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Criteria for Implementing Full-Width/Depth Shoulders to Accommodate Hard Shoulder Running

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Request for Report

WisDOT is considering constructing full-width/depth shoulders along certain freeway segments to carry traffic during future freeway resurfacing or construction projects. The goal of this measure is to minimize lane closures and congestion. WisDOT is interested in learning what criteria other states use for building full-width/depth shoulders.

Summary

This report is divided into two sections:

- Related Guidance and Research
- Survey Results

Related Guidance and Research

We found little guidance in pavement design manuals or elsewhere about criteria for determining when to build full-width/depth shoulders to accommodate hard shoulder running. Although pavement design manuals typically have thickness and width criteria based on a roadway's average traffic volume, these criteria do not take into account the temporary use of the shoulder as a lane. Operational manuals generally refer to criteria triggering the use of existing facilities rather than criteria for building them. What guidance we found usually refers vaguely to expected congestion, level of service and traffic volumes.

Survey Results

We distributed a survey to members of the AASHTO Research Advisory Committee for completion by appropriate staff at their agencies. The survey consisted of the following questions:

1. How often does your state build full-width/depth shoulders along freeways designed to carry traffic during future resurfacing or construction operations?
   - Routinely
   - Occasionally on a case-by-case basis
   - Never
2. If used, what criteria does your agency apply to decide whether to utilize full-width/depth shoulders to handle traffic during future resurfacing or other construction? If available, please forward any process paper, manual section or other documentation relating to these criteria, or provide a Web link.

3. If traffic level is a criterion used in determining whether to utilize full-width/depth shoulders, please provide the threshold levels, if defined.

Staff at 10 state DOTs responded to this survey. Key findings from them include:

- Frequency:
  - Eight states—Illinois, Indiana, Kansas, Montana, Nebraska, Oregon, Texas and West Virginia—use full-width/depth shoulders routinely.
  - One state—Iowa—uses full-width/depth shoulders occasionally.
  - One state—Florida—never uses full-width/depth shoulders because its subgrades and bases are naturally strong.
- Criteria:
  - Three states— Illinois, Oregon and Texas—use full-depth shoulders in all circumstances, regardless of traffic thresholds or other criteria. West Virginia uses full-depth shoulders on all urban arterials.
  - Three states supply precise traffic thresholds as criteria for full-width/depth shoulders:
    - Indiana: 30 million ESALs
    - Iowa: 25,000 vehicles per day
    - West Virginia: Projects with an average daily traffic of 6,000 and truck traffic of 15 percent or greater; projects with an ADT greater than 15,000; all urban arterials
  - Two states—Kansas and Nebraska—say anticipated traffic or expected growth is a criterion, but do not supply specific thresholds. (In Nebraska, ADTs would range from 40,000 to 80,000.)
  - Other criteria mentioned by states include economics (Nebraska); the need for construction/incident management (Iowa, Nebraska and West Virginia); and the condition of the subgrade as detected by falling weight deflectometer measurements (Indiana).

See **Survey Results** beginning on page 5 of this report for the full text of these survey responses.

Related Guidance and Research

Bureau of Design and Environment Manual, Chapter 34 – Cross Section Elements, Illinois Department of Transportation, September 2010.
http://www.dot.il.gov/desenv/BDE%20Manual/BDE/pdf/Chapter%2034%20Cross%20Section%20Elements.pdf
This document was referred to in IDOT's survey response. See pages 34-2.3 to 34-2.4:

- **34-2.02(b) Widths:** Shoulder widths will vary according to functional classification, traffic volumes, urban/rural location, curbed/uncurbed, and the project scope of work. The tables in Chapters 44 through 50 present the shoulder width criteria for these conditions
- **34-2.02(c) Additional Shoulder Thickness:** For all new construction or reconstruction projects on the State system, increase the shoulder pavement thickness to allow the shoulders to be used to carry traffic during current and future construction improvements.

Screening Criteria for Managed Use Lane Projects, New York State Department of Transportation, Region 11, April 2009.
https://www.nysdot.gov/regional-offices/region11/projects/managed-use-lanes-study/repository/MULFinalScreeningCriteria052909.pdf
This document describes a screening process for determining whether conditions warrant the use of managed use lanes and includes thresholds for temporary peak shoulder use that have implications for design (page 25):

- Scheduled maintenance and construction locations predicted to cause congestion and queuing at LOS F for two consecutive peak hours in the peak direction during AM and PM peak periods
- High accident/incident locations identified in Level One
- Sufficient length of facility to alleviate a series of bottlenecks, no less than 3 miles
- Minimum shoulder width of 10 feet, with ability to add emergency refuge areas
- Pavement strength to accommodate vehicles
- Existing or ability to implement ITS/field sensors with traffic management center connections
- Low volume of entering/exiting vehicles if traversing multiple interchanges
- Low turning volumes (arterials)

"Level One" refers to an initial screening of conditions related to the magnitude of average total daily traffic, presence of congestion, excessive delays, incidents and accidents, and identified transit priority corridors (see pages 7-13), and takes into account the following computed values:

- Average ADT ranging from a four-lane value of 75,000 to a six-lane value of 60,000
- Peak period traffic densities at LOS E and F of two or more hours
- Extensive incident durations (more than 20 minutes) and incident/accident rates/100 million vehicle miles
- Frequent transit operations

Guideline for the Deployment of Hard Shoulder Running, Core European ITS Services and Actions, EasyWay, February 2009.
http://www.its-sweden.se/Userfiles/Archive/377/TMS-DG04_-_Hard_Shoulder_Running_-_091209.pdf
This document includes a section (page 3) on characteristics of roads or networks suitable for hard shoulder running:

- Traffic volumes close to the road capacity
- Frequent congestion problems
- The ability to cope with extra capacity upstream

Rigid Pavement Design Manual, Florida Department of Transportation, January 2009.
http://www.dot.state.fl.us/pavementmanagement/pcs/RigidPavementManualJanuary12009.pdf
From page 6.3.0 of the manual: Full depth (tied) concrete shoulders may be used on Limited Access (Urban) facilities where use for future Maintenance of Traffic or Widening is likely.

"Guidance for Implementation of the AASHTO Strategic Highway Safety Plan, Volume 17: A Guide for Reducing Work Zone Collisions," *NCHRP Report 500*, 2005.
http://academic.csuohio.edu/duffy_s/nchrp_rpt_500v17.pdf
From page V-41 of the report: Be aware of the long-term vision of roadway corridors. For example, if a four-lane facility is being constructed, but the plan ultimately calls for six lanes, consideration should be given to the future widening project, and the design of that work zone should be considered during development of the four-lane project. The Ohio DOT is developing guidelines on constructing a full-depth shoulder on roadways where work may be planned within a certain time period.

Guidelines for 1993 AASHTO Pavement Design, Virginia Department of Transportation, May 2003.
http://www.virginiadot.org/business/resources/bu-mat-pde-AASHTOForConsultants0503.pdf
See *Shoulder Design* (page 4): For Interstate routes, the pavement shoulder shall have the same design as the mainline pavement. A full-depth shoulder (same design as the mainline pavement) is also recommended for other high-volume non-interstate routes.

"Paved Shoulders Adjacent to Concrete Pavements: Synthesis of Current Practices in the Midwest," Samuel Owusu-Ababio, Robert L.Schmitt, Joakim Osthus, *TRB Annual Meeting CD ROM*, 2003.
http://www.ltrc.lsu.edu/TRB_82/TRB2003-001968.pdf
This survey of seven Midwestern states was conducted as part of a research study to develop an improved methodology for the design and construction of paved shoulders adjacent to concrete pavements in Wisconsin. It includes a survey of paved shoulder thickness determination practices (page 4) in Midwestern states, with a chart summarizing responses (page 10):

State	Concrete Shoulder	Asphalt Shoulder
Illinois	For 20-year design period: Same thickness as mainline concrete at the pavement-shoulder interface tapering to 6 inches (150 mm) at the outside edge. For 30-year design period: Same thickness as mainline concrete.	Not Applicable (N/A).
Indiana	AASHTO Same thickness as mainline for roadways with at least 30 million ESALs.	A minimum thickness of 2 inches (50 mm) asphalt over compacted aggregate base for roadways with less than 30 million ESALs.

State	Concrete Shoulder	Asphalt Shoulder
Iowa	Same thickness as mainline if shoulder is used for construction staging or is anticipated to be used as a lane in the future; otherwise standard thickness of 7 inches (175 mm).	Same thickness as mainline if shoulder is used for construction staging or is anticipated to be used as a lane in the future; otherwise standard thickness of 8 inches (200 mm).
Michigan	AASHTO Same thickness as mainline. Standard thickness consisting of same thickness at the pavement-shoulder interface and tapering to a minimum of 7 inches (175 mm) at the outside edge of the shoulder.	AASHTO Standard thickness consisting of a minimum of 5.5 inches (137.5 mm) for freeways.
Minnesota	A 6-inch (150-mm) non-reinforced concrete surface tied to the mainline is required over aggregate base layers.	A 3-inches (75 mm) minimum asphalt surface thickness required over aggregate base layers.
Wisconsin	AASHTO (using 2.5% of mainline design ESALs/day); a 6-inch (150-mm) minimum surface thickness is required.	AASHTO (using 2.5% of mainline design ESALs/day); a 2-inch (50-mm) minimum surface thickness is required.

Comprehensive Pavement Design Manual, Chapter 7: Shoulders, New York State Department of Transportation, July 2002.
https://www.nysdot.gov/divisions/engineering/design/dqab/cpdm/repository/chapter7.pdf
This document includes guidance on when to use full-depth shoulders (Section 7.5):

- Some localized shoulder areas are subjected to above normal traffic encroachment, such as across from entrances, inside curves of ramps, intersections or opposite the leg of "T" intersections.
- If it is anticipated that shoulders will be used to carry mainline traffic during construction, the entire shoulder should be full depth.
- Full-depth shoulders should also be used on ramps and intersections with safety widening, where right-turning traffic may illegally utilize the shoulder, where frequent bus traffic on the shoulder is anticipated, and possibly where large vehicles will have trouble negotiating curves or corners without encroaching onto the shoulders.

Design and Engineering Manual, Chapter 34: Pavement Design, District Department of Transportation, Washington, D.C., April 2009.
http://dc.gov/DC/DDOT/Publication%20Files/Projects%20and%20Planning/Standards%20and%20Guidelines/publication_design_and_engineering_ch34__ddot.pdf
This manual includes guidelines for using full-depth shoulders:

- **34.3.5.1, Shoulders:** When PCC shoulders are used they shall have the same PCC slab and base thickness as the mainline roadway. (page 34-4)
- **34.4.2.1.1, Shoulder Buildups:** Shoulders for flexible pavements shall be constructed of the same materials and thickness as the mainline pavement for all Interstate, freeways, expressways, and other multi-lane facilities. This provides for the ability to have a hot longitudinal joint at the pavement-shoulder interface, provides a stable temporary pavement for maintenance of traffic lane shifts, and reduces the complexity of construction. (page 34-6)
- **34.4.4, Shoulders Width:** Shoulder widths shall be a minimum of 10 ft. on freeways and interstate highways. (page 34-7)

Survey Results

The full text of each survey response is provided below. For reference, we have included an abbreviated version of each question before the response; for the full question text, please see the **Summary** on page 1 of this report.

Florida

Contact: David C. O'Hagan, State Roadway Design Engineer, Florida Department of Transportation, (850) 414-4283, david.ohagan@dot.state.fl.us.

1. Frequency of full-width/depth shoulder use
Never. Florida is blessed with very good subgrades and our base beneath our shoulders is also very good. For most construction periods, our shoulders hold up well and any deterioration can be quickly fixed as the structural thickness of the asphalt is only 1" thick.

2. Criteria for utilization
N/A.

3. Traffic thresholds
N/A.

Illinois

Contact: Michael Brand, Acting Policy & Procedures Engineer, Bureau of Design & Environment, Illinois Department of Transportation, (217) 782-7651, michael.brand@illinois.gov.

1. Frequency of full-width/depth shoulder use
Routinely [not explicitly stated but inferred from Illinois response].

2. Criteria for utilization
The Illinois DOT has been "beefing up" its shoulders under certain circumstances since April 2000. The policy can be found in Section 34-2.02(c) of Chapter 34 of our BDE Manual. Here is a link to the manual: http://www.dot.il.gov/desenv/bdemanual.html. [See **Related Guidance and Research** – the document indicates that IDOT uses full depth shoulders on all construction projects].

I believe all of the survey questions will be answered after reading our policy.

Note: This system does not work perfectly. Since we install shoulder rumble strips on the types of roadways that meet the additional shoulder thickness criteria, we typically have to mill out the rumble strips and fill in the resulting void prior to using them as traffic lanes.

3. Traffic thresholds
N/A.

Indiana

Contact: Tommy E. Nantung, Manager for Pavement, Materials, and Construction Research, Division of Research and Development, Indiana Department of Transportation, (765) 463-1521, ext. 248, tnantung@indot.in.gov.

1. Frequency of full-width/depth shoulder use
Routinely.

2. Criteria for utilization
We test with Falling Weight Deflectometer before decid[ing] to utilize the full width/depth shoulder. It is not in the manual, but it is the discretion of the Pavement Engineering Office.

3. Traffic thresholds
Traffic more than 30 million ESALs.

Iowa

Contact: Daniel E. Ohman P.E., Assistant Design Engineer–Development, Office of Design, Iowa Department of Transportation, (515) 239-1505, daniel.ohman@dot.iowa.gov.

1. Frequency of full-width/depth shoulder use
Occasionally on a case-by-case basis.

IDOT uses full depth paved shoulders on a case by case basis. Generally [we use them] on reconstruction projects when it is advantageous for the staging aspects. The typical section becomes a series of 12' wide lanes, of which the inside and outside shoulders are the same depth and width as the lanes. We have also started using full depth shoulders (lane width and depth) on projects where it is felt that the future traffic will warrant an additional lane in the near future. At that time we can add an additional shoulder to create the lane. ROW and grading are accomplished for the full design width.

2. Criteria for utilization
We typically use full depth shoulders as needed for reconstruction projects when traffic warrants maintaining two or more lanes per direction. Typically we retrofit the existing shoulder on the first stage, and then plan for the succeeding stages with the construction. It is determined by volume of traffic, and potential traffic diversion via alternate routes. All [of this is] determined during the concept development on a case by case basis. Traffic volume cut off is approximately 25,000 VPD, but that is also supplemented with peak hour data. We are currently developing guides, but they are not in draft form yet.

3. Traffic thresholds
[As a] rule of thumb, currently 25,000 VPD is the cutoff for head to head traffic without extra study/analysis. Same traffic check [applies] for lane closures for single lane traffic on the four-lane system, for resurfacing or other projects.

Kansas

Contact: Andy Gisi, Geotechnical Engineer, Materials and Research, Kansas Department of Transportation, (785) 291-3856, agisi@ksdot.org.

1. Frequency of full-width/depth shoulder use
Routinely.

2. Criteria for utilization
We routinely construct full-width shoulders using both PCCP and HMA. The thickness ranges from 6" to 8" for PCCP and 5" to 8" for HMA. The thickness is governed by the traffic. We generally design the shoulders for 10 percent of the mainline traffic. Traffic studies from others show that about 10 to 15 percent of the mainline traffic encroaches on the shoulders for some portion of their travel. On a rare occasion, project specific, we have constructed full depth shoulders 12' wide in anticipation that we will use the shoulder as a driving lane to increase the capacity of the roadway in the future. As I stated we only do this when we anticipate that we'll need more capacity in the future. We don't do it for resurfacing or reconstruction operations.

3. Traffic thresholds
No response.

Montana

Contact: Lesly Tribelhorn, Highways Design Engineer, Montana Department of Transportation, (406) 444-6242, ltribelhorn@mt.gov.

1. Frequency of full-width/depth shoulder use
Routinely.

2. Criteria for utilization
MDT routinely designs freeway shoulders with the same typical surfacing sections as the driving lanes. Except where limited by terrain features, freeway shoulders are designed to the standard 10' (outside). Inside shoulders are 4'. These are controlling criteria that require a formal design exception if not used. See Figure 12-2 of the MDT Road Design Manual:
http://www.mdt.mt.gov/other/roaddesign/external/montana_road_design_manual/12_geometric_design_tables.pdf.

3. Traffic thresholds
Not for freeways.

Nebraska

Contacts:

Terry Gibson, Interstate Section Leader, Nebraska Department of Roads, (402) 479-4565, terry.gibson@nebraska.gov.

Brandon Varilek, Assistant Pavement Design Engineer, Materials & Research, Pavement Design, Nebraska Department of Roads, (402) 479-4755, brandon.varilek@nebraska.gov.

1. Frequency of full-width/depth shoulder use
Routinely.

Terry Gibson:

- Nebraska routinely builds full-width/depth tied concrete shoulders on the six lane expansion of I-80. The full depth shoulders are needed to handle the interstate traffic because we are maintaining two lanes of traffic in each direction during all phases of construction.
- NDOR routinely builds full-width/depth tied concrete shoulders on urban freeways to handle traffic during construction and for incident traffic management.

Brandon Varilek: NDOR occasionally builds full-width/depth shoulders, primarily on I-80 between Lincoln and Omaha, our highest volume stretch of interstate.

2. Criteria for utilization
Terry Gibson: The decision on the shoulders for rural freeways is made on a case-by-case basis with economics being one of the major factors. NDOR, for the rural freeway, does not have specific criteria to require full depth shoulders.

Brandon Varilek: The Lincoln to Omaha I-80 segment is being rebuilt/expanded to six lanes. Full depth/width shoulders are being constructed to serve as a future driving lane and to handle traffic during accidents, future construction, etc. The decision was based on future growth predictions which warranted an additional lane during the 50 year service life of the pavement.

3. Traffic thresholds
Traffic level not defined. ADT varies from approximately 40K – 80K on this segment.

Oregon

Contact: Jon Lazarus, Research Coordinator, Construction, Maintenance & Operations, Oregon Department of Transportation, (503) 986-2852, jon.m.lazarus@odot.state.or.us.

1. Frequency of full-width/depth shoulder use
Routinely.

2. Criteria for utilization
Oregon routinely constructs shoulders to sufficient depth to carry traffic. Virtually all of our interstate shoulders have sufficient structure to carry freeway traffic for significant periods of time. As for width, we do not design extra width to accommodate traffic in most cases; however, our standard right shoulder is wide enough to carry traffic.

Occasionally if we need special staging on a project we will also end up having a left shoulder wide enough to accommodate a lane of traffic.

If you need more specifics on any given piece of the interstate, you can contact John Coplantz for assistance: John Coplantz, Pavement Management Engineer, (503) 986-3119, john.s.coplantz@odot.state.or.us.

3. Traffic thresholds
N/A.

Texas

Contact: Mark A. Marek, Director, Design Division, Texas Department of Transportation, (512) 416-2653, mark.marek@txdot.gov.

1. Frequency of full-width/depth shoulder use
Routinely.

2. Criteria for utilization
We use full depth shoulders whenever shoulders are provided. The width is dependent on roadway classification and traffic volumes.

3. Traffic thresholds
The threshold levels are usually the same as AASHTO values for different roadway classifications.

West Virginia

Contact: Joe H. Hall, Technical Section Head, Engineering Division, Division of Highways, West Virginia Department of Transportation, (304) 558-9733, joe.h.hall@wv.gov.

1. Frequency of full-width/depth shoulder use
In the past, WV constructed its interstate system with partial depth shoulders. Criteria [http://www.transportation.wv.gov/highways/engineering/DD/2006%20DD%20Manual%20MASTER.pdf, page 390]:

> **DD-601**
> **Paved Shoulder Width**
> Useable shoulders to the right of traffic will be 10 feet minimum. Twelve feet should be considered if truck traffic exceeds 250 DDHV. The minimum may be reduced to 8 feet in mountainous terrain. Useable shoulders to the left of traffic and along auxiliary lanes will be 4 feet minimum. For six or more lanes, 10 feet should be provided and if truck traffic exceeds 250 DDHV, 12 feet should be considered. Paving of the useable shoulder with concrete or asphalt is required.

2. Criteria for utilization
If a Traffic Control Plan would shift traffic onto a partial depth shoulder for a phase consideration would be given to the traffic volume and the length this phase would be in place. If needed, construction of a Full Depth Shoulder would be the first phase.

3. Traffic thresholds
See DD-646:

> **D. Shoulders**
> Joint spacing on PCC shoulders shall match the spacing of the mainline pavement. For both PCC and asphalt pavements the paved shoulder thickness shall match the mainline pavement section for:
> - Urban arterials
> - Projects with an ADT of 6,000 and truck traffic of 15% or greater
> - Projects with an ADT greater than 15,000