1.1 Subgrade Improvement Impact on Pavement Thickness Design
The Bureau of Technical Services has implemented a statewide policy that incorporates the use of select material in the pavement design process. The philosophy is that the subgrade is improved through the use of select material. Therefore, the support value of the improved subgrade must be increased to include the influence of the select material.

Regardless of the material used to improve the subgrade, it is still considered subgrade and should be given no additional credit in the structural design process beyond what is stated in this procedure.

Note: The use of a sub-base layer is still acceptable.

1.2 Policy

1.2.1 Flexible Pavements
When select material is placed according to the subgrade improvement initiative, the Design Group Index/Soil Support Value chart (Attachment 1.1) includes a second reference line that is to be used in order to establish a SSV of an improved subgrade. This second reference line is for DGI values from 8 to 20.

1.2.2 Rigid Pavements
When select material is placed according to the subgrade improvement initiative, the modulus of subgrade reaction (k) should be increased to 375. This increase is based on the development of a composite k per the AASHTO ’93 Guide for Design of Pavement Structures. One value has been established to cover all circumstances when a select material is used, due to the fact that the input values needed to determine a composite k are resilient modulus of the subgrade and elastic modulus of the subbase (select material).

LIST OF ATTACHMENTS
Attachment 1.1 Soil Support Value vs. Design Group Index

5.1 Basis of Design
5.1.1 Traditional HMA Pavements
Thickness design is based on the structural number (SN) concept of the AASHTO Interim Guide [1]. The majority of the thickness of the pavement structure comes from the paving platform (refer to FDM 14-5-1).

5.1.2 Deep-Strength or Perpetual HMA Pavements
To determine if either a deep-strength or perpetual hot mix asphalt (HMA) pavement design is required during the pavement type selection process, refer to FDM 14-15-1. The design is based on 20-year cumulative design ESALs. When these ESALs are anticipated to be less than 8 million, a deep-strength design is used. If these ESALs are projected to be 8 million or greater, a perpetual design is used.

Deep-strength HMA pavements are similar in design and composition to WisDOT’s traditional HMA pavements; thickness design is based on the structural number. For these pavements, the majority of the structural number comes from the HMA pavement layers. The maximum SN given to the paving platform (either base aggregate dense or base aggregate open graded) is equivalent to that for a 6-inch aggregate base.

Perpetual HMA pavements are designed based on a maximum strain value at the bottom of the HMA pavement. Thickness design is determined using a mechanistic design procedure. These designs will be done by, or in conjunction with, WisDOT’s central office (refer to Originator, FDM 14-1-1).

5.2 Roughness Index
The value of the roughness index for flexible pavement design is 2.5 PSI.
5.3 Traffic Loading
See FDM 14-1-5,"Traffic".

5.4 Soil Support
The soil support value for pavement design is to be determined and subsequently discussed in the soils report.

5.5 Design Equation
The WisPAVE design program uses the AASHTO ’72 Asphalt Design Equation. Its use is based on Design Lane Total Life ESALs. That equation is presented here since there has been a need for designs with design lives less than 20 years (temporary roadways) and pavement evaluations based on accumulated ESALs.

\[
\log(ESAL) = 9.36\log(SN + 1) - 0.2 + \frac{\log(\frac{4.2 - P_t}{1.5})}{0.4 + \frac{1094}{(SN + 1)^{0.15}}} + \log(\frac{1}{R}) + 0.372(S - 3.0)
\]

Where:
- ESAL = Total Life Flexible ESALs (see FDM 14-1-5)
- SN = Structural Number
- Pt = Terminal Serviceability Index (PSI) (WisDOT uses 2.5*)
- R = Regional Factor (WisDOT uses 3.0)
- S = Soil Support Value (refer to Soils Report)

* WisDOT reports in IRI; however, this equation uses PSI.

5.6 Structural Layer Coefficients
The terms “structural layer coefficients,” “layer coefficients,” and “strength coefficients” are used interchangeably.

Attachment 5.1, Structural Layer Coefficients, shows strength coefficients for various materials normally used in pavement structures. These coefficients are not absolute but are consistent with minimum strength values that are expected from materials throughout the state. Each layer of an HMA pavement structure receives the loads from the layer(s) above, spreads them out, and distributes the loads to the layer(s) below. Therefore, the deeper a layer is in the pavement structure, the less load it must support. Due to this behavior, pavement structural layers are typically arranged in order of decreasing material strength (with those having the strongest layer coefficients being at the top). This concept should be used for all WisDOT pavement designs.

Since it is possible that the type of dense graded base (standard spec 305.1) that will be used on a project is not always known, the Pavement Design engineer should use the lower (crushed gravel) structural layer coefficient. This assures that an under-designed pavement will not be built. If the source of aggregate is positively known, or if the design involves rehabilitation of an existing pavement structure with known materials, a different layer coefficient can be used.

5.6.1 Milled and Re-laid or Pulverized Hot-Mix Asphalt Pavement
This material can vary in both strength and stability. Typically, one to two inches of the existing base are pulverized along with the pavement, thereby producing a blend of pavement and base material. Therefore, when processing a thin HMA pavement (e.g., 3 inches), the net effect is essentially a base aggregate dense layer with a structural coefficient of either 0.14 or 0.10 depending on whether the material contains crushed stone or crushed gravel. If processing a thicker HMA pavement (e.g. 6 inches or greater) a structural coefficient as high as 0.25 can be used if the material contains crushed stone. Refer to FDM 14-25-20.4.2 for additional guidance regarding structural layer coefficients of pulverized material.

5.6.2 Rubblized Concrete Pavements
The recommended coefficient for rubblized concrete pavements ranges from 0.20 to 0.24. If the concrete pavement being rubblized is over a sound base and/or subbase, a coefficient of 0.24 could be used for the rubblized material.

5.6.3 Intact Concrete Pavements
The coefficient range for intact concrete pavements is 0.10 to 0.54, depending on the condition of the concrete pavement. For example, a coefficient of 0.54 could be typical of a new concrete pavement.
5.6.4 Cold In-Place Recycled (CIR) Asphaltic Pavement

The structural layer coefficient of cold in-place recycled (CIR) mixtures typically ranges from 0.30 to 0.35. A layer coefficient of 0.32 should be used for design purposes.

5.7 Subbase

Attachment 5.2, Relative Strength Coefficients for Granular Subbase, shows a chart that can be used as a guide for selecting the strength coefficient for granular subbase material, knowing the general gradation of the material available. The chart is based on tests conducted by the Bureau of Technical Services, Geotechnical Section.

When granular subbase is used as part of a pavement structure, the portion of strength it contributes to the total pavement structure shall be limited to a maximum of ten percent of the design SN, regardless of its strength coefficient or thickness used. The purpose of the ten percent limit is to ensure that adequate amounts of pavement and base are used in the pavement structure.

5.8 Staged Construction

For staged construction, individual layers should be analyzed so no one layer is overstressed before the entire structure is completed.

5.9 HMA Mixture Layers

Beginning in 2016, HMA mixture and asphaltic binder are combined into a single bid item. In addition, mixtures are identified with an updated nomenclature (refer to Figure 5.1).

![Figure 5.1 HMA Combined Bid Item Nomenclature](image)

The identification is comprised of four components:

- aggregate gradation (NMAS),
- anticipated traffic level,
- base asphaltic binder grade, and
- asphaltic binder designation level

These components are further detailed in the remainder of this section.

HMA pavement layers should be designed to the nearest 1/4-inch. The plan thickness for lower and upper layers can be determined from standard spec 460.3.2.

Once a pavement thickness is determined, the following procedure can be used to select the final mix type. The final mix type should be one of those listed in the suite of choices in Attachment 5.6 (unless otherwise designated in the approved Pavement Documentation for the project).

5.9.1 Gradation Selection

HMA aggregate gradation (nominal maximum aggregate size (NMAS)) choices are as follows:

1 - 37.5 mm mix
2 - 25.0 mm mix
3 - 19.0 mm mix
4 - 12.5 mm mix
5 - 9.5 mm mix
6 - 4.75 mm mix

Gradations 1 and 6 (37.5 and 4.75mm) are not commonly used on WisDOT projects. They have been entered into the list of options as the materials may become more readily available making them an eventual choice of gradation for a given project.

Gradation 2 (25.0 mm) use in temporary crossovers, asphaltic base, and lower layer HMA pavement applications. Do not use this gradation in the surface, except when a temporary crossover is paved in a single layer and is expected to be removed before winter.
Gradation 3 (19.0 mm) use in crossovers, asphalt base, deep strength/perpetual pavement and as a lower layer in most standard paving (roundabouts, turn lanes, mainline, ramps, etc.). This mix is commonly used in both new construction and overlay situations, when the pavement structure thickness is 4.0 inches or greater. Do not use this gradation in the surface, except when a crossover is paved in a single layer.

Gradation 4 (12.5 mm) use for almost every pavement application, and is the most common surface mix. It is also used as a lower layer when less than 4.0 inches of pavement structure is required.

Gradation 5 (9.5 mm) is also applicable in most every pavement application, and is used as a surface mix. It is also used for wedging/leveling and other specialty applications.

Select appropriate gradations for the upper and lower layers to obtain the required pavement structure needed to meet the WisPAVE structural number while also ensuring the minimum layer thicknesses are met. Refer to FDM 14-15-10 for WisPAVE program information and standard spec 460.3.2 for layer thickness information.

Specific uses for each gradation are summarized in Table 5.1.

<table>
<thead>
<tr>
<th>Gradation</th>
<th>Pavement Layer</th>
<th>Common Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (37.5 mm)</td>
<td>Lower</td>
<td>N/A</td>
</tr>
<tr>
<td>2 (25.0 mm)</td>
<td>Lower</td>
<td>Temporary crossovers, asphaltic base</td>
</tr>
<tr>
<td>3 (19.0 mm)</td>
<td>Lower</td>
<td>Crossovers, asphalt base, roundabouts, turn lanes, mainline, ramps, etc.</td>
</tr>
<tr>
<td>4 (12.5 mm)</td>
<td>Lower, Upper, Leveling, SMA</td>
<td>Almost every pavement application, most common surface mix</td>
</tr>
<tr>
<td>5 (9.5 mm)</td>
<td>Upper, Leveling, SMA</td>
<td>Most every pavement application, generally surface mix</td>
</tr>
<tr>
<td>6 (4.75 mm)</td>
<td>Leveling</td>
<td>N/A</td>
</tr>
</tbody>
</table>

5.9.2 Traffic Category Selection

Traffic categories are as follows:

<table>
<thead>
<tr>
<th>Traffic Level Classifications</th>
<th>ESALs</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT (Low Traffic Volume)</td>
<td>≤ 2 million</td>
</tr>
<tr>
<td>MT (Medium Traffic Volumes)</td>
<td>&gt;2 to ≤ 8 million ESALs</td>
</tr>
<tr>
<td>HT (High Traffic Volumes)</td>
<td>&gt; 8 million ESALs</td>
</tr>
<tr>
<td>SMA (Stone Mix Asphalt)</td>
<td>Consider for &gt;5 million ESALs</td>
</tr>
</tbody>
</table>

The designations for Low, Medium, or High Traffic volumes are based on the number of Equivalent Single Axle Loads (ESALs) expected to be applied to pavement during its service life.

An LT mix is designed to receive up to 2 million ESALs (i.e., ESAL ≤ 2 million) during its design life. The most common applications for this type of mix would be for shouldering of concrete pavements, low volume rural highways, or residential collector streets. These are pavements which will see a relatively low volume of trucks or traffic during the service life.

An MT mix is designed to receive between 2 million and 8 million ESALs (i.e., 2 million < ESAL ≤ 8 million) during its design life. This is the most common pavement used on the rural, 2 lane highway network. These pavements are also used on urban arterial streets, and any other application expecting to receive a moderate to high volume of traffic, and a moderate number of trucks. More than half the pavements built by WisDOT fall under this traffic loading category.
An HT mix is designed to receive greater than 8 million ESALs (i.e., EASL > 8 million) during its design life. This pavement is used on heavily trafficked urban arterial streets, 4 lane divided highways, and intersections that have a high volume of turning and stopping movements. These pavements have a higher volume of trucks, and therefore have a higher aggregate crush count and fine aggregate angularity requirements to help withstand the heavier loading. It is also used on interstate, freeway and other high volume freight corridors.

As anticipated traffic loading exceeds 5 million ESALs, there is a special subset called Stone Matrix Asphalt (SMA) which may be a viable pavement selection. This open graded mixture is used as a surface in many freeway and interstate applications due to its highly angular aggregate structure generally paired with a polymer modified asphalt which allows SMA to resist cracking, provide a quiet ride and have the ability to drain moisture away quickly during rain events. It should be considered for the surface layer in many HT mix applications on continuously moving divided highways as well as rural MT applications expected to experience greater than 5 million ESALs.

Common applications for each traffic category are summarized in Table 5.3 below.

**Table 5.3 Traffic Level Classification Selection**

<table>
<thead>
<tr>
<th>Traffic Level Classification</th>
<th>ESAL</th>
<th>Common Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT</td>
<td>≤ 2 million</td>
<td>Shouldering of concrete pavements, low volume rural highways, residential collector streets</td>
</tr>
<tr>
<td>MT</td>
<td>2 million &lt; ESAL ≤ 8 million</td>
<td>Rural 2 lane highway network, urban arterial streets</td>
</tr>
<tr>
<td>HT</td>
<td>&gt; 8 million</td>
<td>Urban arterial streets, 4 lane divided highways, intersections, interstate, freeway</td>
</tr>
<tr>
<td>SMA</td>
<td>&gt; 5 million</td>
<td>Divided highways, freeways, and interstates</td>
</tr>
</tbody>
</table>

### 5.9.3 Asphalt Binder - Temperature/Project Location Selection

Wisconsin is currently separated into two low temperature zones; the Northern Asphalt Zone and the Southern Asphalt Zone (see Attachment 5.8). Based on this separation, the following binders are recommended for use:

**Northern Asphalt Zone**
- New construction, reconstruction, and pavement replacement: 58-34 S in the upper layer
  - (Note: 58-34 S is required minimum for the upper layer)
- Overlays and lower layers*: 58-28 S

**Southern Asphalt Zone**
- 58-28 S on all pavements*

*Lower layers may need a PG binder grade with designation beyond “S” in specialty situations (e.g., perpetual, deep, strength, etc.) as described below.

Note: If a project crosses the divide between Northern and Southern Asphalt Zones, the Northern Zone requirements will govern for the entirety of the project.

**Table 5.4 Asphalt Binder - Project Location Selection**

<table>
<thead>
<tr>
<th>Asphalt Binder</th>
<th>Project Location</th>
<th>Pavement Layers</th>
</tr>
</thead>
<tbody>
<tr>
<td>58-34S</td>
<td>Northern Zone</td>
<td>Upper layer</td>
</tr>
<tr>
<td>58-28S</td>
<td>Northern Zone</td>
<td>Overlay and lower layer</td>
</tr>
<tr>
<td></td>
<td>Southern Zone</td>
<td>All pavements *</td>
</tr>
</tbody>
</table>

* Lower layers may need a PG binder with designation beyond *S* in specialty situations (e.g., perpetual, deep, strength, etc.)
5.9.4 Asphalt Binder - Designation Selection

Modifications to the PG Binder system include a test protocol that quantifies the modification being made to the asphalt binder, if a modification is needed. The test, known as the Multiple Stress Creep Recovery (MSCR) test protocol, evaluates the level of polymer modification needed to provide resistance to rutting of the mix. This is accomplished by identifying recovered deformations versus permanent deformations of the material under repeated loading and unloading cycles. The MSCR protocol assigns designation of the following categories:

S (Standard Grade) - use in most situations with traffic levels below 8 million ESALs (i.e., ESAL ≤ 8 million). This does not require any polymer modification of the asphalt binder.

H (Heavy Grade) – use in situations of 8 million to 30 million ESALs (i.e., 8 million < ESAL ≤ 30 million) or slower moving traffic at design speeds between 15 to 45 mph. This designation also becomes a reasonable minimum in areas of increased turning, slowing/stopping, accelerating or parking movements; such as waysides, roundabouts, intersections or heavy commercial vehicle parking lots (not passenger vehicle, park and ride lots).

V (Very Heavy Grade) - use in situations with traffic exceeding 30 million ESALs (i.e., ESAL > 30 million) or with anticipated traffic moving slower than 15 mph on a regular basis (e.g. daily rush hours).

E (Extremely Heavy Grade) - use in situations with traffic in excess of 30 million ESALs (i.e., ESAL > 30 million) and standing traffic such as toll plazas, weigh stations and port facilities. This designation is rarely needed in Wisconsin.

The system of S, H, V and E replaces the older system of grade bumping. Instead of grade bumping a 58-28 to a 64-28 as was done in the past, the pavement designer will select a 58-28S in normal situations, and use a 58-28H for an intersection, or 58-28V for a heavily trafficked urban street with many stopping and starting movements. Table 5.5 demonstrates these changes from the former grade bumping system to MSCR protocol.

Table 5.5  Suggested Translation from PG Grade to MSCR Binder Nomenclature

<table>
<thead>
<tr>
<th>Previously Selected PG Grade</th>
<th>Suggested MSCR Binder</th>
</tr>
</thead>
<tbody>
<tr>
<td>58-34</td>
<td>58-34 S</td>
</tr>
<tr>
<td>58-34P</td>
<td>58-34 H</td>
</tr>
<tr>
<td>64-34P</td>
<td>58-34 V</td>
</tr>
<tr>
<td>58-28</td>
<td>58-28 S</td>
</tr>
<tr>
<td>64-28P</td>
<td>58-28 H</td>
</tr>
<tr>
<td>70-28P</td>
<td>58-28 V</td>
</tr>
</tbody>
</table>

Note: P identified a polymer-modified binder in the PG Grading system, but does not specify the level/quantity of modification (i.e., does not indicate the base/neat binder that was modified). This table is not to be read as a direct conversion of binder from PG Grade nomenclature to MSCR Binder nomenclature as several binders from the former PG Grading system may result in the same grade under the MSCR System. See AASHTO M 332 for additional criteria of MSCR.

Common applications for each binder designation level are summarized in Table 5.6 below.

Table 5.6  Selection of Binder Designation Level

<table>
<thead>
<tr>
<th>Binder Designation Levels</th>
<th>Common Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>≤ 8 million ESALs</td>
</tr>
<tr>
<td>H</td>
<td>8 &lt; ESAL ≤ 30 million OR design speeds between 15-45 mph, waysides, roundabouts, intersections, heavy commercial vehicle parking lots</td>
</tr>
<tr>
<td>V</td>
<td>&gt;30 million ESALs OR traffic slower than 15 mph</td>
</tr>
<tr>
<td>E</td>
<td>&gt;30 million ESALs AND standing traffic such as toll plazas, weigh stations, port facilities</td>
</tr>
</tbody>
</table>

Refer to Attachment 5.7 for examples showing selection of mixture type and appropriate binder.
5.9.5 Notes

1. All ESAL designations are 20-year design life values.
2. Use a maximum of three different PG grades per project. Limit to two if possible.
3. Switching the base binder or decreasing the designation level from that required in the contract is not allowed by standard spec 455.2.1. Only changes made to meet these guidelines should be considered and requires a contract change order.
4. Before use of any PG grades not conforming to these guidelines, or if you have any questions about these guidelines or their application, please contact:
   Steve Hefel
   HMA Unit Supervisor
   Materials Management Section
   DTSD, Bureau of Technical Services
   (608) 246-7935
   steven.hefel@dot.wi.gov

5.10 Design Process
WisDOT uses the WisPave program to design pavements. See FDM 14-15-10 for instructions for obtaining this software.

5.11 Edge and End Joints
Attachment 5.3, Attachment 5.4, and Attachment 5.5 show edge and end joints that are appropriate for HMA pavement resurfacing projects. They may be used in estimating quantities of HMA materials as well as providing guidance in preparing special detail drawings for construction plans.

When special details for end joints of the overlap type (see Attachment 5.4) are included in a construction plan, the terminology used to identify this type of joint must clearly differentiate it from ordinary “construction type” butt joints that may also be included in the plan. Use of the notation “overlap joint, butted” will adequately serve this purpose.

Attachment 5.5 shows the notched wedge longitudinal joint, the standard joint to be used at HMA pavement centerlines and lane lines. However, a longitudinal butt joint should typically be used for single layer HMA overlays and for SMA pavements. The notched wedge longitudinal joint should be constructed by tapering the edges of the HMA pavement layers. The taper shall include a notch at the top of the layer and have a 12:1 slope for the remaining layer depth below the notch.

5.12 Tack Coats
Tack coats are used to help bond HMA overlays to existing HMA or concrete pavements. It is recommended that tack coat be applied between each layer of HMA pavement. Traffic should be kept from driving on tack areas until the overlying HMA surface has been placed. The rate of application is provided in standard spec 455.2.5.1 (designer should also refer to ASP 6). Use the lower rates if tack coat will be placed over previously placed lower layers and use the higher application rates if placing over milled HMA, pulverized HMA, concrete or rubblized concrete, etc.

5.13 HMA Cold Weather and Multi-Season Paving
Refer to FDM 19-07-1.2 for guidance relating to paving HMA in cold weather and for paving HMA over two seasons (paving the base layer in the fall and the surface layer in the spring).

5.14 General Application Guidelines
The following guidelines should be used when selecting and placing HMA pavements.

1. Plant-mixed asphaltic bases should not be used in lieu of binder courses in HMA pavement. There appears to be no economic advantage using asphaltic base for this purpose, since to obtain an equivalent structural strength requires the use of approximately one-third more material.
2. Since modern paving equipment can adequately handle minor profile and cross-section deviations, leveling courses should not be used. Major deviations should be corrected as indicated in the standard specifications under "Correcting Sags and Depressions."
3. HMA resurfacing shall not be carried across bridge decks unless the surface is first protected by a waterproof barrier to reduce the deck’s deterioration. An exception to this is when the deck surface is in poor condition and its replacement or major repair is planned within the next five to ten years. In this situation, resurfacing may be carried across the deck without special treatment.
4. When terminating HMA resurfacing at the ends of bridges, project termini, intersections, etc., a butt joint constructed by sawing or grinding the existing pavement is the preferred type of joint.

5. The slow moving or standing loads in intersections, climbing lanes, truck weigh stations, and other slow-speed areas subject the pavement to higher stress conditions. The key to constructing a successful pavement is recognizing that these areas may need to be treated differently.

5.14.1 SMA Usage and Application Guidelines
- Use only as a surface layer (one or multi-layer system)
- Consider use when traffic is greater than 5 million 20-year design ESALs
- Consider use when lower maintenance is beneficial (high-traffic areas)
- Use in other applications when determined to be economically feasible

5.15 References

LIST OF ATTACHMENTS
Attachment 5.1 Structural Layer Coefficients
Attachment 5.2 Relative Strength Coefficients for Granular Subbase
Attachment 5.3 Edge Joints
Attachment 5.4 End Joints
Attachment 5.5 Longitudinal Joints
Attachment 5.6 WisDOT Allowable Mix Types
Attachment 5.7 Pavement Type Selection Process Examples
Attachment 5.8 WisDOT Asphalt Zones

10.1 Standard Pavement Type
WisDOT policy establishes jointed plain concrete pavement with dowels as the standard type of concrete pavement to be used on highways in Wisconsin. Details for this type of concrete pavement are shown in SDD 13C11 and SDD 13C13.

10.2 Traffic Loading
See FDM 14-1-5, "Traffic."

10.3 Modulus of Subgrade Reaction
Westergaard's Modulus of Subgrade Reaction (k) is used in this procedure to express the supporting capability of the subgrade soil. It represents the load in pounds per square inch on a loaded area, divided by the deflection in inches of that loaded area, psi/inch.

The "k" value is best estimated on the basis of previous experience or by correlation with other tests. The "k" value to be used for design purposes is to be determined and reported in the soils report.

10.4 Design Equation
WisDOT uses the WisPAVE program to design concrete pavements. See FDM 14-15-10 for instructions on how to access this software. WisPAVE uses the AASHTO 1972 Portland Cement Concrete design equation [1] as its theoretical basis for concrete pavement thickness design.

10.5 Design Thickness
Design concrete pavements to the nearest 1/2 inch. If WisPave calculates a concrete slab thickness less than six inches, use a 6-inch thickness for undoweled concrete pavements and a 7-inch thickness for doweled concrete pavements in the LCCA.
10.6 Joints
Concrete pavement jointing details are shown in SDD 13C18. When using this SDD, use SPV.0105.XX, Concrete Pavement Joint Layout when using this SDD located at:


10.6.1 Transverse Contraction Joints

10.6.1.1 Spacing
The spacing of transverse contraction joints for rural WisDOT concrete pavements is uniform at 15 feet.
For urban pavements the spacings are as follows:
- 12 feet for pavement thicknesses of 6 and 6-1/2 inches
- 14 feet for pavement thicknesses of 7 and 7-1/2 inches
- 15 feet for pavement thicknesses of 8 inches or greater

10.6.1.2 Orientation
Transverse contraction joints will be constructed normal (90º) to the centerline.

10.6.2 Longitudinal Joints
Two types of longitudinal joints are used in concrete pavement--construction and sawed. Construction type longitudinal joints are used in the following situations:
1. For lane-at-a-time construction
2. Along ramp tapers
3. Along concrete shoulders and curb and gutter (when poured separately)
4. Along lanes added to existing pavement

Tie bars are typically used across these joints. In the fourth case, when adding lanes to existing pavement, holes are drilled into the longitudinal face of the existing slab. Tie bars are then driven into the holes prior to pouring the added lane.

Sawed-type longitudinal joints are used in the following situations:
1. Along the center line or between lanes
2. Along concrete shoulders (when poured with the pavement)

Tie bars are used across this type of longitudinal joint. For tie bar spacing, refer to SDD 13C1 titled, "Concrete Pavement Longitudinal Joints and Pavement Ties."

Pavements greater than 15 feet in width should have a longitudinal joint installed so that the maximum pavement width does not exceed 15 feet. Different situations will dictate the location of the longitudinal joint.

10.7 Filling Joints
Revise FDM 14-10-10.7 (Filling Joints) formerly titled "Sealing") to add guidance for filling joints on low speed urban concrete pavements. For specification reference information refer to 2018 Standard Specifications.

Fill contraction and expansion joints on low speed urban concrete pavements as outlined in Standard Spec
415.2.6 and Standard Spec 415.3.20.

This policy applies to new construction of low speed urban highways, all functional classes of highways, all types of concrete pavement.

10.8 Construction Joints

All transverse construction joints are of the butt type and are doweled or tied as shown on the standard detail drawing for the particular type of concrete pavement being constructed.

On concrete pavement projects with auxiliary lanes the placement of the longitudinal construction joint is important for traffic operations. When the total length of the auxiliary lane, including taper and longitudinal section, exceeds 800 feet the construction joint for concrete pavement shall be located at lane width. The designer should prepare a detail drawing to direct the contractor to "box-out" or otherwise construct the pavement showing the proper lane width, which should also be the construction joint location. Therefore, the construction joint shall be placed at the location of the proposed lane pavement marking.

10.9 Tining

When the design speed of a concrete highway is 40 mph or greater, the surface shall receive a tined finish as described in CMM 4-18 “Texturing and Tining” and specified in Standard Spec 415.3.8.1 (surface finishing).

When tining is required, add a note to the appropriate typical section to indicate which sections of concrete pavement are to be tined.

10.10 References


FDM 14-10-15 Bridge Approach Pavements

15.1 General

Bridge approach pavements represent a special situation. The type of bridge approach should be based on the criteria specified in sections 15.1.1, 15.1.2, and Table 15.1 below. Exceptions to these criteria may be made at the request of the maintaining authority.

Guidance on the use of a paving notch is provided in the Bureau of Structures - Bridge Manual Standard Detail Drawings:


15.1.1 Interstate, US Highways or Other Roadways with Traffic Volumes >3500 AADT

Both a Structural Approach Slab and a Concrete Pavement Approach Slab are required on all interstate and US highway bridges regardless of AADT or any other factor. Both a Structural Approach Slab and a Concrete Pavement Approach Slab are also required on all other roads with traffic volumes greater than 3500 AADT. Conform to SDD 13B2 sheets A and B and applicable Bridge Manual Standard Detail Drawings (refer to Chapter 12 - Abutments for Structural Approach Slabs):


15.1.2 Other Roadways with Traffic Volumes ≤ 3500 AADT

A Structural Approach Slab is not required on all other roads with traffic volumes less than or equal to 3500 AADT. The types of bridge approach on these roads are dependent upon the roadway pavement type and the skew of the bridge deck as explained in 15.1.2.1, 15.1.2.2, and 15.1.2.3 below.

When Concrete Bridge Approaches are constructed without a Structural Approach Slab, the adjacent shoulder shall also be paved with concrete (full width) from the structure to at least the first full-width transverse joint.

15.1.2.1 Concrete Pavement

If the roadway pavement is concrete and the traffic volume of the road is less than or equal to 3500 AADT, then use a Concrete Pavement Approach Slab regardless of the bridge skew. Conform to sheet A of SDD 13B2.

15.1.2.2 HMA Pavement with Bridge Skew > 20 Degrees

If the roadway pavement is HMA and the bridge deck skew is greater than 20 degrees, then use a Concrete Pavement Approach Slab. Conform to sheet A of SDD 13B2.
15.1.2.3 HMA Pavement with Bridge Skew ≤ 20 Degrees

If the roadway pavement is HMA and the bridge skew is less than or equal to 20 degrees, then use HMA pavement between roadway and bridge. Both concrete pavement approach slab and structural approach slab are not required. Design HMA thickness to accommodate current traffic volumes or match the thickness of the roadway pavement.

Regions may consider removing the concrete pavement approach slab only when:

1. The skew is less than a 20 degree angle, and
2. HMA pavement is used to abut the structure or bridge structural approach slab.

The concrete pavement approach slab is still required when the adjacent pavement is concrete even though it is a rehabilitation project.

Table 15.1 Bridge Approach Requirements

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Other Roadways with AADT ≤ 3,500</th>
<th>IH, USH, or Other Roadways with AADT &gt; 3,500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadway Pavement Type</td>
<td>Concrete</td>
<td>HMA</td>
</tr>
<tr>
<td>Bridge Skew</td>
<td>N/A *</td>
<td>Skew ≤ 20°</td>
</tr>
<tr>
<td>Structural Approach Slab</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Concrete Pavement Approach Slab</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

* = Not Applicable

15.2 Local Roads

If a local agency elects to install concrete pavement approach slabs or structural approach slabs and they do not meet the bridge approach requirements outlined in Table 15.1, the local agency is responsible for 100% of the construction cost of the items.

FDM 14-10-20 Highway Ramp Design November 29, 2007

20.1 Pavement Type and Thickness

Interchange ramp pavements present a special situation. The choice of pavement type and pavement thickness should be based upon the following general guidelines.

1. For construction reasons, the pavement within the mainline taper and gore area should be constructed of the same pavement type and thickness as the mainline pavement. The mainline pavement can end, and the ramp pavement structure can begin, at a location where a uniform ramp width begins.

2. The ramp pavement design should be performed independent of the mainline pavement based upon the traffic projections for the individual ramps and with the following considerations:
   - Typically, for cloverleaf or diamond interchanges, all ramps are built according to a single pavement type and structure design. This should be based on the ramp that needs the strongest pavement.
   - Free-flow interchange ramps are usually of sufficient length and widths such that their pavement design and selection should be based upon their own individual traffic projections.

3. Sufficient attention must be paid to maintaining pavement drainage through the interchange tapers, gores and ramps. See FDM 14-5-5 for more details.

4. A LCCA is not required for ramp designs.

FDM 14-10-25 Paved Shoulders November 17, 2010

25.1 Policy

FDM 11-15-1 contains WisDOT’s shoulder paving policy and other guidance on the geometric design of
shoulders.

25.2 Thickness Design
Paved shoulders must be structurally designed to withstand wheel loadings from encroaching truck traffic and should be based on usual design considerations appropriate for each situation. When using the AASHTO Interim Guide procedure to determine shoulder thickness, the number of ESALs per day used for design purposes should be a minimum of 2.5 percent of the value used for the mainline pavement.

Another consideration in determining shoulder thickness is the manner in which the paved shoulder will be constructed. In most cases it is more cost effective to allow contractors to pave the shoulder in conjunction with the driving lane (e.g., a 15-foot wide pass for a 12-foot lane and 3-foot shoulder). If this option is chosen for concrete pavements, a longitudinal joint is not required between the driving lane and the shoulder when their combined widths are 15 feet or less.

For HMA shoulders, the standard minimum thickness is 3½ inches. If the need for a greater thickness is identified, such as the shoulders being used to carry traffic for an extended period of time, use the same thickness design procedures that are used for the mainline.

HMA shoulders can be placed in either one layer or two layers. Situations that may benefit from placing HMA shoulders in one layer include:
- For shoulders paved separate from the mainline, it may be more economical to place in one layer due to a reduction of paving operations
- Increased performance of shoulders when paved over areas of questionable/variable support
- Increased performance of shoulders when they will be subjected to traffic soon after construction

Careful attention should be given to minimum/maximum layer thicknesses as related to size of aggregate in the mix (standard spec 460.3.2) and to the number of layers to be placed, as opposed to a minimum thickness based strictly on traffic loading and support values.

For concrete shoulders the standard minimum thickness is 6 inches.

25.3 Type Selection
The design and selection of the pavement type for paved shoulders should be discussed and documented in the pavement structure design report (see FDM 14-15-1).

A cement factor of at least 5.25 sacks per cubic yard is required for concrete shoulders. However, when shoulders are paved integrally with the mainline pavement, the cement factor must be that of the driving lane.

FDM 14-10-30 Overlay Design November 18, 2009

30.1 General
Once a pavement is judged to have deteriorated beyond the point where it is practical to continue routine maintenance activities, an overlay, either with or without the option of recycling, becomes the next logical step short of complete reconstruction.

Overlays are placed on pavements to improve their structural strength, riding quality, skid resistance, or a combination of these. Because of the different reasons for which an overlay may be required, as well as the diversity of the types and condition of pavements to be overlaid, the determination of overlay thicknesses (either flexible or rigid) has been, and to a large extent still is, empirical.

30.2 Methods of Design
The experience and observation of the designer (empirical method) are the main ingredients used to determine the need of resurfacing, with what, and how much. Basically, if the problem is just surface deterioration, a surface treatment or minimum resurfacing thickness would be called for. Severe problems such as areas with complete base failures require more substantial correction.

Chapter IV of the AASHTO "Interim Guide for Design of Pavement Structure, 1972, contains several analytic overlay design procedures that can be used to verify alternate choices as well as provide aid where questions exist concerning the structural capacity of pavements to be overlaid. One of these procedures (the Asphalt Institute Method) has been modified for use in Wisconsin and has previously been made available for use by the districts.
35.1 General
The term intersections, as used in this procedure, will apply to both traditional intersections (with cross traffic) and roundabouts.

FDM 11-25 and FDM 11-26 contain WisDOT’s policy and other guidance on the geometric design of intersections.

35.2 Pavement Type Selection
Intersection pavements can be constructed of deep strength Hot Mix Asphalt (HMA), perpetual HMA, traditional HMA, or concrete. A Life-Cycle Cost Analysis (LCCA) is not required for pavement type selection.

Some of the factors that should be considered when selecting pavement types for intersections include:
- Adjacent pavement type
- Future or existing developments that impact traffic
- Traffic loadings of certain quadrants
- Condition and age of existing pavement - potential rehabilitation type
- Potential future expansion of intersection
- Continuity of maintenance
- Multiple utilities

The design and selection of the pavement type should be addressed in the pavement design report (see FDM 14-15-1).

35.3 Pavement Design
A separate structural design is not typically prepared for non-critical or low volume intersections. However, in situations where a separate design is to be prepared, the highest leg AADT should be used for the pavement thickness design, unless traffic information of specific turning movements is available, in which case that may be used instead.

Pavements at critical or high volume intersections present a special situation. The intersection pavement design should be performed independent of the mainline pavement based upon the traffic projections for the individual intersection and with the following considerations:
- Length of mainline
- Distance between intersections
- Relative difference in pavement thickness

Turning movements within intersections could increase traffic loadings in certain quadrants. To ensure adequate pavement thickness, consider applying a 1.5 multiplier to the highest leg AADT for the pavement thickness design if detailed traffic information is not available. If information of special turning movements is available, that may be used instead.

35.3.1 Lane Distribution Factor
For lane distribution factors, refer to FDM 14-1-5.

35.3.2 HMA Intersections
To avoid rutting and/or shoving due to the stresses applied by vehicles at high traffic intersections with stop conditions along with a high percentage of turning movements, HMA intersections (including roundabouts and J-Turns) with these conditions should be constructed with an HMA mixture that is increased one traffic level or more from the mainline to ensure good pavement performance. In addition to adjusting the HMA mix type, consideration should be given to increasing the designation level of the asphalt binder up one level from the mainline. See FDM 14-10-5.10 for guidance on asphalt binder selection. Analysis has shown that the intersection mixture is only required in the upper layer of the pavement structure. However, if an increased designation is used, there may be an economic advantage in utilizing a full tanker load of the binder. A typical tanker holds approximately 22 tons of binder, which will produce about 420 tons of HMA mixture. Any extra tonnage may be utilized by paving multiple layers in the intersection, by extending the intersection paving limits, or by paving another intersection.

In traditional intersections, the designer should use judgment in determining how far to extend the intersection mixture. In roundabouts, the enhanced mixture should extend to the pavement alongside the splitter islands (see FDM 11-26-1). In cases where the splitter islands are long, the designer’s best judgment should be used in
determining how far to extend the intersection mixture.

### 35.3.3 Concrete Intersection Jointing

Concrete pavement jointing details are shown in SDD 13C18. When using this SDD, use SPV.0105.XX, Concrete Pavement Joint Layout located at:


Dowel bar size and transverse joint spacing should be in accordance with SDD 13C11 and SDD 13C13, and SDD 13C18.

#### 35.3.3.1 Traditional Intersections

Joint layouts for traditional concrete intersections should be developed using the fundamentals provided in the American Concrete Pavement Association (ACPA) publication titled, “Intersection Joint Layout.” Copies of this publication can be obtained from the Wisconsin Concrete Pavement Association (WCPA) or ACPA.

#### 35.3.3.2 Roundabouts

Two joint layout methods are acceptable for concrete roundabouts: the “Isolated Circle” method and the “Pinwheel” method (see SDD 13C18-e). The “pave-through” method is not allowed, so as to avoid a driver’s misperception of right-of-way entering into or traveling within a roundabout. A general note should be included in the plans specifying WisDOT’s acceptable joint layout methods. Once the method is determined, the joint layout plan should be designed according to SDD 13C18-e and the recommendations provided in ACPA’s Concrete Pavement Research & Technology (R&T) Update titled “Concrete Roundabouts.” Copies of this publication can also be obtained from WCPA or ACPA. The “Pinwheel” method is not referenced in this publication, but an example is shown in SDD 13C18-e.

The joint layout may be influenced by the pavement cross-slope. Align the crown line with the longitudinal joint if possible.

When utilizing either jointing method for concrete roundabouts, the contractor should consider maximizing the amount of concrete that can be placed using a concrete paving machine to reduce labor-intensive handwork. To achieve this, the designer should maximize the use of uniform lane widths through the roundabout and at the approach legs whenever possible.

### 35.4 Roundabout Design Features

The central island should not appear as a traveling surface to drivers, therefore it should not be paved.

To minimize future maintenance disruptions to the roundabout, utility structures (e.g. manholes, valve boxes) should not be located in the circulatory roadway if possible.

SDD 13C18-e shows the two acceptable joint layout methods for concrete roundabouts along with the roundabout elements that are tied and/or doweled.

#### 35.4.1 Truck Aprons

Truck aprons should be 12 inches thick, constructed with concrete and adjacent to mountable curb and gutter. Constructing the truck apron 12 inches thick matches the thickness at the back of the curb, minimizing constructability issues and lessening the chance of differential settlement. Refer to FDM 11-26-30.5.4 for additional information on design guidance of truck apron.

The concrete should be integrally dyed or colored WisDOT red so that the truck apron is recognizably different than the circulatory roadway. A WisDOT red concrete comparison sample is available at each region office. Surface stamps or jointed chevrons are not recommended. Bid items with coloring concrete WisDOT red and concrete roundabout truck apron 12-inch are available for use on truck aprons.

The truck apron should be jointed, but the transverse joints should not be doweled.

Construct truck apron(s) outside of roundabout as needed to accommodate tracking oversize and overweight vehicles. Designer determine size and location(s) of truck apron outside of roundabout. To limit pavement stress and crack propagation, do not tie the outside truck apron to the back side of curb when the truck apron width is 3 feet or greater at any location. See SDD 13C18 sheet e for the details drawings.

#### 35.4.2 Curbing

Refer to FDM 11-26-30.5.21.1 through FDM 11-26-30.5.21.3 for the design guidance on the approach curbs, curb and gutter separating the circulatory roadway from the truck apron (mountable curb and gutter), and the curb and gutter at the inside of the truck apron, respectfully.
35.4.2.1 Curb and Gutter Separating the Circulatory Roadway from the Truck Apron
The mountable curb and gutter between the truck apron and the circulatory roadway should have a gutter thickness of 8 inches and a total maximum thickness of 12 inches regardless of the circulatory roadway pavement type or pavement thickness.

If the circulatory roadway is concrete, the mountable curb and gutter should be tied to the roadway, but not to the truck apron. Expansion joint filler should be used between the truck apron and the mountable curb and gutter.

If the circulatory roadway is HMA, then the truck apron should be tied to the mountable curb and gutter.

35.4.2.2 Curb and Gutter at the Inside of the Truck Apron or Edge Nearest the Central Island
The reverse slope curb and gutter around the central island should be tied to the truck apron.