SUDAS Revision Submittal Form

Status Date: As of 5/12/2017 **Topic:** Pavement overlays
Manual: Design **Manual Location:** Section 5J-1

Requested Revision: *See attached.*

Reason for Revision: New section for HMA and PCC overlays and associated interlayers.

Comments: None.

District: ☐ 1 ☐ 2 ☐ 3 ☒ 4 ☐ 5 ☐ 6
Initial Comments: Cold-in-place recycling before overlays. *Note - will be developed in the future.*
Final Comments: None.
Action: ☐ Deferred ☐ Not Approved ☒ Approved

District: ☐ 1 ☐ 2 ☒ 3 ☐ 4 ☐ 5 ☐ 6
Initial Comments: Page 7 - concrete overlays - slab dimensions in feet. Add interlayers to asphalt. *Note - done.*
Final Comments: Noted some minor errors. *Note - these were corrected.*
Action: ☐ Deferred ☐ Not Approved ☒ Approved

District: ☒ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6
Initial Comments: None.
Final Comments: None.
Action: ☐ Deferred ☐ Not Approved ☒ Approved

District: ☐ 1 ☒ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6
Initial Comments: Pavement preservation seems misleading for the part title (5K) - especially when you look at FHWA descriptions. *Note - moved overlays to a new part called "pavement rehabilitation program."*
Final Comments: When looking at this section, a suggestion was made to add a reference to this section within Table 5D-1.01. *Note - addressed comment by inserting the table into the HMA overlay specifications (Section 7021).*
Action: ☐ Deferred ☐ Not Approved ☒ Approved

District: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☒ 6
Initial Comments: Define CTE (in first table). *Note - done.*
Final Comments: None.
Action: ☐ Deferred ☐ Not Approved ☒ Approved

District:	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☒ 5 ☐ 6
Initial Comments:	None.
Final Comments:	None.
Action:	☐ Deferred ☐ Not Approved ☒ Approved

Final District Action Summary: All 6 districts approved; see comments above.

Board of Directors Action: On page 8, C, 1, a, the 2nd paragraph is confusing. Approved with revisions. *Note* - *deleted sentence that says "In some instances, 3/8 inch diameter aggregate may be utilized for thin lifts."*

Overlays

A. General

Overlays can extend the life of an existing pavement if good selection, design, and construction practices are followed. They can be constructed rapidly and while the roadway is open to traffic if warranted.

In order to achieve successful performance, it is important to choose the correct type of overlay based on the conditions of the existing roadway. This process of evaluation is critical to the success of the pavement and long-term performance. Design practices include thickness design, selection of specific materials, and construction details. Good construction practices include pre-overlay repairs to prepare the existing pavement if required.

B. Concrete Overlays

There are two options for concrete overlays - bonded and unbonded. Bonded overlays are designed as part of the pavement thickness where unbonded overlays are essentially new pavement on a stable base (existing pavement). For complete and detailed guidance on the design and construction of concrete overlays, refer to the *Guide to Concrete Overlays*, Third Edition (Harrington and Fick 2014). This guide includes the latest information on the evaluation of the existing pavement, guidance on the overlay selection and managing concrete overlay design and construction. Table 5J-4.01 summarizes the characteristics and applications of the different types of concrete overlay.

1. **Bonded Overlays:** The purpose of a bonded concrete overlay is to add structural capacity and eliminate surface distresses on pavements that are in good to fair structural condition. The new concrete overlay is bonded to the existing pavement and acts as one monolithic unit that increases the structural capacity and provides a means of addressing surface deficiencies or overall ride quality issues. Typically, bonded concrete overlays are relatively thin - typically 2 to 6 inches thick.

   Bonded concrete overlays are not good solutions when any of the following situations exist:
   - Existing concrete pavement has widespread material related deficiencies issues such as ASR or D-cracking, subgrade support is inadequate or non-uniform, or drainage is poor.
   - Existing asphalt or composite pavement exhibits significant structural deterioration, inadequate base or subgrade support or poor drainage condition.

   When the situations discussed above exist, unbonded concrete overlays may be considered.

2. **Unbonded Overlays:** The purpose of the unbonded concrete overlay is to restore the structural capacity of an existing pavement that is moderately to significantly deteriorated. On unbonded concrete overlays, bonding is not needed to reach the desired performance. Unbonded concrete overlays are considered a minor or major rehabilitation strategy depending on the condition of the existing pavement. When the unbonded concrete overlay is placed on an existing concrete pavement, a separation layer is required to prevent bonding and un-necessary stress between the two layers. The separation layer can be provided by either a thin asphalt layer or a nonwoven geotextile fabric. Typically, unbonded concrete overlays are 4 to 11 inches thick.

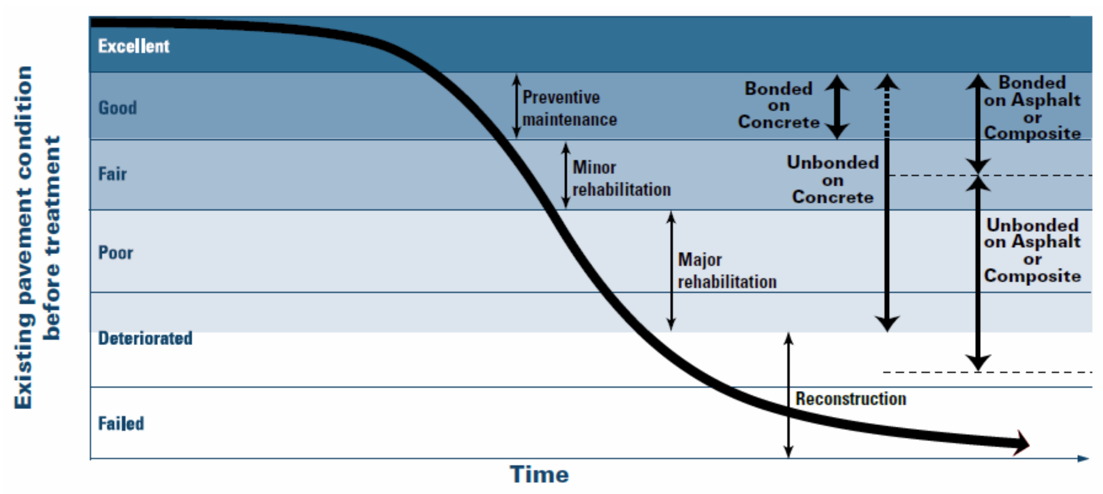
Table 5J-4.01: Concrete Overlay Characteristics and Applications

	Bonded Concrete Overlay	**Unbonded Concrete Overlay**
Purpose	Improve structural capacity & eliminate surface distresses	Restore structural capacity & eliminates surface distresses
Preservation Strategy	Preventative Maintenance	Minor or Major Rehabilitation
Typical Overlay Thickness	2” to 5” (on concrete) 2” to 6” (on asphalt)	4” to 11”
Condition of Existing Pavement	Good to fair structural condition or repaired to that condition	Moderately or significantly deteriorated, must be firm and stable
Special Design/ Construction Considerations	• For bonded concrete overlays of concrete, the coefficient of thermal expansion of the aggregate in the concrete overlay must be similar those of the existing pavement • Existing joints must be in fair to good condition, or repaired • Critical to establish a good bond with existing pavement • Shotblasting or sandblasting may be needed to prepare concrete surfaces • For overlays over existing concrete, joints must match existing spacing and transverse joints sawed through the new overlay plus 0.5”, longitudinal joints shall be at least T/2, new overlay joints must match existing concrete pavement joints • The width of the new overlay joint must be equal to or wider than the joint in the existing concrete pavement • Curing should be applied at 2 times the usual application rate. Apply PAMS per manufacturer’s recommendation. • Surface distress on existing asphalt pavements may be removed by milling 2” or more of surface distortions (min. 3” asphalt shall remain) • For overlays over asphalt-surfaced pavements, smaller square panel sizes from 3’ to 8’ is recommended • For bonded overlays on asphalt, water should be sprinkled on the surface when surface temperature is greater than 120 degrees Fahrenheit during overlay placement	• Full-depth repairs may be needed to restore structural integrity of poor deteriorated areas • Surface distress on existing asphalt pavements may be removed by milling 2” or more of surface distortions • Concrete patches in the existing asphalt pavement should be separated with a bond breaker • For unbonded concrete overlays on asphalt, the underlying asphalt surface temperature should be maintained below 120 ˚F; this can be done by sprinkling the asphalt with water prior to the overlay, no standing water shall remain • Shorter panel sizes may be needed to help address curling and warping stresses • Unbonded concrete overlays on concrete require a separation layer of thin asphalt (typically 1”) or a non-woven geotextile fabric to provide drainage, separation and minimize reflective cracking • If there are material related distress in the existing concrete or existing composite section, repairs may be needed • For unbonded concrete overlays 6” and thinner, curing should be applied at 2 times the usual application rate. Apply PAMS per manufacturer’s recommendation.
Available Design Procedures	ACPA (2014a, 2014b), StreetPave12; AASHTO (1993, 2008, 2015), WinPAS 12; Vandenbossche (2014) BCOA	ACPA (2014b), StreetPave12; AASHTO (1993, 2008, 2015), WinPAS12

Source: Adapted from Harrington and Fick 2014

3. **Evaluation:** The evaluation and characterization of the existing pavement is a critical step in determining the suitability of a concrete overlay for the prevailing design conditions. Figure 5J-4.01 shows a typical pavement condition curve with various preservation strategies and the applicability of bonded and unbonded concrete overlays. Table 5J-4.02 summarizes the steps involved in evaluating an existing pavement.

Figure 5J-4.01: Timing of Application of Bonded and Unbonded Concrete Overlays



Source: Harrington and Fick 2014

Table 5J-4.02: Pavement Evaluation Process

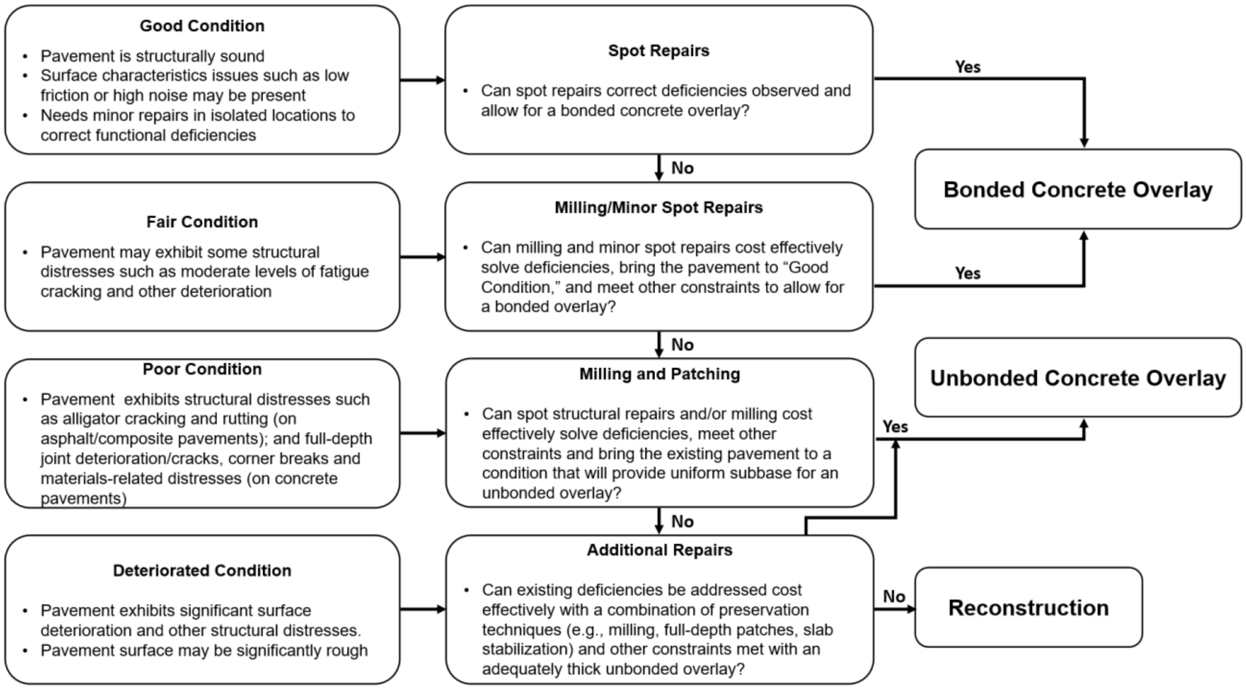
Process	Details
Step 1: Review pavement history and performance goals.	• Pavement design, layer types and thicknesses, length, width, age, drainage system. • Existing traffic and performance level (classification) • Design life and remaining life. • Design traffic and performance requirements. • Existing elevation and grade restrictions. • Other historical information.
Step 2: Perform visual examination of pavement.	• Note visible surface and structural distresses and determine overall condition of pavement (good, fair, poor, deteriorated). PCI may be determined and compared to condition curve.
Step 3: Conduct a thorough examination of pavement structure through core analysis.	• Identify type, extent, and severity of pavement distress. • Verify pavement layer types and thicknesses.

Step 4: Optional Analysis
• Material-related tests (4a)
• Subsurface test (4b)
• Surface texture tests (4c)
	• Material-related tests:
	  ○ Petrographic analysis to identify material-related distress issues and determine quality of air-void system in existing concrete.
	  ○ Determine if asphalt stripping issues exists.
	  ○ Determine aggregate coefficient of thermal expansion for existing concrete.
	• Tests of existing pavement:
	  ○ Falling weight deflectometer testing to determine:
	    ▪ Subgrade/subbase support (k-value) or stiffness.
	    ▪ Subgrade/subbase variability.
	    ▪ Load transfer efficiency of concrete pavements.
	    ▪ Presence of voids.
	    ▪ Concrete flexural strength.
	  ○ Subgrade tests to determine:
	    ▪ Frost heave characteristics.
	    ▪ Shrink-swell characteristics.
	    ▪ Soil strength (dynamic cone penetration or standard penetration test).
	  ○ Surface texture tests: conduct if before/after comparisons of pavement surface friction are needed.

Source: Adapted from Harrington and Fick 2014

After the evaluation, it is necessary to select the type of concrete overlay. Figure 5J-4.02 illustrates the basic steps involved. The process begins by entering the flowchart on the left, based on the condition of the existing pavement, and then following through the chart.

Figure 5J-4.02: Selecting Appropriate Concrete Overlay Solution



Source: FHWA Tech Brief

4. **Construction Materials:** Conventional concrete materials are utilized in concrete overlay construction including cement, supplementary cementitious materials (SCMs), aggregate, water and chemical admixtures. Other conventional materials including steel tie bars, dowel bars, curing compound, and joint sealant are used. The key considerations related to concrete overlay materials and mixtures are summarized in the *Concrete Overlays*.

   a. **Fibers:** Although the use of structural fibers are not normally necessary for most concrete overlays, their use may be warranted in certain situations including those where the overlay thickness is limited, heavier weight traffic loads are expected and increased joint spacing is desirable. Structural fibers improve residual strength of the overlay. Structural fibers can perform the following functions in a concrete mix:
      1) Help increase concrete toughness
      2) Help control differential slab movement caused by curling and warping, heavy loads, temperatures, etc. (allowing for longer joint spacing)
      3) Increase concrete's resistance to plastic shrinkage cracking (enhancing aesthetics and concrete performance)
      4) Hold cracks tightly together (enhancing aesthetics and concrete performance)

      Table 5J-4.03 provides a summary of the different types of fibers, including general descriptions and typical application rates. Additional details on the characteristics and application of fibers in concrete overlays is provided in Appendix C of the *Guide to Concrete Overlays*.

Table 5J-4.03: Summary of Fiber Types

Fiber Type	Size (D = dia.) (L = length)	Years Used in U.S.	Typical Fiber Volume (lb/yd^3)	Comments
Micro Synthetic Fibers	D < 0.012 in. L 0.50 to 2.25 in.	35	1.0 to 3.0	To reduce plastic shrinkage cracking and settlement cracking; limited effect on concrete overlay overall performance; more workability issues when using higher rates
Macro Synthetic Fibers	D > 0.012 in. L 1.50 to 2.25 in.	15	3.0 to 7.5	Increases post-crack flexural performance, fatigue-impact endurance; thinner concrete thickness; longer joint spacing; tighter joints, cracks; better handling properties, dispersion characteristics than steel fibers; not subject to corrosion
Macro Steel Fibers (carbon)	L 0.75 to 2.50 in.	40	33 to 100	Increases strain strength, impact resistance, postcrack flexural performance, fatigue endurance, crack width control per ACI 544.4R
Blended		15	Varies	Blend a small dosage of micro synthetic fibers and larger dosage of either macro synthetic fibers or macro steel fibers

Source: Harrington and Fick 2014

b. Separation Layer Materials: Separation layers for unbonded concrete overlays on concrete may serve three purposes.

- Provide isolation from movement of the underlying pavement. The separation layer is a shear plane that relieves stress, mitigates reflective cracking, and may prevent bonding with the existing pavement
- Provide drainage separation either by use of an impervious material or channel water along the cross slope to the pavement edge
- Provide a cushion or bedding layer to reduce bearing stress and to prevent keying from the underlying pavement

The separation layer may be either a hot mix asphalt or a non-woven geotextile fabric.

1) Asphalt Separation Layer: Conventional HMA mixtures have been used for several years to provide separation for unbonded concrete overlays. Typically, a 1 inch thick layer is used to provide separation from irregularities in the existing pavement, although thicker layers may be used when the irregularities are large enough to impact placement operations.

Poorly drained unbonded concrete overlays under heavy traffic may result in scouring or stripping of the asphalt interlayer. In an effort to reduce scour pore pressure and decreased stability, some agencies increase the porosity of asphalt mixtures. The sand content is reduced and the volume of 0.38 inch chip aggregate is increased. This modified (porous) mixture has a lower unit weight and lower asphalt content, and is comparable in cost to typical surface course mixtures.

2) Nonwoven Geotextile Separation Layer: Nonwoven geotextile interlayers are an alternative to an asphalt interlayer in providing separation, drainage and cushion for an unbonded concrete overlay. The structural condition of the existing concrete pavement must be carefully assessed before geotextile layers are used in lieu of an asphalt interlayer. Leykauf and Birmann (2006) also note that geotextile interlayers are especially recommended for concrete overlays on old concrete pavements.

The fabric is secured to the existing pavement with pneumatic hammers at approximately 6 feet spacing or through the use of adhesives. It is critical that the fabric is free of wrinkles and no more than three edges overlap at one location. The weight of the fabric is dependent on the thickness of the overlay. Recommended weights for nonwoven geotextile fabrics for unbonded concrete overlays are as follows:

Overlays $\leq$ 4 inches – 13.3 oz/yd^2
Overlays $\geq$ 5 inches – 14.7 oz/yd^2

Temperature of the surface upon which the overlay is to be placed is critical to minimize fast drying out and shrinkage cracks in the PCC overlay. One method to assist in keeping the surface cooler is to specify a fabric interlayer that is white or light colored for the hot, summer months. A black or dark fabric interlayer can be used in the cooler spring and fall months.

Specifications for the nonwoven geotextile separation layer are included in SUDAS Specifications Section 7011.

5. **Thickness Design:** There are several design procedures available for determining the thickness of concrete overlays. Designers should reference the *Guide to the Design of Concrete Overlays Using Existing Methodologies* (Torres et al. 2012) for recent guidance. This document provides guidance on the following design procedures, in addition to more recent software design. The following design methodologies are most common:
   - Bonded Concrete Overlays on Asphalt (BCOA) Thickness Designer (ACPA 2012)
   - Bonded Concrete Overlays on Asphalt ME (Vandenbossche 2013) for overlays on asphalt
   - Guide for Design of Pavement Structures 4th Edition (AASHTO 1993)
   - StreetPave (ACPA 2012)

   Table 10 from the *Guide to Concrete Overlays* provides a summary of typical design and software parameters.

6. **Construction:** Concrete overlays are constructed using conventional concrete paving equipment and procedures. Construction time for concrete overlays is significantly shorter than reconstruction due to the lack of earthwork required as well as the potential for the paving equipment to move faster due to the thinner layer. Payment for concrete overlays are typically based on square yards of concrete placement and cubic yards of concrete delivered to the site. Table 21 from the *Guide to Concrete Overlays* provides a detailed list of construction consideration items and how they relate to bonded and unbonded concrete overlays.

   Joints are one of the most critical elements for overlay construction. Timing of joint sawing is critical and because of the smaller joint spacing, the sawing operation is likely to determine daily production limits. Joint spacing requires special consideration based on the type of overlay and the type of underlying pavement.

   For bonded overlays over concrete pavement, the joints in the overlay need to match the joints in the underlying pavement. The joints should be cut full depth plus 1/2 inch for transverse joints and T/2 for longitudinal joints. The width of the transverse saw cut must be equal to or greater than the width of the crack at the bottom of the transverse joint in the existing pavement.

   The recommended joint pattern for bonded overlays over asphalt pavement should not exceed 1 1/2 times the overlay thickness. Transverse joints should be sawed to T/3 using conventional saws and not less than 1 1/4 inches using an early entry saw. Longitudinal joints should be cut to T/3.

For unbonded overlays, it is generally a good practice to mismatch joints or cracks to maximize load transfer from the underlying pavement. Slab dimensions (in feet) should not exceed 1 1/2 times the overlay thickness for overlays less than 6 inches thick, and should not exceed 2 times the thickness with an absolute maximum of 15 feet for overlays greater than 6 inches thick. Transverse saw cuts for conventional saws and longitudinal joints should be T/3. Transverse cuts for early entry saws should be at least 1 1/4 inches deep.

C. HMA Overlays

1. HMA Overlays:

a. Conventional: Conventional HMA overlays are typically 2 to 4 inches thick, placed in multiple lifts. Lift thickness varies but are typically 1 1/2 inches to 3 inches thick. The overlay is expected to improve rideability, surface friction, profile, crown, and cross slope. In addition, specific distress types of low severity cracking, raveling, roughness, low severity bleeding, and low severity block cracking are improved. HMA overlays rely on timely compaction to be successful. Typically, HMA overlays are dense-graded but may also be open-graded if a porous mix is desired.

In order for the aggregate in the HMA overlay to properly align itself during compaction and achieve required density, the nominal maximum aggregate size must be no larger than 1/3 the thickness of the overlay. For example, for a 1 1/2 inch thick asphalt lift, nominal aggregate size should be no larger than 1/2 inch. See SUDAS Specifications Section 7020.

b. Thin Lift: Sometimes called thinlays, thin lift overlays generally range from 3/4 inch to 1 1/2 inches thick. With the thin lift overlays, the nominal maximum aggregate size must be no larger than 1/3 the thickness of the overlay. The mix has more asphalt binder (approximately 8%) than a traditional mix in order to cover the surface area. The binder (PG 58-34E) is formulated to be softer, which helps the mix be more durable and resistant to cracking than traditional mixes.

Because of its nature and the overlay being very thin, it is critical to have a sound underlying pavement for the thin lift overlay to perform properly. In addition to the condition of the underlying pavement, one of the biggest factors for success is cleanliness, especially if milling is involved.

In most cases, milling of the underlying pavement will help improve smoothness as well as remove defects that could reflect through the new thin lift overlay. Milling will roughen the surface, which should improve the bonding and thus the shear resistance. With or without milling, cleaning of the roadway is imperative. Any amount of dust will impact the tack coat. Due to the thin nature, tack failure will lead to debonding and slippage.

The smaller aggregate size used in thin lift overlays can present production and transport challenges. If the air temperatures are cooler and the transport distance long, the mix may lose heat quicker than standard mixes and thus workability and compaction can be compromised. Production temperatures may need to be greater for thin lift overlays because they cool more quickly. Production time for thin lift overlay mixes is generally slower than for standard mixes. Fine aggregates generally retain more moisture than coarse aggregates and thus require more drying time. In addition, the fine aggregates require more asphalt to fully coat the greater surface area they exhibit.

A uniformly applied tack coat is essential to the success of thin lift overlays. Raveling and slipping of the surface course at the interface with the existing pavement are problems when tack coats are insufficient or applied in streaks.

With the thin lift thickness, it is difficult to isolate the density of the overlay from the density of the underlying pavement. Thus, in most cases, a rolling pattern is established. To date, experience has shown that three passes with a vibratory steel-wheeled roller provides appropriate density.

As noted, the performance of thin lift overlays will depend on traffic, climate, underlying pavement quality, surface preparation, materials, and construction quality. In colder climates such as in Iowa, special attention needs to be paid to thermal cracking and damage created by snowplows.

Because of the thin lift thickness, the mix will cool quicker than normal; therefore, it is important the ambient air temperatures be at least 60°F and rising before initiating pavement placement. Ensure the entire mat has cooled to a point below 150°F before opening to traffic.

c. **Interlayers:** HMA interlayers can be placed prior to the HMA overlay to minimize reflective cracking from the underlying pavement. An asphalt interlayer is a specially designed lift of HMA placed over a pavement and under an asphalt overlay. The asphalt interlayer is usually about 1 inch thick and uses a highly polymerized asphalt binder (PG 58-34E), fine aggregates, and a higher than normal asphalt cement content to develop a flexible layer. The interlayer will have the elasticity to resist and partially absorb the tension, shear, and bending exerted on the pavement. The asphalt interlayer assists in retarding reflective cracking of the HMA overlay caused by movement of the underlying pavement. The asphalt interlayer also helps keep additional moisture from penetrating through any cracks that are reflected and thus delaying any further deterioration of the pavement structure.

The condition of the underlying pavement is critical. If an underlying pavement has deteriorated or become unstable, it may be necessary to do removal and patching or placement of a leveling course with standard HMA prior to placement of the interlayer. Due to the higher cost, the asphalt interlayer should not be used as a leveling course.

2. **Crack and Seat with HMA Overlay:** Cracking and seating with HMA overlay is considered a major rehabilitation. Crack and seat will typically reduce the occurrence and severity of reflection cracks in the asphalt surface overlay. The existing concrete is broken with a guillotine or segmental type breaker to produce hairline cracks at approximately 3 to 4 foot spacing. The cracked slabs are then seated by use of a weighted roller to reestablish support between the underlying subbase or subgrade and the existing pavement. The roller is usually a rubber tired piece of equipment with a minimum gross load of 30 tons.

Crack and Seat - Photo courtesy of Antigo Construction

In urban areas, a full depth saw cut along the curbline is required prior to conducting crack and seat operations. In addition, a guillotine style breaker should be used with caution where structures are near the roadway. Impacts from the large single breaker can vibrate structures and cause concerns for property owners. A segmental breaker results in lower magnitude vibrations and is recommended for crack and seat projects in urban areas.

3. **Rubblizing with HMA Overlay:** Rubblizing of an existing concrete pavement and placement of an HMA overlay is an optional major rehabilitation method. This process includes breaking up the concrete pavement into small pieces and rolling it into place to produce a sound base, which prevents reflective cracking in the asphalt surface. Rubblizing a concrete pavement successfully is predicated on having a stable subgrade so the concrete material does not intermix with the subgrade. In urban areas, care must be taken not to damage utilities with minimal cover. The final surface is HMA overlay.

Rubblizing - Photo courtesy of Antigo Construction

It may be necessary to work with the rubblizing contractor to establish a 100 to 200 foot test section as a means of determining the effectiveness of the rubblization. The goal is to break the existing PCC pavement into pieces with a nominal maximum size of 4 inches. In certain circumstances, the designer may allow larger pieces but they should not exceed 12 inches in size and should only be allowed for a limited area. It may be appropriate to require the contractor to excavate a test pit (4’ X 4’) to assure that the PCC has been fractured throughout its entire thickness and that the bond between any steel and the concrete has been broken.

The displacement of the rubbilized pieces into the subgrade should be minimized. A steel drum vibratory roller having a minimum gross weight of 10 tons is required to compact the rubbilized pavement.

In areas of soft subgrade, it may be necessary to remove the pavement and patch with 2 inch limestone chokestone. Geogrid may be used under the patch rock to add additional support.

A 2 inch to 3 inch rock interlayer of 3/4 inch roadstone may be placed on the rubbilized concrete and rolled prior to placing the HMA overlay if surface variations remain after rolling. The use of the interlayer provides a more stable work platform and enhances the overlay’s ability to stop reflective cracking.

D. References

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