FDM 14-10-1 General

August 17, 2020

1.1 Design

WisDOT uses the WisPave program for pavement design. See FDM 14-1-1.5 for instructions on how to access this software. The WisPave design program uses the AASHTO 1972 design equations for concrete and asphalt pavements.

1.2 Pavement Type Selection Policy

It is the policy of the department to include both a hot mix asphalt (HMA) pavement and a concrete pavement option in the pavement type selection process for pavement replacement and reconstruction projects. See FDM 14-10-35.2 for information on intersection pavements.

On Majors and Backbone projects, it is the policy of the department to also include either a deep-strength or perpetual HMA pavement design alternative in the pavement type selection process. These alternatives may also be considered on other projects at the discretion of the designer. See FDM 14-10-10.1.2 for more information on how to select a deep-strength or perpetual HMA pavement design.

Pavement type selection may consist of two components; a structural design and a Life Cycle Cost Analysis (LCCA). See FDM 14-15 to determine if a structural design and/or LCCA is needed.

1.3 Soil Support

The soil support value used for pavement design is to be determined and discussed in the Soils Report. See FDM 14-5 for more information on soils.

1.4 Traffic Loading

For traffic information, see FDM 14-7.

1.5 International Roughness Index (IRI)

The Federal Highway Administration (FHWA) requests that State DOTs report roughness measurement data for the Highway Performance Monitoring System (HPMS) in International Roughness Index (IRI) units. IRI was chosen as a standard reference for road roughness to establish nationwide uniformity in the roughness data. The department uses IRI as the principal roughness measurement tool.

The IRI is a roughness defined as a specific mathematical model of a longitudinal road profile. WisDOT measures IRI directly using inertial profilers, lightweight or high speed. IRI is reported in units of inches-per-mile, a higher IRI value indicates a rougher road surface.

1.6 Terminal Serviceability

Terminal Serviceability is the value, within the Present Serviceability Index (PSI), an agency uses as their serviceability level. The index ranges from 0 (dead) to 5 (perfect). WisDOT uses 2.5 for both concrete and HMA pavements. This value is only used by WisDOT in the AASHTO pavement design equations.

1.7 Design Equation

The WisPave design program uses the AASHTO 1972 concrete and asphalt design equations. These equations are based on Design Lane Total Life ESALs, terminal serviceability, strength of materials and condition of subgrade.

Pavement design considers a pavement's design life or performance period. This is the period a pavement is expected to last before the next rehabilitation or reconstruction. WisDOT uses a performance period of 20 years.

FDM 14-10-5 Concrete Pavement Design

August 17, 2020

5.1 Standard Pavement Type

Department 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.

5.2 Design Equation

The WisPave design program uses the AASHTO 1972 Concrete Pavement design equation for concrete pavement thickness design (Figure 5.1).

$$\log(ESAL) = 7.35\log(D+1) - 0.06 + \frac{\log\left(\frac{4.5 - P_t}{4.5 - 1.5}\right)}{1 + \frac{1.62x\,10^7}{(D+1)^{8.46}}} + (4.22 - 0.32\,P_t)\log\left[\left(\frac{f_t}{690}\right)\frac{D^{0.75} - 1.132}{D^{0.75} - \frac{18.42}{\left(\frac{E}{k}\right)^{0.25}}}\right]$$

where: ESAL = Total Life Rigid (concrete pavement) ESAL's (see FDM 14-7-1)

D = Concrete Slab Thickness (inches)

P_t = Terminal Serviceability Index (PSI) (WisDOT uses 2.5)

f_t = Working Stress of Concrete (490 psi)

E = Modulus of Elasticity of Concrete (4,200,000 psi)

k = Modulus of Subgrade Reaction (psi) (refer to Soils Report)

***Figure 5.1* Concrete Pavement design equation**

5.3 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 based on 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.

5.4 Design Thickness

Design concrete pavements to the nearest ½-inch. If WisPave calculates a concrete slab thickness less than 6 inches, use a 6-inch thickness for undoweled concrete pavements and a 7-inch thickness for doweled concrete pavements in the LCCA.

5.5 Joints

Concrete pavement jointing details are shown in SDD 13C18. When using this SDD, use STP-415-020.

5.5.1 Transverse Contraction Joints

5.5.1.1 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

5.5.1.2 Orientation

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

5.5.2 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.

5.6 Filling Joints

It is department policy to fill contraction and expansion joints on low speed urban concrete pavements with a design speed less than 40 mph.

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

Designers should include the Concrete Pavement Joint Filling bid item in all contacts with new concrete pavement with a design speed less than 40 mph. Calculate the estimated quantity as described for measurement in Standard Spec 415.4 based on the square yards of affected concrete pavement and linear feet of adjacent curb and gutter.

5.7 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.

5.8 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.

FDM 14-10-10 Hot Mix Asphalt (HMA) Pavement Design — *August 17, 2020*

10.1 Basis of Design

10.1.1 Traditional HMA Pavements

Thickness design is based on the structural number (SN) concept of the AASHTO Interim Guide. The majority of the thickness of the pavement structure comes from the paving platform (refer to FDM 14-5-10).

10.1.2 Deep-Strength or Perpetual HMA Pavements

To determine if either a deep-strength or perpetual HMA pavement design is required, refer above to FDM 14-10-1.2. The design is based on 20-year cumulative design Equivalent Single Axle Loads (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. This does not apply to intersection pavements.

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, refer to FDM 14-5) 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 completed by, or in conjunction with, WisDOT Central Office (refer to Originator, FDM 14-1-1).

10.2 Design Equation

The WisPave design program uses the AASHTO 1972 Asphalt Pavement Design Equation (Figure 10.1).

$$\log(ESAL) = 9.36\log(SN+1) - 0.2 + \frac{\log\left(\frac{4.2-P_t}{4.2-1.5}\right)}{0.4 + \frac{1094}{(SN+1)^{5.19}}} + \log\left(\frac{1}{R}\right) + 0.372(S-3.0)$$

Where:

ESAL = Total Life Flexible (HMA pavement) ESALs (see FDM 14-7-1)

SN = Structural Number

P_t = Terminal Serviceability Index (PSI) (WisDOT uses 2.5)

R = Regional Factor (WisDOT uses 3.0)

S = Soil Support Value (refer to Soils Report)

***Figure 10.1* HMA Pavement design equation**

10.3 Design Thickness

HMA pavement layers should be designed to the nearest ¼-inch.

10.4 Structural Layer Coefficients

The terms “structural layer coefficients,” “layer coefficients,” and “strength coefficients” are used interchangeably.

Attachment 10.1, 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 material (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.

10.4.1 Milled and Re-laid or Pulverized HMA 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.

10.4.2 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.

10.4.3 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.

10.4.4 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.

10.5 Subbase

Attachment 10.2, 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 Unit.

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.

10.6 Staged Construction

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

10.7 HMA Mixture Layers

HMA mixture and asphaltic binder are combined into a single bid item. In addition, mixtures are identified with an updated nomenclature (refer to Figure 10.2).

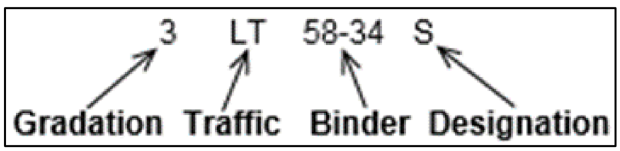

***Figure 10.2* HMA Combined Bid Item Nomenclature**

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. Refer to Attachment 10.3 for a reference guide on the HMA Mixture Selection Process.

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 Attachment 10.4 (unless otherwise designated in the approved Pavement Documentation for the project).

10.7.1 Gradation Selection

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 Standard Spec 460.3.2 for layer thickness information.

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

Gradation 1 (37.5mm) is not commonly used on WisDOT projects. It has been entered into the list of options as the materials may become more readily available making it 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 upper layer, 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 inches or greater. Do not use this gradation in the upper layer, 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 upper layer. It is also used as a lower layer when less than 4 inches of pavement structure are required.

Gradation 5 (9.5 mm) is also applicable in most every pavement application and is used as an upper layer. It is also used for wedging/leveling and other specialty applications.

Gradation 6 (4.75 mm) is applicable as an upper layer of 1.25 inches or less for roadways with design speeds of 45 mph or lower. It is also used as a lower layer or wedging/leveling layer.

Specific uses for each gradation are summarized in Table 10.1.

***Table 10.1* Gradation Selection**

Gradation	Pavement Layer	Common Uses
1 (37.5 mm)	Lower	N/A
2 (25.0 mm)	Lower	Temporary crossovers, asphaltic base
3 (19.0 mm)	Lower	Crossovers, asphalt base, roundabouts, turn lanes, mainline, ramps, etc.
4 (12.5 mm)	Lower, Upper, Leveling, SMA	Almost every pavement application, most common upper layer
5 (9.5 mm)	Upper, Leveling, SMA	Most every pavement application, generally upper layer
6 (4.75 mm)	Lower, Upper, Leveling	Generally upper layer for design speeds ≤ 45mph

10.7.2 Traffic Category Selection

The designations for Low, Medium, or High Traffic volumes are based on the number of 20-year Equivalent Single Axle Loads (ESALs).

An LT mix is designed to receive up to 1 million ESALs (i.e., ESAL ≤ 1 million). 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 pavement's life.

An MT mix is designed to receive between 1 million and 8 million ESALs (i.e., 1 million < ESAL ≤ 8 million). 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). 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 2 million ESALs, there is a special subset called Stone Matrix Asphalt (SMA) which may be a viable pavement selection. This gap graded mixture is used as an upper layer 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 drain moisture away quickly during rain events. It should be considered for the upper layer in many HT mix applications on divided highways and may be considered for MT applications expected to experience greater than 2 million ESALs.

Common applications for each traffic category are summarized in Table 10.2 below.

***Table 10.2* Traffic Level Classification Selection**

Traffic Level Classification	ESAL	Common Applications
LT (Low Traffic Volume)	≤ 1 million	Shouldering of concrete pavements, low volume rural highways, residential collector streets
MT (Medium Traffic Volume)	1 million < ESAL ≤ 8 million	Rural 2 lane highway network, urban arterial streets
HT (High Traffic Volume)	> 8 million	Urban arterial streets, 4 lane divided highways, intersections, interstate, freeway
SMA (Stone Matrix Asphalt)	> 2 million	Divided highways, freeways, and interstates

10.7.3 Asphalt Binder Grade - Temperature/Project Location Selection

Wisconsin is currently separated into two low temperature zones; the Northern Asphalt Zone and the Southern Asphalt Zone (see Attachment 10.5). Based on this separation, the following binders are recommended for use:

Northern Asphalt Zone

New construction, reconstruction, and pavement replacement: 58-34 in the upper layer

Overlays and lower layers: 58-28

Southern Asphalt Zone

58-28 on all pavements

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 10.3* Asphalt Binder - Project Location Selection**

Asphalt Binder Grade	Project Location	Pavement Layers
58-34	Northern Zone	Upper layer
58-28	Northern Zone	Overlay and lower layer
	Southern Zone	All pavements

10.7.4 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 Designation) - 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 Designation) – 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 Designation) - 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 Designation) - 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 58-28 S in normal situations, and use a 58-28 H for an intersection, or 58-28 V for a heavily trafficked urban street with many stopping and starting movements. Table 10.4 demonstrates these changes from the former grade bumping system to MSCR protocol.

Table 10.4 Suggested Translation from PG Grade to MSCR Binder Nomenclature

Previously Selected PG Grade	Suggested MSCR Binder
58-34	58-34 S
58-34 P	58-34 H
64-34 P	58-34 V
58-28	58-28 S
64-28 P	58-28 H
70-28 P	58-28 V

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 not 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 10.5 below.

Table 10.5 Selection of Binder Designation Level

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

Refer to Attachment 10.6 for examples showing selection of mixture type and appropriate binder.

10.7.5 Notes

1. Use 20-year ESALS for mixture selection.
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

10.7.6 Specialty HMA Mix Usage and Application Guidelines

10.7.6.1 SMA (STSP 460-030)

- Recommended for Majors, Backbone projects, and other high-traffic applications
- Use only as an upper layer (one or multi-layer system)
- May be considered when traffic is greater than 2 million 20-year design ESALs

10.7.6.2 Interlayer (STSP 460-070)

- Use to mitigate reflective cracking when overlaying existing concrete
- Use only as a lower layer in multi-layer system
- Does not add structural capacity to the pavement (i.e. no layer coefficient)
- Consider use when lower maintenance is beneficial (high-traffic areas)
- May be considered as part of functional thickness required in resurfacing (RSRF 10, 15, 20 & 25) treatments
- Contact DTSD HMA Unit Supervisor prior to including on projects

10.8 Edge and End Joints

Attachment 10.7 and Attachment 10.8 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 10.8) 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.

10.9 Longitudinal Joints

SDD 13c19 shows the notched wedge longitudinal joint, the standard joint to be used at HMA pavement centerlines and lane lines. For SMA pavements, the notched wedge longitudinal joint should be milled out prior to placing the adjacent lane. The notched wedge longitudinal joint should be constructed by tapering the edges of the HMA pavement layers.

10.10 Tack Coats

Tack coats are used to help bond HMA overlays to existing HMA or concrete pavements. It is recommended that the 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 455.3.2. 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.

10.11 HMA Cold Weather and Multi-Season Paving

Refer to FDM 19-5-3.2 for guidance relating to paving HMA in cold weather and for paving HMA over two seasons (paving the lower layer in the fall and the upper layer in the spring).

10.12 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 lower layers 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 or wedging layers may not be necessary for minor corrections. When major cross-slope or surface corrections are necessary, use leveling or wedging layers according to Standard Spec 460.3.2.
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.

LIST OF ATTACHMENTS

Attachment 10.1	Structural Layer Coefficients
Attachment 10.2	Relative Strength Coefficients for Granular Subbase

Attachment 10.3	WisDOT HMA Mixture Selection Process Guide
Attachment 10.4	WisDOT Allowable HMA Mixture Types
Attachment 10.5	WisDOT Asphalt Zones
Attachment 10.6	HMA Mixture Type Selection Process Examples
Attachment 10.7	Edge Joints
Attachment 10.8	End Joints

FDM 14-10-15 Overlay Design *August 15, 2019*

15.1 General

WisDOT currently only uses HMA overlays. Overlays are placed over existing pavements to improve their structural strength, ride quality, skid resistance, or a combination of these.

Once a pavement is determined to have deteriorated beyond the point where it is practical to continue routine maintenance activities, an overlay becomes the next logical step, short of pavement replacement or a complete reconstruction.

15.2 Design

Overlay designs will use WisPave to determine the structural number.

Mix type will be selected based on 20-year ESALs and follows the process in FDM 14-10-10.7.

FDM 14-10-20 Paved Shoulders *May 17, 2022*

20.1 Policy

FDM 11-15-1 contains the Department's Shoulder Paving Policy and other guidance on the geometric design of shoulders.

20.2 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 WisPave 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 tied longitudinal joint is not required between the driving lane and the shoulder when their combined widths are 15 feet or less.

For tied concrete shoulders paved independently, the standard minimum thickness is 6 inches.

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.

20.3 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 14-15-20).

A cement factor of at least 494 pounds 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 14-10-25 Bridge Approach Pavements — November 17, 2020

25.1 General

Bridge approach pavements represent a special situation. The type of bridge approach should be based on the criteria specified in Sections 25.1.1, 25.1.2, Table 25.1, and WisDOT Bridge Manual Chapter 12. 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:

https://wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrces/strct/bridge-manual-standards.aspx

25.1.1 Interstate, US Highways or Other Roadways with Traffic Volumes >3,500 AADT (Future Design Year)

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. A Structural Approach Slab is recommended, and a Concrete Pavement Approach Slab is required on all other roads with traffic volumes greater than 3,500 AADT (Future Design Year). Conform to SDD 13B2 sheets A and B and applicable Bridge Manual Standard Detail Drawings (refer to Chapter 12 - Abutments for Structural Approach Slabs):

https://wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrces/strct/bridge-manual-standards.aspx

25.1.2 Other Roadways with Traffic Volumes ≤ 3,500 AADT (Future Design Year)

A Structural Approach Slab is not required on all other roadways with traffic volumes less than or equal to 3,500 AADT (Future Design Year). 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 25.1.2.1, 25.1.2.2, and 25.1.2.3.

When Concrete Pavement Approach Slabs 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.

25.1.2.1 Concrete Pavement

If the roadway pavement is concrete and the traffic volume of the road is less than or equal to 3,500 AADT, then use a Concrete Pavement Approach Slab regardless of the bridge skew. Conform to sheet A of SDD 13B2.

25.1.2.2 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.

25.1.2.3 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. Neither Concrete Pavement Approach Slab or Structural Approach Slab are 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 25.1 Bridge Approach Requirements

Criteria	Other Roadways with AADT ≤ 3,500			IH, USH, or Other Roadways with AADT > 3,500
Roadway Pavement Type	Concrete	HMA		N/A *
Bridge Skew	N/A *	Skew ≤ 20°	Skew > 20°	N/A *
Structural Approach Slab	No	No	No	Yes **
Concrete Pavement Approach Slab	Yes	No	Yes	Yes

*Not Applicable

**Required for IH and USH Roadways and recommended for other roadways with AADT > 3,500. See WisDOT Bridge Manual Chapter 12 for additional requirements.

25.2 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 25.1, the local agency is responsible for 100% of the construction cost of the items.

FDM 14-10-30 Highway Ramp Design

May 15, 2019

30.1 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. (see SDD 13C18 sheet g)

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.
4. A LCCA is not required for ramp designs.

FDM 14-10-35 Intersections

August 17, 2020

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 department policy and other guidance on the geometric design of intersections.

35.2 Pavement Type Selection

Intersection pavements can be constructed of deep strength 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
- Condition and age of existing pavement - potential rehabilitation type

- Continuity of maintenance
- Future or existing developments that impact traffic
- Multiple utilities
- Potential future expansion of intersection
- Traffic loadings of certain quadrants

The design and selection of the pavement type should be addressed in the pavement design report (see FDM 14-15-20).

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:

- Distance between intersections
- Length of mainline
- 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 14-7-1.

35.3.2 Concrete Intersection Jointing

Concrete pavement jointing details are shown in SDD 13C18. When using this SDD, use STSP 415-020, *Concrete Pavement Joint Layout, item 415.5110.S.*

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

35.3.3 HMA Intersections

HMA intersections (including roundabouts and J-Turns) should be designed to avoid rutting and/or shoving due to the stresses applied by vehicles at high traffic intersections with stop conditions and a high percentage of turning movements. HMA intersections with these conditions, should be constructed with a HMA mixture that is increased by 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 14-10-10.7 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.

35.3.3.1 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 sheet 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 sheet 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 sheet 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 sheet 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. WisDOT red coloring is similar to Federal Standard 595-FS 31136, refer to Standard Spec 405.

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.