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Chapter 14: Pavements

Section 14-15 Pavement Type Selection

Section 14-25 Pavement Rehabilitation

FDM 14-1-1 General

November 15, 2022

1.1 Originator

The Chief of the Materials Management Section in the Bureau of Technical Services is the Originator of this chapter.

1.2 Objective

A roadway pavement is a structure of superimposed layers of select materials placed on the existing subgrade. The main structural function of these materials is to support wheel loads and distribute those loadings to the subgrade. Pavement surfaces are typically considered to be flexible (Hot Mix Asphalt (HMA) pavements) or rigid (concrete pavements).

The objective of pavement design is to provide the most economical combination of pavement structure layers, over the subgrade, that will reduce the stress caused by loading to within the load-carrying capacity of the subgrade soil during the selected design performance period.

1.3 Asset Management

In embracing a systemwide asset management approach, WisDOT pavement design recognizes that treatment choices at the project level must be tempered and harmonized with what is best for entire system. Pavement asset management uses an iterative analysis that combines the engineering science of pavement design with the financial realities of annual funding constraints to arrive at an optimized statewide pavement treatment strategy. Optimized system health is the balance point of miles of needy pavement treated and best possible treatment strategy within a constrained budget. If there is an attempt to treat too many miles, the robustness of the statewide treatment strategy is reduced to cover the cost of those additional miles. Conversely, if there is an attempt to put too robust a treatment strategy on the needy miles, the number of miles treated is reduced to cover the costs of that more robust treatment strategy.

The iterative asset management optimization results in thematic metrics for how pavement conditions within the entire statewide system would prioritize for treatment, and what category of treatment that would be (referred to as the Theme). The Theme includes an aggressive pursuit of preservation and life extension actions to achieve that systemwide optimization. Preservation seeks to provide low cost pavement treatments to certain, more robustly designed pavements while they are still in reasonably good condition as a low cost means to maximize the life cycle period of good pavement condition. Life extension provides low cost pavement treatments on segments near the end of remaining life to infuse additional remaining life before their condition becomes unserviceable. However, even with these strategies, it may not be possible to attend to all pavements currently meeting need thresholds warranting treatment attention. Segments put into this group are strategically chosen and referred to as backlog. Backlog segments, while meeting need criteria, are still serviceable pavements with low operational demands that may allow them to remain needy yet serviceable for an additional number of years.

If looked upon only from a project-by-project perspective, it could appear that funding is being spent on better condition roads at the expense of lower condition roads. However, when viewed in aggregate from a systemwide perspective, these are data-driven strategic choices that provides the highest possible statewide system health within current funding constraints. Asset management dispels the historical project-by-project view of ‘worst first’, where prioritization was determined almost solely on ranking segmental pavement conditions. Iterative asset management analysis shows the ‘worst first’ concept leads to an overall decrease in statewide system pavement conditions.

Therefore, as one proceeds through FDM Chapter 14 on the engineering details for WisDOT pavement design, it is imperative to keep the systemwide asset management concept firmly in mind. It provides the basis for achieving Performance Based Practical Design within the pavement design process. The performance of the entire system in aggregate is paramount for making practical pavement design decisions at the project level.

Purpose and Need statements in project environmental documentation should reference this section, FDM 14-1-1.3, WisDOT Pavement Asset Management statewide system prioritization metrics. Template wording for this topic within a project’s environmental documentation can be found on WisDOT’s Environmental forms and tools site.

1.4 Design Procedures

In general, WisDOT follows the pavement design procedures provided in the American Association of State Highway &Transportation Officials (AASHTO) Interim Guide for Design of Pavement Structures, 1972, Chapter III Revised, 1981.

1.5 WisDOT Pavement Design Software: WisPave

For pavement design, WisDOT developed and uses the WisPave 4 design program (refer to Section 14-15 Pavement Type Selection).

To request access to WisPave 4, send an email to WisPave's administrator (peter.kemp@dot.wi.gov), with your complete name, company name, and your Wisconsin Web Access Management System (WAMS) User ID (do not send your WAMS password). Users must have a WAMS account to access WisPave.

Self-register for a WAMS account at:

https://on.wisconsin.gov/WAMS/home

You will not be able to access WisPave without sending the requested information and receiving authorization. After you have received authorization, you can access WisPave 4 at:

https://trust.dot.state.wi.us/wispave/home.do

Refer to the WisPave 4 User Manual for further information regarding the computer program.

https://wisconsindot.gov/Documents/doing-bus/eng-consultants/cnslt-rsrces/tools/qmp/wpmanual.pdf

FDM 14-5-1 Soils

May 15, 2019

1.1 General

Soils information should come from the soils report. In lieu of the report, standard correlations between pavement parameters are listed in Table 1.1.

Table 1.1 Soil Parameters for Pavement Design

Material	AASHTO	Soil Support Value	Wisconsin Design Group Index	Subgrade K
I – well sorted	A-1-a	5.5-5.4	0-2	300
	A-1-b	5.3-5.2	3-4	275
	A3	5.1-5.0	5-6	250
	A-2-4	4.9-4.7	7-8	225
	A-2-4/A-4	4.6-4.5	9-10	200
	A-4/A-6	4.4-4.2	11-12	175
II – poorly sorted	A-4	4.2	12	150
	A-4/A-6	4.1-3.8	13-15	125
	A-7-6	3.7-3.5	16-17	100
	A-7-5	3.3-3.0	18-20	75

Design Group Index as it relates to Frost Index

0-1	F-0 to F-1
1-6	F-2
6-15	F-3
15-20	F-4

FDM 14-5-5 Subgrade

May 15, 2019

5.1 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.

5.2 Policy

5.2.1 Concrete Pavements

When select material is placed according to FDM 11-5-15, 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 1993 Guide for Design of Pavement Structures. One value has been established to cover all circumstances when a select material is used, the input values needed to determine a composite k are resilient modulus of the subgrade and elastic modulus of the subbase (select material).

5.2.2 Hot Mix Asphalt (HMA) Pavements

When select material is placed according to FDM 11-5-15, the Design Group Index(DGI)/Soil Support Value (SSV) chart (Attachment 5.1) includes a second reference line that is to be used to establish a SSV of an improved subgrade. This second reference line is for DGI values from 8 to 20.

LIST OF ATTACHMENTS

Attachment 5.1 Soil Support Value vs. Design Group Index

FDM 14-5-10 Base Aggregate Dense *May 15, 2019*

10.1 General

The Department uses a base aggregate that meets the specifications of Standard Spec 301.

Adequate moisture in base aggregate dense is required to prevent segregation and ensure proper compaction. Include bid item 624.0100 Water, MGal with base aggregate dense material. The application rates for water vary widely but may be estimated at a rate of approximately 10 - 20 gallon/ton of base aggregate dense. Refer to FDM 19-21-10 if the special provision for QMP base aggregate dense 1 1/4-inch compaction is required.

10.2 Paving Platform

10.2.1 Concrete Pavements

A standard 6-inch base aggregate dense should be used. When using base aggregate open graded, refer to FDM 14-5-15.

10.2.2 Traditional HMA Pavements

A ratio of 1:2 or 1:3 HMA pavement depth to base aggregate dense depth.

Example: 5 inches of HMA pavement over 10 to 15 inches of base aggregate dense.

When using base aggregate open graded, refer to FDM 14-5-15.

10.2.3 Deep-Strength or Perpetual HMA Pavements

A standard 6-inch base aggregate dense should be used. When using base aggregate open graded, refer to FDM 14-5-15.

10.2.4 Design Thicknesses

Calculate the design thickness of base aggregate layers to the nearest 1-inch.

10.3 Design Guidance

The Standard Specifications contain bid items for base aggregate dense that are referenced by their maximum size: 3-inch, 1 1/4-inch, and 3/4-inch.

The following figures show how these base materials would typically be incorporated into pavement sections according to the Standard Specifications. Standard Spec 305.2.2.1 allows the contractor the option of using 3-inch base in the lower layer. If designers leave this option in the contract, they should use Figure 10.1 as guidance to label typical sections or to prepare a similar plan detail.

10.3.1 Base Aggregate Dense 3/4-Inch on Foreslopes

With the option of the 3-inch base in the lower layer, the 3/4-inch base should be used from the edge of paved shoulder to the edge of the base portion of the foreslope. The 3-inch base should be covered with the 3/4-inch base to avoid future maintenance problems. If the use of the 3-inch base is excluded, then 3/4-inch base on the foreslope is not necessary.

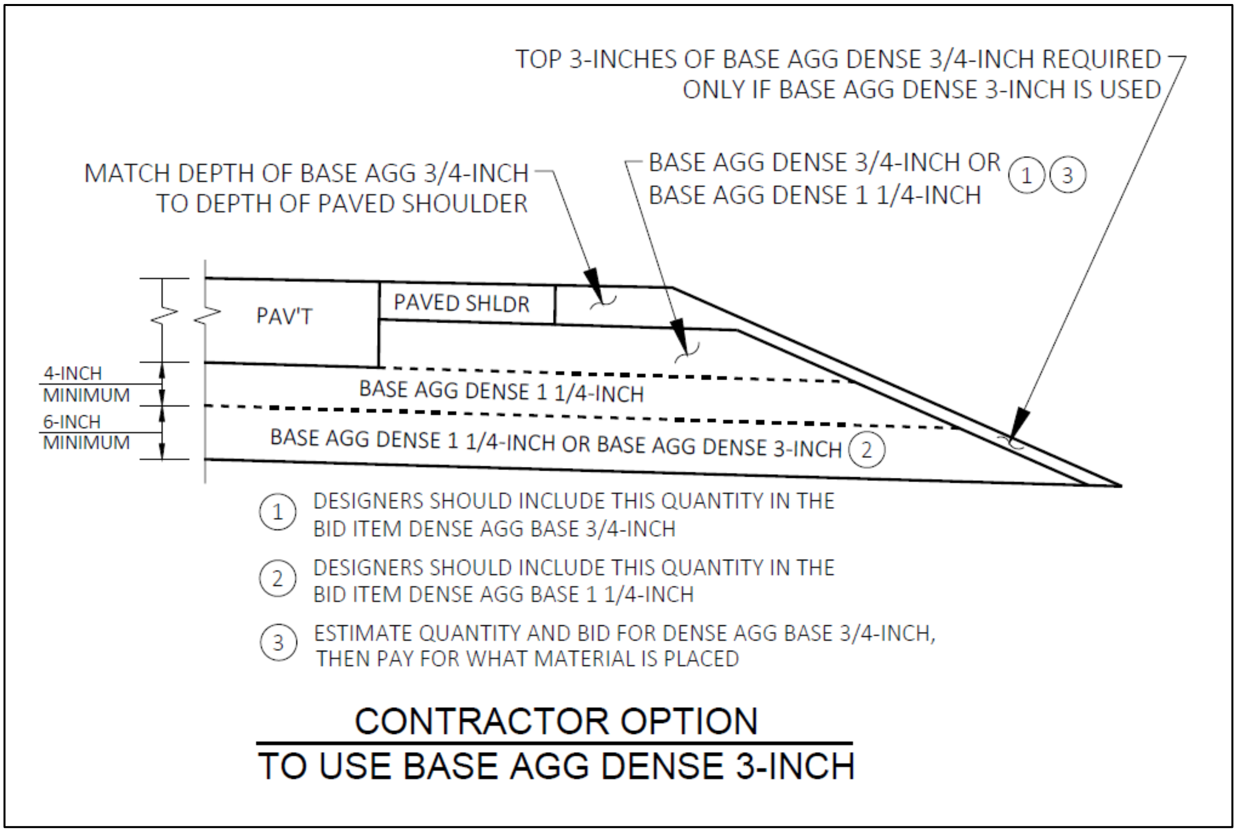


***Figure 10.1* Contractor Option to use Base Aggregate Dense 3-Inch**

10.3.2 Base Under the Finished Shoulder

Both the 3/4-inch base and the 1 1/4-inch base are acceptable under the paved shoulder and the adjacent finished shoulder. Designers should show this note on their plans and not restrict the shoulder construction to just one material. There are cost advantages to allowing both materials in this area. While both bases are allowed in this area, designers should include the quantity of this material in the bid item of Base Aggregate Dense 3/4-Inch.

10.3.3 Use of Base Aggregate Dense 3-Inch

The 3-inch base has a top size of 3 inches and is well graded through the remainder of the sieve ranges. It is a coarse material intended for use only in the lower portion of the base layer. The coarse size and maximum density-based gradation make it a very stable material with superior load carrying and load distribution properties. However, it is unsuited for use as base surface material or as shoulder material since the coarse size will make it difficult to finish. When produced from a quarry, it is expected to have a lower unit cost than 1 1/4-inch base, since less crushing effort will be required.

Quarries are the most logical source of 3-inch base. Producing this material from a gravel pit would be problematic due to both the size of the material and the requirement for 58% fracture on one face of the material retained on the No. 4 sieve.

As previously stated, the Standard Specifications allow the contractor the option of using 3-inch base in the lower layer. However, designers may require the use of the 3-inch base, or they may preclude it and instead require the use of the 1 1/4-inch base, as shown on Figure 10.2 and Figure 10.3. Designers should use these details as guidance to label typical sections or to prepare similar plan details.

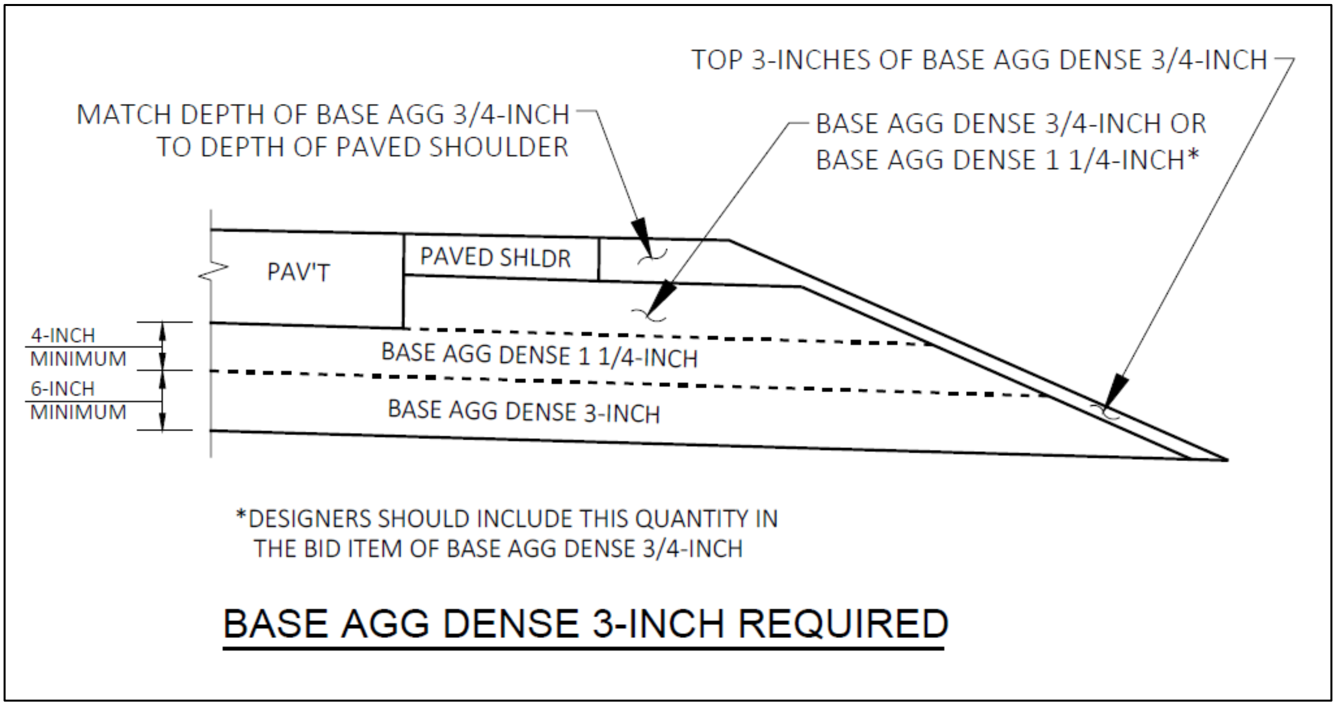


***Figure 10.2** Base Aggregate Dense 3-Inch Required*

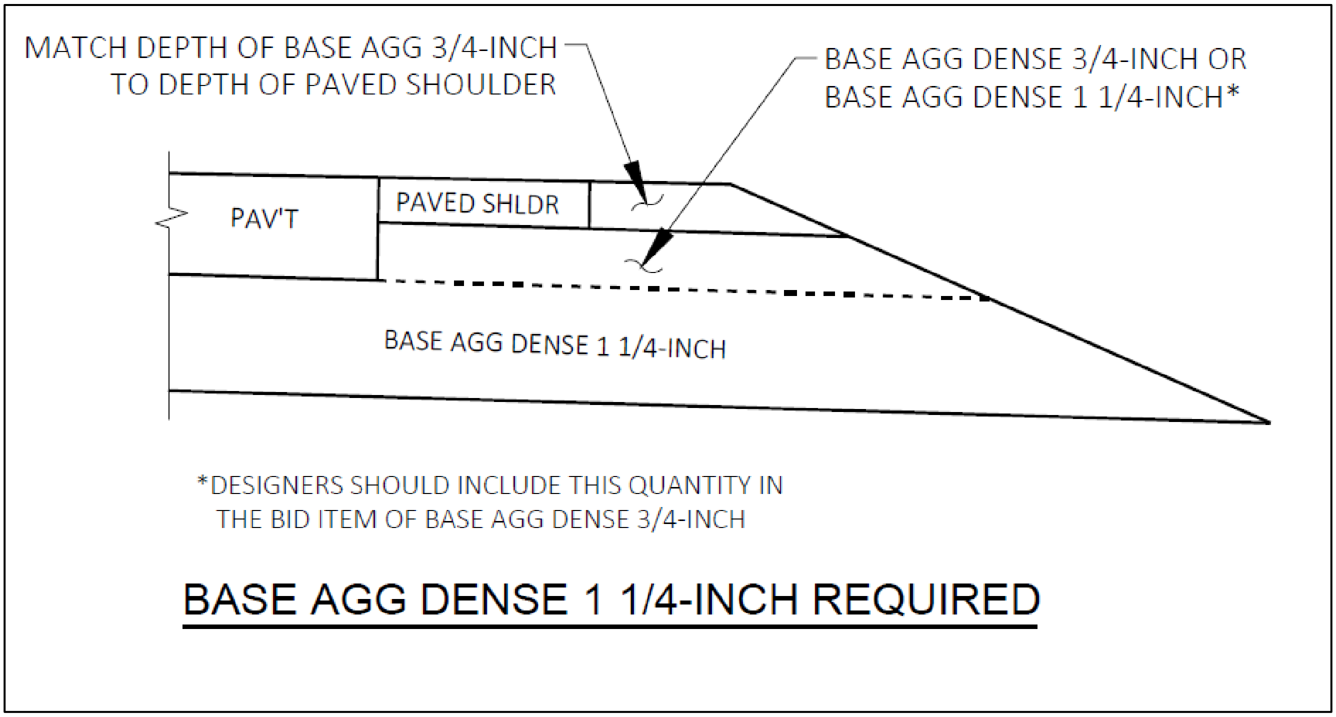


***Figure 10.3** Base Aggregate Dense 1 1/4 - Inch Required*

The designer may require 3-inch base in the typical section under these conditions.

1. The total thickness of the base layer under the pavement is 10 inches or greater. Given the required 4-inch minimum layer of 1 1/4-inch base, 6 inches or more of the 3-inch base course would be required.
2. The project is in an area where quarries are the normal source of aggregates. The region soils engineer can provide guidance on specific projects, but the limestone regions that form an arc through the western, southern, and eastern portions of the state would have the most potential for economic production of 3-inch base. This would include most of the SW and SE regions and parts of the NW and NE regions.

3. A project contains items for the removal and the disposal of relatively large volumes of concrete pavement that would be suitable for crushing.

The use of 3-inch base is not recommended in areas where gravel pits are the primary source of base materials. The cost of production will be excessive, unless the pit contains large amounts of cobbles or boulders. Areas where this restriction would apply include nearly all of the NW and NC regions along with portions of the NE region. The region soils engineer can provide project specific information.

Do not allow the use of the 3-inch base if the total base thickness under the pavement is less than 10 inches.

FDM 14-5-15 Base Aggregate Open Graded (BAOG) *May 15, 2019*

15.1 General

The Department uses only one type of Base Aggregate Open Graded. The following elements are essential to ensure maximum performance of a drained pavement structure.

1. A permeable Base Aggregate Open Graded (BAOG)
2. A filter layer
3. A longitudinal edge drain collector system

15.2 BAOG Filter Layer

The target permeability of BAOG is 1,000 ft/day.

BAOG can be used in two different applications; the first is placed directly on the subgrade when the subgrade soils are coarse-grained, sandy soils with AASHTO classifications of A-1, A-3, and possibly some A-2 classifications. These soils are naturally permeable and can help drain the pavement structure. However, the subgrade soils must be analyzed to ensure they are compatible with the BAOG based upon the filter criteria. The particle size of the soil and BAOG must meet the following three filter criteria as shown in Figure 15.1.

$$\frac{D_{15}\ \text{BAOG}}{D_{85}\ \text{SUBGRADE}} \leq 5$$

$$\frac{D_{15}\ \text{BAOG}}{D_{15}\ \text{SUBGRADE}} \geq 5$$

$$\frac{D_{50}\ \text{BAOG}}{D_{50}\ \text{SUBGRADE}} \leq 25$$

***Figure 15.1* Filter Criteria**

The symbol "D" represents the diameter of the particle at the indicated percent passing on the grain size distribution curve of each material. All three criteria must be met to ensure that the subgrade does not contaminate the BAOG. Contamination of the layer will result in a decrease in permeability, a loss of structural support, and clogging of the edge drains. If the filter criteria are not met, it is not a good practice to increase the thickness of the BAOG layer with the assumption that only part of the layer will be lost to contamination. Research has shown that the pumping action of water will continue to move the contamination through the entire depth of the layer.

If the subgrade soil has an AASHTO classification of A-1, A-3 or A-2, BAOG should be proposed on the project, and placed directly on the subgrade. The subgrade soil type will be identified in the Soils Report. That report will also furnish the necessary inputs to perform the filter criteria analysis, provide a range of subgrade permeability values and make a recommendation for the use of this material. The minimum thickness of the BAOG layer, when placed directly on subgrade, is 8 inches regardless of pavement type (refer to sheet ‘c’ of SDD 8D15). This thickness is required to provide enough hydraulic capacity to obtain a good level of drainage as per the criteria outlined by AASHTO and FHWA.

The other condition for use of BAOG is when the filter criteria cannot be met. In this situation, a filter layer of 6 inches of crushed aggregate base course is required to protect the BAOG layer from contamination. A geotextile can also be considered if it can be economically justified and construction operations will facilitate its use. A minimum thickness of 4 inches is required for the BAOG layer (refer to sheet ‘b’ of SDD 8D15).

15.3 Use of BAOG

The use of BAOG does not depend on ESALs. The designer will determine if BAOG is to be used. Situations, such as sag areas, should be considered. The feasibility and necessity of BAOG is still being researched.

15.4 Stabilization

There could potentially be cost and constructability advantages to stabilizing BAOG. Stabilization will be at the contractor's discretion with no additional cost to the Department.

The effect of stabilization should not be factored into the design of the pavement structure and the strength coefficients for unstabilized open graded base course should be used.

15.5 Edge Drains

An edge drain system is required for installation with BAOG. The edge drain used shall be a conventional circular pipe underdrain with a 6-inch diameter. The advantage to these edge drains is their flow capacity and, more importantly, their ability to be maintained. For proper performance, edge drains must be maintained. The edge drain should not be wrapped with geotextile fabric due to the potential for the fabric to become plugged and/or reduce the hydraulic capacity of the system. Refer to FDM 13-40-1 and the edge drain detail series SDD 8D15.

Interchanges have proven to be difficult locations for the placement of BAOG edge drains and outlets. Pavement drainage must be maintained through the interchange. The base aggregate open graded layer should be extended out to drain the ramp tapers and gore. The edge drain should also be moved out and placed at the edge of the ramp taper and gore pavements so that they can be maintained. Outlets must be strategically placed such that all water entering the pavement can drain.

Note: Edge drains should not be retrofit under concrete pavements with dense graded base course. The Department’s experience indicates concrete pavements do not receive any benefit from this combination of features.

15.5.1 Trench

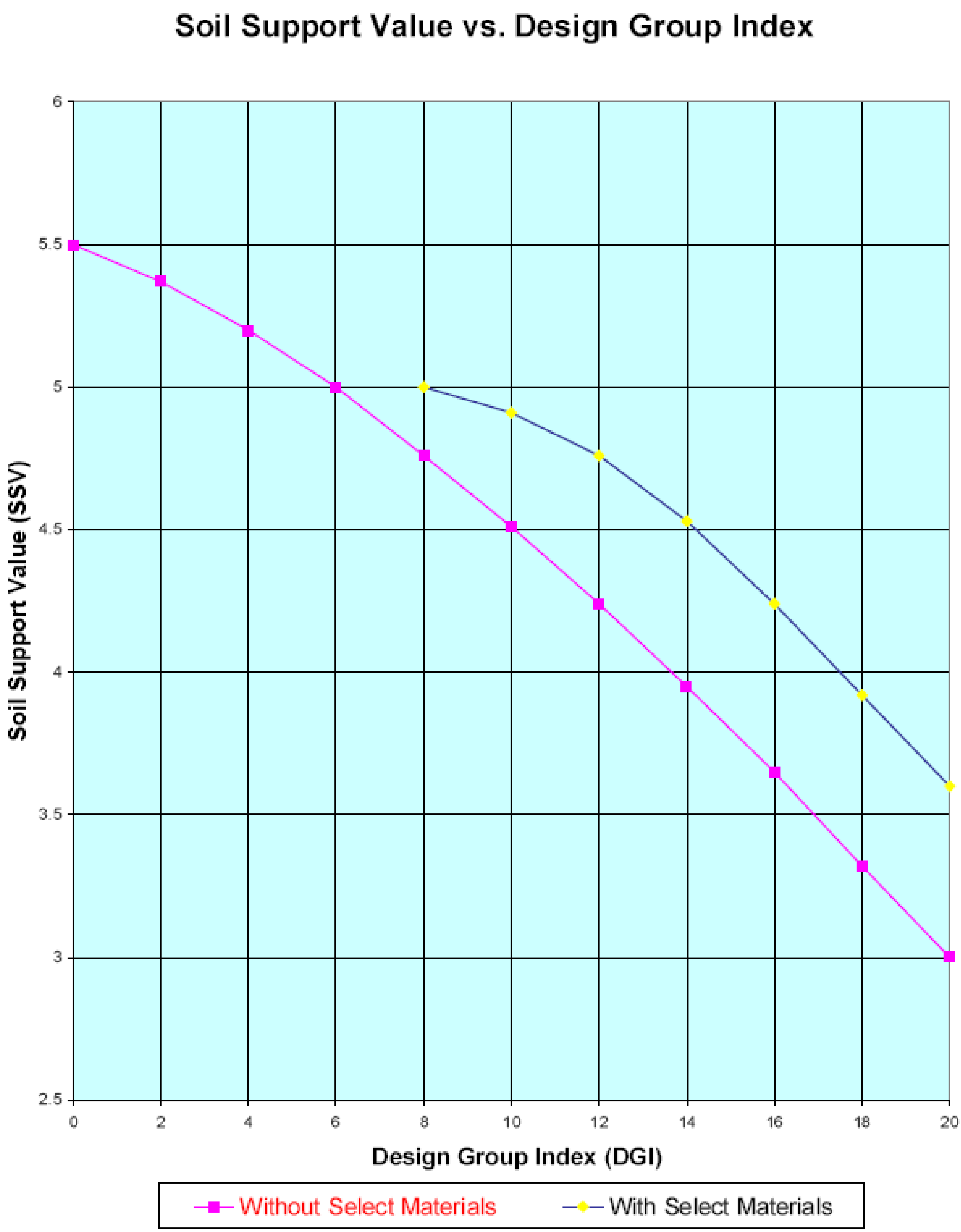
In an urban situation, it is recommended that the edge drain and trench be located under the concrete curb and gutter to protect the system from utilities and other activities that take place within the right-of-way area.

To ensure proper drainage, connect the edge drains to inlets, manholes, or catch basins of the storm sewer system (refer to sheet ‘a’ of the SDD 8D15).

15.5.2 Outlet Pipe

Careful attention must be given to the location of the outlet pipes such that outlets are placed at the sags of vertical curves and prior to bridge abutments. For maintenance purposes, the practical maximum spacing between outlets is 250 feet. To prevent damage to the outlet, the location of the endwall should be marked with a flexible marker post or some other method for easy identification by county maintenance forces.

Refer to the SDDs, titled "Reinforced Concrete Apron Endwall for Pipe Underdrain" and “Edgedrain Outlet and Outfall Markers”.


Soil Support Value vs. Design Group Index
Soil Support Value (SSV)
6
5.5
5
4.5
4
3.5
3
2.5
0
2
4
6
8
10
12
14
16
18
20
Design Group Index (DGI)
Without Select Materials
With Select Materials

FDM 14-7-1 General

August 17, 2020

1.1 Traffic Information

Traffic information for pavement design is available from the Division of Transportation Investment Management, Traffic Forecasting Section. See FDM 11-5-2 for guidance on how to obtain traffic data. Information typically required for pavement design will include:

1. Current year Annual Average Daily Traffic (AADT)
2. Construction year AADT
3. Design year AADT
4. Truck classification percentage, by axle configuration, of the construction year AADT. In some cases, the construction year classification may be projected to the design year and both classification counts will be shown. The designer should then use a straight-line average classification between the two counts. Truck classification data for pavement design is available on the Traffic Forecast webpage.

Truck classifications for pavement design purposes are listed in Table 1.1.

Table 1.1 Truck Classifications

Heavy Single Unit Trucks	Designation
2 Axles, 6 Tires	2D
3 Axles	3SU
Tractor-Semitrailer	Designation
3 or 4 Axles	2S-1, 2S-2
5 Axles and Above	3S-2
Tractor-Semitrailer-Trailer	Designation
5 Axles and Above	2-S1-2
(Double Bottom)	

A traffic analysis period of 20 years is used.

After obtaining the traffic projection data, the region can determine the Design Lane Traffic (DLT). The DLT is equal to the average of the Construction Year AADT and the Design Year AADT, multiplied by a Direction Factor (DF) and a Lane Distribution Factor (LDF), as expressed by the formula in Figure 1.1:

$$DLT = \frac{(\text{Construction Year AADT} + \text{Design Year AADT})}{2} \times DF \times LDF$$

where:

DLT	=	The traffic volume in the lane that carries the highest number of trucks.
Construction Year AADT	=	The expected AADT for the year during which the project is built.
Design Year AADT	=	The expected AADT at the end of the design period.
DF	=	A factor representing the greater percentage of the AADT that is traveling in either direction on a 2-lane or multi-lane highway. Normally, DF = 0.50; however, where traffic generators such as industrial parks cause a greater volume of truck traffic in one direction, DF may be greater than 0.50. DF should not be confused with the term "Directional Distribution" (D). D is the directional split of traffic during the chosen design hour, expressed as a percentage of the Design Hour Volume (DHV).
LDF	=	A factor representing the percentage of truck traffic that is traveling in the outside lane of a multi-lane highway. Values for LDF are given in Table 1.2.

***Figure 1.1* Design Life Traffic Equation**

***Table 1.2* Lane Distribution Factors**

MULTI-LANE HIGHWAYS AND TRADITIONAL INTERSECTIONS (WITH CROSS TRAFFIC)		
Design Year AADT	Outside Lane LDF	
	Low End AADT of Design Year	High End AADT of Design Year
Two Lanes	1.0	1.0
Four Lanes		
Less than 10,000	0.95	0.95
10,000 to 25,000	0.95[A]	0.90[A]
25,000 to 40,000	0.90[A]	0.85[A]
Over 40,000	0.85	0.85
Six or More Lanes		
25,000 to 40,000	0.65[A]	0.50[A]
Over 40,000	0.50	0.50
ROUNDABOUTS		
One-Lane	1.0	
Multi-Lane	0.95	

[A] Where a range of LDF values are given for a range of design year AADTs, the larger LDF shall be used with the lower AADTs in the range.

1.2 Traffic Loading

From the DLT the number of trucks in each truck classification shall be determined by multiplying the DLT by the percent of trucks in each classification. These values will be used to determine the Equivalent Single Axle Load (ESAL) for pavement design. An ESAL is the measure of an axle load expressed relative to an 18,000 lb axle load.

Normal highway traffic consists of a random mixture of vehicles with different axle loads and number of axles. Factors have been developed for each truck type so that a truck can be expressed as a certain number of ESALs.

ESAL factors used by the Department for pavement design are given in Table 1.3.

Table 1.3 ESAL Factors

Truck Type	Hot Mix Asphalt (HMA) Pavement ESAL Factors	Concrete Pavement ESAL Factors
2D	0.3	0.3
3SU	0.8	1.2
2-SI, 2-S2	0.5	0.6
3-S2 & Above	0.9	1.6
Double Bottoms	2.0	2.1
Note: Load factors are not given for automobiles and light trucks, as they are insignificant for pavement design purposes.		

With these factors and a forecast of future truck traffic, the number of ESALs a pavement will experience over its design life can be estimated.

Design Daily ESALs for asphaltic pavements is defined as follows:

$$\text{Design Daily ESALs} = \frac{AADT_c + AADT_p}{2} \times DF \times LDF \times \left\{ \begin{array}{l} 0.3(2D) \\ 0.8(3SU) \\ 0.5(2\text{-}S1 + 2\text{-}S2) \\ 0.9(3\text{-}S2+) \\ 2.0(\text{Double Bottoms}) \end{array} \right\}$$

where: $AADT_C$ is the Annual Average Daily Traffic for the construction year

$AADT_P$ is the Annual Average Daily Traffic projected for the design year

DF is the Directional Factor (usually 0.5)

LDF is the Lane Distribution Factor

2D, 3SU, 2-S1, 2-S2, 3-S2+ and Double Bottoms are the percentage of trucks (expressed as decimal fractions) in these categories

Figure 1.2 Design Daily ESALs Equation

The 20-year Design Life ESALs is just the Design Daily ESALs multiplied by 365 days per year and 20 years (Figure 1.2).

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).

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

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).

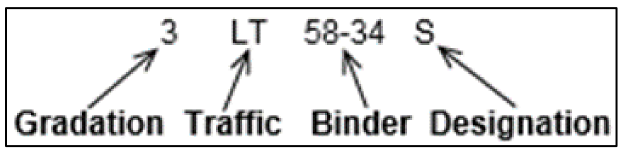


***Figure 10.2* HMA Combined Bid Item Nomenclature**

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 10.3	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.

Structural Layer Coefficients

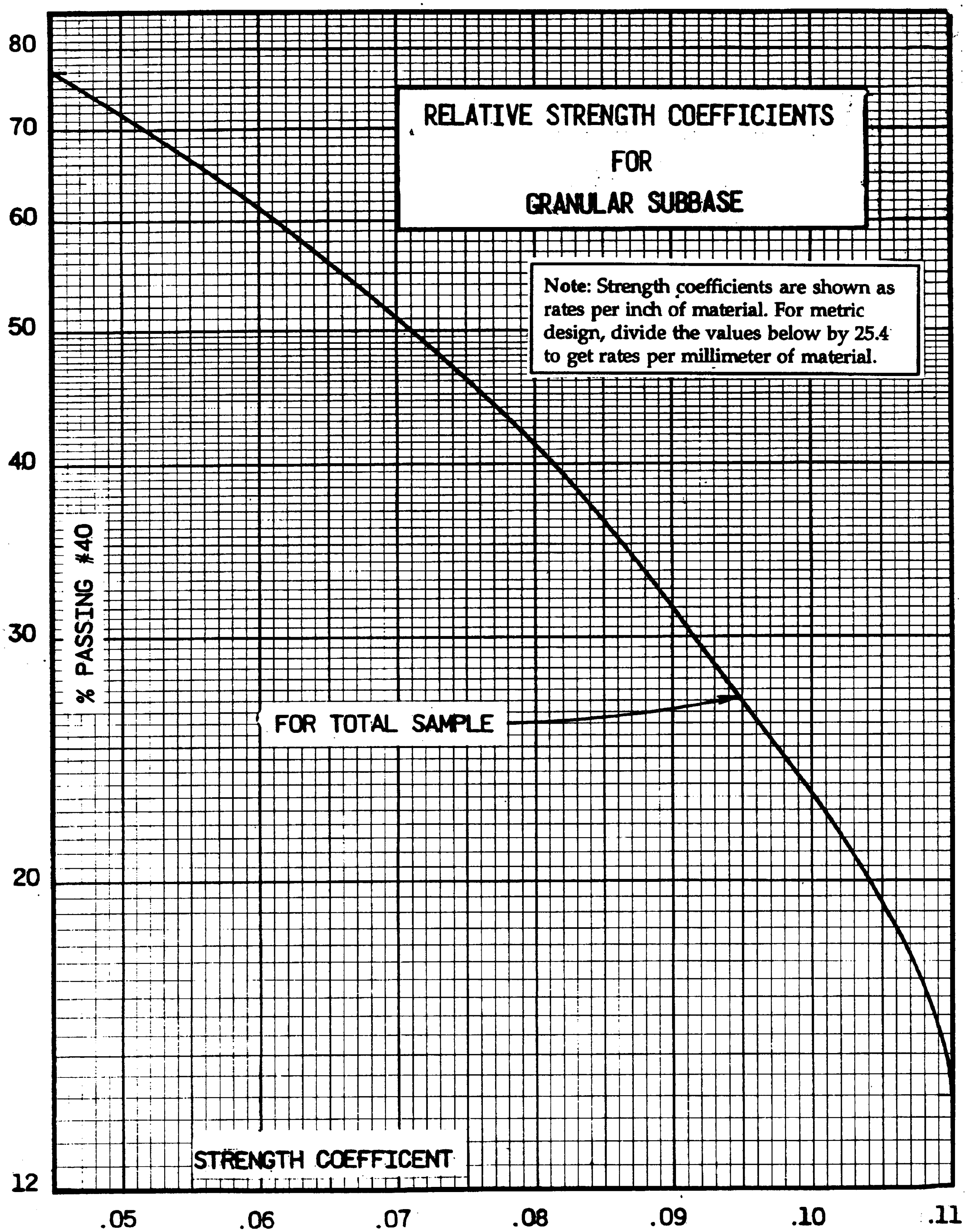
(For new or reconstructed pavements)

Structural Layer	Coefficient (English)
New HMA Pavement	0.44
HMA Pavement, Intact	0.10 – 0.44
Base Aggregate Dense	
crushed stone	0.14
crushed gravel	0.10
Base Aggregate Open Graded	
crushed stone	0.14
crushed gravel	0.10
Select Crushed Material	
crushed stone	0.14 *
crushed gravel	0.10 *
Subbase	See Attachment 5.2 **
Asphaltic Base	0.34
Concrete Base	0.40
Cement Stabilized Base Aggregate Open Graded	
crushed stone	0.14
crushed gravel	0.10
Asphalt Stabilized Base Aggregate Open Graded	
crushed stone	0.14
crushed gravel	0.10
Rubblized Concrete	0.20-0.24
Milled and Re-laid HMA Pavement	0.10-0.25
Pulverized HMA Pavement	0.10-0.25
Concrete Pavement, Intact	0.10-0.54
(if placing on HMA overlay)	0.10-0.44
Cold In-Place Recycling (CIR)	0.30-0.35
Cracked and Seated Concrete	0.20-0.40

Notes:

* Do not count this material as part of the pavement structure if it is known it will be lost due to poor subgrades.

** Granular subbase may contribute a maximum of 10% of the design SN regardless of its strength coefficient or thickness used.


RELATIVE STRENGTH COEFFICIENTS
FOR
GRANULAR SUBBASE
Note: Strength coefficients are shown as rates per inch of material. For metric design, divide the values below by 25.4 to get rates per millimeter of material.
% PASSING #40
80
70
60
50
40
30
20
12
FOR TOTAL SAMPLE
STRENGTH COEFFICENT
.05
.06
.07
.08
.09
.10
.11

Step 1: Select Aggregate Gradation (Nmas) based on layer
Step 2: Select Traffic Classification based on 20-year design ESALs
Step 3: Select Asphaltic Binder Grade based on layer, project type and zone
Step 4: Select Asphaltic Binder Designation based on expected traffic levels

4 HT 58-34 H

(1) Gradation

(2) Traffic

(3) Binder Grade

(4) Binder Designation

(1) Gradation	**(2) Traffic Level**		**(3) Binder Grade**		**(4) Binder Designation**	
Upper Layer Options	**Class**	**ESALs**	**Upper Layer** **Northern Zone**	**Upper Layer** **Southern Zone**	**Traffic Categories**	
3 – 19.0 mm (crossovers) **4** – 12.5 mm **5** – 9.5 mm **6** – 4.75 mm	**LT**	≤ 1 million	**58-34** (New, Reconstruction, Pave. Replacement)	**58-28** (All Project Types)	**S**	Standard (≤ 8 million ESALs)
	MT	1 million to ≤ 8 million	**58-28** (Other - Overlay, etc.)		**H**	Heavy (8 million < ESALs ≤ 30 million OR design speeds between 15–45 mph)
Lower Layer Options	**HT**	> 8 million	**Lower Layer** **Northern Zone**	**Lower Layer** **Southern Zone**	**V**	Very Heavy (> 30 million ESALs OR traffic <15 mph)
2 – 25.0 mm **3** – 19.0 mm **4** – 12.5 mm **5** – 9.5 mm **6** – 4.75 mm	**SMA**	consider for > 2 million	**58-28** (All Project Types)	**58-28** (All Project Types)	**E**	Extremely Heavy (> 30 million ESALs AND standing traffic)

For this example:

- Gradation: 12.5 mm
- Traffic Level: > 8 million ESALs
- Binder Grade: upper layer, northern zone, reconstruction
- Binder Designation: 8 million < ESALs ≤ 30 million

≤ 1 Mil ESALs	> 1 to ≤ 8 Mil ESALs	> 8 Mil ESALs	> 2 Mil ESALs
Low Volume	**Med Volume**	**High Volume**	**SMA**
3 LT 58-28 S	2 MT 58-28 S	2 HT 58-28 S	4 SMA 58-28 H
4 LT 58-28 S	3 MT 58-28 S	3 HT 58-28 S	5 SMA 58-28 H
5 LT 58-28 S	4 MT 58-28 S	4 HT 58-28 S	4 SMA 58-34 H
6 LT 58-28 S	5 MT 58-28 S	5 HT 58-28 S	5 SMA 58-34 H
3 LT 58-34 S	6 MT 58-28 S	6 HT 58-28 S	4 SMA 58-28 V
4 LT 58-34 S	2 MT 58-34 S	2 HT 58-34 S	5 SMA 58-28 V
5 LT 58-34 S	3 MT 58-34 S	3 HT 58-34 S	4 SMA 58-34 V
6 LT 58-34 S	4 MT 58-34 S	4 HT 58-34 S	5 SMA 58-34 V
4 LT 58-28 H	5 MT 58-34 S	5 HT 58-34 S	4 SMA 58-28 E
5 LT 58-28 H	6 MT 58-34 S	6 HT 58-34 S	5 SMA 58-28 E
6 LT 58-28 H	4 MT 58-28 H	2 HT 58-28 H	4 SMA 58-34 E
4 LT 58-34 H	5 MT 58-28 H	3 HT 58-28 H	5 SMA 58-34 E
5 LT 58-34 H	6 MT 58-28 H	4 HT 58-28 H	
6 LT 58-34 H	4 MT 58-34 H	5 HT 58-28 H	
	5 MT 58-34 H	6 HT 58-28 H	
	6 MT 58-34 H	2 HT 58-34 H	
	4 MT 58-28 V	3 HT 58-34 H	
	5 MT 58-28 V	4 HT 58-34 H	
	6 MT 58-28 V	5 HT 58-34 H	
	4 MT 58-34 V	6 HT 58-34 H	
	5 MT 58-34 V	4 HT 58-28 V	
	6 MT 58-34 V	5 HT 58-28 V	
		6 HT 58-28 V	
		4 HT 58-34 V	
		5 HT 58-34 V	
		6 HT 58-34 V	

Reasons you may not find specific mix types in the above table are summarized as follows:

- Gradation #2 (25mm) is not typically used for LT pavements.
- It is not typical to need anything greater than an S binder designation for LT pavements.
- It is uncommon to use a polymer modified binder (i.e., H and V binder designation) in the lower layers for LT or MT, which is the layer where one typically uses Gradation #2 or #3 (25mm or 19mm). It is up to region's discretion.
- For HT pavements, there may be a need for H binder designation with Gradation #2 or #3 due to traffic loading, but typically there is no justification for a V binder designation with such gradations.
- SMA pavements are restricted to either gradation #4 or #5 (12.5mm or 9.5mm).

Key:

Gradation (NMAS)		Traffic Volume		Asphalt Binder	Binder Designation Level *	
1	37.5 mm	LT	Low Traffic	58-28	S	Standard
2	25.0 mm	MT	Medium Traffic	58-34	H	Heavy
3	19.0 mm	HT	High Traffic		V	Very Heavy
4	12.5 mm				E	Extremely Heavy
5	9.5 mm					
6	4.75 mm					

* See FDM 14-10-10.7.4 for additional details on Asphalt Binder Designation Selection.

Notes:

1. The final mix type should be one of those listed in the suite of choices shown above, unless otherwise designated in the approved Pavement Documentation for the project.
2. Bid Item numbers can be found beginning on the following pages..

BID ITEMS:

LT Pavement Types

460.5223	3 LT 58-28 S	TON
460.5224	4 LT 58-28 S	TON
460.5225	5 LT 58-28 S	TON
460.5226	6 LT 58-28 S	TON
460.5243	3 LT 58-34 S	TON
460.5244	4 LT 58-34 S	TON
460.5245	5 LT 58-34 S	TON
460.5246	6 LT 58-34 S	TON
460.5424	4 LT 58-28 H	TON
460.5425	5 LT 58-28 H	TON
460.5426	6 LT 58-28 H	TON
460.5444	4 LT 58-34 H	TON
460.5445	5 LT 58-34 H	TON
460.5446	6 LT 58-34 H	TON

MT Pavement Types

460.6222	2 MT 58-28 S	TON
460.6223	3 MT 58-28 S	TON
460.6224	4 MT 58-28 S	TON
460.6225	5 MT 58-28 S	TON
460.6226	6 MT 58-28 S	TON
460.6242	2 MT 58-34 S	TON
460.6243	3 MT 58-34 S	TON
460.6244	4 MT 58-34 S	TON
460.6245	5 MT 58-34 S	TON
460.6246	6 MT 58-34 S	TON
460.6424	4 MT 58-28 H	TON
460.6425	5 MT 58-28 H	TON
460.6426	6 MT 58-28 H	TON
460.6444	4 MT 58-34 H	TON
460.6445	5 MT 58-34 H	TON
460.6446	6 MT 58-34 H	TON
460.6624	4 MT 58-28 V	TON
460.6625	5 MT 58-28 V	TON
460.6626	6 MT 58-28 V	TON
460.6644	4 MT 58-34 V	TON
460.6645	5 MT 58-34 V	TON
460.6646	6 MT 58-34 V	TON

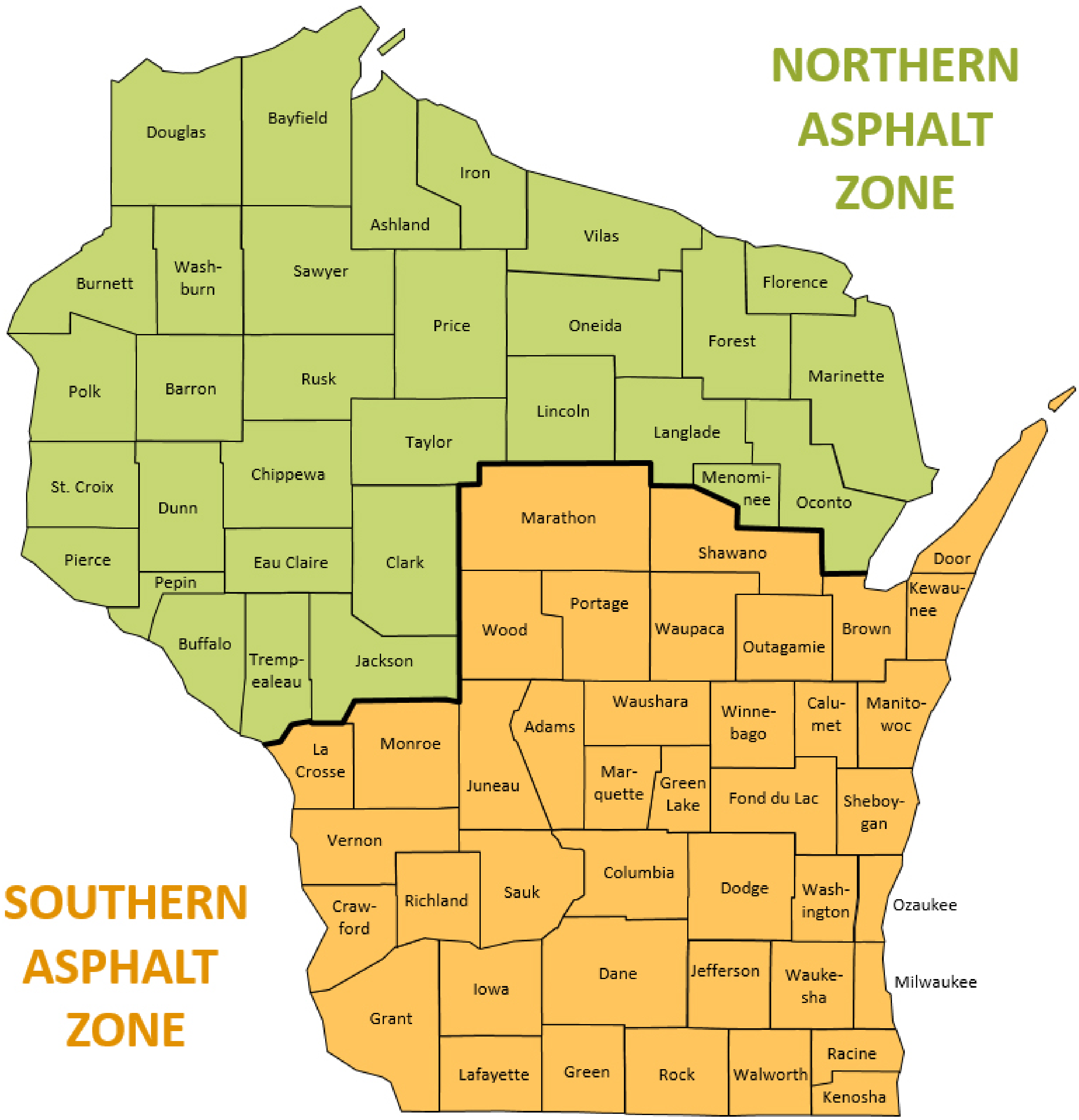
HT Pavement Types

460.7222	2 HT 58-28 S	TON
460.7223	3 HT 58-28 S	TON
460.7224	4 HT 58-28 S	TON
460.7225	5 HT 58-28 S	TON
460.7226	6 HT 58-28 S	TON
460.7242	2 HT 58-34 S	TON
460.7243	3 HT 58-34 S	TON
460.7244	4 HT 58-34 S	TON
460.7245	5 HT 58-34 S	TON

460.7246	6 HT 58-34 S	TON
460.7422	2 HT 58-28 H	TON
460.7423	3 HT 58-28 H	TON
460.7424	4 HT 58-28 H	TON
460.7425	5 HT 58-28 H	TON
460.7426	6 HT 58-28 H	TON
460.7442	2 HT 58-34 H	TON
460.7443	3 HT 58-34 H	TON
460.7444	4 HT 58-34 H	TON
460.7445	5 HT 58-34 H	TON
460.7446	6 HT 58-34 H	TON
460.7624	4 HT 58-28 V	TON
460.7625	5 HT 58-28 V	TON
460.7626	6 HT 58-28 V	TON
460.7644	4 HT 58-34 V	TON
460.7645	5 HT 58-34 V	TON
460.7646	6 HT 58-34 V	TON

SMA Pavement Types

460.8424	4 SMA 58-28 H	TON
460.8425	5 SMA 58-28 H	TON
460.8444	4 SMA 58-34 H	TON
460.8445	5 SMA 58-34 H	TON
460.8624	4 SMA 58-28 V	TON
460.8625	5 SMA 58-28 V	TON
460.8644	4 SMA 58-34 V	TON
460.8645	5 SMA 58-34 V	TON
460.8824	4 SMA 58-28 E	TON
460.8825	5 SMA 58-28 E	TON
460.8844	4 SMA 58-34 E	TON
460.8845	5 SMA 58-34 E	TON



The Northern Asphalt Zone includes the following counties:

Ashland, Barron, Bayfield, Buffalo, Burnett, Chippewa, Clark, Douglas, Dunn, Eau Claire, Florence, Forest, Iron, Jackson, Langlade, Lincoln, Marinette, Menominee, Oconto, Oneida, Pepin, Pierce, Polk, Price, Rusk, Saint Croix, Sawyer, Taylor, Trempealeau, Vilas, and Washburn.

The Southern Asphalt Zone includes the following counties:

Adams, Brown, Calumet, Columbia, Crawford, Dane, Dodge, Door, Fond du Lac, Grant, Green, Green Lake, Iowa, Jefferson, Juneau, Kenosha, Kewaunee, La Crosse, Lafayette, Manitowoc, Marathon, Marquette, Milwaukee, Monroe, Outagamie, Ozaukee, Portage, Racine, Richland, Rock, Sauk, Shawano, Sheboygan, Vernon, Walworth, Washington, Waukesha, Waupaca, Waushara, Winnebago, and Wood.

HMA Mix Type Examples

(FDM 14-10-10.7 is used to determine the asphalt mix to be used for a project.)

Example 1: A 4" thick HMA pavement is needed for an overlay of a concrete pavement on a 4 lane, rural divided highway in Barron County. The traffic forecast is for 9,000,000 ESALs in the design timeline. The highway is high speed divided highway with a posted speed limit of 65 mph.

Step 1: Gradation (following FDM 14-10-10.7.1)

Using the layer thickness guidelines as defined in standard spec 460.3.2, the following options are available.

Lower Layer: 3 (19.0 mm) or 4 (12.5 mm)

Upper Layer: 4 (12.5 mm) or 5 (9.5 mm)

Depending on which surface material is chosen with the minimum layer thickness guidelines, the pavement designer has four options:

1) 2.25" thick lower layer (Gradation 3) with a 1.75" thick upper layer (Gradation 4)
2) 2.5" thick lower layer (Gradation 3) with a 1.5" thick upper layer (Gradation 5)
3) 2.0" thick lower layer (Gradation 4) with 2.0" thick upper layer (Gradation 4)
4) 2.5" thick lower layer (Gradation 4) with 1.5" thick upper layer (Gradation 5)

In this case, the pavement designer has several options, but it is generally agreed that the above gradations are listed in order of most to least cost-effective, with larger gradations more economical. Knowing that the facility is a high-speed highway, and that the concrete being overlaid is in relatively good shape, with little heaving or patching necessary, the designer chooses to use Option 1 with Gradation 3 in the lower layer and Gradation 4 in the upper layer. If the pavement would have needed wedging, cross slope correction, or other repairs to try and restore a proper profile, use of Gradation 4 in the lower layer may have been justified.

We are left with the following:

Gradation: Lower = 3, Upper = 4

Step 2: Traffic Category (following FDM 14-10-10.7.2)

With 9,000,000 ESALs being expected during the pavement design life, an HT is selected. An SMA could have also been selected if there is a high volume of trucks on the pavement for the design period.

Step 3: Select the Asphalt Binder - Temperature (following FDM 14-10-10.7.3)

Since the project is in Barron County, which is in the Northern Asphalt Zone, the base binder selection is normally a 58-34, but because this pavement is an overlay, the use of 58-28 is allowed.

Step 4: Select the Asphalt Binder – Designation (following FDM 14-10-10.7.4)

One can see from the table of allowed designs (Attachment 10.4) that gradations 3 and 4 with 58-28 binder can be selected at the designation level of S or H for the HT category. Since there is little stopping and starting, and the speed is high, standard (S) would normally be specified and is reasonable for lower layers. However, in a traffic category like HT, there are benefits in specifying polymer modified asphalts to resist rutting of the pavement. Also, polymer modified asphalts have generally shown to be more resistant to thermal cracking, which is more prevalent in the northern part of the state. The pavement designer encouraged the use of a heavy grade (H) binder in this case due to the advantages mentioned.

Conclusion. The resulting mixes for this project are as follows:

Lower Layer: 3 HT 58-28 S

Upper Layer: 4 HT 58-28 H

Example 2: A roundabout is being built in Jefferson County at the intersection of two state highways. Traffic for the E-W and N-S roads approaching the roundabout is approximately 1,000,000 and 1,500,000 ESALs, respectively. The pavement design calls for 8" of HMA on top of the base aggregate.

Step 1: Gradation (following FDM 14-10-10.7.1)

Using the layer thickness guidelines as defined in standard spec 460.3.2, the following options are available.

Lower Layers: 2 (25.0 mm) or 3 (19.0 mm)

Upper Layer: 4 (12.5 mm) or 5 (9.5 mm)

Given the total 8" pavement thickness required, a pavement engineer has many gradation choices. In an effort to minimize the number of mix designs, the pavement engineer would usually call for 2 layers of a single gradation for construction of the lower layer. With that in mind, the pavement designer has three options:

1) Two 3.25" thick lower layers (Gradation 2) with a 1.5" thick upper layer (Gradation 5)
2) Two 3.0" thick lower layer (Gradation 3) with a 2.0" thick upper layer (Gradation 4)
3) Two 3.0" thick lower layer (Gradation 3) with 2.0" thick upper layer (Gradation 5)

It can be seen that selection of Gradation 2 for the lower layers limits the choices for the upper layer due to the increased minimum thickness required for the lower layers.

The pavement engineer may rely on past experience with various mix designs and material costs within their region to differentiate between Options 1 and 2 in this case (both are acceptable). Let's assume the engineer chooses Option 2 resulting in two 3.0" layers of Gradation 3 (19.0 mm) for the lower layers, and a 2.0" layer of Gradation 4 (12.5 mm) for the surface.

Gradation: Lower Layers = 3, Upper Layer = 4

Step 2: Traffic (following FDM 14-10-10.7.2)

With the legs of the roundabout providing approximately 1,000,000 and 1,500,000 ESALs, nearly 3 million ESALs are anticipated in the circular roadway which corresponds to a MT design. Following FDM 14-10-35.3.3, the mixture type level needs to be increased by one level for roundabout intersections and therefore a HT pavement is chosen.

Step 3: Asphalt Binder – Temperature (following FDM 14-10-10.7.3)

Since the project is in Jefferson County, in the Southern Asphalt Zone, a PG 58-28 is selected.

Step 4: Asphalt Binder – Designation (following FDM 14-10-10.7.4)

This kind of pavement sees significant turning, slowing and accelerating shearing motions. It would be classified as a lower speed where a polymer-modified asphalt would be appropriate. A move from S binder to H is required for the surface. In the lower layers, modification would not be necessary, as the surface is handling most of the stress from the vehicle movements, so S binder is acceptable in this case. (Per FDM 14-10-35.3.3 considering small tonnage of material being used usually for roundabout projects, it is recommended to use H binder in lower level as well if it has economic advantages.)

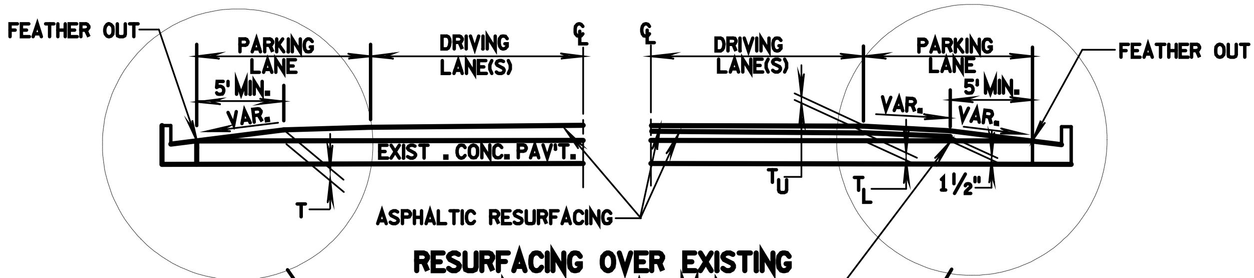
Conclusion: The resulting mixes for this project are as follows:

Lower Layers – 3 HT 58-28

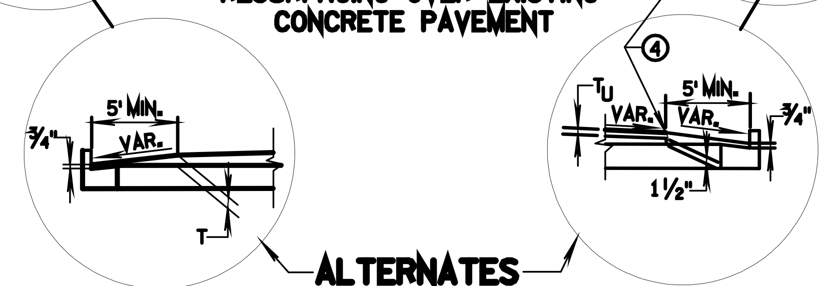
S Upper Layer – 4 HT 58-28

H

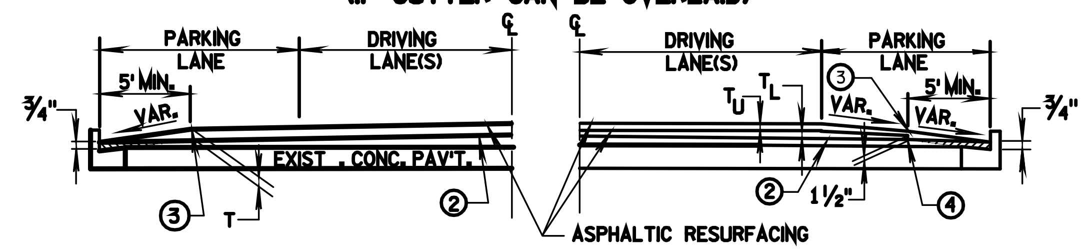
EDGE JOINTS



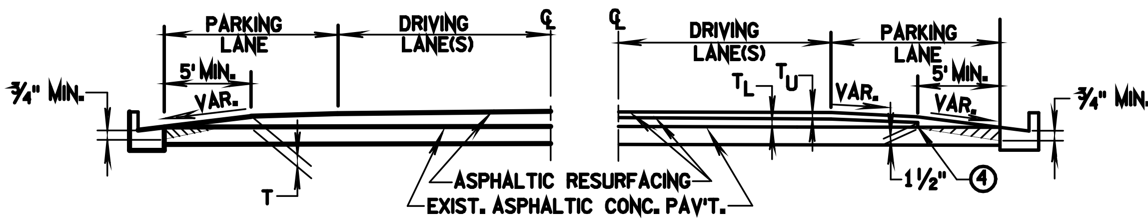
RESURFACING OVER EXISTING CONCRETE PAVEMENT



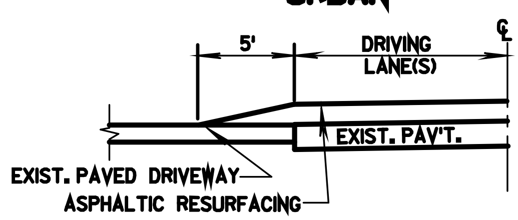
ALTERNATES
(IF GUTTER CAN BE OVERLAID)



RESURFACING OVER PREVIOUS RESURFACING



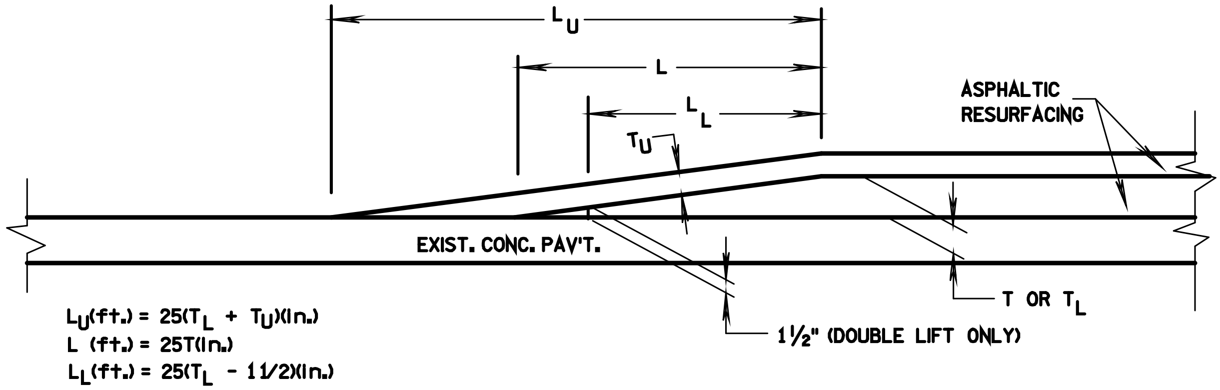
RESURFACING OVER EXISTING ASPHALTIC CONCRETE PAVEMENT
URBAN



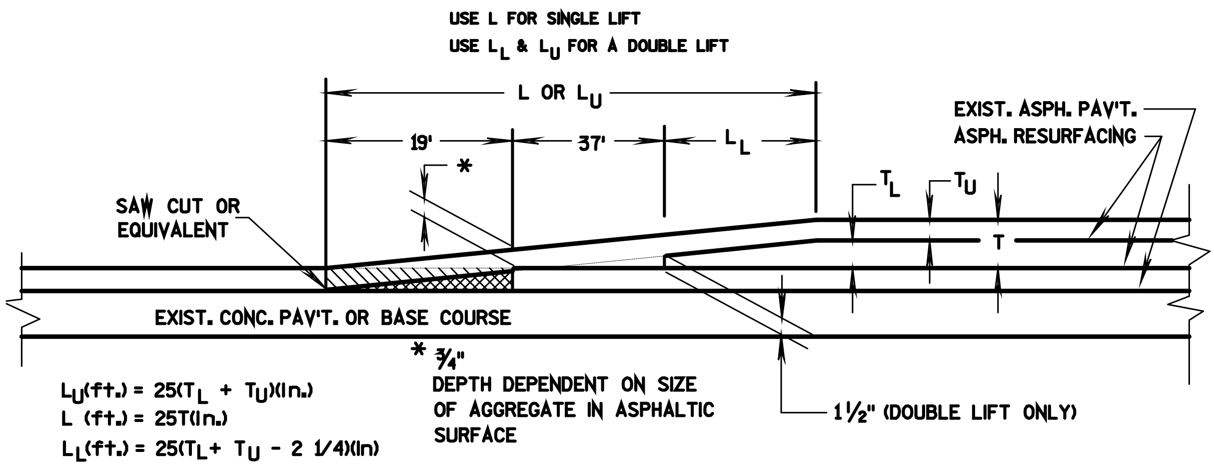
DRIVEWAYS
RURAL

SEE FIGURE 4 FOR NOTES AND LEGEND

END JOINTS



OVER EXISTING CONCRETE PAVEMENT
OVERLAP JOINT



OVER EXISTING ASPHALTIC PAVEMENT
OVERLAP JOINT, BUTTED

NOTES:	LEGEND:
← Existing asphaltic surfaces with excess crown or with parabolic crown should have the excess crown eliminated as required. ↑ On roadways where previous resurfacing will cause the elevation at the edge of pavement to be less than two inches below the top of curb, consider reconstructing the curb or removing the previous resurfacing. → Vertical edges may be raked down at the option of the engineer.	T = Plan thickness of single lift of asphaltic resurf. T_L = Plan thickness of lower layer T_U = Plan thickness of upper layer L = Length of wedge for single lift L_L = Length of lower wedge L_U = Length of upper wedge ▧ Remove existing pavement ▩ Wedge with surface material prior to placing surface course

FDM 14-15-1 General — May 15, 2019

1.1 Objective

The objective of this procedure is to define the Pavement Type Selection process. The process described herein applies to the following road projects: state trunk highways including 3R, Majors, Backbone, SE Freeways; connecting highways (refer to FDM 4-5-5); and local road projects that receive state or federal funds. Areas in this section that only pertain to one or the other project type are titled accordingly.

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. (refer to FDM 14-10-1.2)

FDM 14-15-5 Structural Design — August 17, 2020

5.1 Structural Design Process

The goal of a structural design is to determine the thickness, number of layers and material composition of a pavement structure required to withstand a given load. WisPave is WisDOT's official software to be used for pavement structural design. Refer to FDM 14-1-1.5 for WisPave access information. A pavement design must meet or exceed the required structure number (SN). If the pavement design deviates from the required SN, justification must be provided in the report.

5.2 Structural Design Need

5.2.1 State Highways

Table 10.1 identifies which types of projects require a structural design. Table 10.2 lists types of pavement work that define the different project types listed in Table 10.1. See FDM 11-1 Attachment 10.1 for more information on Improvement Type and Application of Design Criteria.

5.2.2 Local Roads

Use the structural design method specified in Table 10.3.

5.2.3 Exemptions

A structural design is not required for the following project types, regardless of the road type:

- Bridge: pavement between approaches and existing roadway
- Bridge: pavement under structure requiring work to allow for proper clearance
- Preservation/Restoration (see Table 10.1 and Table 10.2)
- Resurfacing (RSRF10, 15, 20 & 25; see Table 10.1 and Table 10.2)
- Temporary pavements (generally removed prior to project close such as crossovers)
- Culvert (box or circular) replacement associated with pavement sections under 500 ft

All projects not specified above require a structural design. If a project does not require a structural design, then an abbreviated report must be completed as discussed in FDM 14-15-25.2.

FDM 14-15-10 Life-Cycle Cost Analysis (LCCA) — May 17, 2021

10.1 LCCA Process

Pavement type selection is primarily based on the outcome of the LCCA. The LCCA is a process for comparing alternatives over a specified period of time. During this period, each alternative has expenditures for initial construction, maintenance and rehabilitation. The expenditures are converted to present worth costs and then summed together.

To make this process rational, uniform and consistent, the use of WisPave Pavement Design and LCCA computer program is considered policy. Refer to FDM 14-1-1.5 for WisPave access information.

10.2 LCCA Need

10.2.1 State Highways

Table 10.1 identifies which types of projects require an LCCA. Table 10.2 lists types of pavement work that define the different project types listed in Table 10.1. See FDM 11-1 Attachment 10.1 for more information on Improvement Type and Application of Design Criteria.

Table 10.1 Structural Design and LCCA Requirement Criteria

Highway Improvement Type	Improvement Concept Code	Structural Design Required?	LCCA Required?
Preservation/Restoration	PSRS10, 20, 30, 40	No	No
Resurfacing	RSRF10, 15, 20, 25 RSRF30 COLD10, 20	No Yes Yes	No
Pavement Replacement	PVRPLA COLD30	Yes	Yes
Reconstruction	RECST	Yes*	Yes*
Expansion and New Construction	RECSTE BRNEW	Yes*	Yes*
Bridge Preventative	BRPVTV	No	No
Bridge Rehabilitation	BRRHB	No	No
Bridge Replacement	BRRPLE BRRPL	Yes*	Yes*

*Not required when replacing a short segment of pavement between a new or reconstructed bridge and an existing pavement.

***Table 10.2* Types of Pavement Work**

Types of Pavement Work	Improvement Concept Code				
Preservation/Restoration:					
Concrete joint/crack or spot repair	PSRS10				
HMA seal coat, crack fill, surface mill, micro surface	PSRS10				
Concrete repair and grind, slab replace, patch	PSRS20				
HMA patch, rut fill	PSRS20				
Concrete some combo of patch, slab replace, crack repair	PSRS30				
HMA some combo of patch, crack fill, seal coat	PSRS30				
HMA Short term overlay/mill and overlay	PSRS40				
Resurfacing:					
Concrete overlay	RSRF10				
Concrete repair, grind, overlay, patch	RSRF20				
Concrete base or spot repair, patch, slab replace, overlay	RSRF30				
HMA overlays	RSRF10	RSRF15	RSRF20	RSRF25	RSRF30
HMA partial depth mill & overlay	RSRF10	RSRF15	RSRF20	RSRF25	RSRF30
HMA overlay over Cold In-Place Recycling (partial depth)	COLD10	COLD20			
Bridge Rehabilitation:	BRRHB				
Pavement Replacement:					
Concrete rubblization with HMA overlay	PVRPLA				
HMA pulverization with HMA overlay	PVRPLA				
HMA full-depth mill with HMA overlay	PVRPLA				
HMA overlay over Cold In-Place Recycling (full-depth)	COLD30				
Bridge Replacement:	BRRPLE	BRRPL			
Reconstruction:					
New pavement	RECST	BRNEW			
Expansion:					
New pavement	RECSTE	BRNEW			

10.2.2 Local Roads

If the project is not exempt from an LCCA, then refer to Table 10.3 for the pavement type selection method. If the pavement type selection method is based on a life-cycle cost analysis, then see FDM 14-15-10 for LCCA guidance.

***Table 10.3* Pavement Structural Design and Pavement Type Selection for Local Road Projects**

	Posted Speed	Construction Year AADT	Method of Pavement Structural Design and Pavement Type Selection
Rural	Not applicable	Less than 1,500	Based on local experience and knowledge.
	Not applicable	1,500 or greater	Pavement structural design using WisPave and pavement type selection based on life cycle cost analysis.
Urban	Posted Speed Limit of 40 mph or Less	4,500 or less	Based on local experience and knowledge.
		Greater than 4,500	Pavement structural design using WisPave and pavement type selection based on life cycle cost analysis.
	Posted Speed Limit of 45 to 55 mph	Less than 1,500	Based on local experience and knowledge.
		1,500 or greater	Pavement structural design using WisPave and pavement type selection based on life cycle cost analysis.

As previously noted, a Pavement Design Report is required for all local road projects receiving state or federal funds, regardless of the structural design or the pavement type selection method used. Table 10.3 describes the methods to use and document within the report.

10.2.3 Exemptions

A LCCA is not required for the following project types, regardless of road type:

- Auxiliary lanes
- Bridge: approaches
- Bridge: pavement between approaches and existing roadway
- Bridge: pavement under structure requiring work to allow for proper clearance
- Highway Safety Improvement Program (HSIP)
- Jurisdictional Transfer (JT)
- Preservation/Restoration (see Table 10.1 and Table 10.2)
- Ramps
- Reconditioning (see Table 10.1 and Table 10.2)
- Resurfacing (see Table 10.1 and Table 10.2)
- Roundabouts
- Temporary pavements (generally removed prior to project close such as crossovers)
- Transportation Economic Assistance (TEA)

10.3 The LCCA Parameters

The LCCA involves the development of two or more structurally equivalent alternatives, a HMA pavement and a concrete pavement. In addition to the pavement surface type, pavement structures are classified as “drained” and “un-drained. The selection of a drained system should be based on need. In an LCCA, a drained pavement structure should not be compared to an un-drained pavement structure.

Once the structural designs are complete, quantities, bid item costs, future rehabilitation and maintenance costs need to be estimated. WisPave will perform these calculations, then bring them together to complete the LCCA. The LCCA is used only to analyze pavement related costs for each alternative. WisPave is not to be used for PS&E estimates.

10.3.1 Bid Item Costs

WisPave has a list of pavement related bid items for which the user inputs the bid item costs. These costs should consider the quantity of materials as well as the location and type of project being analyzed.

10.3.2 Unit Weights of Materials

Table 10.4 gives unit weights that are used in the quantity computations in WisPave and are considered policy values. These unit weights are based on statewide averages that have been adjusted to better represent typical construction quantities (the goal is statewide uniformity and consistency).

Table 10.4 Material Unit Weights used in WisPave

Material	Unit Weight
HMA Pavement	112 LB/SY/INCH
Base Aggregate Dense 3/4-Inch	2.1 TON/CY
Base Aggregate Dense 1 1/4-Inch	2.0 TON/CY
Base Aggregate Dense 3-Inch	2.2 TON/CY
Base Aggregate Open Graded	1.9 TON/CY
Breaker Run	1.8 TON/CY
Select Crushed Material	1.9 TON/CY
Pit Run	1.8 TON/CY
Granular Backfill Grade 1 or 2	1.7 TON/CY *

*WisPave currently calculates quantities of this material in Tons.

10.3.3 Typical Rehabilitation Scenarios and Standard Sequences

To establish the most probable sequence of rehabilitations for each pavement type, a standard sequence of rehabilitations has been developed. Following this sequence assumes that the initial pavement and the subsequent rehabilitations all perform as expected and are scheduled according to the typical planning and pavement management thresholds.

The actual decision for the rehabilitation will be made in the future based on new technologies and the best practices at that time. To build a uniform, consistent, repeatable and defensible LCCA, the most probable sequence of rehabilitations, based upon today's knowledge and technology, is required. Table 10.5 and Table 10.6 show typical rehabilitation scenarios and standard sequences that should be used as guidance.

Table 10.5 Concrete (JPCP with dowels) Pavement Life Cycle

Scenario	Options*
Initial Construction	New Construction or Reconstruction or Pavement Replacement
First Rehabilitation	Concrete Repair and Grind** or Concrete Repair and HMA Overlay
Second Rehabilitation	Concrete Repair and Grind** or Concrete Repair and HMA Overlay or Mill, Concrete Repair and HMA Overlay
Third Rehabilitation	Concrete Repair and HMA Overlay or Mill, Concrete Repair and HMA Overlay
Reconstruction	Reconstruction or Pavement Replacement (including Rubblization)

*See Table 10.9 for service lives.

**Grinding is not always necessary. The cost can be omitted from WisPave's LCCA by selecting "None" under *Grind Limits*.

Table 10.6 HMA Pavement Life Cycle

Scenario	Options*	
	Traditional HMA Pavements	Deep-Strength or Perpetual HMA Pavements
Initial Construction	New Construction, Reconstruction, or Pavement Replacement	New Construction, Reconstruction, or Pavement Replacement
First Rehabilitation	HMA Overlay** or Mill and HMA Overlay	Mill top layer of HMA plus 1/2-Inch and overlay a minimum of same thickness as removed
Second Rehabilitation	HMA Overlay or Mill and HMA Overlay	Mill top layer of HMA plus 1/2-Inch and overlay a minimum of same thickness as removed
Third Rehabilitation	HMA Overlay or Mill and HMA Overlay	Mill top layer of HMA plus 1/2-Inch and overlay a minimum of same thickness as removed
Reconstruction	Reconstruction or Pavement Replacement (including Pulverization and CIR)	Reconstruction or Pavement Replacement (including Pulverization and CIR)

*See Table 10.9 for service lives.

**Minimum overlay thickness to be determined based on layer thicknesses set forth in Standard Spec 460.3.2

10.3.4 Maintenance Costs

The maintenance costs outlined in Table 10.7 are to be considered as policy values. The costs are estimated based on a typical maintenance sequence identified by Bureau of Highway Maintenance, Highway Maintenance Section. These costs tend to be very erratic, so the use of a statewide average is the most practical approach for use in a LCCA. The cost also includes the maintenance activities for shoulders. These costs will be reviewed periodically and adjusted if warranted.

The maintenance costs are categorized by the pavement surface material. A pavement, regardless of the type, will typically undergo two separate maintenance cycles between rehabilitation or reconstruction activities. The time periods at which the maintenance activities occur are estimated based on the service life of the previous construction or rehabilitation activity. When a pavement is rehabilitated, the maintenance cycle starts over and follows the maintenance sequence for the pavement surface material.

Table 10.7 Maintenance Costs

PAVEMENT SURFACE TYPE	PAVEMENT SURFACE AGE (yrs.) *	One Time Cost per Lane Mile**
Concrete	1/3 of Service Life	$4,000
Concrete	2/3 of Service Life	$8,000
HMA	1/3 of Service Life	$2,000
HMA	2/3 of Service Life	$2,500

*The pavement surface age at the time of maintenance cycles are estimated to occur at 1/3 and 2/3 of the service life of the previous construction or rehabilitation activity.

**Cost per lane mile was reviewed and revised in 2014.

10.3.5 Pavement Design Service Lives

Pavement service lives play a very influential role in the LCCA. The service life is defined as the historical performance life of a pavement treatment, before the next rehabilitation or reconstruction. The following table of service lives contains policy values. The values represent statewide values that are computed from WisDOT's Pavement Management System.

Table 10.8 Initial Service Life

Initial Construction	Service Life (years)
Concrete	25
Concrete (drained)	31
Concrete over Rubblized Concrete	31
HMA – Traditional or Deep-Strength	18
HMA (drained) – Traditional or Deep-Strength	22
HMA – Perpetual	16
HMA over Pulverized HMA	18
HMA over Rubblized Concrete	22
HMA Overlay over Cold In-Place Recycling	18

Table 10.9 Rehabilitation Service Life

Rehabilitation	Service Life (years)
Concrete Pavement Repair and Grind	8
Concrete repair & HMA Overlay	15
Mill, Concrete Repair & HMA Overlay	15
HMA Overlay (over Traditional or Deep-Strength HMA Pavement)	12
Mill and HMA Overlay (over Traditional or Deep-Strength HMA Pavement)	12
HMA Overlay over Continuous Reinforced Concrete Pavement (CRCP)	8
HMA Overlay over Jointed Reinforced Concrete Pavement (JRCP)	8
HMA Overlay over JPCP	15
Mill and HMA Overlay (1^{st} or 2^{nd} Overlay over Perpetual HMA Pavement)	16
Mill and HMA Overlay (3^{rd} Overlay over Perpetual HMA Pavement)	12

The service lives for drained pavement structures are estimates that add 25 percent more life onto like undrained pavement structures. Service lives of pavement rehabilitations over drained bases are considered the same as like pavement rehabilitations over undrained bases.

10.4 The LCCA Computation

After all the LCCA parameters are identified, the LCCA calculation is performed using standard engineering economic analysis procedures for computing present worth costs. WisDOT policy uses a 5% discount rate and a 50-year analysis period. For alternatives that have rehabilitation cycles that extend beyond 50 years, a “Rehabilitation Salvage Value” is calculated and credited back into the alternative’s “Total Facility Cost.” The “Rehabilitation Salvage Value” calculation consists of discounting the linearly prorated rehabilitation cost.

FDM 14-15-15 Exception Process

May 15, 2019

15.1 General

In most cases the lowest Total Facility Cost pavement alternative identified by the LCCA will be the selected pavement structure. However, other factors may influence the choice of a pavement structure.

If the lowest Total Facility Cost LCCA alternative is chosen, then the process is complete. If the cost difference between the desired option and the LCCA low-cost option is ≤5% then the selection is at the pavement designer’s discretion, however supporting documentation must be placed in the project files and included in the Pavement Design Report.

15.1.1 State Highways

If the difference between the desired pavement structure option and the low-cost LCCA option is greater than 5% then a review committee meeting can be requested by the Region Pavement Engineer. This committee is established on a case-by-case basis and consists of region representatives and a Materials Management Section representative designated by the Chief Materials Management Engineer. The responsibility of the committee is to reach a consensus, that is then documented in the Pavement Design Report. The region's designated approving authority approves the Pavement Design Report once the committee has convened and a consensus has been reached.

15.1.2 Local Roads

If the difference between the desired pavement structure option and the low-cost LCCA option is greater than 5% then the local agency is responsible for all costs that exceed the LCCA lowest Total Facility Cost alternative for the entire project length, without regard to the 5% margin.

The regional Local Program Project Manager reviews Pavement Design Reports for projects on the local road system with an exception. As noted above, the local agency is responsible for the difference in costs for the entire project length. If a high-cost alternative is chosen, this information must be documented in the Pavement Design Report.

FDM 14-15-20 Pavement Design Report

May 18, 2020

20.1 Requirement and Purpose

A Pavement Design Report using the template is required for all road projects: Perpetuation, Rehabilitation and Modernization. The purpose of the Pavement Design Report is to document the pavement structure design and method of determination and the Pavement Type Selection process. This report will be used as the basis for pavement type selection approval. By following "Pavement Design Report Content" (FDM 14-15-25) and using the department's pavement design and Life Cycle Cost Analysis (LCCA) software, WisPave 4, uniform and consistent pavement type selections can be determined (Refer to FDM 14-15-25 Attachment 25.1).

A full Pavement Design Report is not needed when a pavement structural design is not required, for these projects, an abbreviated report is sufficient. An abbreviated report must at least include applicable information under *Correspondence/Memorandum, Subject*, *Executive Summary*, *Traffic* and *Exhibits* of the *Abbreviated Pavement Design Report Template* (Refer to FDM 14-15-25 Attachment 25.2).

20.2 Need for Reevaluation

If the treatment type is subject to a structural design and during the project development process, it is observed that the construction year of a project has changed by four or more years, the Pavement Design Report is subject to reevaluation from a structural standpoint, by the regional pavement design engineer. Any reevaluations performed must be documented.

20.3 Pavement Design Report and Certification Approval

20.3.1 State Highways

All Pavement Design Reports and Pavement Design Certifications (Attachments 25.1 & 25.2) for state trunk highway or connecting highway projects are approved and certified in the region by the region's designated approving authority. For any exceptions, follow the process described in FDM 14-15-15.

20.3.2 Local Roads

The Local Public Agency (LPA) approves Pavement Design Reports for local road projects. For any exceptions follow the process described in FDM 14-15-15.

20.4 Pavement Design Report Submittal

20.4.1 WisPave Designs

Pavement Design Reports are reviewed annually for statewide policy conformance. If WisPave is used for the structural design and/or the LCCA, then the 'Status' of the WisPave electronic file should be set as 'Final' on the General Information screen, once it is approved. The electronic file should be left in the WisPave database for at least two years after the approval date.

20.4.2 Reports

20.4.2.1 State Highways

Consultants should electronically transmit their Pavement Design Reports to the regions. Regions should send electronic copies in pdf format of all completed and approved Pavement Design Reports to the Pavements' FTP site (see section FDM 14-15-20.4.2.3) when they are approved or by the end of each state fiscal year.

20.4.2.2 Local Roads

The regional Local Program Project Manager should send electronic copies in pdf format of all completed and approved Pavement Design Reports to the Pavements' FTP site (see section FDM 14-15-20.4.2.3) when they are approved or by the end of each state fiscal year.

20.4.2.3 Viewing and Downloading Reports to the Pavements FTP Site

Pavement design reports can be viewed by authorized persons on the Pavements' FTP site by opening the link below.

ftp://pavuser:dotpave@ftp.dot.wi.gov

From there, select <reports>, then <State> or <Local>, and then the appropriate region folder.

Follow the instructions detailed below to copy reports to the FTP site.

1. Do not open the FTP site by selecting the link above; instead, right click the link above and select <Copy Link Location>.
2. Open Windows Explorer (or an equivalent file managing application), left click in the address bar to highlight the default location, paste the FTP address that's on your clipboard, and then select <Enter>.
3. Select <reports>, then <State> or <Local> to see folders of all five regions. Leave the screen there.
4. Open a second file manager and adjust its size and location on the screen so that it can be viewed next to the FTP site window. Navigate to the folder containing the reports.
5. Copy the Pavement Design Reports to the FTP site by dragging and dropping them, or by copying and pasting them, into the correct regional folder.
6. Name the pavement design report containing design date (current calendar year), region (SWR, SER, NER, NCR, NWR), state (or local), project ID without dash, highway number, and improvement type

   Example: PDR_2020_NCR_State_16200303_STH 13_RSRF10.pdf

To delete files from the Pavements' FTP site, follow steps 1-3 above, and then just select and <Delete>.

FDM 14-15-25 Pavement Design Report Content

May 15, 2019

25.1 Introduction

The purpose of a Pavement Design Report is to bring together all the information that is essential for evaluating alternate pavement designs. The report provides the supporting data and logic for the recommended pavement alternative in a clear and organized way.

25.2 Report Content

Pavement Design Report Templates have been developed to include content in a standard order and format. Use the Pavement Design Report Template in Attachment 25.1 for a full report or Attachment 25.2 for an abbreviated report. An Abbreviated report can be completed in two formats either a word or an excel document. If using the excel document regional traffic information must be imported into the document. Contact the regional planning or traffic sections for the required information. Provide all information in the templates that pertain to the project, all reports should be submitted in pdf format. Table 25.1 provides information regarding the report contents.

The executive summary should be brief and concise; detailed information must be included in the main body of the report. Identify the project improvement type in the executive summary of the report, which should be consistent with one of the improvement types in FDM 3-5-1 and FDM 3-5-5.

If a project is exempt from a structural design or LCCA, according to FDM 14-15-5.2 or FDM 14-15-10.2, respectively, then include justification after the improvement type (e.g. Resurfacing – RSRF20, or Reconstruction - HSIP). If none of the improvement types apply, then *Miscellaneous* can be used followed by a brief description.

If WisPave is used for the pavement design and/or the LCCA, then include the WisPave report in the Pavement Design Report.

Table 25.1 Pavement Design Report Guidance

Subject	Description
Correspondence/Memorandum	If different signatures are needed the pavement engineer may change the signature blocks. Additionally, if more signatures are required the pavement engineer can copy and paste the blocks
Subject	Provide all information.
Executive Summary	The recommend pavement structure items shall be modified as necessary depending on the type of pavement proposed. For projects with multiple pavement types, shoulders which differ from the main pavement type, ramps, side roads, etc. the pavement engineer can copy and paste the information and note which area the information pertains to. Clearly identify the proposed structural design and the basis for its selection.
Project Description	Where the template asks for a year, the calendar that opens up gives the date, month, year, etc. if the actual date is known it can be selected, otherwise choosing any date in the year will place the year only in the document. Where the template references an Exhibit, choose the Exhibit letter corresponding to the Exhibit at the end of the report.
Soil Parameters	Identify the source or author of the Soils Report if different from the person preparing the Pavement Design Report. Reference the WisPave Exhibits.
Traffic Data	This is the data used to calculate the ESALs for the concrete and HMA pavement designs. If traffic data other than traffic projections are used, explain their use here. Reference the WisPave Exhibits. ESALs should be rounded to the nearest 10,000. Note: provide Directional Factor, not Directional Distribution. See FDM 14-7.
Alternatives	State all the alternatives evaluated including pavement type/thickness and base type/thickness, etc. Clearly state why/why not specific layers of the existing pavement structure were utilized and whether the thickness of the existing pavement structure used in the design is average, minimum or other. Provide reference Exhibits for each alternative.
Life-Cycle Cost Analysis	Reference the WisPave exhibits in this section.
Recommendations & Considerations	The pavement type selection process and the exception process are defined in FDM 14-15. If something other than the lowest cost alternative is recommended, provide the reason for this recommendation here. Note also if the design was presented to the pavement review committee.
Other Discussion	Include any other important information or unique circumstances not already discussed.
Exhibits	Provide Exhibits for each alternative presented.

LIST OF ATTACHMENTS

Attachment 25.1 Pavement Design Report Template

Attachment 25.2 Abbreviated Pavement Design Report Template

SAMPLE TRANSMITTAL LETTER

(For a working file of this template: FDM 14-15 A25.1 File 1)

CORRESPONDENCE/MEMORANDUM ____________________ State of Wisconsin

Date: Click or tap to enter a date.

To: Click or tap here to enter text.

From:

Pavement Engineer Name:

Pavement Engineer Title:

Regional Office or Company Name:

Subject: PAVEMENT CERTIFICATION AND DESIGN REPORT
Project I.D.:
Region: Pick Region
Roadway:
Termini:
Highway Number or indicate if local road:
County:

Upon review of the attached pavement design documentation, the pavement type selection recommendation is approved for the above-mentioned project. We certify the Final Pavement Design Report meets the required design criteria.

Reviewed:

X	
Regional Technical Services Designated Approving Authority - Signature, Title	Date

Concurrence:

X	
Regional Project Development Designated Approving Authority - Signature, Title	Date

PAVEMENT DESIGN REPORT

1.0 Subject

Project I.D.:
Region: Pick Region
Roadway:
Termini:
Highway Number or indicate if local road:
County:
Prepared by:
Date Prepared:

2.0 Executive Summary

2.1 Theme Recommended Improvement (PEM): Select improvement concept code.
Proposed Improvement (if different than above): Select improvement concept code.
2.2 Recommended Pavement Structure Description:

Pavement Material: ☐ Concrete ☐ HMA

Location 1: Click or tap here to enter text.
Additional Notes: Click or tap here to enter text.

<table>
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<tr><td rowspan="3">HMA</td><td rowspan="2">Existing Pavement Thickness(in)</td><td rowspan="2">Mill Depth(in)</td><td rowspan="2">Proposed HMA Thickness(in)</td><td colspan="2">Layer Thickness(in)</td><td colspan="2">Mix Type</td></tr>
<tr><td>Lower</td><td>Upper</td><td>Lower</td><td>Upper</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td colspan="3"></td><td colspan="4"></td></tr>
<tr><td rowspan="2">Base Material</td><td colspan="3">Type</td><td colspan="2">Thickness (in)</td><td colspan="2">Drainage? (yes/no)</td></tr>
<tr><td colspan="3">Choose an item.</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td rowspan="2">Subbase Material</td><td colspan="3">Type</td><td colspan="2">Thickness (in)</td><td colspan="2">Subgrade Improvement</td></tr>
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</table>

Existing pavement thickness source: Click or tap here to enter text.

Location 2: Click or tap here to enter text.
Additional Notes: Click or tap here to enter text.

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<tr><td rowspan="3">HMA</td><td rowspan="2">Existing Pavement Thickness(in)</td><td rowspan="2">Mill Depth(in)</td><td rowspan="2">Proposed HMA Thickness(in)</td><td colspan="2">Layer Thickness(in)</td><td colspan="2">Mix Type</td></tr>
<tr><td>Lower</td><td>Upper</td><td>Lower</td><td>Upper</td></tr>
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Concrete Thickness(in)</td></tr>
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(yes/no)</td></tr>
<tr><td colspan="3">Choose an item.</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td rowspan="2">Subbase Material</td><td colspan="3">Type</td><td colspan="2">Thickness (in)</td><td colspan="2">Subgrade Improvement</td></tr>
<tr><td colspan="3"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td rowspan="2">Shoulders</td><td colspan="3">Type</td><td colspan="2">Width (ft)</td><td colspan="2">Thickness (in)</td></tr>
<tr><td colspan="3"></td><td colspan="2"></td><td colspan="2"></td></tr>
</table>

Existing pavement thickness source: Click or tap here to enter text.

2.3 Unique Pavement Related Issues: If applicable.

2.4 Constructability concerns: If applicable.

2.5 Pavement Related Special Provisions: If applicable.

2.6 Pavement Type Selection Basis: Choose method. Enter justification if other is selected.

2.7 Additional Information for Local Road Projects: If applicable.

Rural or Urban: Choose Type.

Posted Speed: Enter Speed Limit.(MPH)

Design AADT: Enter rounded Value.

3.0 Project Description

3.1 Purpose of Project: Can be summarized from MOU, CDR, etc.

3.2 Project Length: Enter number of miles. (miles)

3.3 Number of Lanes: Click here to enter text.

3.4 Functional Classification: Choose Type.

3.5 Roadway Design Classification: Choose an item.

3.6 Design Speed: Enter Speed Limit. (MPH)

3.7 Existing Facility: Enter description.

Year Built: Click here for year.

Number of lanes: Enter number of lanes.

Rehabilitation history: Enter year and type of rehabilitation.

Results of pavement cores (See Exhibit Choose Exhibit.: Pavement Coring/Boring Logs)

Existing pavement structure description: Material type and thickness of each layer.

3.8 Existing Pavement Condition:

PCI Values (Click to pick year.): Minimum = PCI Maximum = PCI

IRI Values (Click to pick year.): Minimum = IRI Maximum = IRI

Type, severity, and extent of surface distress: Enter information here.

4.0 Soil Parameters

4.1 WisPave Design: (See Exhibit Choose Exhibit.: WisPave Report)

Design Group Index (DGI): Choose Value.

Soil Support Value (SSV): Choose Value.

Modulus of Subgrade Reaction (k): Choose value.

4.2 Discussion of predominant soil type: Click here to enter text.

4.3 Any potential construction/future problems or specific information: Click here to enter text.

4.4 Subgrade Improvement: Is SI required?

4.5 Author of soil report and date of soil report: Click here to enter text. (Click here to enter a date.)

5.0 Traffic Data

5.1 WisPave Design: (See Exhibit Choose Exhibit.: Traffic)

Construction Year AADT: Enter AADT. (Enter Year.)

Design Year AADT: Enter AADT. (Enter Year.)

Directional Factor: Enter Number.

Lane Distribution Factor: Choose a factor.

Percent truck traffic (total):

Percent of AADT for each truck type:

Truck Type	% of AADT
2D	
3-SU	
2-S1, 2-S2	
3-S2	
SBL-BTM	
Total % of Trucks	

Design ESALs:

ESALs for concrete pavement: Enter rounded value

ESALs for HMA pavement: Enter rounded value

6.0 Alternatives

6.1 Brief discussion of pavement structure alternatives: Click or tap here to enter text.

Name of Alternative	Pavement (type/width/thickness)	Base (type/thickness)	Subbase (type/thickness)	Shoulder (type/width/thickness)

Explain how existing pavement layers will be utilized: Click or tap here to enter text.

7.0 Life Cycle Cost Analysis (LCCA)

7.1 LCCA alternatives:

Alternatives				
Initial Const. Costs				
Total Facility Costs				
Percent Difference				

8.0 Recommendations and Considerations

8.1 Is LCCA low cost selected? Choose an item.

If no, Choose an item.

If Review Committee selected:

Name of committee members: Click or tap here to enter text.

Date: Click here to enter a date.

Location: Click or tap here to enter text.

Outcome: Click or tap here to enter text.

If Not Applicable selected:

Provide justification for selected alternative: Click or tap here to enter text.

8.2 Local Road Projects: Choose an item.

Low cost selected? Choose an item.

If no, Choose an item.

Local Program Project Manager review.

Date: Click here to enter a date.

Outcome: Click or tap here to enter text.

8.2 Preference of any cost sharing participant and cost share required: Click here to enter text.

8.3 Discussion of results if presented before the “5% Rule” review panel: Click here to enter text.

9.0 Other discussions (if applicable)

9.1 Crossovers: Click here to enter text.

9.2 Detours: Click here to enter text.

9.3 Ramps: Click here to enter text.

9.4 Roundabouts: Click here to enter text.

9.5 Side Roads: Click here to enter text.

9.6 Temporary Roads: Click here to enter text.

9.7 Transition Sections: Click here to enter text.

10.0 Exhibits

Exhibit Choose Exhibit.: Concept Documentation (CDR, PMP, Masterworks, other)

Exhibit Choose Exhibit.: Project Location Map

Exhibit Choose Exhibit.: Pavement Coring/Boring Logs

Exhibit Choose Exhibit.: Traffic

Exhibit Choose Exhibit.: FWD Report/Analysis

Exhibit Choose Exhibit.: WisPave Report (all alternatives considered including rehabilitations)

Click or tap here to enter text.	Click here to enter a date.
Pavement Design Engineer	Date

SAMPLE TRANSMITTAL LETTER

(For a working file of this template: FDM 14-15 A25.2 File 2 - WORD)
(For a working file of this template: FDM 14-15 A25.2 File 2 - EXCEL)

CORRESPONDENCE/MEMORANDUM ____________________ State of Wisconsin

Date: Click here to enter a date.

To: Click or tap here to enter text.

From:

Pavement Engineer Name:

Pavement Engineer Title:

Regional Office or Company Name:

Subject: ABBREVIATED PAVEMENT DESIGN AND CERTIFICATION REPORT
Project I.D.:
Region: Pick Region
Roadway:
Termini:
Highway Number or indicate if local road:
County:

Upon review of the attached abbreviated pavement design documentation, the pavement type selection recommendation is approved for the above-mentioned project. We certify the Final Abbreviated Pavement Design Report meets the required design criteria.

Reviewed:

X	
Regional Technical Services Designated Approving Authority - Signature, Title	Date

Concurrence:

X	
Regional Project Development Designated Approving Authority - Signature, Title	Date

ABBREVIATED PAVEMENT DESIGN REPORT

(*required information)

<u>*1.0 Subject</u>
Project I.D.:
Region: Pick Region
Roadway:
Termini:
Highway Number or indicate if local road:
County:
Prepared by:

Date prepared: Click here to enter a date.

<u>2.0 Executive Summary</u>
*2.1 Theme Recommended Improvement (PEM): Select improvement concept code.
Proposed Improvement (if different than above): Select improvement concept code.
2.2 Recommended Pavement Structure Description:
*Pavement Material: ☐ Concrete ☐ HMA
Location 1: Click or tap here to enter text.
Additional Notes: Click or tap here to enter text.

<table>
<tr><th rowspan="3">HMA</th><th rowspan="2">Existing Pavement Thickness(in)</th><th rowspan="2">Mill Depth(in)</th><th rowspan="2">Proposed HMA Thickness(in)</th><th colspan="2">Layer Thickness(in)</th><th colspan="2">Mix Type</th></tr>
<tr><th>Lower</th><th>Upper</th><th>Lower</th><th>Upper</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><th rowspan="2">Concrete</th><td colspan="3">Existing Pavement Thickness(in)</td><td colspan="4">Proposed Concrete Thickness(in)</td></tr>
<tr><td colspan="3"></td><td colspan="4"></td></tr>
<tr><th rowspan="2">Shoulders</th><td colspan="3">Type</td><td colspan="2">Width (ft)</td><td colspan="2">Thickness (in)</td></tr>
<tr><td colspan="3"></td><td colspan="2"></td><td colspan="2"></td></tr>
</table>

Existing pavement thickness source: Click or tap here to enter text.

Location 2: Click or tap here to enter text.

Additional Notes: Click or tap here to enter text.

<table>
<tr><td rowspan="3">HMA</td><td rowspan="2">Existing Pavement Thickness(in)</td><td rowspan="2">Mill Depth(in)</td><td rowspan="2">Proposed HMA Thickness(in)</td><td colspan="2">Layer Thickness(in)</td><td colspan="2">Mix Type</td></tr>
<tr><td>Lower</td><td>Upper</td><td>Lower</td><td>Upper</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Concrete</td><td colspan="3">Existing Pavement Thickness(in)</td><td colspan="4">Proposed Concrete Thickness(in)</td></tr>
<tr><td colspan="3"></td><td colspan="4"></td></tr>
<tr><td rowspan="2">Shoulders</td><td colspan="3">Type</td><td colspan="2">Width (ft)</td><td colspan="2">Thickness (in)</td></tr>
<tr><td colspan="3"></td><td colspan="2"></td><td colspan="2"></td></tr>
</table>

Existing pavement thickness source: Click or tap here to enter text.

2.3 Unique Pavement Related Issues: If applicable.

2.4 Constructability concerns: If applicable.

2.5 Pavement Related Special Provisions: If applicable.

2.6 Additional information for Local Road Projects: If applicable.

Rural or Urban: Choose Type.

Posted Speed: Enter Speed Limit.(MPH)

Design AADT: Click here to enter text.

2.7 Preference of any cost sharing participant and cost share required: Click here to enter text.

3.0 Traffic

3.1 Traffic data:

*Design ESALs: Enter rounded Value.

Construction Year AADT: Enter AADT. (Enter Year.)

Design Year AADT: Enter AADT. (Enter Year.)

Percent of AADT for each truck type:

Truck Type	% of AADT
2D	
3-SU	
2-S1, 2-S2	
3-S2	
SBL-BTM	
Total % of Trucks	

4.0 Exhibits (if applicable)

Exhibit Choose Exhibit.: Concept Documentation (CDR, PMP, Masterworks, other)

Exhibit Choose Exhibit.: Project Location Map

Exhibit Choose Exhibit.: WisPave Report

Click or tap here to enter text.	Click here to enter a date.
Pavement Design Engineer	Date

FDM 14-25-10 Pavement Rehabilitation Guidelines

May 15, 2019

10.1 General

These guidelines are intended to help determine the best method for rehabilitating pavements. Pavement rehabilitation is a structural or functional enhancement that extends the pavement life, by significantly improving the pavement condition and ride quality.

The recommendations presented are intended as general guidance for the pavement evaluation process and are not intended as absolute criteria applicable to all circumstances. Therefore, each project must be evaluated on its own merits.

An important preliminary activity is an assessment of the existing condition of the pavement. This assessment examines the International Roughness Index (IRI) and Pavement Condition Index (PCI) history and draws conclusions from that data. The assessment should also include a field survey of the project for evaluating pavement condition and estimating repair quantities.

A visual survey, involving a field review of the pavement in person, does have limitations. The level of distress at a joint or crack may not be fully determined simply by visual inspection of the surface. However, it is not in the scope of any one design project to core or perform nondestructive testing on every joint or crack to determine if there is underlying distress. Therefore, the designer must rely on resources such as PMDSS, the Concrete Pavement Rehabilitation Manual, and the limited coring performed on each project.

The base and subgrade conditions also play a significant role in performance. If serious base and/or subgrade problems exist, then a more extensive rehabilitation may be needed. Designers should request their Regional Soils engineer to drill soil borings and help determine the cause of the base or subgrade problems. If a more extensive rehabilitation level cannot be attained, a lower level of performance can be expected of the rehabilitation. It is important to determine the cause of the distress so that the correct rehabilitation strategy can be identified.

One of the key criterion governing the choice of a pavement rehabilitation strategy is the amount of existing pavement in need of repair. When the amount of repair necessary exceeds an amount economically feasible for the project, the pavement should be reconstructed. Each project should be evaluated individually utilizing Life Cycle Cost Analysis to determine if rehabilitation or reconstruction is most cost effective.

Typically, the term repair refers to a full depth procedure, except in the case of Partial Depth Repair. Just as typically, the term “patch” refers to a partial depth procedure.

10.2 Concrete Pavement

There are several distresses in concrete pavements that justify a pavement rehabilitation. Some common distresses are transverse or longitudinal cracking, joint deterioration, and faulting. Concrete pavement rehabilitation methods used by WisDOT consist of full/partial depth repair, slab replacement, diamond grinding, and rubblization. More guidance on concrete pavement rubblization can be found in FDM 14-25-15.

The May 1992 version of the Concrete Pavement Rehabilitation Manual (Exhibit 10.1) should be used as a resource for estimating repair quantities. This manual provides the methodology, based upon type and rehabilitation strategy, for the assessment of distresses in concrete pavements.

If *Concrete Pavement Repair* or *Concrete Pavement Repair SHES* are part of a project, designers should also consider including *Concrete Pavement Replacement* and *Concrete Pavement* bid items since unforeseen pavement patching/repairs may extend beyond 15 feet in length.

10.3 Hot Mix Asphalt (HMA) Pavement

There are several distresses in HMA pavements that justify a pavement rehabilitation. Some common distresses are alligator/fatigue cracking, centerline joint deterioration, reflective cracking, and rutting. Common methods of HMA pavement rehabilitation used by WisDOT are mill and overlay, Cold In-Place Recycling(CIR), and pulverization. More guidance on HMA pavement pulverization can be found in FDM 14-25-20 and CIR in FDM 14-25-25.

LIST OF EXHIBITS

FDM 14-25-15 Concrete Pavement Rubblization

November 15, 2022

15.1 General

The purpose of this procedure is to provide guidance on rubblization of concrete pavement. Further guidance can be found in CMM 3-50. The use of crack/break and seat is not recommended on the state trunk highway system.

The objective of rubblizing concrete pavement is to produce a structurally sound base and to prevent reflective cracking in an overlay by destroying the integrity of the existing slab. This objective is achieved by fracturing the distressed concrete pavement in place, thereby reducing the concrete to rubble. The rubblized material acts as an interlocked unbound layer comparable to a high-quality aggregate base.

The rubblization process is applicable to Jointed Plain Concrete (JPC), Jointed Reinforced Concrete (JRC), and Continuously Reinforced Concrete (CRC) pavement. Reinforcing steel in JRC and CRC pavement must become debonded from the concrete to be successful and meet the performance expectations.

Rubblization, along with an HMA or concrete overlay, is considered pavement replacement. Conform with FDM 14-15-10, Table 10.2 for standard rehabilitation scenarios.

15.2 Why Rubblize

Reflective cracking is a major problem in HMA overlays placed over intact concrete pavement, even when used in combination with other repair techniques (such as slab-jacking, partial and full-depth slab replacement, etc.). Reflective cracks can start to appear in the overlay within a few years after overlay placement. These reflective cracks then should be sealed and maintained to prevent further deterioration of the overlay. Rubblization addresses the reflective cracking problem by thoroughly fracturing the concrete pavement to produce a uniform, high quality base, thus eliminating slab action. Some benefits to rubblization include:

- Prevents reflective distresses in the overlay
- Recycles concrete into a high-quality base material
- Reduces or eliminates the need to haul the existing concrete
- Can be accomplished next to live traffic lanes
- Can be accomplished over existing utilities
- Can be accomplished in urban and rural situations
- Reduces time of construction

15.3 Selecting Rubblization Projects

Rubblization is an effective pavement replacement technique in many situations, but inadequate project scoping can lead to constructability problems. Proper project scoping should follow these steps:

1. Check the condition of the existing concrete pavement
2. Check for roadway features
3. Verify subgrade conditions

15.3.1 Condition of Existing Concrete Pavement

Determine the condition and distresses of the existing concrete pavement. Rubblization is considered a viable option when the concrete pavement has no remaining life – i.e., exhibits extensive structural distress along the project. Remedial action may need to be performed on joints prior to rubblization. However, there may be cases where the pavement is far too deteriorated for rubblization to be used as a valid treatment, i.e, wide open joints, severe faulting.

To maximize the initial construction investment of the concrete pavement, rubblization should be considered when one or more of the following structural deficiencies exist(s):

- Greater than 20% of the concrete pavement joints need repair
- Greater than 20% of the concrete surface has been patched
- Greater than 20% of the concrete slabs exhibit the “slab breakup” pavement distress
- Greater than 20% of the project length exhibits “longitudinal joint distress” greater than 4 inches wide

If delamination is present in the existing concrete pavement, additional breakage and/or equipment may be needed.

15.3.2 Roadway Features

Many conditions need to be addressed before rubblizing. The following is a non-inclusive list of roadway features that need to be addressed in the design phase:

- Matching into existing curb and gutter that will remain in place (milling is required)
- Cross-slope correction (milling or additional material may be required)
- Location of any utility structures, e.g., manholes, catch basins (positive identification for construction)
- Profile changes (check overhead clearances)
- Existing shoulder pavement structure (if required for handling traffic)
- Underlying rigid layer, e.g., bedrock, an old intact concrete pavement (additional breakage may be needed)
- Old/brittle underground utilities (gas lines, water lines, etc.) that are within 4 feet of the rubblized layer (requires detailed evaluation)

FDM Chapter 11 contains additional feature constraints.

15.3.3 Subgrade Conditions & Drainage

Past construction practices of paving concrete pavement directly on subgrade or “weak” subgrade make rubblization susceptible to subgrade yielding problems during construction operations. Consult the Regional Soil engineer for guidance on classifying the soil and the assignment of a Design Group Index (DGI) value. Based on WisDOT research and experience, the rubblization construction process experiences difficulties with soil classified with a DGI greater than 12 (AASHTO A-6 & A-7 classification) or when the water table is less than 4 feet from the top of the existing subgrade. If the water table is less than 4 feet from the top of the existing subgrade, a more detailed investigation may be needed. Consult the Regional Soil engineer for guidance.

It is not statewide standard practice to use edge drains on rubblization projects. However, rubblizing the concrete slabs significantly increases the permeability of the concrete layer, and any surface water entering the rubblized layer can be removed through the use of edge drains, especially for pavements supported by fine-grained soils with low permeability. In areas with coarse-grained soils that have high permeability, edge drains are not typically needed. If a drainage system is desired, the edge drains and outfalls can be designed similar to typical drainage systems when open graded base course is used on a project. The use of drains in spot locations is an acceptable practice.

15.3.3.1 Edge Drains

When used, edge drains should be installed before rubblizing to ensure that there is sufficient time to allow the subbase and subgrade to drain and dry out. If edge drains are installed before rubblizing, attention must be paid to ensure that the trench is well compacted and protected. An HMA layer may be paved over the trench before allowing traffic next to the trench. If staging requires a high volume of traffic over the trench for an extended period, an HMA layer should be placed over the trench. Consult the Regional Soil engineer to determine any drainage needs of rubblization projects.

15.3.3.2 Subgrade Investigation

To help determine the foundation support conditions and strength before construction, a supplementary subgrade investigation can be performed. Falling Weight Deflectometer (FWD), Ground Penetrating Radar (GPR) and Dynamic Cone Penetrometer (DCP) testing are methods used to evaluate the current subgrade condition. FWD and GPR testing will provide information on subgrade uniformity, and the computed Resilient Modulus (M_R) values. DCP testing, which requires coring of the existing concrete pavement, will provide information on the subgrade bearing capacity. Contact the Geotechnical Unit supervisor at (608) 246-7952 to request subgrade testing for a project. For the DCP testing method, the Department recommends the following procedure:

Determine the base course thickness from as-built plans. Penetrate the rod of the DCP to the bottom of the base course, i.e. to the top of the subgrade. From that point, record the Penetration Rate (PR), in inches per blow, until a rock or other obstruction is hit or until the rod cannot go any deeper. The PR for that location can be an average or a common value of the individual recordings. Using Figure 15.1, convert the PR to the California Bearing Ratio (CBR). Then, use Figure 15.2 to determine whether the subgrade, rubblized concrete, and base aggregate layer provide enough support to accommodate the construction process, or whether any remedial action is required. Use the CBR value determined from Figure 15.1 as the x-axis value for Figure 15.2. The y-axis value can be calculated by adding the thickness of any existing base aggregate to the thickness of the rubblized concrete pavement. The intersection of these values identifies a support relationship that is to be compared to the curve shown in Figure 15.2. If the support relationship falls above the curve, then adequate support for construction is present. If the support relationship falls below the curve, then remedial improvements to the base structure are required. An intermediate base layer can be used to provide the required support.

Note that the figures could also be used in reverse order by first determining the minimum CBR needed, then determining the maximum penetration rate permissible to provide adequate support.

Each DCP test location along a project should be analyzed individually. The individual tests should also be compiled and the information looked at in unison to arrive at generalized project conditions for pavement design. Additional testing in soft/weak areas may be needed to determine the exact limits requiring remedial improvements.

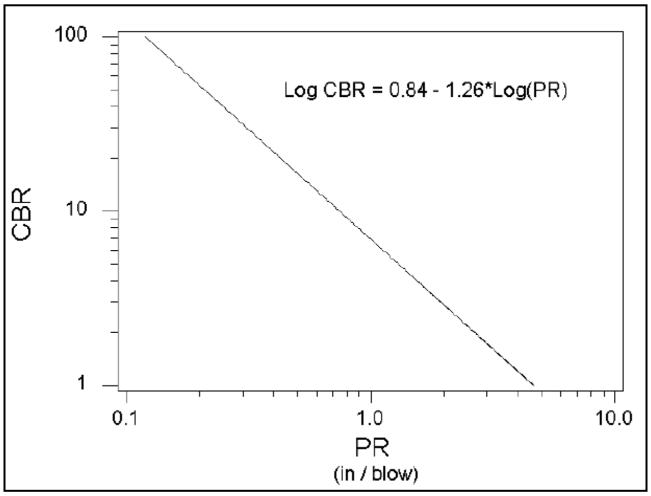


Figure 15.1. DCP Data Conversion to CBR

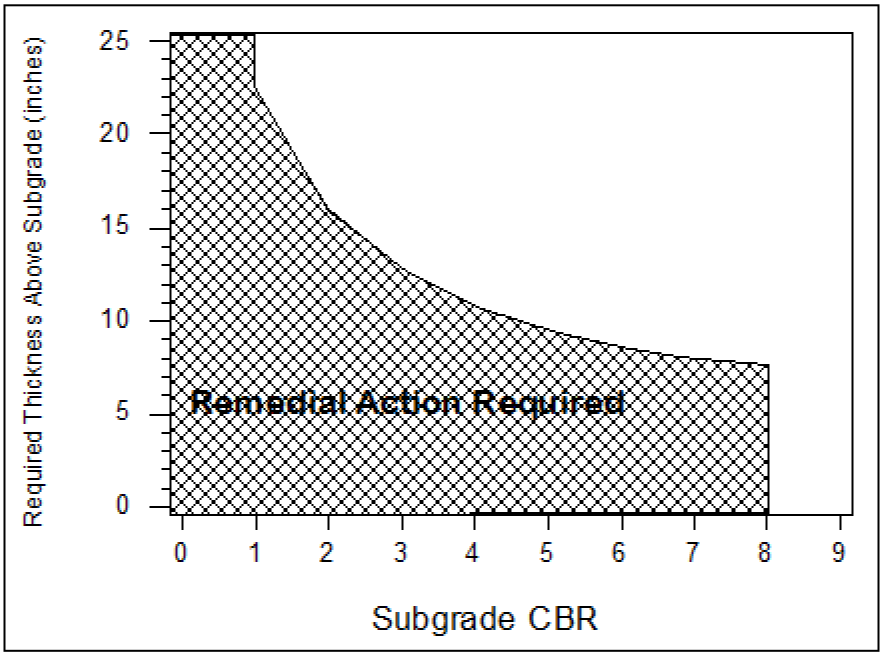


Figure 15.2. Subgrade/Base Layer Adequacy

For localized areas of poor stability, the specification allows for some modification to the broken particle sizes during construction. Excavation Below Subgrade (EBS) or increasing the overlay thickness are other possible solutions for these poor areas. It is important to remember that the rubblized layer must still provide a good working platform for paving operations and a stable foundation for the new pavement.

It should be noted that judgment is involved in determining existing and corrective subgrade needs. DCP and

FWD test results are dependent on the subsurface conditions at the time of testing and may differ from the conditions at the time of construction. The time of year construction occurs and the amount of rainfall during construction may have a large effect on subgrade stability.

15.4 Structural Design

WisPave is WisDOT's official software for pavement structural design.

15.4.1 HMA Pavement

When determining the HMA overlay thickness, both constructability and structural requirements of the rubblized pavement must be satisfied. The specific design input is the structural layer coefficient for each structural layer within the flexible pavement. The structural capacity of the entire pavement structure is represented using the Structural Number (SN) index, which is a sum of the product of the layer coefficient and layer thickness of all layers. The nationwide typical structural layer coefficient assigned to the rubblized layer is in the range of 0.14 to 0.30. Wisconsin policy is to use a range of 0.20 to 0.24.

The minimum HMA overlay thickness placed over rubblized concrete is 4 inches from a constructability standpoint. The first layer of HMA must be thick enough to adequately cover the rubblized concrete pavement and carry the expected construction traffic temporarily until the additional layers are placed. When making cross-slope corrections with the first layer of HMA pavement, maintain an adequate thickness at both the centerline and the edge of the pavement. Minimum HMA pavement layer thicknesses are found in Standard Spec 460.3.

Estimated quantities for the first layer of HMA are to be calculated by using the following formula:

Width (ft) x Length (ft) x [{112 lb/SY/inch x Depth (inch)} + 20 lb/SY] x 1 SY/9 ft^2 x 1 ton/2000 lbs = _____ tons

This method adds 20 lb/SY to account for possible irregularities in the rubblized surface.

15.4.2 Concrete Pavement

Give credit to the rubblized material in the thickness design by increasing the k value, provided in the soils report, by an amount directly related to the thickness of the rubblized concrete pavement. Table 15.1 indicates the increase in the k value for different thicknesses of rubblized material. These values should be interpolated for intermediate thicknesses. The modified k value should be used in WisPave to determine thickness design.

***Table 15.1* Modified k Values for WisPave**

Thickness of Rubblized Material	Increase in k Value
Less than 6"	0
6"	45
8"	90
10"	120
12"	150
16" and up	175

When placing concrete pavement over rubblized concrete, a bond breaker layer must be used. This should be a thin layer (about 1 1/2 inches) of asphalt treated permeable base, standard HMA pavement, open graded base, dense graded base. The purpose of the bond breaker is to allow for curling and warping of the concrete pavement. A bond breaker does not affect the structural coefficient of the rubblized material.

15.4.3 Intermediate Base Layer

The surface of the rubblized concrete layer cannot be bladed with a motor grader but is generally suitable for paving over.

If an intermediate base layer is proposed to restore the grade, make cross-slope corrections, and/or to improve base support, the following materials (and associated bid items) can be specified:

ITEM NUMBER	DESCRIPTION	UNIT
305.0110	Base Aggregate Dense 3/4-Inch	TON
305.0115	Base Aggregate Dense 3/4-Inch	CY
305.0120	Base Aggregate Dense 1 1/4-Inch	TON
305.0125	Base Aggregate Dense 1 1/4-Inch	CY
306.0110	Salvaged Asphaltic Pavement Base	TON
306.0115	Salvaged Asphaltic Pavement Base	CY

An intermediate base layer should be a minimum of 4 inches thick for constructability purposes. Therefore, it should be accounted for in the structural design. The structural coefficient of the rubblized layer should not exceed the structural coefficient of the intermediate base layer material. The layers of a HMA pavement structure are usually arranged such that the quality of materials decreases with increasing depth. Rubblized concrete pavement is allowed a structural coefficient ranging from 0.20 to 0.24, and an intermediate base layer can consist of several materials ranging in coefficients from 0.10 to 0.25. Therefore, depending on material used, an intermediate base layer can decrease the structural coefficient of the rubblized material. (FDM 14-10, Attachment 10.1)

When estimating quantities add 20 lb/SY to account for possible irregularities in the rubblized surface.

15.5 Structure Clearance

Often, special circumstances are required to accommodate overhead structure clearances. Each situation must be evaluated to determine which design will best provide long-term pavement performance while meeting project requirements.

Options available in these areas include reconstruction, partial-depth concrete milling and pavement inlay, or simply an overlay.

Some factors to consider are:

- Reconstruction: Existing elevations can be maintained or even lowered. Reflective cracking is eliminated.
- Partial-depth concrete milling and pavement inlay: This process can be completed quickly and under traffic. Existing elevations can be maintained. Reflective cracking of the overlay should be expected.
- Overlay: This process can be completed quickly and under traffic. The pavement elevation will increase but not as much as with the rubblize and overlay alternative. Reflective cracking of the overlay should be expected.

15.6 Other Considerations

Any existing asphaltic overlay must be removed before rubblizing the underlying concrete. This will require a separate bid item. Full-depth concrete pavement repair is not necessary. Full-depth asphalt patches, in good condition, may remain in place. Refer to Standard Spec 335.3.3 for the removal requirements of other materials. For severely deteriorated concrete joints not previously repaired, replace the joint with concrete base patching prior to rubblization or remove the joint and replace with base aggregate dense 1 1/4-inch or 3/4-inch.

15.7 Staging

If staging is required for a rubblization project, special consideration must be given in certain areas.

15.7.1 Shoulders and Edge Drains

It is vital to protect the shoulders and edge drains. Following are three common staging scenarios along with a suggestion for protecting the shoulder and edge drains:

1. Roadway closed to traffic: edge drain system is installed, concrete is rubblized, and asphalt overlay is paved on travel lanes and shoulders before opening to traffic.
2. Construction with single lane closures and edge drains installed in advance of rubblizing and paving operation: the edge drain trench is capped either with HMA, crushed aggregate, or asphalt millings to provide an adequate shoulder before opening the adjacent lane to traffic.
3. Construction with single lane closures and edge drain installed just ahead of rubblizing: edge drain system is installed, concrete is rubblized, asphalt overlay is paved on the closed lane and adjacent shoulder before opening to traffic.
4. Edge drains should be maintained to provide proper performance for the life of the pavement.

15.7.2 Traffic Over Rubblized Concrete

The rubblized pavement should not carry traffic. It is best to provide traffic control that will not allow traffic to travel on rubblized pavement or on a thin layer of HMA over the rubblized pavement. If traffic must travel on one layer of HMA over the rubblized pavement, a sufficient HMA thickness must be in place.

If staging requires that traffic travel on an intermediate layer of HMA pavement before the full pavement is placed, consider providing an undistributed quantity of patching in the contract. Patching can be specified under one or more of the following bid items:

ITEM NUMBER	DESCRIPTION	UNIT
390.0103	Base Patching	SY
390.0201	Base Patching Asphaltic	TON
390.0203	Base Patching Asphaltic	SY
465.0110	Asphaltic Surface Patching	TON

15.7.3 Ramps and Intersections

Stage the rubblization and paving at ramps and intersections to maintain traffic flow. Require the contractor to provide proper traffic control.

FDM 14-25-20 HMA Pavement Pulverization — May 15, 2019

20.1 General

Pulverization is a pavement replacement technique that involves the in-place, full-depth pulverizing and mixing of an HMA pavement and a predetermined amount of the underlying base material. The objective of pulverization is to produce a structurally sound, homogeneous base and to prevent reflective cracking by reducing the distressed HMA pavement into a base material.

Pulverize and relay differs from mill and relay in that pulverize and relay cannot be performed on HMA pavements over concrete, whereas mill and relay can. The other major difference between the two techniques is the size of the reprocessed material. See Standard Spec 325 and Standard Spec 330.

Pulverization is considered a pavement replacement option. Conform with FDM 14-15-10, Table 10.2 for standard rehabilitation scenarios.

20.2 Why Pulverize

Overlaying an HMA pavement may result in reflective cracking, premature pavement distress, and reduced overlay performance. Pulverization addresses these problems by reprocessing the entire HMA pavement in-place to produce a uniform, high quality base material.

Pulverization benefits include:

- Can be accomplished next to live traffic lanes
- Can be accomplished over existing utilities
- Can be accomplished in urban and rural situations
- Reduces or eliminates the need to haul material
- Provides a window of opportunity to fix localized subgrade problems
- Recycles HMA into a base material
- Provides a high-quality base material
- Prevents reflective distresses

20.3 Selecting Pulverization Projects

Pulverizing is an effective pavement replacement technique in many situations, but inadequate project scoping can lead to constructability problems. Proper project scoping should follow these steps:

- Check the condition of the existing HMA pavement
- Check for roadway features
- Verify subgrade conditions

20.3.1 Existing HMA Pavement

Any HMA pavement, except those directly on concrete, can be pulverized. To maximize the initial construction investment of the HMA pavement, pulverization should be considered after at least one rehabilitation cycle, or when one or more of the following structural deficiencies exist(s):

- Alligator cracking
- Block cracking
- Extensive potholing or patching
- Structural rutting
- Longitudinal or transverse distortion (e.g. shoving or tenting)
- Extensive transverse cracking (banded or spacings (10 feet)

20.3.2 Roadway Features

Many conditions need to be addressed prior to pulverizing. The following is a non-inclusive list of roadway features that need to be addressed in the design phase:

- Matching into existing curb and gutter that will remain in place
- Cross-section
- Location of any utility features
- Profile changes

FDM Chapter 11 contains additional feature constraints.

20.3.3 Verify Roadway and Subgrade Conditions

The pavement must be cored to determine the HMA thickness. The base thickness and the condition of the subgrade should be determined by roadway borings. Coring and boring logs or a summary table showing pavement thickness, base thickness, and subgrade information should be included in the plans.

HMA pavements that were placed on very thin base materials may be problematic during pulverization in that the pulverizer may get into the subgrade material. The pulverized material may also be susceptible to subgrade yielding problems if the thickness of the pavement or base materials is inadequate. If poor subgrades exist, improvements to the subgrade are required. It is important to remember that the pulverized layer must still provide a good working platform for paving operations and a stable foundation for the new pavement. Susceptible soils can also be problematic if the pulverized material is inadequately compacted or unpaved and exposed to rain. Each project must be individually analyzed during the design phase for potential problems.

If the pulverized material will not provide adequate base thickness or desired gradation, additional base material may be added. Additional base material should be spread on the existing pavement and pulverized with the pavement if possible. If not, consider limiting exposure to rain.

If the pulverized material will not have the structural strength or necessary mechanical properties to support the traffic loads, additional base material and/or a stabilizing additive (such as liquid asphalt, foamed asphalt, asphalt emulsion, or fly ash) may be required.

Additional required materials will be paid for separately.

20.4 Structural Design of Pavements Over Pulverized Material

WisPave is Wisconsin DOT’s official software for pavement structural design.

20.4.1 HMA Pavements

Use WisPave to design HMA pavements over pulverized material using the structural layer coefficients guidance given below.

20.4.2 Structural Layer Coefficients

Pulverized material can vary in both strength and stability; therefore, its structural layer coefficient ranges from 0.10 to 0.25. Despite the thickness of the existing HMA, one to two inches of the existing base material is typically incorporated with the pavement thereby producing a blend of pavement and base material. If a thin HMA pavement (e.g., 3 inches) is pulverized, and another 1-2 inches of base material is mixed with it, the net effect is essentially an aggregate base layer with a layer coefficient typical of crushed stone or crushed gravel (0.14 or 0.10). On the other hand, if a thick HMA pavement (6 inches or greater) is subject to the same operation, producing a blend of predominantly pavement material, the net effect is a layer coefficient greater than that of aggregate base material. When pulverizing these thick pavements, a structural layer coefficient as high as 0.25 can be used if the base consists of crushed stone. An important factor in the range for this material is whether the existing base material is crushed gravel or crushed stone. In the absence of this knowledge, it is recommended that a crushed gravel be assumed. The type of aggregate within the HMA pavement to be pulverized is irrelevant.

Table 20.1 provides guidelines to determine the appropriate structural layer coefficients of the material:

Table 20.1 Structural Layer Coefficients

Percentage of Base Material in Pulverized Mix (%)	Structural Layer Coefficient	
	Crushed Gravel or Unknown Base	Crushed Stone Base
> 25	0.10	0.14
> 20 and ≤ 25	0.14	0.18
> 14 and ≤ 20	0.18	0.22
≤ 14	0.21	0.25

Note: Use 0.25 as a structural layer coefficient if a stabilizing additive is used.

20.4.3 Minimum HMA Thickness

Consider the thickness of the first layer of HMA. It must be thick enough to adequately cover the pulverized material and carry traffic temporarily until the additional layer or layers is/are placed. Minimum HMA pavement layer thicknesses are specified in Standard Spec 460.3. Cross-slope corrections should typically be done while re-shaping and compacting the pulverized material. However, when making cross-slope corrections with the first layer of HMA pavement, maintain an adequate thickness not only at the centerline but also at the edge of the pavement.

20.4.4 Concrete Pavements

Credit should be given to the pulverized material in the thickness design. This should be done by increasing the k value by an amount directly related to the thickness of the pulverized material. Table 20.2 indicates the increase in the k value for different thicknesses of pulverized material. These values should be interpolated for intermediate thicknesses. The modified k value should be used in WisPave to determine thickness design.

Table 20.2 Modified Values for WisPave

Thickness of Pulverized Material	Increase in k Value
Less than 6”	0
6”	30
8”	50
10”	80
12”	120
16” and up	150

20.5 How to Pulverize

Any HMA patches may remain in place. Loose asphaltic joint fillers visible on the pulverized surface must be removed before the new pavement is placed.

The maximum pulverizing depth of most pulverizers in one pass is 16 inches. The pulverization process must include a minimum of one inch of base material to provide cooling for the pulverizer. HMA pavements greater than 15 inches must be milled prior to pulverizing. The standard width that can be pulverized in one pass is 8 feet. To achieve proper compaction, it is important that a sufficient amount of water be added. Therefore, it is recommended that water be paid for as a separate bid item at a rate of 10 gallons/ton of pulverized material. The volume increase of the pulverized material, after compaction, is approximately 10-15 percent. The pulverization specifications are located in Standard Spec 325.

Selecting an appropriate pulverization depth depends on the uniformity of pavement thickness, as determined from the cores. Avoid getting into the subgrade.

HMA shoulders will be pulverized with and at the same depth as driving lanes. Base shoulder material, extending beyond or in lieu of HMA shoulders, can be left in place if the structure is not to be widened.

The characteristics of the compacted pulverized base will vary depending on the grade of the existing asphalt, temperature, amount of aggregate in the mix, and any stabilizing additives used.

20.6 Pavement Design Report

Specify in the Pavement Design Report, the depth of base material to be pulverized and the width to which the material should be spread.

20.7 Pavement Widening

The existing shoulder material and the finished cross-section should both be considered if the pavement is to be widened. HMA shoulders will be pulverized with and at the same depth as driving lanes. Treatment options of base shoulder material, extending beyond or in lieu of HMA shoulders, include:

- Excavating and spreading the existing base shoulder material onto the existing pavement before pulverizing
- Moving existing base shoulder material so it is not pulverized.

The pulverized material shall be spread across the desired widened width to provide a homogeneous mixture. Quantity is to be paid for per Standard Spec 325.4 or Standard Spec 325.5.

20.8 Curb and Gutter

Pre-milling along the edge of the gutter is required. Excess material may be hauled or stockpiled for other uses. These items will be paid for according to Standard Spec 330.

20.9 Structure Clearance

Special considerations are often required to accommodate structure clearances. Each situation must be evaluated to determine which design will best provide long-term pavement performance while meeting project requirements. Options available in these localized areas include:

- Reconstruction
- Partial-depth milling and pavement overlay
- Partial-depth milling, pulverizing, and applying a new pavement
- Pulverizing, removing some of the material and applying a new pavement, or
- Simply an overlay

Some factors to consider are:

- Reconstruction – Existing elevations can be maintained or even lowered. Reflective cracking is eliminated.
- Partial-depth HMA milling and pavement overlay – This process can be completed quickly and under traffic. Existing elevations can be maintained. Reflective cracking of the overlay may occur.
- Partial-depth milling, pulverizing, and applying a new pavement - This process can be completed quickly and under traffic. Existing elevations can be maintained. Reflective cracking is eliminated.
- Pulverizing, removing some of the material and applying a new pavement - This process can be completed quickly and under traffic. Existing elevations can be maintained. Reflective cracking is eliminated.
- Overlay - This process can be completed quickly and under traffic. The elevation will be increased, but not as much as in the pulverize and overlay sections. Reflective cracking of the overlay may occur.

20.10 Traffic Over Pulverized HMA

Traffic may be allowed to travel on pulverized material according to Standard Spec 325. Evaluate the quality of old road mixes that are pulverized because they may take longer to set prior to handling traffic loads.

20.11 Tack Coat

When placing an HMA pavement on pulverized HMA, if the pulverized mix contains less than 25 percent of original base material, a tack coat should be applied to the pulverized surface. Tack coat shall be applied according to Standard Spec 455 and FDM 14-10-10.10.

FDM 14-25-25 HMA Pavement Cold In-Place Recycling (CIR) November 17, 2020

25.1 General

Cold In-Place Recycling (CIR) is an asphalt pavement rehabilitation or reconstruction technique where existing asphaltic pavement is recycled in-place without application of heat. The process is sometimes referred to as partial depth recycling because only the upper asphalt pavement materials are recycled. Typically, the underlying materials and some of the asphalt pavement is left intact. CIR treatment depth is generally from 3 to 4 inches. In the CIR process, milled material from the existing pavement is crushed and sized to the required gradation and mixed with a stabilizing agent. Nationally, foam asphalt and emulsified asphalt are commonly used as stabilizing agents, however WisDOT only uses foam asphalt. The milled Recycled Asphalt Pavement (RAP) is mixed with the stabilizing agent then placed and compacted using conventional paving equipment. A final surfacing layer is placed over the CIR layer. This is to protect the CIR layer from moisture ingression and to provide additional structural support for the design traffic load.

Designers should consider CIR, along with HMA overlay, as pavement resurfacing or pavement replacement type of work during the scoping/design stage, depending on CIR treatment depth.

The CIR process is considered as resurfacing when only a portion of the HMA layer is recycled, leaving a 1" minimum of the existing HMA layer. If the CIR process recycles the entire HMA pavement thickness, then CIR is considered pavement replacement. Conform to FDM 14-15-10, Table 10.2 for standard rehabilitation scenarios and FDM 3-5-1 for Highway Improvement Type definitions.

25.2 Reasons for CIR

When pavement distresses exist deep in the asphalt layer, traditional rehabilitation methods such as mill and overlay do not provide a long-term solution. In such situations, the CIR process can be a viable rehabilitation alternative. In most cases, within a short period of time after rehabilitation of the pavement with mill and overlay technique, pavement distresses, primarily cracking, reflect through the new HMA overlay. Reflected cracks affect ride quality and allow water to penetrate the underlying base and subgrade. This causes the asphalt mix to deteriorate and the base and subgrade to soften. Consequently, the service life of the pavement is reduced. The CIR process disrupts existing crack patterns and produces a crack free layer for the new surface, such as an asphalt overlay or an asphalt surface treatment. For maximizing the effectiveness of CIR in mitigating cracking, as much as possible of the existing asphaltic pavement layer should be treated.

The following are some of the benefits of CIR process:

- Potential cost savings compared to mill and overlay rehabilitation technique with equivalent depth of treatment
- Reflective cracking eliminated/mitigated
- Pavement structural improvements may be achieved without significantly changing geometry
- Conservation of non-renewable resources
- Reduced traffic disruptions and road user inconvenience
- Can be used in urban and rural roadways
- No need to haul material from project, therefore minimize hauling costs and trucking

25.3 Selecting CIR Projects

Project selection is among the most important factors in assuring the success of a CIR project. The selection process should include the following steps:

- Distress identification
- Traffic assessment
- Historic Information assessment
- Geometric assessment
- Roadway, subgrade, and drainage conditions

25.3.1 Distress Identification

CIR can be used to address several distresses, both load and non-load related. CIR should be considered when one or more of the following deficiencies exist(s):

- Non-Load Associated Cracking
  - Block
  - Longitudinal
  - Transverse

    - Reflective
- Surface Defects
    - Weathering and Raveling
    - Pot holes
    - Flushing/bleeding
    - Skid resistance
- Deformations
    - Surface rutting <1/2”
    - Rut depth >1/2” (should be investigated to determine the cause. Rutting caused by instability of base and/or subgrade layers are not candidates for CIR).
- Load Associated Cracking
    - Fatigue - bottom up and top down should be investigated to determine the cause (Low and medium severity level fatigue cracking can be treated with CIR if the distress is not caused by poor drainage or a soften base or subgrade).
- Poor ride quality. Pavement roughness caused by an unstable base and subgrade cannot be adequately treated by CIR.

If the distresses present are caused by poor base, soft subgrades or lack of proper drainage, CIR would not be an appropriate rehabilitation strategy without prior corrective action. When small areas of failure are encountered, generally less than 10 percent of the project area, it may be feasible to perform full depth repair for those areas, then proceed with a complete CIR rehabilitation of the remaining roadway.

Depending on the available HMA overlay thickness and the condition of the underlying concrete pavement, CIR may be applied to composite pavements (i.e. HMA overlays of concrete pavements). CIR on composite pavement may be an option to removing and replacing the HMA overlay. However, this option is only feasible if the underlying concrete is in fair to good condition. If there is underlying slab movement or differential settlement, this may indicate unstable or non-uniform subgrade support. In such situations, CIR on composite pavement cannot be considered as a viable alternative.

25.3.2 Historic Information Assessment

When assessing the required CIR treatment depth and surface requirements, a review of available historic information can be helpful. The review of historic or existing information includes:

- Pavement age
- Previous distress survey results
- Thickness of as-built layers
- Maintenance history

Pavement age and past distress surveys can be used to assess the rate of pavement deterioration. Maintenance records such as patching material types would affect the number of mix design required or the requirement of surface milling.

25.3.3 Geometric Assessment

Roadway geometry will influence the types of areas which can be treated with a CIR in a project segment, especially in urban settings. CIR equipment can handle moderate radius turns such as acceleration/deceleration lanes, turn lane, etc. depending on the type of CIR train to be used in the project. Single-unit trains measure about 70 feet in length, while multi-unit trains can stretch up to 150 feet long. Some conditions may need to be addressed prior to CIR. The following is a non- inclusive list of roadway features that must be considered in the design phase:

- Matching into existing curb and gutter that will remain in place
- CIR equipment access and maneuverability
- Roadway profile
- Location of utility manhole covers
- Vertical overhead clearances
- Roadway intersections

FDM Chapter 11 contains Department policy and other guidance on roadway geometrics.

25.3.4 Verify Roadway, Subgrade, and Drainage Conditions

The existing pavement thickness must be determined and included in the contract documents. The pavement thickness may be determined for the entire project length using Ground Penetrating Radar (GPR). GPR is an effective device to determine thickness and variability of the pavement structure. Boring and/or coring shall be taken periodically along the project length to verify the GPR data. Contact Bureau of Technical Services, Geotechnical Unit, to request GPR testing.

The condition of the subgrade, if questionable, should be determined by roadway borings. Coring and boring logs or a summary table showing pavement thickness, base thickness, and subgrade information should be included in the plans. Falling Weight Deflectometer (FWD) can be used to assess the load-carrying capacity and uniformity of the existing base, subbase and subgrade by back-calculating subgrade resilient modulus. Contact Bureau of Technical Services, Geotechnical Unit, to request FWD testing.

It is important to remember that the CIR technique is only able to correct distresses within the layer being recycled. Beneath this layer must exist a stable foundation and a good working platform for CIR and paving operations for the new pavement. In general, if there is a minimum of one inch of asphalt pavement or six inches of granular base remaining below the CIR treatment depth, the risk of equipment break-through is low. If poor subgrades exist, improvements to the subgrade are required. Likewise, pavement damage due to poor drainage conditions cannot be corrected using CIR treatment. CIR candidate projects should have an adequate drainage system in terms of surface and subsurface drainage.

HMA pavements that were placed in varying thicknesses may also be problematic during CIR. If the treatment depth is equal to the total HMA layer thickness, caution needs to be exercised to minimize the incorporation of underlying material into the CIR mixture. Locations of any thin HMA sections must be identified in the plan to allow for an adjustment of machine depth or for a separate CIR mix design to be prepared for incorporating some of the base materials. Locations incorporating base material may require additional quantities of stabilizing agent.

25.4 Structural Design of Pavements Over CIR Material

WisPave is Wisconsin DOT’s official software for pavement structural design. Consult the Regional Soils engineer for guidance on classifying the soil and the assignment of a Design Group Index (DGI) value to be used by WisPave.

25.4.1 HMA Pavements

Use WisPave to design HMA overlays over CIR material. When determining the HMA overlay thickness, both constructability and structural requirements of the pavement must be satisfied.

25.4.2 Structural Layer Coefficients

The structural layer coefficient of CIR mixtures typically ranges from 0.30 to 0.35. A layer coefficient value of 0.32 shall be used for design purpose.

25.4.3 Minimum HMA Thickness

Thickness design is based on the structural number concept. Minimum HMA pavement layer thicknesses are specified in Standard Spec 460.3.2 based on nominal size mixtures.

25.5 How to Construct CIR

Some CIR projects may require surface milling prior to CIR operation in order to maintain existing roadway profile, minimum overhead clearance and to match existing curb and gutter profile. In addition to maintaining roadway geometry, surface milling will remove excess deteriorated HMA layer to allow the CIR process to penetrate deeper into the HMA pavement layer. The surface mill will also remove any deleterious materials, such as vegetation or loose asphaltic joint/crack filler material, from the pavement surface. Surface mill items will be paid for according to Standard Spec 330. After any required surface milling, the pavement surface should be inspected for areas of yielding subgrade. Areas of yielding subgrade should be corrected and paid for in accordance with Base Repair for CIR Pavement special provision. To minimize contamination by the shoulder material, the existing base aggregate shoulders should be bladed away from the asphaltic surface edge.

The first step in the CIR process itself is to mill the existing asphaltic surface to the specified depth and then size this material to the proper gradation. Some systems will be able to mill and size the material in a single operation; others will mill the material and transfer the millings into a sizing/crushing component to achieve the required gradation as per CIR special provision.

If utility covers (manholes and valves) are encountered in the project segment, manholes and valves should be lowered to at least 2 inches below the CIR treatment depth and their locations accurately recorded. Manholes should be covered with a strong steel plate and the excavation can then be backfilled with cold or hot mix asphalt. CIR treatment of the roadway can then take place in an uninterrupted manner. Prior to the placement of the overlay, the manholes and valves should be raised. Any upgrading of existing underground utilities should be undertaken prior to the CIR treatment. In areas where utility covers cannot be lowered in the CIR process, the pavement is milled around the utility and the materials placed in front of the CIR train and the area paved back. The utilities are later raised up through final overlay.

The processed RAP material will be blended with the mix design, specified proportions of stabilizing agent, and water. It is recommended that stabilizing agent application be estimated for plan production at a rate of 2.0 percent. There are two different systems, employing different methods, to complete this step. One system will inject the stabilizing agent into the RAP material and mix it as it lays on the grade. The second type of system will transfer the processed material into a separate mixing unit or pug mill where it will be injected and mixed before being re-laid.

The stabilized RAP material is then re-laid or spread to the specified grade, elevations, and slopes. This is accomplished by transferring the stabilized material, either directly from the mixing unit or by picking up the material from a windrow on the grade, into a standard asphalt paving machine. This asphalt paving machine then places the stabilized material much like it would hot mix asphalt. Depending on the RAP gradation and environmental conditions, CIR material can be expected to increase in thickness approximately 10 to 15 percent once processed, stabilized, and compacted.

If the pavement is to be widened, HMA shoulders will be processed with and at the same depth as driving lanes. The CIR material shall be spread across the desired widened width to provide a homogeneous mixture. Additional asphalt binder will need to be added when incorporating aggregate base shoulder material (base aggregate dense material under paved shoulder). Crushed aggregate shoulders (surface) generally will not be incorporated in the CIR process. In rare cases where crushed aggregate shoulders (surface) are needed to be incorporated into CIR process, the design and work plan needs to be approved by, or in conjunction with, WisDOT Central Office (refer to Originator, FDM 14-1-1).

The final step of the CIR process is to compact the material. Compaction of CIR mixture is an important part of the construction process. Poor compaction can lead to premature failure or poor performance in terms of smoothness, load capacity, resistance to rutting and shoving, and disintegration. Typically, CIR mixes are stiffer than HMA mixes and require additional compaction efforts. This is due to the high internal friction developed between mixture particles, the higher viscosity of the aged binder, and colder compaction temperature. A combination of vibratory smooth double drum roller and pneumatic rollers are used to get to the final target density per CIR special provision. Additional breakdown and intermediate rolling is accomplished with both pneumatic-tired rollers and double drum vibratory steel rollers. Smooth double drum rollers in static mode can be used as the finishing roller to remove roller marks.

25.6 Pavement Design Report

Specify in the Pavement Design Report, the depth and corresponding locations (stationing) of the CIR treatment.

25.7 Curb and Gutter

CIR equipment can generally process to the edge of a curb and gutter section. If the area is not accessible by CIR equipment, pre-milling can be done with a small milling machine(s) ahead of the main CIR equipment. The area will be replaced with CIR mix by use of an extendable screed on the paver.

25.8 Structural Clearance

Special considerations are often required to accommodate structure clearances. CIR trains may require as much as 14 feet of vertical clearance with some of the smaller single unit trains. Clear span heights for bridges, underpasses, and utilities must be checked.

25.9 Traffic Over CIR Rehabilitated Surface

Traffic may be allowed to travel on CIR material. It is the contractor's responsibility to determine when the CIR is stable enough to be subjected to traffic loading. Subjecting the CIR material to loading too early or for too long may result in deformation (rutting or shoving) or surface raveling, respectively.

Traffic control for CIR projects is similar to mill and overlay projects except mill and overlay generally requires more trucks. However, the CIR train is longer and maintaining traffic through and around the construction zone needs to be considered. Use of pilot cars should be considered for CIR projects with longer closures.

25.10 Surfacing

Due to the high voids in total mix content, CIR mixes need a wearing surface to protect the mixture from intrusion of surface moisture.

Roadways requiring additional structural support for the design traffic loadings will require additional structural contribution from HMA overlays. For these type of roadways, structural design to determine overlay thickness shall follow FDM 14-10-15.

25.11 Tack Coat

When placing an HMA pavement on CIR a tack coat should be applied to the CIR surface. Tack coat shall be applied according to Standard Spec 455 and FDM 14-10-10.10.

FDM 14-25-10 Concrete Pavement Rehabilitation Guidelines

Exhibit 10.1 Concrete Pavement Rehabilitation Manual

Revision date: March 11, 2002

Concrete Pavement Rehabilitation Manual

May 1992

WISCONSIN DEPARTMENT OF TRANSPORTATION
Division of Highways
Central Office Materials
Pavement Section

Concrete Pavement Rehabilitation Manual

The purpose of this manual is to aid pavement structural design and project design engineers in estimating the amount of repair that an existing concrete pavement requires in order to achieve the proposed service life for the rehabilitation project. An early estimate of the amount of repair required would allow for a more informed decision on the proper rehabilitation of the pavement or whether it is more appropriate to reconstruct the pavement structure.

This manual is also intended to provide a guide for use in the field by construction and maintenance engineers responsible for determining the final pavement repair locations. This manual provides the methodology for the assessment of the joints; cracks and other distresses in a concrete pavement such that consistency is achieved between the estimated plan quantities and actual field repair quantities to the pavement.

Regardless of whether the manual is being used for a design, maintenance, or construction purpose the engineer must keep in mind that the key to a good pavement rehabilitation project is uniformity of support if the pavement is being overlaid or continuity of pavement if the existing surface is being rehabilitated. A joint or crack which does not require repair on one project may require repair on the next. Each project needs to be evaluated as a single project with the goal of uniformity or continuity for the entire length.

The manual is separated into four sections based upon pavement types, i.e., Jointed Reinforced Concrete Pavement (JRCP with dowels), Continuous Reinforced Concrete Pavement (CRCP), Jointed Plain Concrete Pavement (JPCP) without dowels, and Jointed Plain Concrete Pavement with dowels. All sections are set up to evaluate the repair based upon two basic rehabilitation strategies. The two strategies are to rehabilitate the existing surface (repair or repair and grind) and to rehabilitate with surfacing (overlay or repair or overlay).

The terms repair and patch are used quite extensively in this manual. And, to avoid confusion of their use in this manual, their definitions are as follows:

> A repair is a full depth repair of the concrete pavement.
>
> A patch is a partial depth repair of the concrete pavement.

This manual does have limitations. First, it is recognized that the level of distress at a crack or joint may not be known simply by visual inspection of the surface. However, it is not in the realm of any one design, construction, or maintenance project to core or perform nondestructive testing or every single joint and crack to determine if there is underlying distress. Therefore, we must rely on the collective experience of the District and Central Office personnel that helped in creation of this manual. Second, it is also recognized that the base and subgrade conditions play a significant role in the performance of the pavement rehabilitation. If serious base and/or subgrade problems exist then a more extensive rehabilitation may be needed other than just rehabilitation of the concrete pavement. If level cannot be achieved a lower level of performance can be expected of the rehabilitation.

SECTION ONE: Jointed Reinforced Concrete Pavement (JRCP)

These are typically pavements with wire mesh reinforcement and doweled joints usually with 80-foot joint spacings, built from the 1950's to early 1970's. The most common distresses are deteriorated joints and midpanel cracking. Faulting is not generally a problem at joints but can occur at cracks and is influenced by the age and loading on the pavement as well as the condition of the base and subgrade materials.

The two rehabilitation strategies for JRCP are as follows:

Repair and Grind

The minimum repair for a rehabilitation of the existing surface is a full depth repair with concrete and dowels, that are a full lane width and is a minimum of six feet long. This is described in the Standard Specifications Subsections 416.2.3 to 416.2.6, 416.3.6 to416.3.9, and 415.3.12 and 415.3.17 concrete pavement repair. This is also shown on SDD 13C9 sheet a and sheet b. Upon completion of the repairs to the concrete pavement the pavement is ground to achieve a uniform texture for the entire length of the project.

In a maintenance repair situation an additional requirement of the repair is that it be textured the same as the existing concrete pavement.

A full depth repair is required for deteriorated longitudinal joints as part of this rehabilitation strategy.

Repair and Overlay

The minimum joint repair for the rehabilitation with resurfacing alternative is a full depth repair with undoweled concrete, that is, a full lane width and of a length such that all deteriorated concrete is removed. It is anticipated that the typical length of these repairs will be approximately three feet. Removal of the deteriorated concrete should be accomplished by hammering, with a heavy-duty chisel on a backhoe or other method to create a rough vertical edge. This step is critical to assure that the clean rough surface will provide for good mechanical interlock between the new and old concrete since dowel bars are not used. The repair is then completed by placing new concrete finished flush with the adjacent pavement.

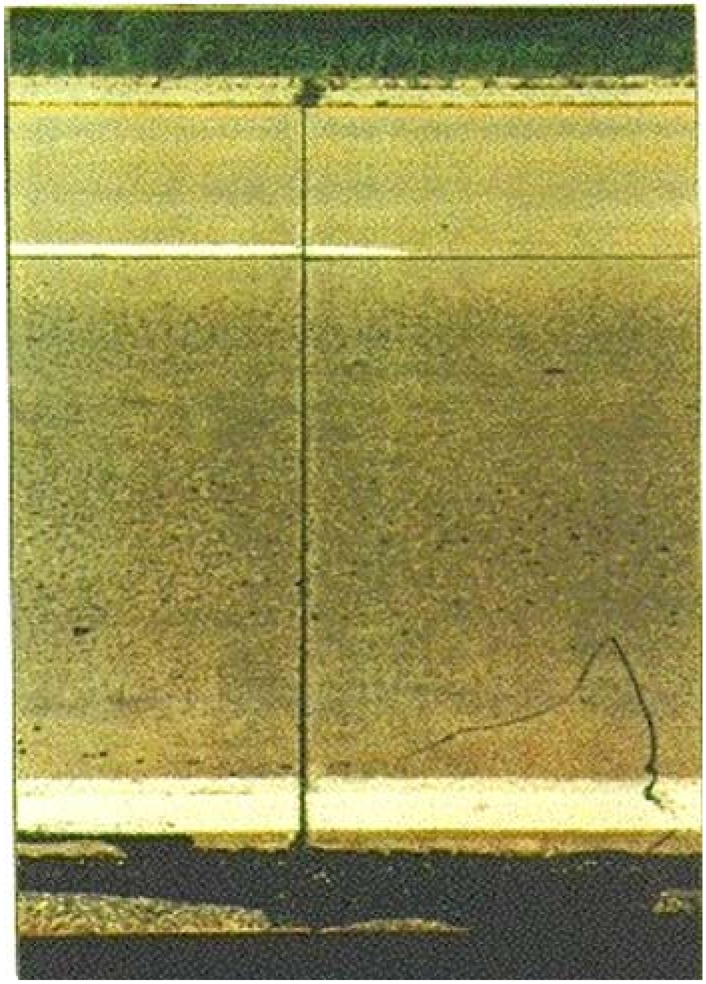
As part of the rehabilitation with resurfacing alternative, partial depth repairs can be considered, especially for longitudinal joints and spalling of mid-panel transverse cracks. The repair consists of griding 2 to 3 inches deep (and going deeper if necessary with jack hammers to remove deteriorated concrete) and generally two feet wide. Filling may be either concrete or asphaltic concrete (AC).

Deteriorated longitudinal joints can be repaired full depth or partial depth dependent upon the extent of the deterioration.

The following pictures are joints and cracks at different levels of distress with the criteria for repair based upon the two rehabilitation strategies.

Jointed Reinforced Concrete Pavement

1. JOINT



Repair and Grind

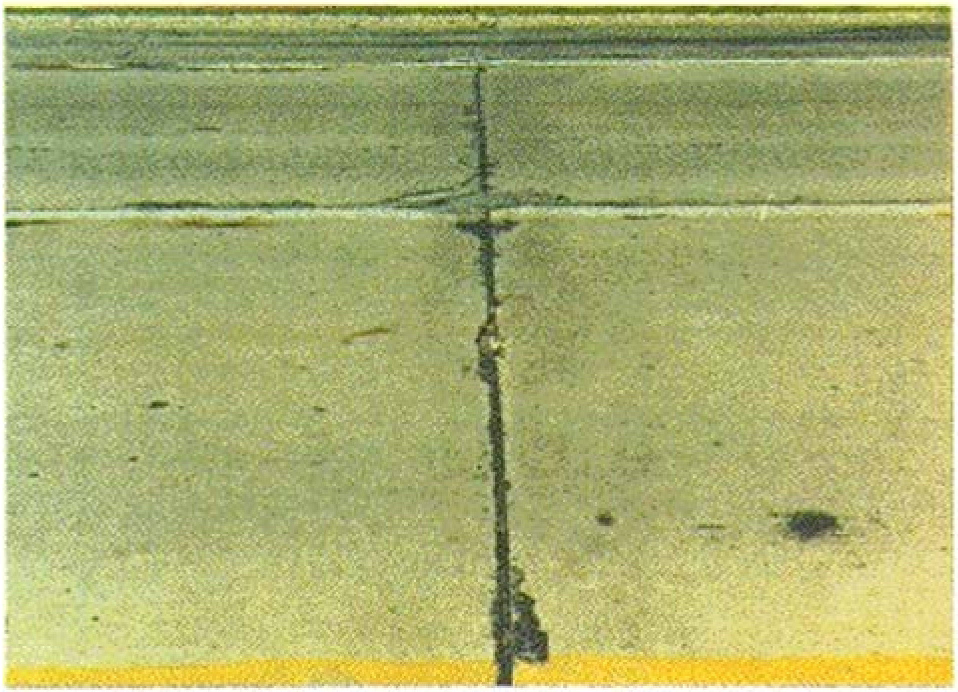
Joint is in excellent condition. No repair required.

Repair and Overlay

Same

Jointed Reinforced Concrete Pavement

1. JOINT



Repair and Grind

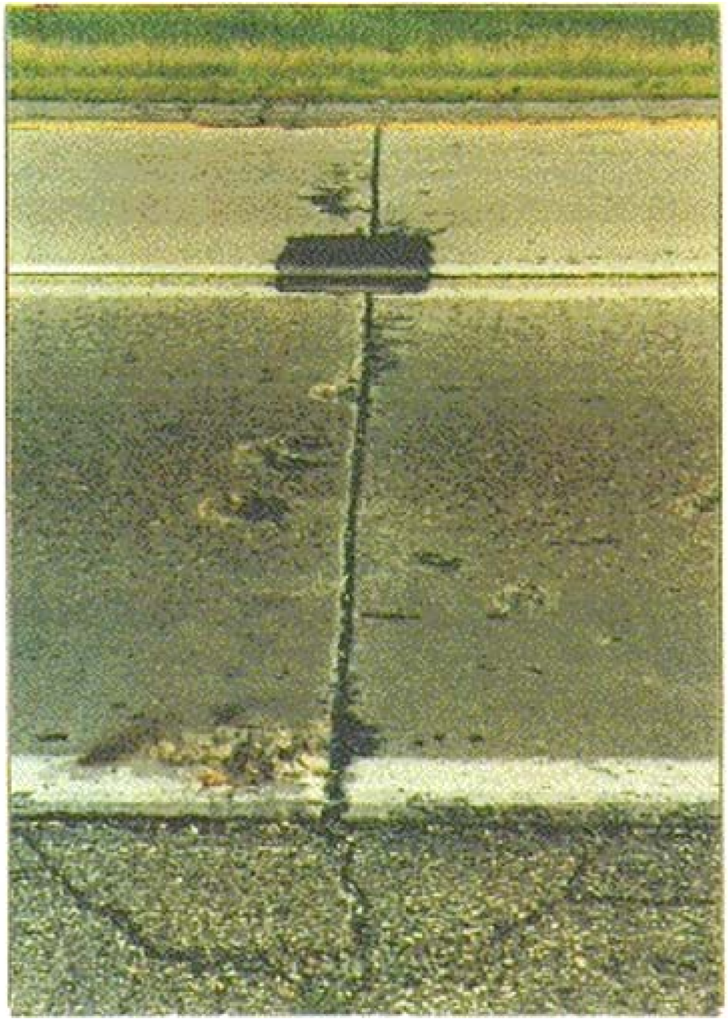
This joint is in good condition. There is a minor amount of spalling at the surface along the joint, but this will be removed during the grinding operation. Note the asphalt sealant material around the joint and make sure this material is not masking more severe distresses. This joint should be left alone for this rehabilitation alternative.

Repair and Overlay

This joint is in good condition and requires no additional treatment prior to overlay.

Jointed Reinforced Concrete Pavement

1. JOINT



Repair and Grind

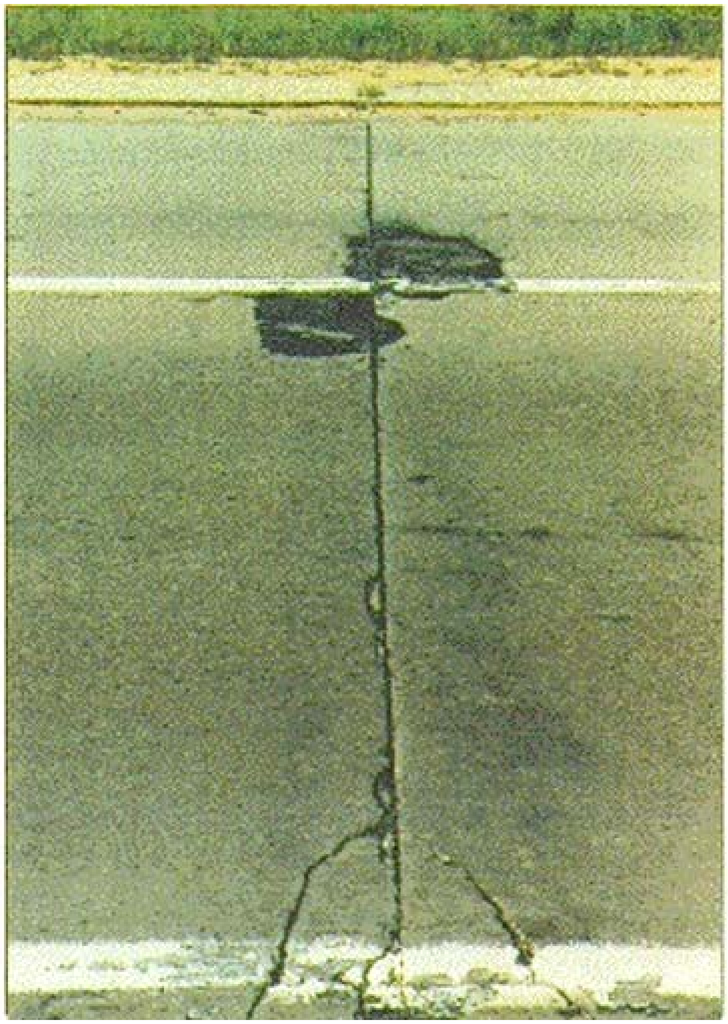
This joint is in a more severe state of distress with the deep spalling at and around the joint. Also, the asphalt patch at the centerline is a sign of additional deterioration at the joint. The asphalt patch would not be compatible with the grinding operation. This joint should be selected for a full depth, full lane concrete repair under this rehabilitation alternative.

Repair and Overlay

This joint is still in good condition for this rehabilitation alternative. The spalled areas should be jackhammered or ground to remove the delaminated concrete and filled with AC or concrete before placement of the overlay.

Jointed Reinforced Concrete Pavement

1. JOINT



Repair and Grind

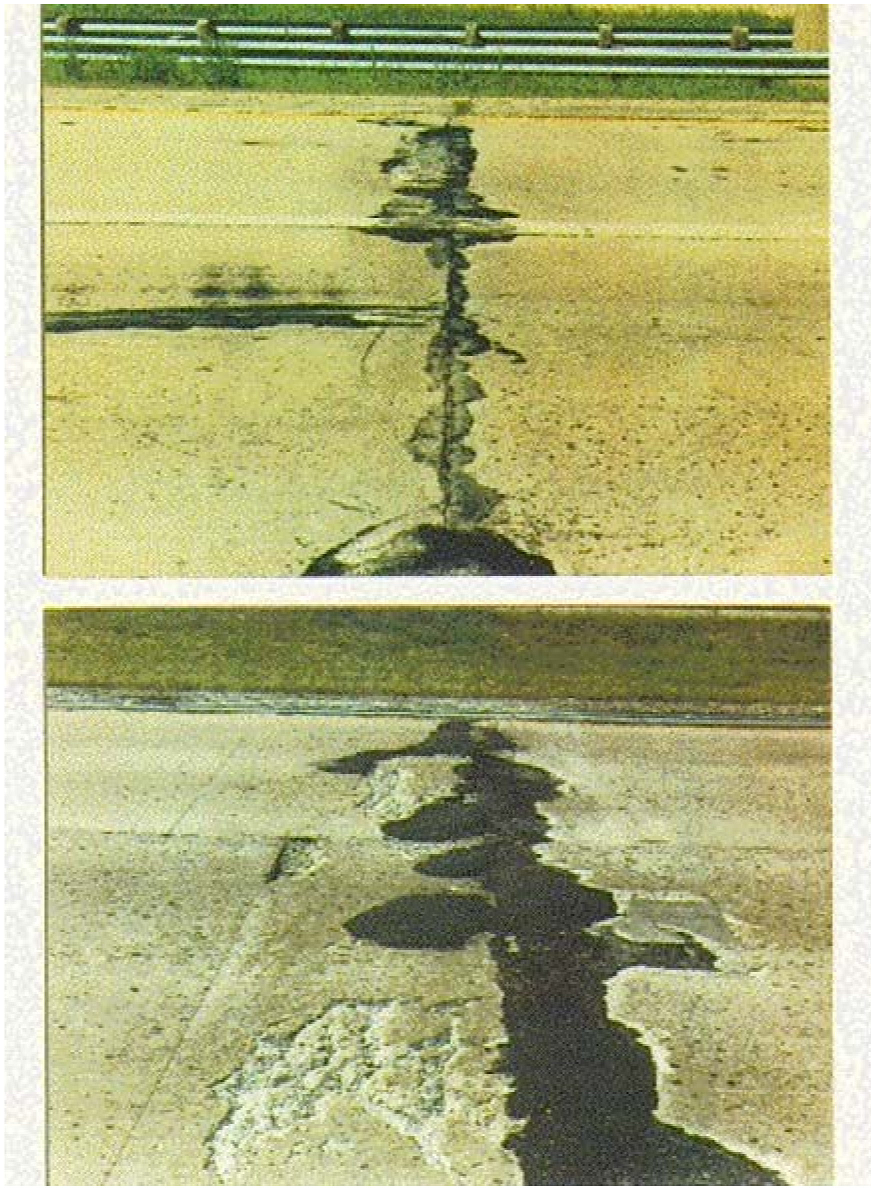
This joint should be repaired as part of the rehabilitation strategy. The broken pieces at the edge and center of the pavement are not compatible with the grinding operation.

Repair and Overlay

As part of the resurfacing rehabilitation, this joint should be repaired due to the broken pieces as the edge and centerline of the pavement. Note the staining around the joint, this is an indication of age not of a significant D-cracking problem, (this pavement is 25 years old.) If this were a significant D-cracking problem the staining and subsequent cracking would have occurred much earlier in the pavement's life. Caution should be exercised in using the staining as a basis for repair. When cracking around the joint begins to develop along with the staining a repair is warranted. However, a joint with staining only should be more closely investigated and compared to the overall condition of the joints over the entire project. From that engineering judgment should be used to decide on whether to repair or leave in place.

Jointed Reinforced Concrete Pavement

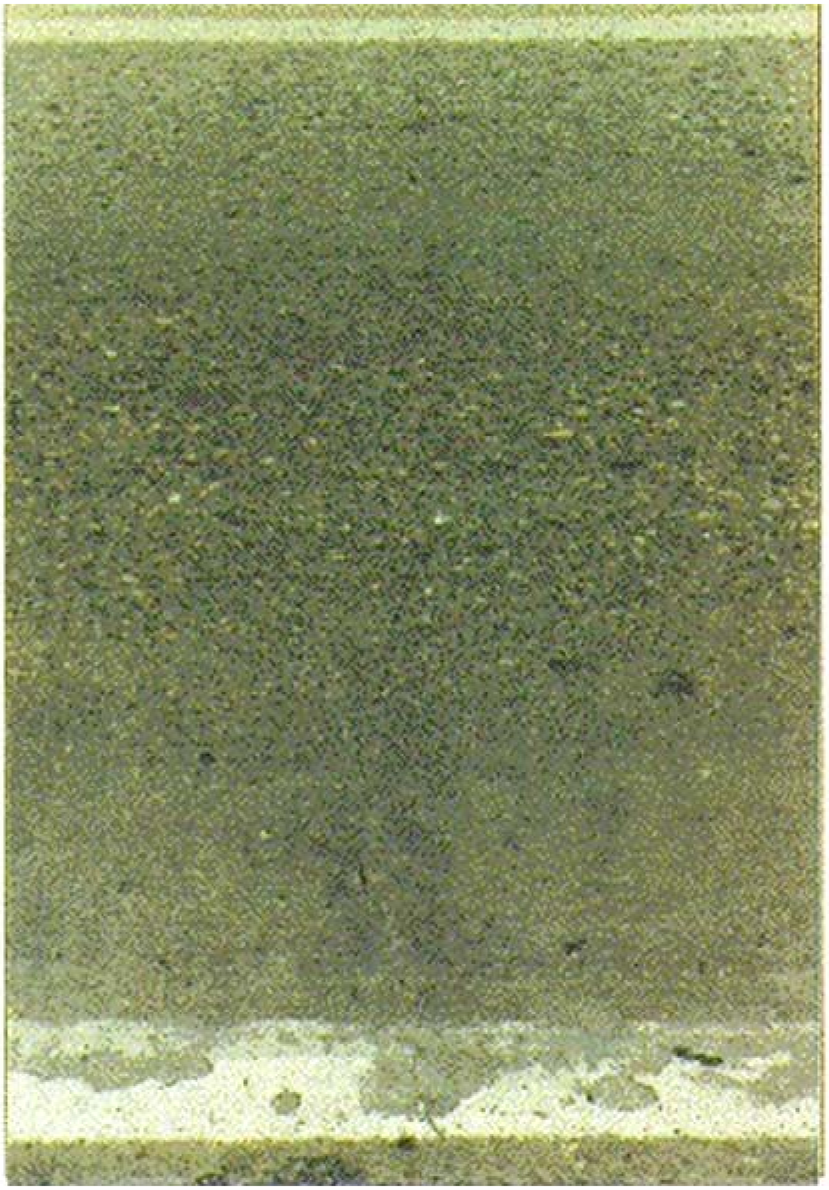
1. JOINT



These joints require full depth repair regardless of rehabilitation strategy. The repair should be completed as outlined for each rehabilitation strategy. There is parallel cracking along the joint and material is being removed by traffic.

Jointed Reinforced Concrete Pavement

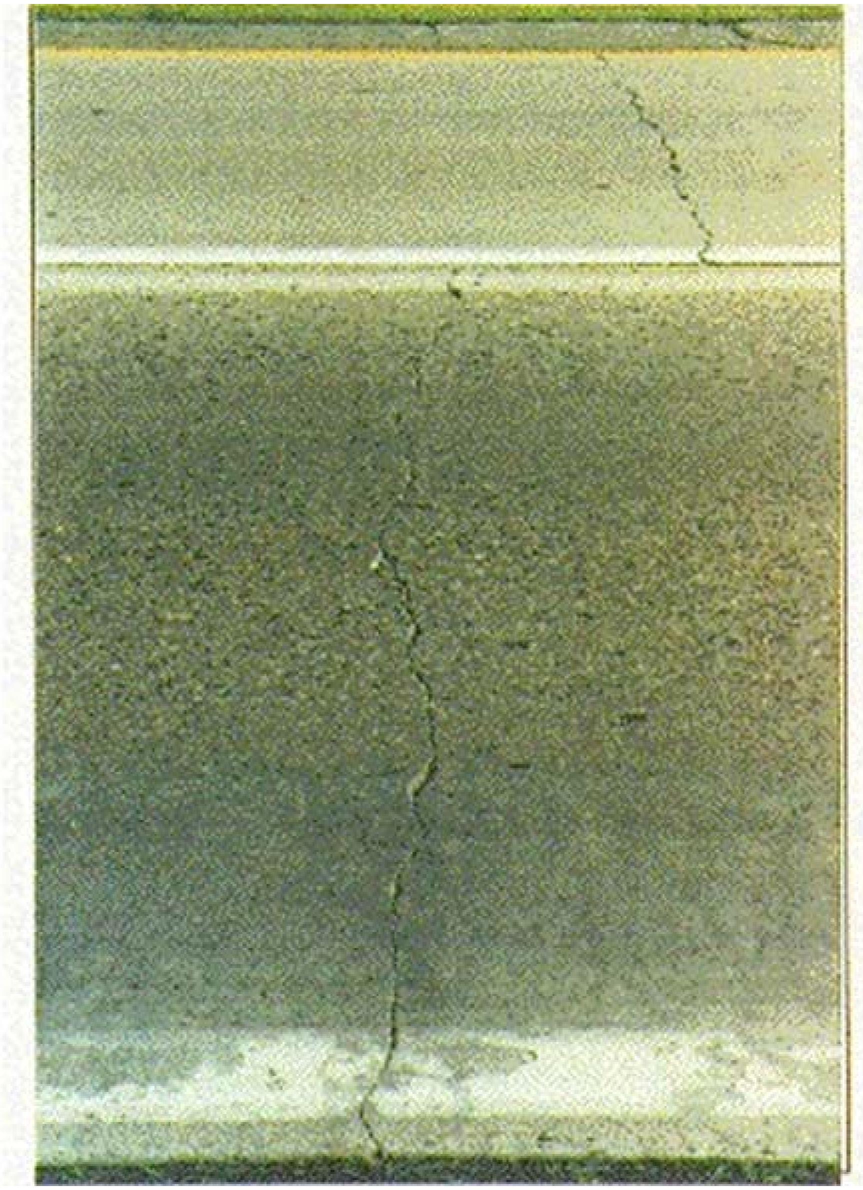
1. CRACK



This hairline crack requires no attention regardless of rehabilitation strategy.

Jointed Reinforced Concrete Pavement

1. CRACK



Repair and Grind

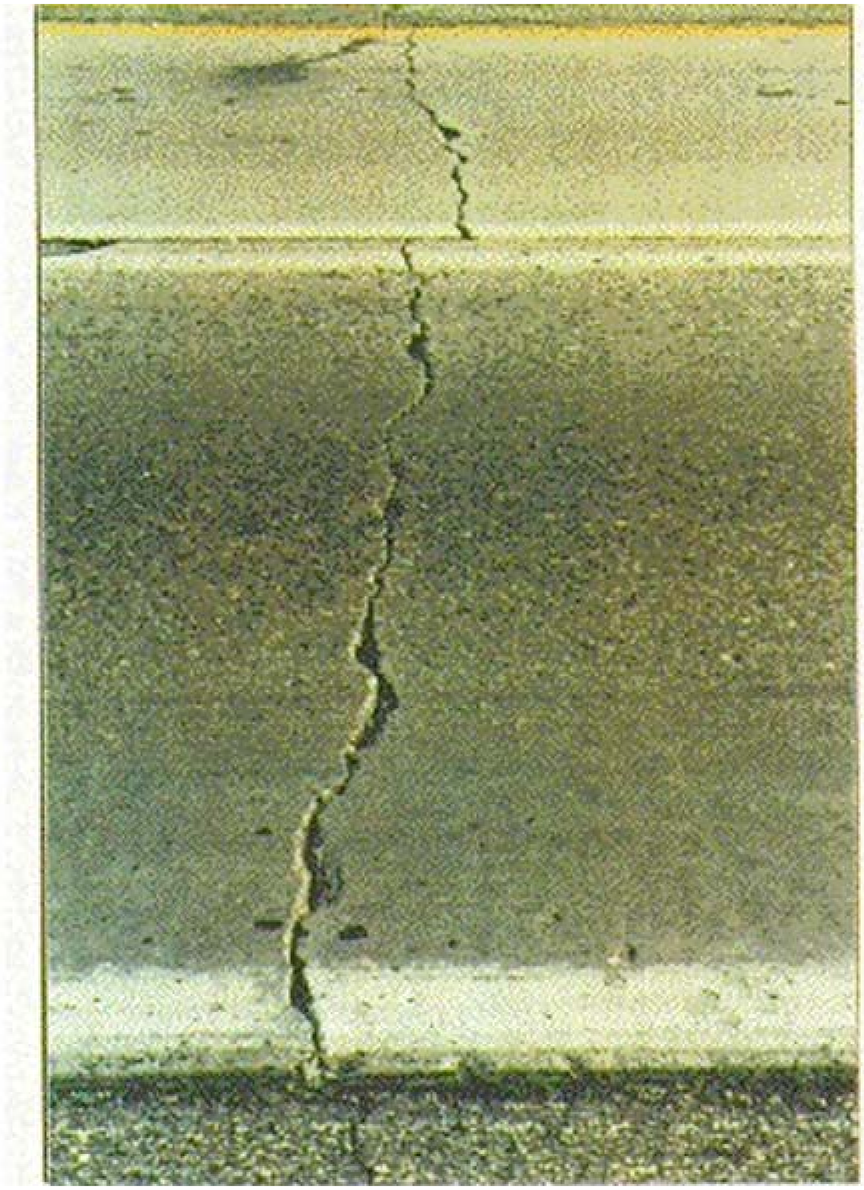
This crack is in good condition with a few minor spalls along the length of the crack. These spalls will be removed as part of the grinding operation.

Repair and Overlay

No treatment required prior to placement of the overlay.

Jointed Reinforced Concrete Pavement

1. CRACK



Repair and Grind

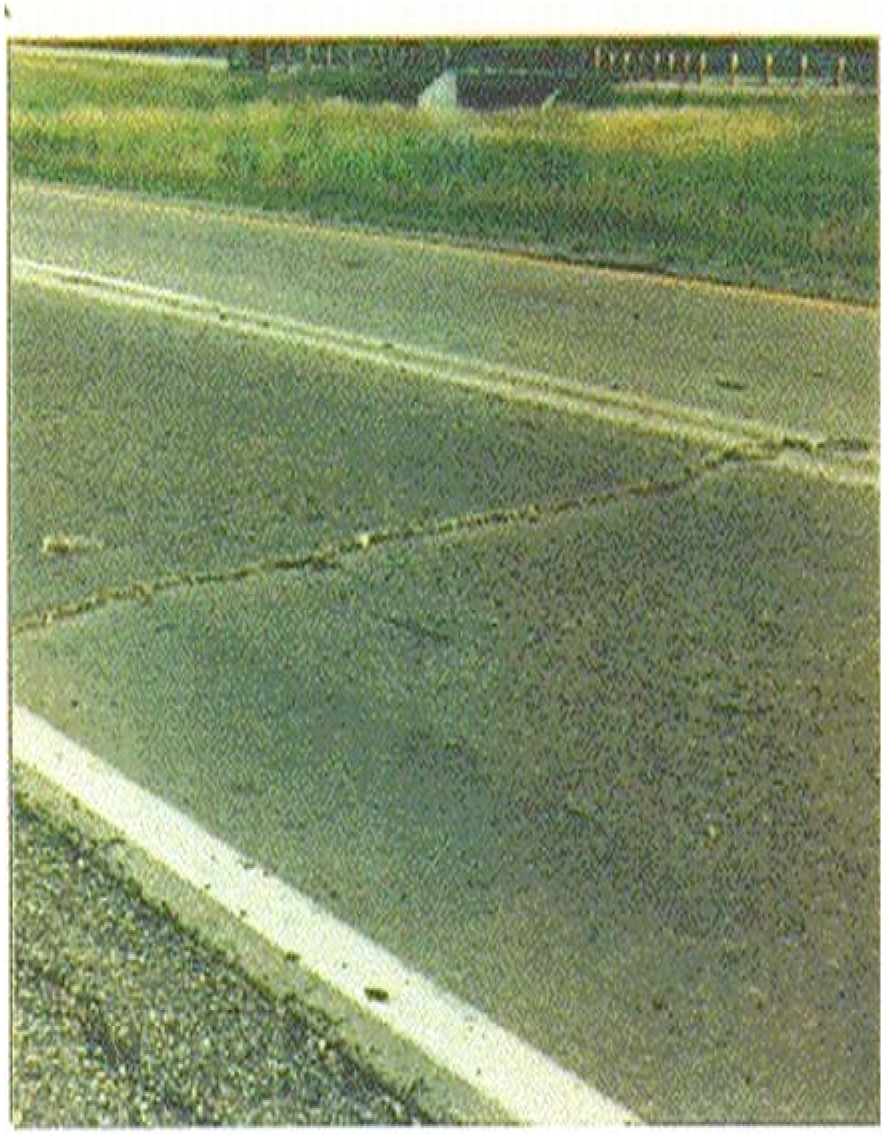
This crack has more severe spalling, but is not faulted. A careful inspection of the spalled areas needs to be made. If the depths of these spalls are significant (1-3 inches) and additional visible distress is evident, the pavement should be repaired. This particular crack shows no distress other than the spalls. Therefore, it should not be repaired as part of this rehabilitation alternative.

Repair and Overlay

This crack would not require repair prior to overlay.

Jointed Reinforced Concrete Pavement

1. CRACK



Repair and Grind

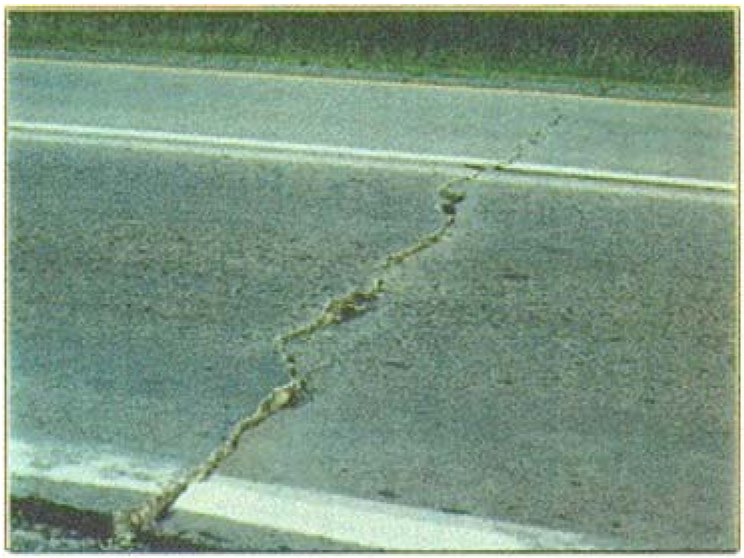
This crack is in good condition with exception of the faulting. No repair is required prior to the grinding operation

Repair and Overlay

No repair is required as part of this rehabilitation strategy. Recent practice has been to construct a leveling course of AC prior to the binder course to aid in bridging significant faults.

Jointed Reinforced Concrete Pavement

1. CRACK



Repair and Grind

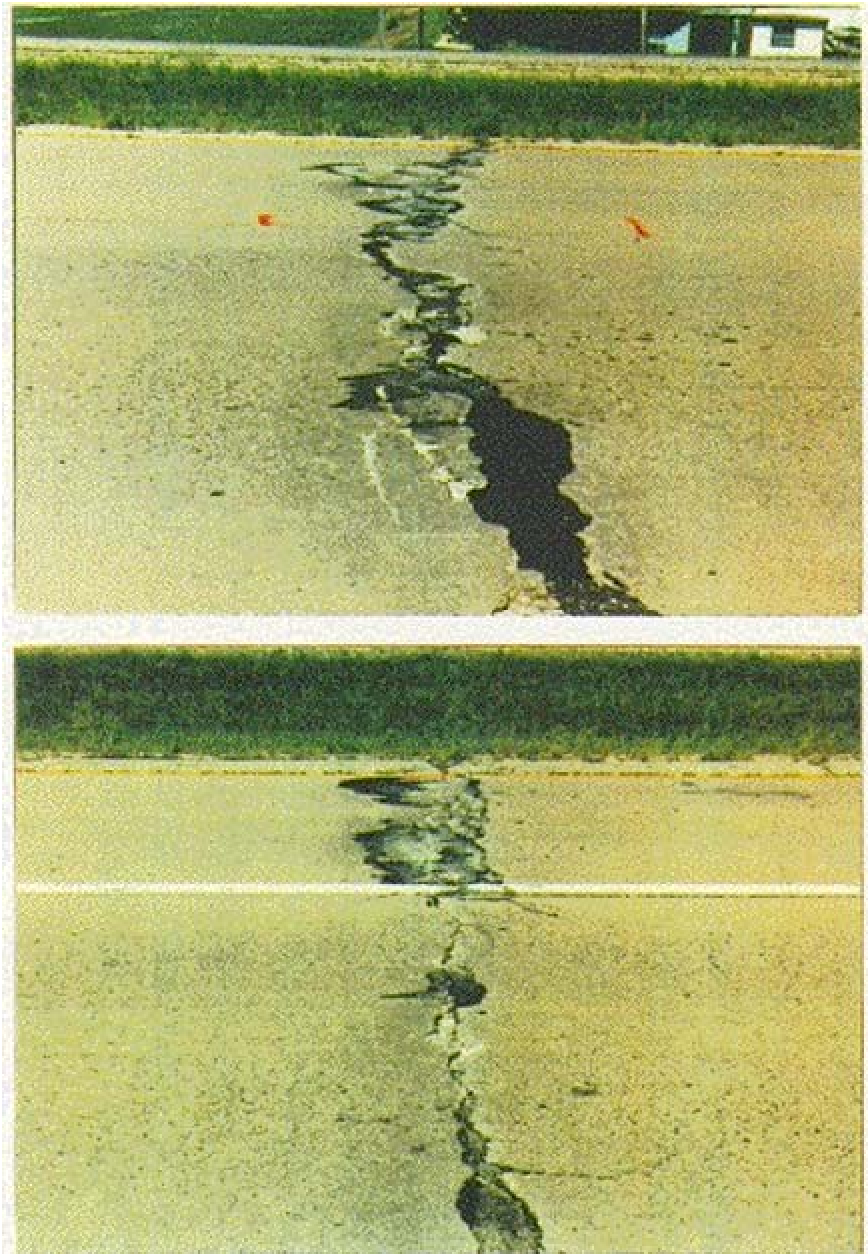
Both of these cracks have secondary cracking adjacent to them that have formed large pieces of concrete. These pieces would be dislodged during grinding and form a large void at the surface. The secondary cracking is also an indication that more advanced distress has occurred. This crack should be repaired.

Repair and Overlay

Due to the secondary cracking these cracks should also be repaired prior to the overlay.

Jointed Reinforced Concrete Pavement

1. CRACK



These cracks require full depth repair regardless of rehabilitation strategy. The repair performed should be as previously outlined for each rehabilitation strategy.

<u>SECTION TWO</u>: Continuously Reinforced Concrete Pavement (CRCP)

Most of these pavements were constructed from the mid-1960's to the late 1980's. The presence of the continuous reinforcement in this type of pavement provides for high quality ride even at elevated levels of distress. However, as the pavement approaches the end of its service life the rate of deterioration can accelerate very rapidly causing failures to occur over a short period of time.

The two rehabilitation strategies for CRCP are as follows:

<u>Repair</u>

The repair of distressed areas and wide cracks must be full depth concrete repair. The minimum repair for a rehabilitation of the existing surface is a full lane width and should be of a length such that the repair will be adjacent to sound concrete. The removal operation should use a partial depth saw cut and hammering. The existing bar steel reinforcement should be removed except for a minimum length of two feet onto which the new steel can be tied. The completed repair should be finished flush with the existing surface and textured the same as the existing concrete pavement.

The most severe distresses in CRCP are longitudinal cracking over the bars and delamination of the adjacent concrete. Experience has shown that partial depth patching on CRCP to repair this distress has not been successful and should not be considered as part of this rehabilitation strategy. The basis of this rehabilitation strategy is that the CRCP is in relatively good condition and in need of a small amount of repairs. Past history of CRCP performance has been once the longitudinal cracking above the bars begins to occur it becomes increasingly more difficult to repair the pavement.

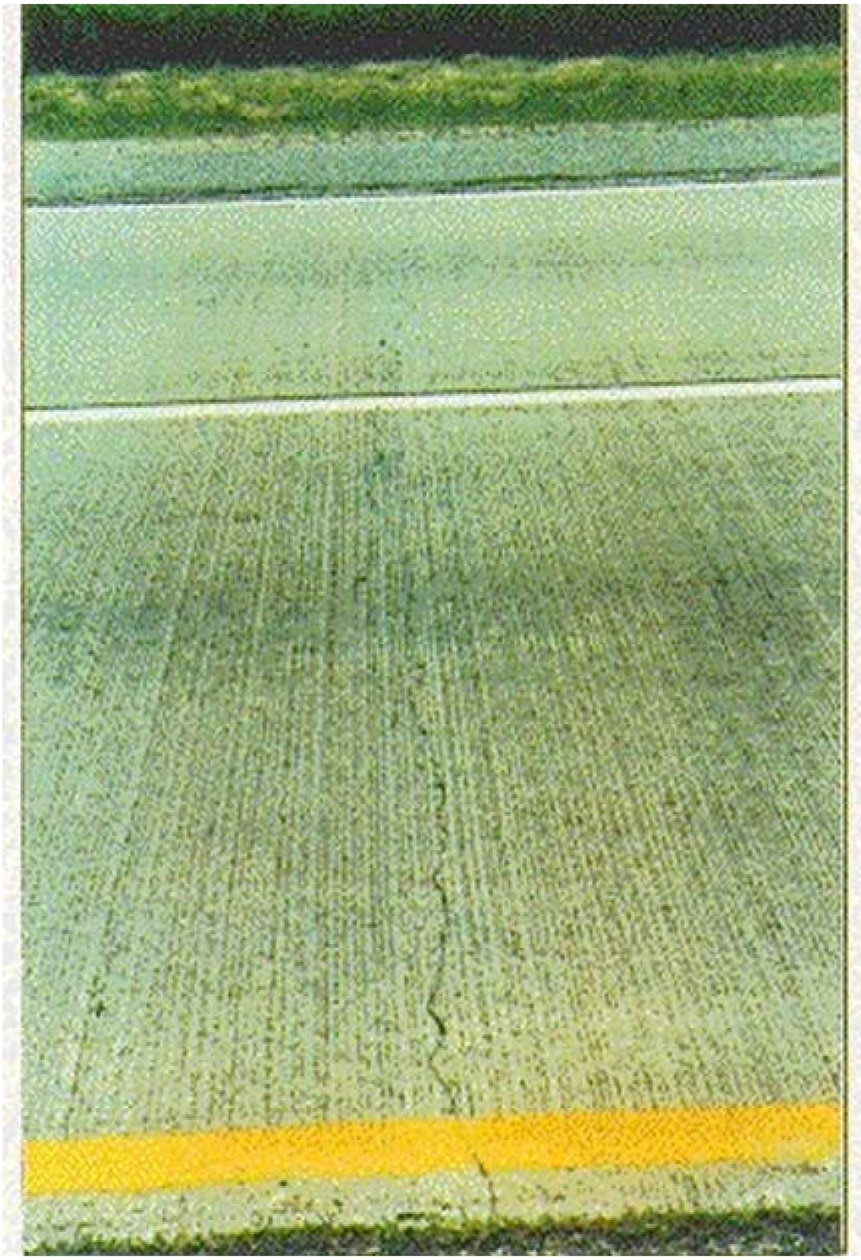
<u>Repair and Overlay</u>

The minimum repair for the rehabilitation with resurfacing alternative is the identical repair as outlined above. Following completion of the repairs the pavement is overlaid with HMA. The overlay serves to restore or maintain ride quality and to reduce the rate of deterioration of the concrete base. Also, as part of this rehabilitation strategy partial depth repairs can be considered. This type of repair can be utilized to repair spalling and other types of distress. The overlay should serve as a mechanism to slow down deterioration typically seen on partial depth patching done in the past that has not been overlaid. Partial depth patching of areas in which longitudinal cracking and delamination is occurring can be accomplished to an extent as part of this rehabilitation strategy. This patching can be accomplished with AC as well as concrete.

The following pictures are sections of CRCP at different levels of distress with the recommendations for repair based upon the two rehabilitation strategies.

Continuously Reinforced Concrete Pavement

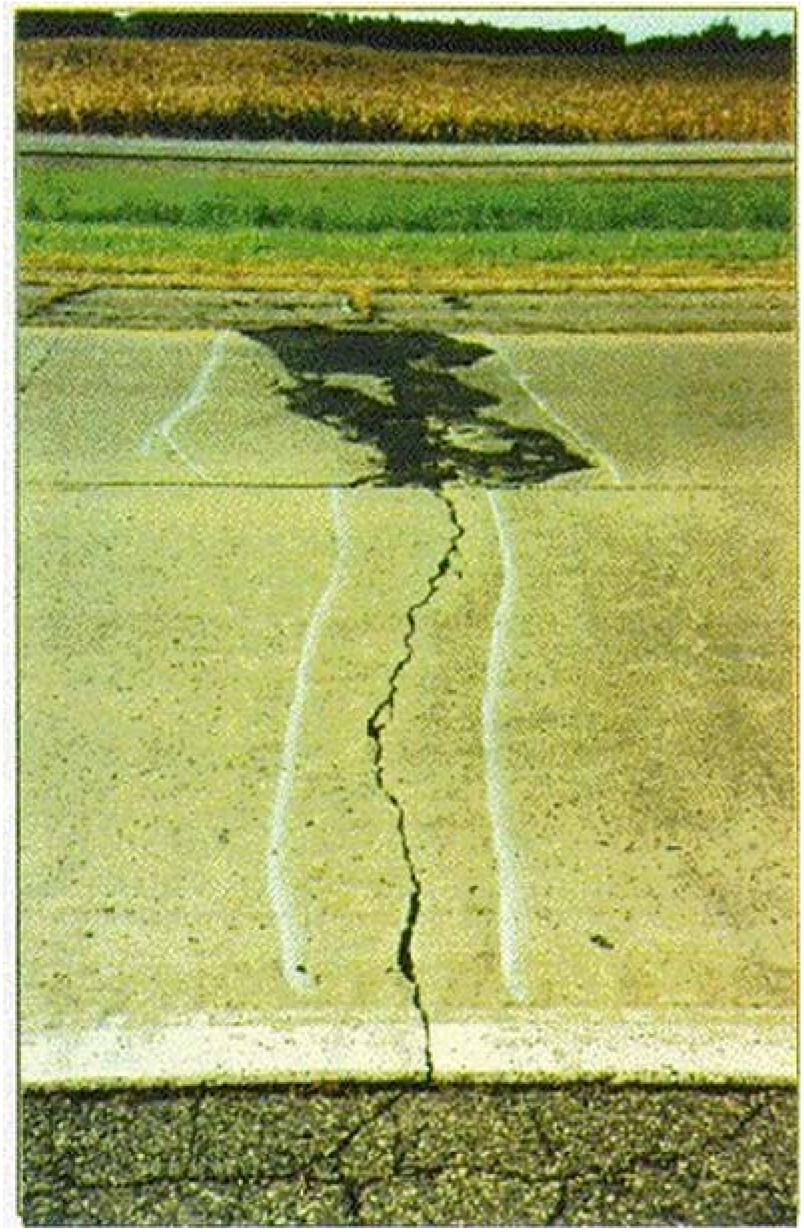
1. SINGLE TRANSVERSE CRACK



This crack requires no attention regardless of rehabilitation strategy. This is a typical crack for CRCP pavements and it normally occurs at 3-10 foot intervals.

Continuously Reinforced Concrete Pavement

1. SINGLE TRANSVERSE CRACK



Repair

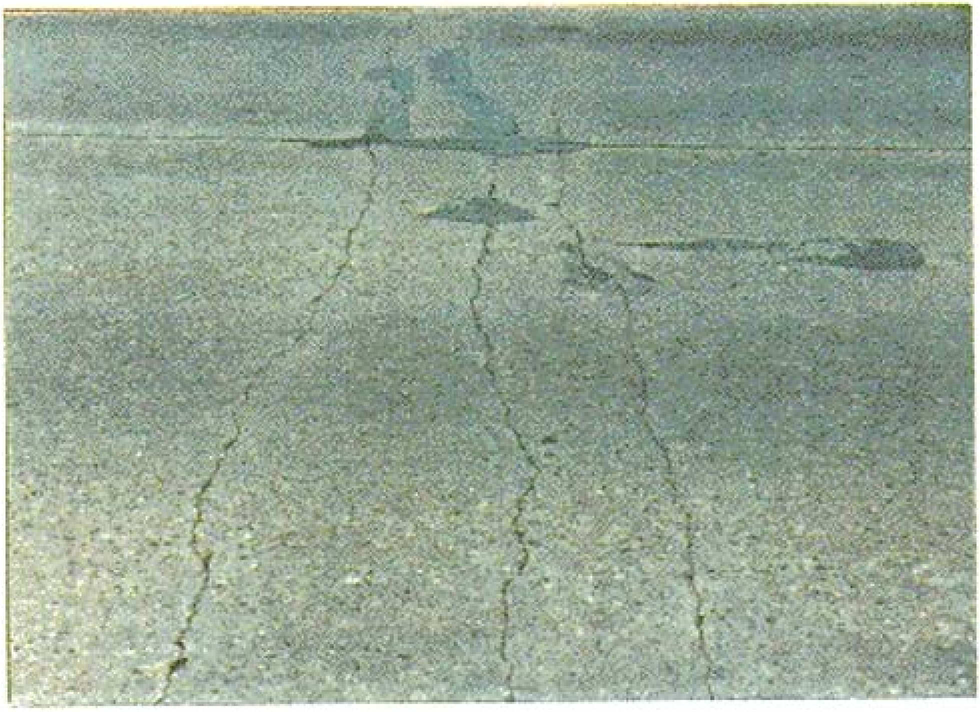
Both lanes require a full depth repair when using this rehabilitation strategy. It is obvious that the inside lane requires repair. However, the outside lane is not so obvious. As a general rule, any crack on a CRCP pavement with a crack width of ¼ inch or greater is an indication that the steel has ruptured across the crack and load transfer has been lost. This makes that crack a location with the potential for additional distress to occur in a very short time. Therefore, a full depth repair is also recommended for the outside lane.

Repair and Overlay

Under this rehabilitation strategy only the inside lane requires a full depth repair prior to placement of the overlay. The additional structure of the overlay should bridge the formation of additional distresses occurring at the crack in the outside lane.

Continuously Reinforced Concrete Pavement

1. MULTIPLE TRANSVERSE CRACKS



Repair

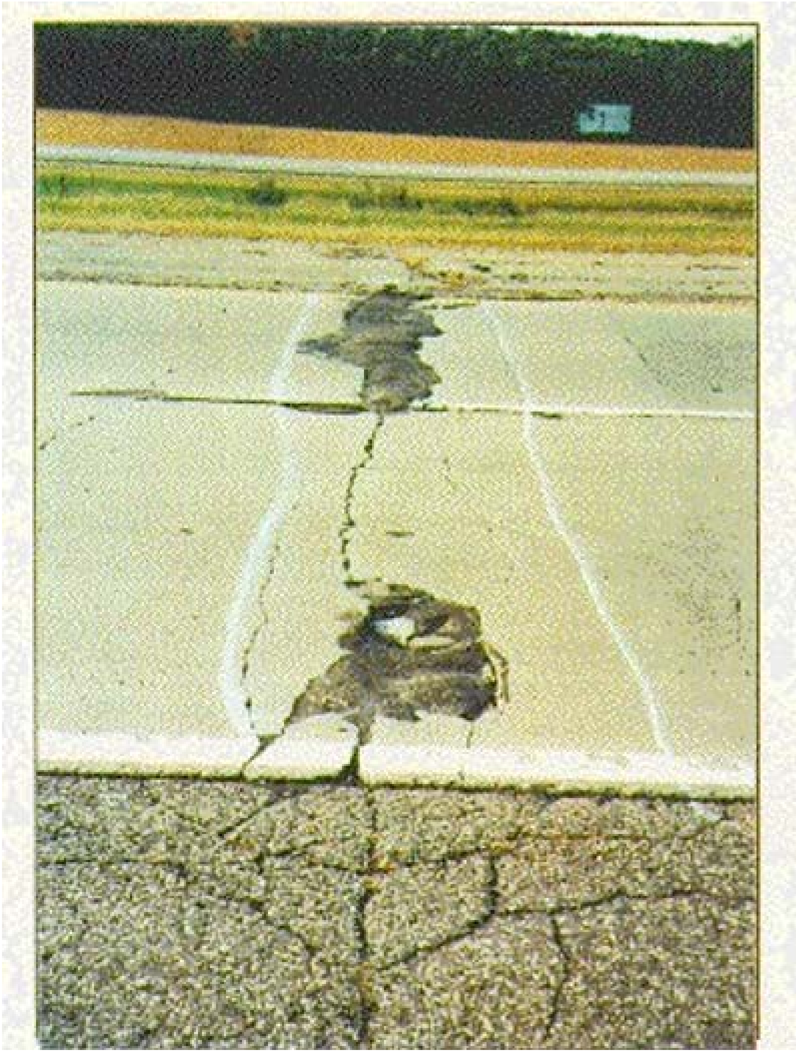
This series of cracks does not require repair. They are all still tight with insignificant spalling. Close inspection of the CRCP is required here. The presence of longitudinal cracking must be determined here. The confirmation of the existence or nonexistence of the longitudinal cracking is important to assure performance of the repair.

Repair and Overlay

These cracks do not require repair as part of this rehabilitation alternative.

Continuously Reinforced Concrete Pavement

1. MULTIPLE TRANSVERSE CRACKS



Repair

The distress that has taken place at this location between cracks requires a full depth repair as part of this rehabilitation strategy. The steel has ruptured at the cracks and additional deteriorated areas have formed adjacent to the crack.

Repair and Overlay

A full depth repair is also required for this rehabilitation strategy prior to place of the overlay.

Continuously Reinforced Concrete Pavement

1. DETERIORATED AREAS

Repair

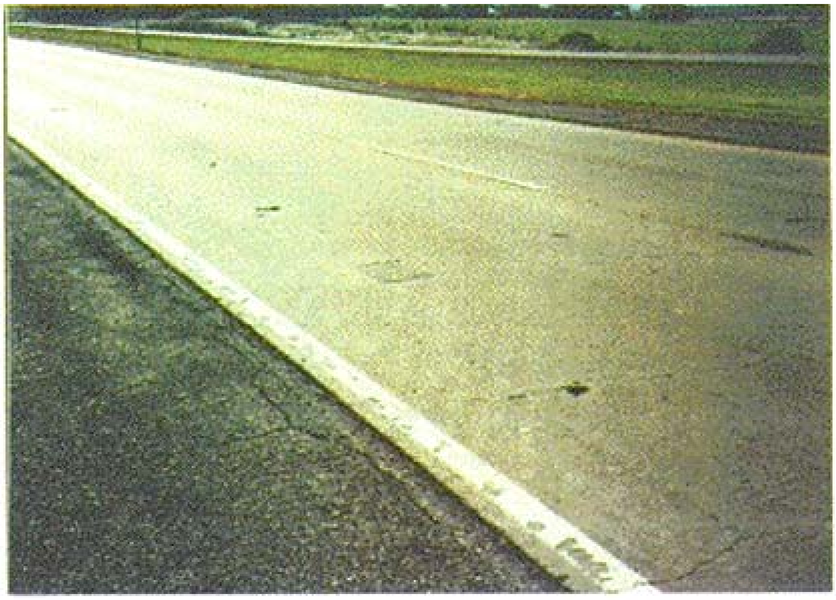
These deteriorated areas require repair as part of this rehabilitation strategy.

Repair and Overlay

A determination of the extent of the deterioration must be made. If the deterioration is full depth, a full depth repair is required. If it is partial depth, a partial depth repair with either AC or concrete is required prior to placement of the overlay.

Continuously Reinforced Concrete Pavement

1. SPALLS



Repair

The top pictures is a section of CRCP with a few minor spalls in the background. Repair of spalls is difficult because full depth repair is not required. The bottom picture is a severely distressed section of CRCP with spalls caused by high steel, a full depth repair is required if this is a localized condition.

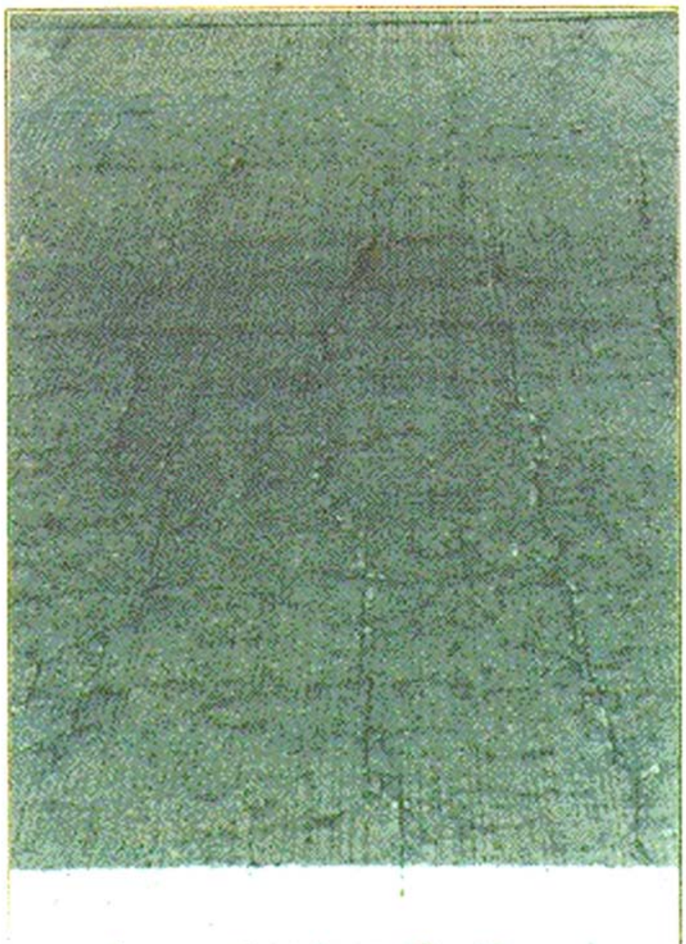
Repair and Overlay

No repair is required for the top section of CRCP prior to the overlay. If the condition in the bottom photo is not localized and occurs over a significant amount of the project repair and overlay is the correct rehabilitation strategy. Partial depth patching with AC or concrete prior to placement of the Hot Mix Asphalt (HMA) overlay is required.

Continuously Reinforced Concrete Pavement

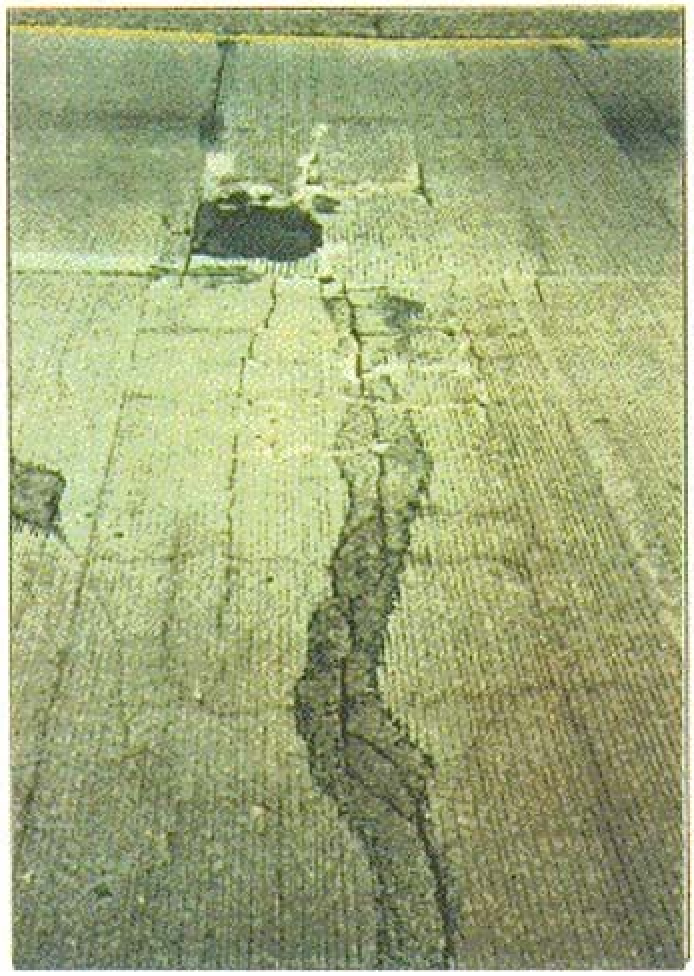
1. CRCP ADVANCED DISTRESS

The following pictures are of CRCP in advanced stages of distress. A repair is required on a short section of pavement with an isolated distress. It is also necessary for the repair to be adjacent to sound concrete. Because of the distressed condition of these pavements, the areas in need of repair are likely to be extensive and the existence of sound concrete is unlikely. Therefore, extensive repair of these sections is not recommended from a practicality standpoint. Repairs should be minimized to those locations where it is absolutely required for placement of the overlay. These pavements warrant reconstruction of the pavement structure. However, if funding or some other factor requires that these pavements be rehabilitated the best option available would be placement of an HMA overlay with minimum repairs being made to the concrete.



Continuously Reinforced Concrete Pavement

Continuously Reinforced Concrete Pavement



A full depth repair is required at this location regardless of rehabilitation strategy. The punchout failures at the centerline and far lane must be repaired prior to placement of the HMA overlay.

<u>SECTION THREE</u>: Jointed Plain Concrete Pavement (JPCP) – undoweled

These pavements were constructed from the mid 1970's to late 1980's and are jointed but do not have dowels or wire mesh reinforcement. The joints on these pavements are normally skewed and are at the random spacing of 13'-19'-18'-12' (Average of 15.5'). Due to the lack of load transfer at the joints these pavements have had significant problems with faulting.

The two rehabilitation strategies for JPCP are as follows:

<u>Repair and Grind</u>

These pavements have been performing very well with the exception of the faulting at the joints. Other distresses at the joints is very uncommon. Therefore, it is anticipated that joint repair will be a minor part of the overall rehabilitation strategy. However, if a joint repair is required a minimum 6-foot long full depth repair without dowels should be performed. An important element of the repair is that the repair also be at the same skew as the joint. This will minimize any faulting that will occur at the repair. There may be situations where a doweled repair is warranted. This will require evaluation on a project specific basis. All repairs should be completed prior to grinding.

No partial depth repairs are recommended for this type of pavement.

Surface grinding to remove the faults has generally been the preferred rehabilitation technique because it restores the ride quality to the otherwise structurally sound pavement, has relatively low cost, and produces minor disruption to traffic.

In general, a pavement that has faulting between ¼ and ½ inch would be repaired as necessary and ground.

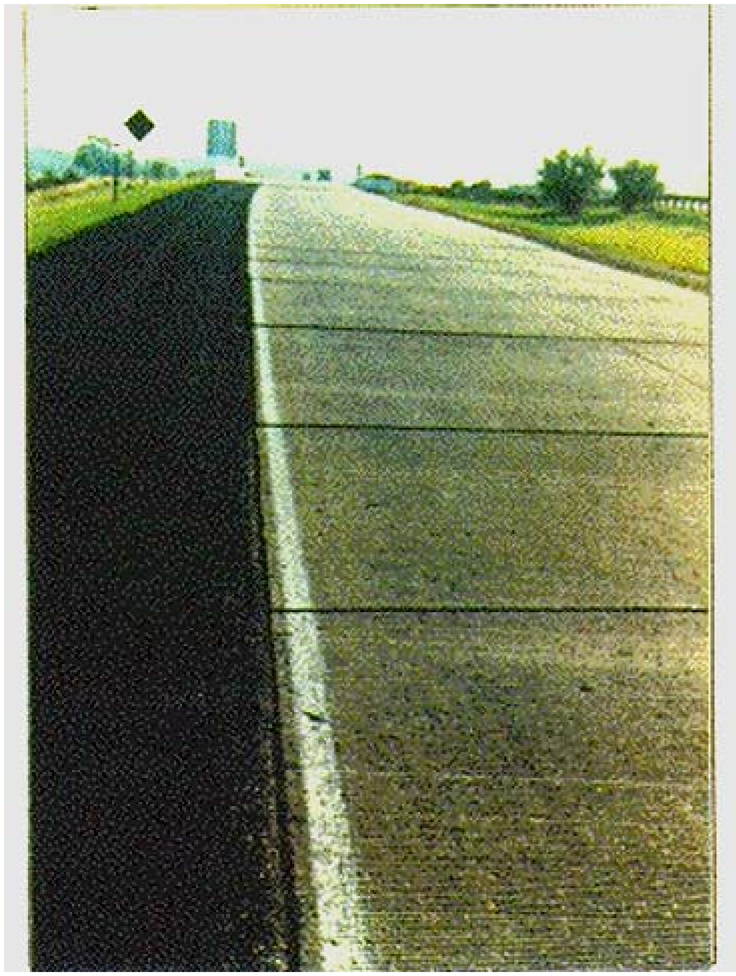
If a slab is cracked, the decision to repair is consistent with the previously outlined criteria in the section on Jointed Reinforced Concrete Pavement. However, due to the short joint spacings any repair being performed should be completed by replacing the entire slab, rather than performing a six-foot long repair.

<u>Repair and Overlay</u>

Due to the fact that these pavements have not yet approached their second rehabilitation cycle, a second grinding operation or HMA overlay have not been considered to date. Consequently, we have no historical pavement performance information and cannot make recommendations on this rehabilitation strategy at this time. Therefore, this is not covered in this manual.

Jointed Plain Concrete Pavement-undoweled

1. FAULTED JOINTS

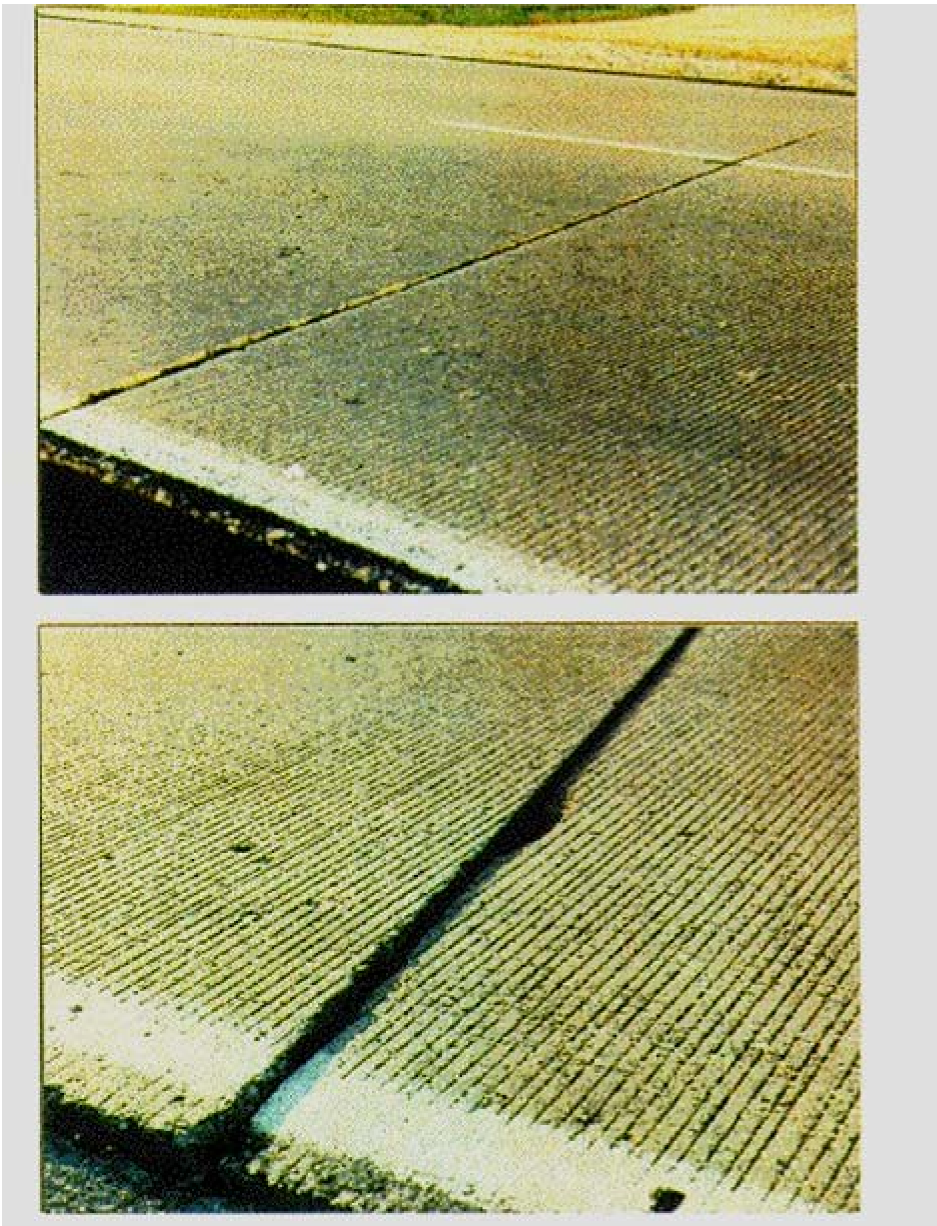


Repair and Grind

This section of highway is a faulted pavement. Although it is faulted, there are no visible distresses to the individual slabs. This section of highway is an excellent candidate for this rehabilitation strategy because faulting on the average is less than ½ inch.

Jointed Plain Concrete Pavement-undoweled

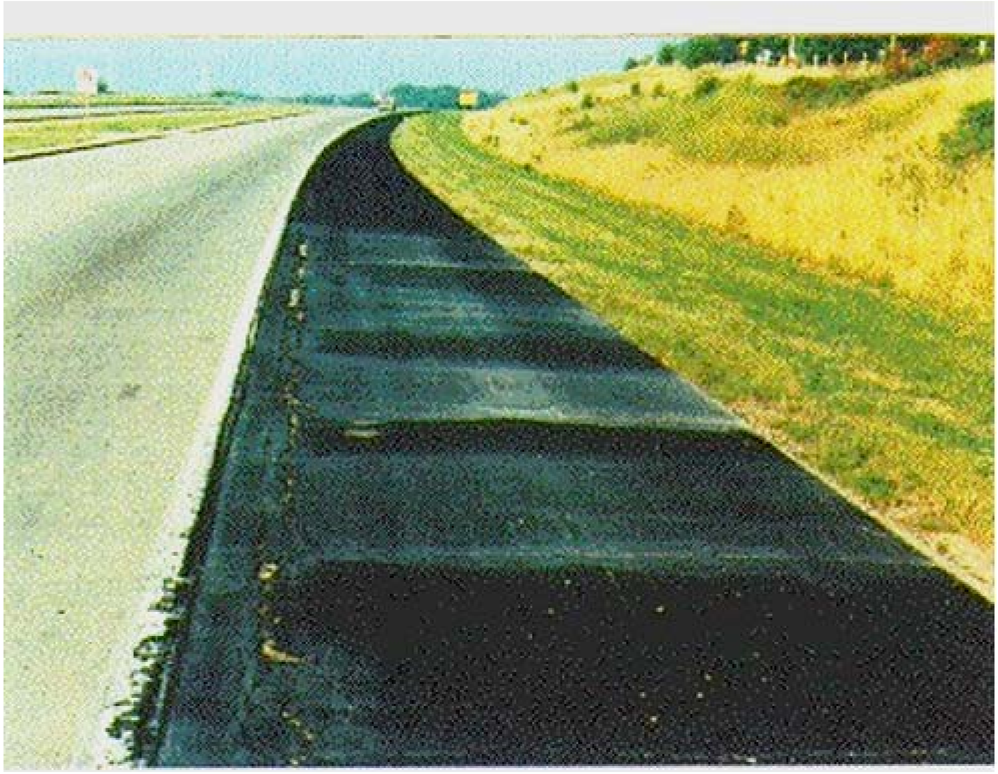
1. FAULTED JOINTS



These pictures are supplements to the previous picture to aid in giving an indication of the degree of faulting on that particular section of highway.

Jointed Plain Concrete Pavement-undoweled

1. PUMPING

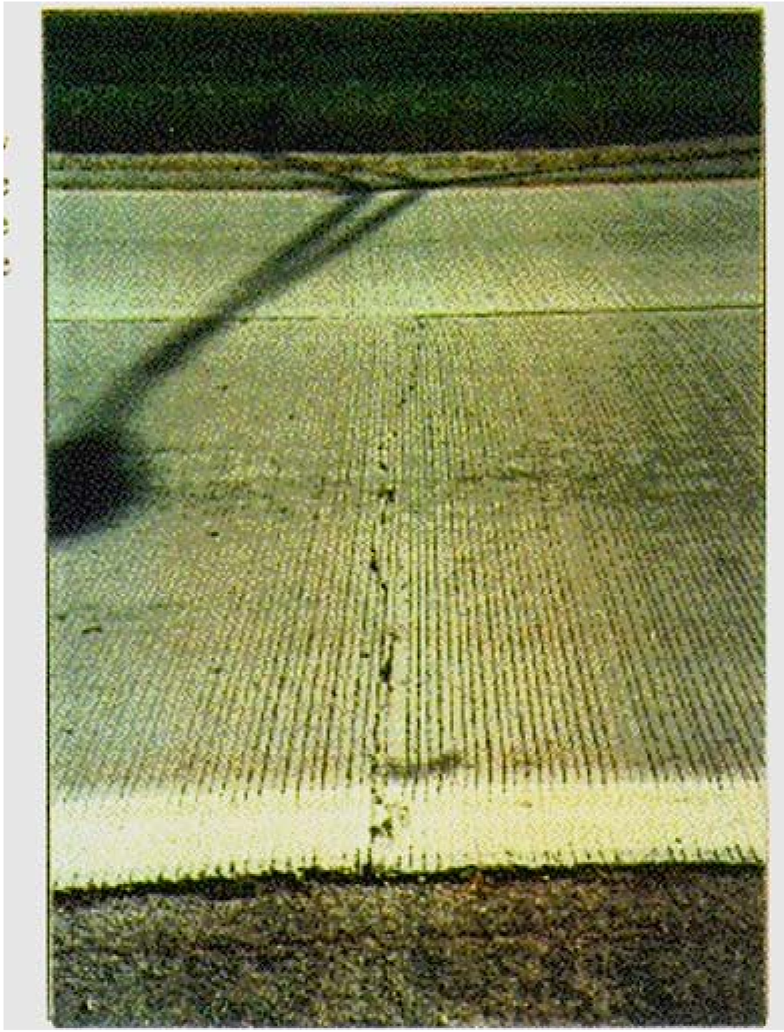


Repair and Grind

The white staining on the shoulder in the above picture is an indication that pumping of the base is taking place. All necessary repairs to the concrete pavement that are required as previously outlined should be performed. The past practice of retrofitting a longitudinal edgedrain in this situation is not recommended. Current research efforts by the Department indicate that these retrofit drains are not draining water from the pavement structure and are not preventing recurrence of faulting in these types of pavements.

Jointed Plain Concrete Pavement-undoweled

1. CRACK

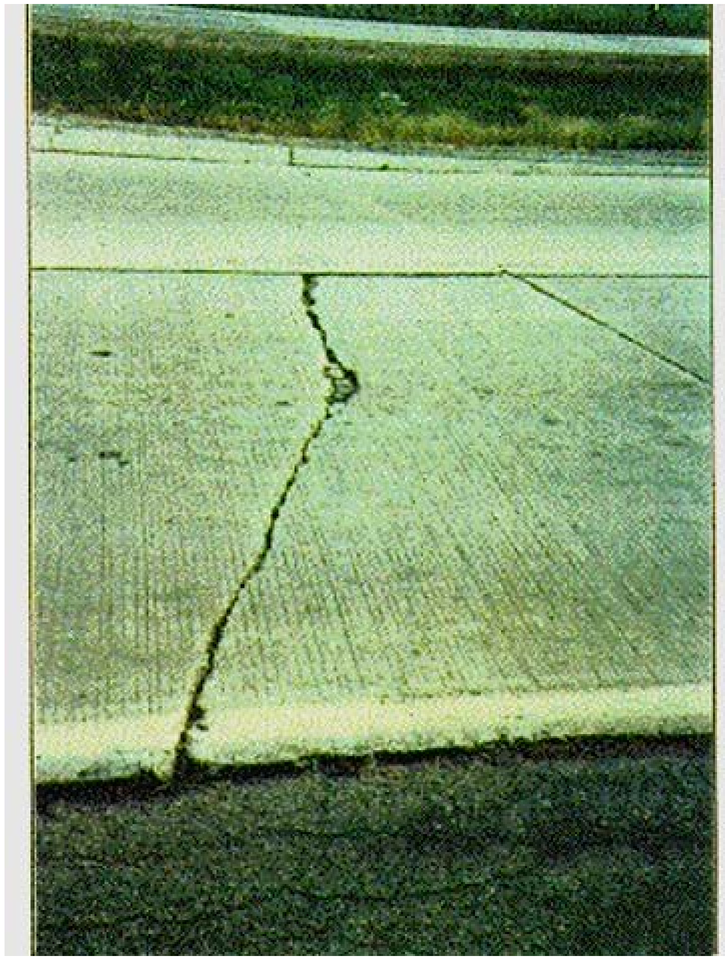


Repair and Grind

This crack is in good condition with a few minor spalls along the length of the crack. No repair is required. These spalls will be removed as part of the grinding operation.

Jointed Plain Concrete Pavement-undoweled

1. TRANSVERSE CRACK



Repair and Grind

The above crack is faulted, spalled and has some secondary cracking running parallel to it. A replacement of this slab is required for this rehabilitation strategy.

Jointed Plain Concrete Pavement-undoweled

1. LONGITUDINAL CRACKING

Repair and Grind

Longitudinal cracks should be assessed from two standpoints. The first is the condition of the crack and secondly is the affect is has on ride quality. The cracks shown in the photo above are in successive slabs and have significant spalling. The slabs have also settled along the shoulder. This type of distress is an indication of a base or subgrade problem and a full depth repair is needed. However, it is not the intention of this manual to make a recommendation on subgrade or base repair.

SECTION FOUR: Jointed Plain Concrete Pavement-doweled

This section addresses jointed plain concrete (JPCP). These Pavements have been constructed since the late 1980's and have doweled joints but do not have wire mesh reinforcement. Due to the short joint spacing on these pavements, less than or equal to 20 feet, there should be few or no intermediate cracks to repair. The rehabilitation strategies and the methods of repair are the same as that of jointed reinforced concrete pavement; therefore Section One of this manual should be consulted when working with this type of pavement.