Application of Design Criteria for Rehabilitation Projects

Overview

Segments or locations on Rehabilitation projects will evaluate the use of cross-sectional and geometric improvements to existing roadway features ***beginning with the use of the lower end of the range*** (when a range exists) for design criteria values. The values shown should be considered a starting point. An iterative design approach along with the application of a predictive safety benefit/cost analysis will be used to determine the final design values to use.

See FDM 11-38 for additional information regarding predictive safety benefit/cost analysis.

This attachment applies to S-2 Application unless otherwise noted.

Controlling Criteria

1. **Design Speed**
   - **STH routes (NHS and non-NHS):** The lower end of the range for design speed for both rural and urban routes is the posted speed with the upper end of the range being the posted speed plus 5 mph.
   - **Non-STH routes:** The lower end of the range for design speed for both rural and urban routes is the posted speed with the upper end of the range being the posted speed plus 5 mph.
   - **Expressways and non-Interstate Freeways:** The design speed is the posted speed plus 5 mph.
   - **Interstate Highways:** The design speed is the posted speed plus 5 mph.

   See FDM 11-10-1.5 for additional guidance on Design Speed selection.

2. **Superelevation Rate**

   Superelevation Rate is a controlling criterion if the project design speed is 50 mph or greater.

   Ideally, superelevation rate modifications should be consistent with adjacent sections of the roadway, and not reduce the existing curve speed rating.

   Superelevation rates exceeding 8% are undesirable and should be flattened if possible within the project scope. According to 2018 GDHS, “Superelevation rates above 8 percent are only used in areas without snow and ice.”[1]

   See FDM 11-10-5.3 for guidance on superelevation rates.

   Superelevation Rate Design Criteria
   - **STH and non-STH routes (NHS and non-NHS):** Determine the existing emax that was the basis for the existing original superelevation design by inspecting super-elevation information on as-built plans. Use FDM 11-10 Table 5.7 to determine the design emax. Rehabilitation projects will use the Design Lower values for emax.
   - **Non-STH routes:** Determine the existing emax that was the basis for the existing original superelevation design by inspecting super-elevation information on as-built plans. Use FDM 11-10 Table 5.7 to determine the design emax. Rehabilitation projects will use the Design Lower values for emax.
   - **Expressways and non-Interstate Freeways:** Provide superelevation rate based on the project design speed and design emax for S-3 application. See FDM 11-10 Table 5.7. Rehabilitation projects will use the Design Upper values for emax.
   - **Interstate Highways:** Superelevation rates should be improved to meet the appropriate rate for S-3 application. See FDM 11-10 Table 5.7. Rehabilitation projects will use the Design Upper values for emax.

   See FDM 11-1-10 for additional information regarding S-3 application.

3. **Horizontal Curve Radius**

   Horizontal Curve Radius is a controlling criterion if the project design speed is 50 mph or greater.

   All horizontal curves located within project limits will be screened through the Safety Certification

[1] A Policy on Geometric Design of Highways and Streets, 7th Edition. AASHTO, 2018, Page 3-32.

Process (SCP).

Horizontal curves that have been identified as not having discernable safety or operational issues will use S-1 application. This will allow the retention of the existing curve radii. Even if a curve doesn't contribute to crashes, improvements may still be desirable.

Horizontal curves that have been identified as having discernable safety or operational issues will be evaluated for reconstruction using S-2 application and low-cost safety mitigation measures as shown in FDM 11-38.

If a deflection without a horizontal curve exceeds the maximum shown in FDM 11-10 Table 5.4 then it is considered a deficient horizontal curve.

See FDM 11-10-5.2 for guidance on horizontal curve radii.

See FDM 11-1-10 for additional information regarding S-1 and S-2 applications.

Horizontal Curve Radius Design Criteria

- **All routes (NHS and non-NHS):** Determine the curve radius that was used for the existing horizontal curve by inspecting horizontal curve information on as-built plans. Starting with the existing curve radius, perform an iterative predictive safety benefit/cost analysis to determine a curve radius value that acceptably meets the project purpose and need.

  The final curve radius value chosen will be based on the results of the predictive safety benefit/cost analysis in conjunction with the social, economic, or environmental impact evaluations completed as part of the environmental process described in FDM Chapter 20.

  See FDM 11-38 for additional information regarding predictive safety benefit/cost analysis.

4. **Stopping Sight Distance**

Stopping Sight Distance (SSD) is a controlling criterion if the project design speed is 50 mph or greater.

SSD applies to horizontal alignments and vertical alignments. Deficient SSD is caused by a physical obstruction along the SSD line-of-sight (e.g., roadside structures, crest vertical curves, overpasses, ditch backslopes, barrier located along the inside of a horizontal curve). Sag vertical curves are not a physical obstruction along the SSD line-of-sight.

All SSDs associated with existing horizontal and vertical curves located within the project limits will be screened through the SCP.

SSDs that have been identified as not having discernable safety or operational issues will use S-1 application. This will allow the retention of the existing SSD.

SSDs that have been identified as having discernable safety or operational issues will use S-2 application and low-cost safety mitigation measures as shown in FDM 11-38.

See FDM 11-10.5.2 for guidance on SSD.

See FDM 11-1-10 for additional information regarding S-1 and S-2 applications.

Stopping Sight Distance Design Criteria

- **All routes (NHS and non-NHS):** Use S-2 application based on the project design speed for the sight distance categories as shown in FDM 11-10-5.

5. **Maximum Grades**

Maximum Grades is a controlling criterion if the project design speed is 50 mph or greater.

See FDM 11-10-5.4.1 for design guidance on grades.

Maximum Grade Design Criteria

- **All routes (NHS and non-NHS):** Perform an iterative predictive safety benefit/cost analysis using the existing grade as a starting point to determine a grade that acceptably meets the project purpose and need.

  The final grade value chosen will be based on the results of the predictive safety benefit/cost analysis in conjunction with the social, economic, or environmental impact evaluations completed as part of the environmental process described in FDM Chapter 20.

  See FDM 11-38 for additional information regarding predictive safety benefit/cost analysis.

6. **Lane Width**

Lane width is a controlling criterion if the project design speed is 50 mph or greater.

a. Rural Lane Width Design Criteria

- **STH routes (NHS and non-NHS):** Lane widths for rural STH two-lane highways shall be the greater of either existing or as shown in Attachment 7.2 and 7.3, unless the existing width is greater than the higher value requirement for S-3 Application projects as shown in FDM 11-15 Attachments 1.1 to 1.3. In that case, the width may be reduced to match the higher value requirements for S-3 application.
- **Non-STH routes:** Lane widths for rural non-STH two-lane highways shall be the greater of either existing or as provided on Attachments 7.4, 7.5 and 7.6, unless the existing width is greater than the higher value requirement for S-3 application as shown in FDM 11-15 Attachments 1.1 to 1.4 and FDM 11-15 Attachments 1.15 to 1.17. In that case, the width may be reduced to match the higher value requirement for S-3. For CTH highways, see Trans 205.
- **Expressway and non-Interstate Freeways:** Use lane width requirements for Design Class A3 per FDM 11-15 Attachment 1.1.
- **Interstate Highways:** All lanes shall be at least 12 feet wide.

See FDM 11-1-10 for additional information regarding S-3 application.

b. Urban Lane Width Design Criteria

- **STH and non-STH routes (NHS and Non-NHS):** Through lane widths shall meet the requirements in FDM 11-20 Attachment 1.1 and FDM 11-20 Attachment 1.5. Federally designated long truck routes (i.e. the "National Network" as defined in 23 CFR Part 658) shall contain at least one 12-foot lane in each direction of travel.

  Lowest curb offsets are 1-foot when the design speed is 40 mph or less.

  Transitions from rural to urban cross section are desirably located on tangent where drivers have an unobstructed view. Introduce curbs at the edge of the shoulders and then continue with a tapered urban cross section to transition to the typical urban section. In general, use sloping curbs where the design speed is more than 45 mph.
- **Expressways and Non-Interstate Freeways:** Use lane width requirements for Design Class A3 per FDM 11-15 Attachment 1.1.
- **Interstate Highways:** All traffic lanes shall be at least 12 feet.

7. Shoulder Width Design Criteria

Shoulder width is a controlling criterion if the project design speed is 50 mph or greater.

See FDM 11-40-1.5.1 for paved shoulder guidance.

- **STH Routes (NHS and non-NHS):** See Attachments 7.2 and 7.3 for shoulder width design criteria.

  Shoulder widths (useable)[2] for rural two-lane highways shall be the greater of either existing or as provided in Attachments 7.2 and 7.3, unless the existing widths are greater than the higher value requirements for S-3 application as shown in FDM 11-15 Attachments 1.1 to 1.3. In those cases, the widths may be reduced to match the higher value requirements for S-3 application.

  Parking lanes widths shall meet the requirements of FDM 11-20-1.
- **Non-STH routes:** See Attachments 7.4, 7.5 and 7.6 for shoulder width design criteria.

  Shoulder widths (useable)[1] for rural two-lane highways shall be the greater of either existing or as provided in Attachments 7.4, 7.5 and 7.6, unless the existing widths are greater than the higher value requirements for S-3 application as shown in FDM 11-15 Attachments 1.1 to 1.4 and FDM 11-15 Attachments 1.16 to 1.18. In those cases, the widths may be reduced to match the higher value requirements for S-3 application. For CTH highways, see Trans 205.
- **Expressway and non-Interstate Freeways:** Shoulder widths (usable)[2] shall be per shoulder width requirements for Design Class A3 per FDM 11-15 Attachment 1.1.
- **Interstate Highways:** All right shoulders shall be paved to a full width of 10 feet. On all highways of six or more lanes, the left shoulders shall be paved 10 feet in width. The left

[2] Usable shoulder width is controlling criteria per FHWA when design speed is 50 MPH or greater. See FDM 11-40-1.5.2 for additional discussion and guidance on computing usable shoulder width.

shoulders on all four-lane highways shall be paved to a width of 4 feet.

See FDM 11-1-10 for additional information regarding S-3 application.

8. Pavement Cross Slope Design Criteria

Pavement cross slope is a controlling criterion if the project design speed is 50 mph or greater.

- **STH and non-STH Routes (NHS and Non-NHS):** Provide a pavement cross slope of 2% when Rehabilitation projects include new pavement or pavement resurfacing.

  A cross slope of 1.5% lower minimum may be provided when resurfacing Portland cement concrete pavements which have a cross slope of 1% or flatter.

  The existing pavement cross slope may be retained on projects involving patching only or patching and grinding. The rollover rate between adjacent travel lanes cannot exceed 5%.
- **Expressway and Non-Interstate Freeways:** Normal pavement cross slope is 2.0 percent per FDM 11-15-1.3.

  The pavement cross slope may be a lower minimum of 1.5 percent when necessary to match the existing pavement cross slope. However, increase the pavement cross slope to 2.0 percent if the cost is reasonable.

  Where multiple adjacent lanes are sloped the same way (i.e., no crown between them) the cross slope should be 2.0 percent.
- **Interstate Highways:** On tangent sections, the pavement cross slope should be a lower minimum of 2.0 percent.

  For resurfacing or widening projects when necessary to match existing cross slopes the lower minimum shall be 1.5 percent and desirably 2.0 percent. However, the cross slope should be increased to 2.0 percent when practicable.

9. Vertical Clearance

Vertical Clearance is a controlling criterion if the project design speed is 50 mph or greater.

- Vertical Clearance for construction of new bridges, replacement bridges, and bridges on which the superstructure is being replaced: see FDM 11-35 Attachment 1.8
- Lower Minimum Vertical Clearance for existing bridges which are not being replaced and for existing bridges on which the superstructure is NOT being replaced: See FDM 11-35 Attachment 1.9

  See FDM 11-10-5.4.3 for additional guidance on vertical clearance criteria.

Non-Controlling Criteria

1. Vertical Alignments

A Vertical alignment consists of a series of tangents (aka “grades”) that are either ascending, descending or flat, which are typically (but not always) connected by vertical curves. A vertical curve provides a safe, smooth transition between two consecutive tangents.

There may also be other safety issues besides the SSDs themselves contributing to crashes. Examine potential hazards at crest vertical curves. Potential hazards such as intersections, sharp horizontal curves or narrow bridges hidden by vertical curves may require reconstruction or other less costly safety mitigation measures including relocating or correcting the hazards and providing warning signs.

See FDM 11-10-5.4.2 for guidance on vertical alignments.

a. Crest Vertical Curve Design Criteria

Although a crest vertical curve is a non-controlling design criterion, it is evaluated based on whether it obstructs the line-of-sight of the required sight distance along a roadway. The lower minimum required sight distance along a roadway is SSD.

See FDM 11-10 Attachment 5.4 for crest vertical curve design criteria.

Perform an iterative predictive safety benefit/cost analysis to determine a design value that acceptably meets the project purpose and need.

The final design value chosen will be based on the results of the predictive safety benefit/cost analysis in conjunction with the social, economic, or environmental impact evaluations completed as part of the environmental process described in FDM Chapter 20.

See FDM 11-38 for additional information regarding predictive safety benefit/cost analysis.

- **STH and non-STH Routes (NHS and Non-NHS):** Evaluate the application of appropriate low-cost safety mitigation measures as shown in FDM 11-38 if deficient crest vertical curves are not reconstructed or are reconstructed to less than the project design speed. Use lower minimum values as a starting point per FDM 11-10 Attachment 5.4.
- **Expressway and Non-Interstate Freeways:** Use S-3 application (upper minimum values) as a starting point per FDM 11-10 Attachment 5.4.
- **Interstate Highways:** Use S-3 application (upper minimum values) as a starting point per FDM 11-10 Attachment 5.4.

See FDM 11-1-10 for additional information regarding S-3 application.

b. Sag Vertical Curve Design Criteria

Perform an iterative predictive safety benefit/cost analysis to determine a design value that acceptably meets the project purpose and need.

The final design value chosen will be based on the results of the predictive safety benefit/cost analysis in conjunction with the social, economic, or environmental impact evaluations completed as part of the environmental process described in FDM Chapter 20.

See FDM 11-38 for additional information regarding predictive safety benefit/cost analysis.

- **STH and non-STH Routes (NHS and non-NHS):** Deficient sag vertical curves may be retained unless they are contributing to a crash problem. If sag vertical curves are contributing to a crash problem, use lower minimum values as a starting point per FDM 11-10 Attachment 5.6.
- **Expressways and non-Interstate Freeways:** Use S-3 application (upper minimum values) as a starting point per FDM 11-10 Attachment 5.6.
- **Interstate Highways:** Use S-3 application (upper minimum values) as a starting point per FDM 11-10 Attachment 5.6.

2. Minimum Grades

See FDM 11-10-5.4.1 for guidance on grades.

Minimum Grade Design Criteria

- **All routes (NHS and non-NHS):** Perform a predictive safety benefit/cost analysis using the existing grade as a starting point to determine a grade that acceptably meets the project purpose and need.

  The final grade value chosen will be based on the results of the predictive safety benefit/cost analysis in conjunction with the social, economic, or environmental impact evaluations completed as part of the environmental process described in FDM Chapter 20.

  See FDM 11-38 for additional information regarding predictive safety benefit/cost analysis.

3. Shoulder Cross Slopes

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

Shoulder Cross Slope Design Criteria

- **STH and non-STH Routes (NHS and non-NHS):** Shoulder cross slopes should be as provided in FDM 11-15-1.7 except on tangent sections and crown runoff sections, a maximum slope of 6% downward from the adjacent pavement edge may be used, provided that the rollover rate between the travel lane and shoulder doesn't exceed 8%.
- **Expressway and non-Interstate Freeways:** Use shoulder cross slope requirements per FDM 11-15-1.7 except a maximum shoulder cross slope of 6 percent is allowed.
- **Interstate Highways:** Use shoulder cross slope requirements per FDM 11-15-1.7 except shoulder cross slopes should range between 4 and 6 percent and should be at least 1 percent more than the pavement cross slope on the tangent sections to facilitate drainage.

4. Intersections

See FDM 11-25 for design guidance on intersections.

5. Intersection Sight Distance

Guidance for Intersection Sight Distance (ISD) can be found in FDM 11-10-5.

If the SCP has determined that ISD is contributing to crash problems, then perform an iterative predictive safety benefit/cost analysis using the existing ISD as a starting point to determine an ISD that acceptably meets the project purpose and need.

The final ISD value chosen will be based on the results of the predictive safety benefit/cost analysis in conjunction with the social, economic, or environmental impact evaluations completed as part of the environmental process described in FDM Chapter 20.

See FDM 11-38 for additional information regarding predictive safety benefit/cost analysis.

6. Vision Triangles

See FDM 11-10-5.1.4.3 for additional guidance regarding vision triangles.

7. Intersection Angle

See FDM 11-25-2.8 for guidance on intersection angles.

8. Auxiliary Lanes

a. Rural Auxiliary Lanes

See FDM 11-25-35 for a discussion and definition of auxiliary lanes.

See FDM 11-25-5.4.2 for additional guidance about TWLTLs.

Rural Auxiliary Lane Design Criteria

- **All routes (NHS and Non-NHS):** The lower value for the width of auxiliary lanes shall be the greater of existing or 10-feet. The lower value for auxiliary lane shoulder width shall be the greater of existing or 3 feet.

b. Urban Auxiliary Lane Design Criteria

- **All Routes (NHS and Non-NHS):** Turning lane widths shall meet the requirements in FDM 11-25 Attachment 5.1 (but not be less than existing).

  The lowest lane width of an existing two-way left turn lane (TWLTL) shall be the greater of existing or 12 feet. See FDM 11-25-5.4.2 for additional guidance about two-way left turn lanes.

9. Lateral Clearance

Lateral clearance (also known as “operational offset") is defined in FDM 11-15-13.2.2 as an obstruction free area beginning at the edge of driving lane and extending a lower minimum distance so as not to interfere with the operation of the roadway.

Lateral Clearance Design Criteria

- **All routes (NHS and Non-NHS):** Lateral clearances for urban and rural roadways shall meet the following:
  - For rural highways, lateral clearances should be as shown in Table 7.2.
  - For urban and suburban roadways with shoulders, lateral clearances should be as shown in Table 7.2.
  - For roadways with curbs, the lateral clearance design criteria widths are 2-feet measured from face of curb, but not less than the existing lateral clearances. The least lateral clearance widths are 1.5-feet measured from the face of curb, but not less than the existing lateral clearances.

Table 7.2 Lateral Clearances from Edges of Driving Lanes for Rural Highways[1]

ROAD TYPE	WITHOUT roadside barrier[2]	WITH roadside barrier[3]
All STHs Arterials non-STH Collector and Local Roads (non-arterials) with Design Year AADT >1500	The GREATER of 6 ft. OR finished shoulder widths[4] + 2 ft.	The GREATER of 4 ft. OR finished shoulder widths[4]
non-STH Collector and Local Roads (non-arterials) with Design Year AADT<1500	The GREATER of 2 - 6 ft. OR finished shoulder widths[4] + 2 ft.	The GREATER of 2 - 4 ft. OR finished shoulder widths[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 Clearances extend beyond the edge of the finished shoulders. Also, additional clearances may be needed at some locations - particularly at intersections - to compensate for off-tracking.*

[3] *Lateral Clearances should be provided to the face of the barriers, but not extend behind them. Other offsets behind the barriers or beyond the edges of the finished shoulders may apply. 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.*

Table 7.3 Lateral Clearances from Edges of Driving Lanes for Urban Streets[1]

Parking Condition	Urban Roadway Type	WITHOUT roadside barrier[2] **Upper end of range** (Lower end of range)	WITH roadside barrier at curb face[3] **Upper end of range** (Lower end of range)
With Parking	ALL	**Parking lane width + 4-feet[4]** (Parking lane width + 2 feet[4])	**Should not allow parking where roadside barrier is used**
Without Parking	HIGH SPEED and TRANSITIONAL	The Larger of 6 feet *OR* **the offset from edge of driving lane to face of curb + 4 feet[5]** (The offset from edge of driving lane to face of curb + 2 feet[5])	The Larger of 6 feet *OR* **the offset from edge of driving lane to face of curb[5]** (The GREATER of 1.8 feet *OR* the offset from edge of driving lane to face of curb[5])
	LOW SPEED and TURNING LANES	The Larger of 4 feet *OR* **the offset from edge of driving lane to face of curb + 2 feet[5]** (The offset from edge of driving lane to face of curb + 2 feet[5])	The Larger of 4 feet *OR* **the offset from edge of driving lane to face of curb[5]** (The GREATER of 1.8 feet *OR* the offset from edge of driving lane to face of curb[5])

[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 (2), titled "Erecting Mailboxes on Streets and Highways."*

[2.] *Lateral clearances extend behind the curb faces.*

[3.] *Lateral Clearances must be provided to the faces of barriers, but do not extend behind them. Other offsets behind barriers or curb faces may apply. Also, consider the potential deflections of the roadside barriers (see FDM 11-45).*

[4.] *Parking lane widths include gutter widths.*

[5.] *Include gutter widths - see this Procedure for guidance on offsets from edges of driving lanes to faces of curbs.*

10. Roadside Hazards

See FDM 11-40-1.11.2 for general guidance regarding roadside hazards.

11. Clear Zones

Do not reduce existing clear zone widths on Rehabilitation projects.

Clear zone widths on Rehabilitation projects are the greater of the existing clear zone width or the lower minimum clear zone widths shown below. If the original project clear zone widths still exist, then retain that clear zone width, unless it is less than the lower minimum clear zone widths shown below. If subsequent projects have reduced the clear zone widths to less than the original project clear zone widths, then document in the DSR why the original project clear zone widths are not being reestablished. Include the width of existing clear zones, the safety impacts of not reestablishing clear zones and any potential safety countermeasures being considered for use.

Clear Zone Design Criteria

- STH and non-STH Routes (NHS and Non-NHS): Provide Clear Zones per guidance in FDM 11-15-1 and FDM 11-15 Attachments 1.9, 1.10 and 1.11.
- Expressways and non-Interstate Freeways: Provide Clear Zones per guidance in FDM 11-15-1 and FDM 11-15 Attachments 1.9, 1.10 and 1.11.
- Interstate Highways: Provide Clear Zones per guidance in FDM 11-15 Attachments 1.9, 1.10 and 1.11 and the 2011 AASHTO Roadside Design Guide for guidance regarding warranted clear zone widths. Any fixed objects within the clear zone limits shall be removed, made breakaway, or made safe through shielding by roadside barriers, crash cushions, or a combination of both.

12. Side Slopes

Steep foreslopes can be safety hazards and are difficult and costly to maintain. Steep foreslopes also reduce the safety and functionality of shoulders and clear zones.

The likelihood of crashes increases as shoulder widths decrease (Highway Safety Manual, Volume 3 (HSM3), chapter 13-page 13-11[3]; Also, FHWA-RD-99-207, “Prediction of the Expected Safety Performance of Rural Two-Lane Highways”, pages 31-34[4])

Clear zones should not contain any critical slopes, i.e. non-traversable slopes or any traversable but non-recoverable slopes unless there are clear run-out areas at the toes of the slopes. See page 2 of FDM 11-15 Attachment 1.9.

The likelihood of crashes increases for reduced clear zones and steeper side slopes (HSM3, chapter 13, pages 13-19 to 26[3]; Also, FHWA-RD-99-207, page 41[4]) and TRB Special Report 214, pages 83-86[5])

TRB’s Special Report 214, page 200[5](2), recommends:

- “Flatten slopes of 3:1 or steeper at locations where run-off -road crashes are likely (e.g. outside of sharp horizontal curves).
- Retain current slope widths (without steepening sideslopes) when widening lanes and shoulders unless warranted by special circumstances.”

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[3] Highway Safety Manual Part D: Crash Modification Factors, volume 3, 1st edition. AASHTO, Washington, DC, 2010. https://bookstore.transportation.org/collection_detail.aspx?ID=135. Ref ID: 938

[4] Harwood, D. W., F. M. Council, E. Hauer, W. E. Hughes, A. Vogt, and Midwest Research Institute. FHWA-RD-99-207: Prediction of the Expected Safety Performance of Rural Two-Lane Highways. Federal Highway Administration, Office of Safety Research and Development, McLean, VA, 2000. http://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf. Ref ID: 968

[5] TRB Special Report 214: Designing Safer Roads: Practices for Resurfacing, Restoration, and Rehabilitation. Transportation Research Board, National Research Council, Washington, DC, 1987. http://onlinepubs.trb.org/Onlinepubs/sr/sr214/sr214_001_fm.pdf. Ref ID: 341

Side Slope Design Criteria

- **STH and non- STH Routes (NHS and Non-NHS):** Don't steepen foreslopes on a Rehabilitation projects beyond what is described below in Table 7.4, including when widening or raising lanes and shoulders.

Table 7.4 Rehabilitation Project Foreslope Criteria

Existing Foreslopes in Clear Zone	Maximum Constructed Foreslopes in Clear Zone
4:1 or flatter*	4:1
Between 3:1 and 4:1**	Not steeper than existing
Steeper than 3:1**	3:1

* If there are Run off Road crash (ROR) history issues at locations that are already 4:1 or flatter, maintain the existing foreslopes and try to determine the ROR crash history cause(s) and provide appropriate safety countermeasures.

** Improve foreslopes steeper than 4:1 at locations with a ROR crash history and at locations on the outside of sharp horizontal curves where ROR crashes may occur. Options include:

- Provide 3:1 slopes with flat runout areas at the toes of slopes with no fixed objects on slopes and no fixed objects in the runout areas.
- Provide a 4:1 slope with appropriate clear zones for the projects.
- Provide a foreslopes flatter than 4:1 if there are issues with ditch traversability or if the ditches are within the clear zones.

Proposed unshielded foreslopes to be constructed outside the clear zones under rehabilitation work should not be steeper than 3:1.

If there are traversable, but non-recoverable foreslopes (i.e. between 3:1 and 4:1) within the clear zone, recovery areas, per FDM 11-15 Attachment 1.9, may be required.

Evaluate shielding hazardous slopes where slope flattening is not possible or not practical. Typically, shielding is less desirable than slope flattening for roadside safety.

Existing critical foreslopes (i.e. steeper than 3:1) that are outside of the proposed construction limits should be evaluated for possible flattening or shielding.

- **Expressway and non-Interstate Freeway Routes:** Use S-3 application per FDM 11-15 Attachment 1.7 for side slopes on Rehabilitation projects whenever practicable. This means re-grading existing side slopes not meeting S-3 application and maintaining recoverable slopes and clear zones when Rehabilitation projects raise the surface elevations of pavements.

  Regrading side slopes to S-3 application is sometimes not practical. For these cases, use the following guidance, but only if using S-3 application will result in unacceptable social, economic or environmental consequences:

  - Construct enough recoverable slopes (4:1 or flatter) to meet the clear zone requirements of FDM 11-15 Attachment 1.9. Embankment slopes between 3:1 and 4:1 are considered traversable but non-recoverable. These steeper embankments may be built into the clear zone provided there is enough 4:1 or flatter slope contiguous to the shoulder to meet the requirements shown on page 2 of FDM 11-15 Attachment 1.9 (Note: recoverable slopes contiguous with the finished shoulders are required). Traversable slopes between 3:1 and 4:1 may require clear runout areas of at least 10 feet wide beyond the toes of the non-recoverable slopes.
  - Slopes outside the clear zones should not be steeper than 3:1

    If it is not practicable to correct an existing non-recoverable slope, then investigate if roadside barrier is warranted.
- **Interstate Highways:** Foreslopes shall be either recoverable (4:1 or flatter), traversable (3:1 MAX) with adequate recovery areas to meet the clear zone requirements of FDM 11-15 Attachment 1.9, or barriers should be installed as warranted in accordance with current criteria.

See FDM 11-1-10 for additional information regarding S-3 application.

13. Ditches

Traversable ditches are a Clear Zone element.

Ditch Design Criteria

- **STH and non-STH Routes (NHS and Non-NHS):** Evaluate ditch cross sections to determine whether they are traversable. Preferred ditch cross sections are shown in FDM 11-15 Attachment 1.11.

  Perpetuate existing traversable ditches. Consider safety improvement of ditches with rehabilitation work, when practical.

- **Expressway and non-Interstate Freeways and Interstate Highways:** Ditch cross sections within clear zones must be traversable. See FDM 11-15 Attachment 1.11 for preferred ditch cross sections.

  Evaluate non-traversable ditch cross sections outside of clear zones for safety improvements if the SCD indicates ROR crash problems.

Miscellaneous Items

1. **Intersection Design Vehicle and Intersection Check Vehicle**

   See FDM 11-25-2.1 and FDM 11-25 Table 2.1 for guidance on intersection design vehicles.

2. **Rural Rumble Strip Design Criteria**

   Install centerline and shoulder rumble strips in accordance with FDM 11-40-1.7.

3. **Pavement Edge Drop Design Criteria**

   Pavement edge drops are undesirable, no matter how they develop, because of safety implications associated with the vehicle recovery maneuver. Pavement edge drops can develop between the pavement surface and the adjacent unpaved shoulder or roadside.

   Avoid potential edge drops by:

   - Paving the shoulders when warranted by policy.
   - Selectively paving shoulders at points where encroachments are likely to create pavement edge drops, such as on the insides of horizontal curves.
   - Providing safety-edges as described in FDM 11-45-30.7.
   - Restoring gravel shoulders.

4. **Curb & Gutter Design Criteria**

   A 4% gutter cross slope is the typical slope and replaces the longstanding 3/4" per foot (6.25%) gutter cross slope. The 3/4" per foot (6.25%) gutter cross slope may be used for select conditions per criteria below.

   Select the appropriate gutter cross slope based on the following criteria:

   - Use 4% gutter cross slope on Rehabilitation projects where new curb and gutter will be constructed.
   - Use 3/4" per foot (6.25%) gutter cross slope to match existing slopes for curb and gutter spot improvements on resurfacing/preservation improvement projects. Use 4% gutter cross slope for longer (e.g. approximately one continuous block) segments of curb and gutter replacement.
   - Maintain consistent gutter cross slopes within contract plans whenever possible. An acceptable setting to include two different gutter cross slopes, for example, is a project with separate reconstruction segments (e.g. 4%) and spot improvement, hand-formed curb and gutter replacement segments (e.g. 6.25%).

   Refer to FDM 11-46-10.3 for gutter cross slope design guidance with curb ramp applications. Provide inlet spacing per FDM 13-25-15 for the selected gutter slope design.

   Label any non-typical (i.e. other than 4%) gutter cross slope locations within the plans. At a minimum, include gutter cross slope labels or notes within the contract typical cross sections and miscellaneous quantities. Include additional labels or notes within contract construction details and cross sections for all gutter cross slopes as needed and to provide further clarity.

S-2 Application for Rehabilitation Projects on Rural State Trunk Highways Functionally Classified as Arterials

TRAFFIC			ROADWAY WIDTH DIMENSIONS [1]			
			Traveled Way Width [2] (feet)			
Design Class	Design AADT	Design Speed [3] (mph)	>= 10% Trucks	< 10% Trucks	Shoulder Width [4] (feet)	Roadway Width (feet)
RA1-1	0 - 750	All	NHS 22 Non-NHS 20	NHS 22 Non-NHS 20	2	Traveled Way width plus 2 x shoulder Width
RA1-2	751 - 2,000	< 50	22	NHS 22 Non-NHS 20	2	
		>= 50	24	22	3	
RA1-3	2,001-3,499	All	24	22	6	
RA2-1	>=3,500	All	24	24	6	

[1] Do not use a value less than existing - unless using S-1 application.

[2] Use a traveled way width of 24 feet on federally designated long truck routes (i.e. the “National Network” as defined in 23 CFR Part 658).

A traveled way width of 24 feet is acceptable on state truck routes and other highways having current heavy vehicle (six or more tires) traffic volumes exceeding 10% of design AADT.

[3] The upper end of the range for design speed is 5 mph greater than the posted speed. The lower end of the range for design speed is equal to the posted speed limit.

[4] See FDM 11-40-1.5.1 for Shoulder Paving and FDM 11-40-1.7 for Rumble Strip Policy. Provide adequate shy distance at bridge railings and roadside safety barriers.

S-2 Application for Rehabilitation Projects on Rural State Trunk Highways Functionally Classified as Collectors and Locals

TRAFFIC			ROADWAY WIDTH DIMENSIONS [1]			
			Traveled Way Width (feet) [2]			
Design Class	Design ADT	Design Speed [3] (mph)	>= 10% Trucks	< 10% Trucks	Shoulder Width [4] (feet)	Roadway Width (feet)
RC1	0 - 750	< 50	NHS 22 Non-NHS 20	NHS 22 Non-NHS 18	2	Traveled Way width plus 2 x shoulder Width
		>= 50	NHS 22 Non-NHS 20	NHS 2 Non-NHS 20	2	
RC2	751 – 2,000	< 50	22	NHS 22 Non-NHS 20	2	
		>= 50	24	22	3	
RC3	Over 2000	All	24	22	6	

1 Do not use a value less than existing - unless using S-1 application.

2 Use a traveled way width of 24 feet on federally designated long truck routes (i.e. the “National Network” as defined in 23 CFR Part 658).

A traveled way width of 24 feet is acceptable on state truck routes and other highways having current heavy vehicle (six or more tires) traffic volumes exceeding 10% of design AADT.

3 The upper end of the range for design speed is 5 mph greater than the posted speed. The lower end of the range for design speed is equal to the posted speed limit.

4 See FDM 11-40-1.5.1 for Shoulder Paving and FDM 11-40-1.7 for Rumble Strip Policy. Provide adequate shy distance at bridge railings and roadside safety barriers.

S-2 Application for Rehabilitation Projects on Town Roads [1]

TRAFFIC VOLUME			ROADWAY WIDTH DIMENSIONS		
Design Class	Design AADT	Design Speed [2] (mph)	Traveled Way (feet)	Shoulder (feet)	Roadway (feet)
TR1	0-250	Less than 50	18	2	22
		50 or greater	20	2	24
TR2	251 – 400	50 or greater	20	2	24
TR3	401- 750	50 or greater	22	2	26
TR4	Over 750	55	22	4	30

1. Source: TRANS 204, Existing Town Road Improvement Standards.
2. The upper end of the range for design speed is 5 mph greater than the posted speed. The lower end of the range for design speed is equal to the posted speed limit.

S-2 Application for Rehabilitation Projects on Rural County Trunk Highways Functionally Classified as Arterials[1]

TRAFFIC VOLUME			ROADWAY WIDTH DIMENSIONS		
Design Class	Design AADT	Design Speed (mph)	Traveled Way[2] (feet)	Shoulder (feet)	Roadway (feet)
3RA1	Under 750	55	22	3	28
3RA2	750 – 2000	55	24	4	32
3RA3	Over 2000	55	24	6	36

1. Source: TRANS 205, County Trunk Highway Standards

2. The traveled way width shall be 24 feet on federally designated long truck routes (i.e. the “National Network” as defined in 23 CFR Part 658.) A traveled way width of 24 feet is acceptable on state truck routes and other highways that have current heavy vehicle (six or more tires) traffic volumes greater than 10 percent of Design AADT.

S-2 Application for Rehabilitation Projects on Rural County Trunk Highways Functionally Classified as Collectors and Locals[1]

TRAFFIC VOLUME			ROADWAY WIDTH DIMENSIONS		
Design Class	Design AADT	Design Speed (mph)	Traveled Way[2] (feet)	Shoulder (feet)	Roadway (feet)
3RC1	Under 750	55	20	3	26
3RC2	750 – 2000	55	22	4	30
3RC3	Over 2000	55	22	6	34

1. Source: TRANS 205, County Trunk Highway Standards.

2. The traveled way width shall be 24 feet on federally designated long truck routes. A traveled way width of 24 feet is acceptable on state designated long truck routes and other highways which have current heavy vehicle (six or more tires) traffic volumes greater than 10 percent of Design AADT.

Perpetuation and Rehabilitation Design Criteria for Interstate Highways

Number of Travel Lanes (Total Both Directions)		4-Lane	6-Lane or More
Sideslopes		4:1 or flatter (Recoverable) or 3:1 maximum (Traversable) with Recovery Area meeting FDM 11-15 Attachment 1.9	
Traffic Lanes	Widths	12 feet	12 feet
	Cross Slope	1.5 to 2%[1]	1.5 to 2%[1]
	Superelevation	6% maximum	6% maximum
Shoulders	Widths	10 feet Right / 4 feet Left	10 feet Right and Left
	Cross Slope	4 - 6%[2]	4 - 6%[2]
New and Replacement Bridges	Vertical Clearance	16'- 4" lower minimum. See FDM 11-35 Attachment 1.8	
	Roadway Width[3]	Full Approach Roadway Width except Major Long Span Structures shall provide 4-foot minimum from edge of traffic lanes to parapets[3]	
	Design Loading Structural Capacity[4]	HL-93 (HS-20) minimum [4]	HL-93 (HS-20) minimum[4]
Bridges to Remain in Place	Vertical Clearance (Feet)	16'-0" minimum (See FDM 11-35 Attachment 1.9)	16'-0" minimum (See FDM 11-35 Attachment 1.9)
	Lane Widths (Feet)	12 feet	12 feet
	Shoulder Widths (Feet)	10 feet Right / 3.5 feet Left minimum except 3.5 feet Left and Right minimum for Major Long Span Structures	10 feet Right and Left minimum except 3.5 feet Left and Right minimum for Major Long Span Structures
Lateral Clearance[5]		See FDM 11-15 Table 1.2 [5]	
Roadside Design	Curb or Curb and Gutter	Barrier curbs shall not be used. Mountable curbs, when used, should be located at the outer edge of the shoulder. Also, where guardrail is used, the face of the curb should be flush with the face of guardrail or behind it.	
	Clear Zone Widths and Fixed Objects	FDM 11-15 Attachment 1.9 and the 2011 AASHTO Roadside Design Guide should be used for guidance regarding warranted clear zone widths. Fixed Objects within the clear zone should be removed, made breakaway or made safe through shielding by a roadside barrier, crash cushion, or a combination of both.	
	Median Inlets and Ditch Checks	Median inlets should have 6:1 or flatter traversable grates and 10:1 or flatter ditch checks.	
	Median and Maintenance Crossovers	Median/Maintenance Crossovers should be eliminated whenever possible or constructed to have 10:1 or flatter side slopes.	
	Construction Crossovers	Removed after project completion unless they are planned to be used for future maintenance or other traffic control operations. Construction crossovers left-in-place should 10:1 or flatter side slopes and appropriate safety devices installed along their length to minimize the potential for median-crossing crashes and unauthorized U-turns.	
Traffic Control Devices/Signing		Shall be in conformance with the current Manual on Uniform Traffic Control Devices (MUTCD) and the Wisconsin Manual on Uniform Traffic Control Devices (WMUTCD).	
Access Control		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.	

Notes:

[1] Refer to FDM 11-40 Attachment 7.1 controlling criteria item number 8.

[2] Refer to FDM 11-40 Attachment 7.1 non-controlling criteria item number 3.
[3] Normally provide full widths of approach roadways across all new bridges. Justifications may be made when the bridges are considered major structures on which design dimensions are subject to individual economic studies because of high unit costs.
[4] See WisDOT Bridge Manual and consult with Bureau of Structures for appropriate Bridge Design Loading.
[5] Lateral clearance design criteria for underpass bridges are included in FDM 11-35-1.