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500 Pavement Design Procedures for Minor Rehabilitation

500.1 Introduction

Minor rehabilitation occurs when the pavement has deteriorated beyond the point at which a surface treatment is cost effective or the pavement is structurally deficient for the anticipated ESALs but has not yet deteriorated to the point where major rehabilitation is required. Minor rehabilitation usually consists of some combination of planing, repair, and overlay. ODOT designs minor rehabilitation overlays using a non-destructive, deflection-based procedure.

501 Non-Destructive Testing

Non-destructive testing (NDT) is a means of analyzing pavement properties without causing damage. ODOT uses non-destructive deflection measuring equipment for pavement analysis. Deflection measuring equipment imposes a load on the pavement and measures the response. Deflections can be correlated to the structural condition of the pavement and the subgrade. Designers can interpret the deflections and provide recommendations for pavement rehabilitation. ODOT uses the Falling Weight Deflectometer to measure pavement deflections.

501.1 Falling Weight Deflectometer

The Falling Weight Deflectometer (FWD) is an impact load response device used to measure pavement deflection. The impact force is created by dropping a weight of 110, 220, 440, or 660 pounds (50, 100, 200, 300 kg) from a height of 0.8 to 15 inches (20 to 380 mm). By varying the drop height and weight, a peak force ranging from 1500 to 24,000 pounds (6.7 to 106.8 kN) can be generated. The load is transmitted to the pavement through a loading plate, 11.8 inches (300 mm) in diameter, to create a load pulse in the form of a half sine wave with a duration of 25 to 30 ms. The actual magnitude of the load applied depends on the stiffness of the pavement and is measured by a load cell. Deflections are measured by seven to nine velocity transducers (i.e. sensors), one located at the center of the loading plate with the remaining six to eight placed at locations up to 7.4 feet (2.25 m) from the center of the load plate. Deflection measurements are recorded on a computer located in the tow vehicle.

501.1.1 Sensor Setup

For minor rehabilitation analysis, ODOT typically collects seven sensors of measurements located at -12, 0, 12, 24, 36, 48 and 60 inches (-305, 0, 305, 610, 915, 1220, 1525 mm) from the load plate and these are noted as W(-12), W(0), W(12), W(24), W(36), W(48) and W(60) respectively.

501.2 Other Non-Destructive Testing

Ground Penetrating Radar (GPR) is another non-destructive testing method that may provide additional insight into the presence of pavement anomalies (i.e. air, water, or differences in material dielectric constant) as well as estimate in-place thicknesses. Pavement cores are required to correlate GPR scans to pavement thickness. ODOT has not had success correlating the GPR-identified pavement anomalies with scoping pavement repairs and rehabilitation strategies.

A Profilometer is another non-destructive testing method primarily used to obtain the international roughness index (IRI) otherwise known as smoothness. IRI may provide insight into determining if and where the ride needs improvement through planing or diamond grinding. This type of non-destructive testing is most often used by ODOT for smoothness acceptance in construction as specified in proposal note 420.

502 Deflection Testing and Analysis

502.1 Testing

Deflection measurements taken when the subgrade is frozen are meaningless for design. The testing season in Ohio runs approximately April through November. Deflection testing is completed by the Office of Pavement Engineering.

502.1.1 Annual Testing Program

Each year a testing program is established that consists of projects approximately two to three fiscal years in the future to encompass the construction season two years in the future. Testing requests need to include the county, route, begin log, end log, length, PID, fiscal year, pavement type, date needed, etc. All projects must include the exact limits of the project by straight line mileage. In conjunction with research needs, deflection testing is prioritized based on the date needed and scheduled accordingly.

Deflection testing requires a lane closure as the equipment must be stationary to run the test. The Office of Pavement Engineering coordinates with ODOT county forces to schedule traffic control for testing within a county.

502.1.2 Additional Testing Requests

Districts may need to add project sections during the testing season. Additional requests are honored on a first-come, first-served basis, subject to scheduling considerations. Requests made too late in the season may not be tested until the following year. Research testing needs take priority during many of the summer months. The best time to submit requests is just prior to and early in the testing season. Additional requests need to include the same project information described in Section 502.1.1.

502.1.3 Re-testing Requirements

Deflection measurements represent a snapshot of the pavement at the time of measurement. As the pavement continues to deteriorate, the snapshot changes. Deflection measurements should not be obtained more than four years prior to the anticipated construction year. If the project is delayed such that the data will be more than five years old, new deflection measurements should be requested and the design checked against the new measurements to ensure validity.

502.1.4 Testing Protocol

At each location where deflections are measured, the load plate and sensors are placed on the pavement before applying an approximate 9000 pound (40 kN) seating load. After the load plate is seated on the pavement surface, loads of approximately 9000, 12,000 and 15,000 pounds (40, 53.4, and 66.7 kN) are applied to rigid and composite pavements and loads of approximately 6000, 9000 and 12,000 pounds (26.7, 40, and 53.4 kN) are applied to flexible pavements.

The three load responses (deflections) are measured and recorded on the computer in the tow vehicle for each location. Some sections that do not have a uniform build-up for the length of testing may keep the same loading set-up. Measurements are ideally collected in the outside wheel path of the driving lane approximately every 100 to 500 feet (30.5 to 152.4 m) with every third test location a joint approach/leave measurement on composite and rigid pavements. Field restrictions may result in a different test pattern or spacing. For routine analysis and design, a minimum of 30 locations of mid slab type measured deflections is required.

502.2 Analysis

Deflection measurements yield a great deal of information about the pavement when properly interpreted. This Manual is not intended to make the reader an expert in analyzing deflection data. The Office of Pavement Engineering analyzes the deflection measurements and provides District pavement engineers with processed FWD measurements in Excel files and a pavement rehabilitation recommendation letter. The file contains deflection measurements normalized to a 1000 pound (4.4 kN) load, the Edwards Ratio, Design Modulus, Load Transfer, and Joint/Crack Support Ratios as discussed in Sections 502.2.1 to 502.2.4. Separate Excel files are provided for each direction of measurement (i.e. divided sections typically have two files, one for each direction while undivided sections typically have just one file corresponding to the direction collected).

502.2.1 Edwards Ratio

A useful parameters derived from the FWD measurements is called the Edwards Ratio; named after William F. Edwards, former Bureau Chief of Research and Development at ODOT. The Edwards Ratio states that if the W(0) sensor reading divided by the W(60) sensor reading is greater than three, the pavement is acting as a flexible pavement and should be analyzed as such. If it is less than three, the pavement is acting as a rigid pavement and should be analyzed as such. This is very useful when trying to decide how to analyze a brick pavement or a previous break & seat or crack & seat.

502.2.2 Design Modulus

The W(60) sensor can be used to estimate the subgrade support. The estimated subgrade design modulus is listed on the statistical summary tab in the Excel file provided to District pavement engineers.

502.2.3 Load Transfer

Load Transfer can indicate joints that have deteriorated and are no longer effectively transferring the load. Load Transfer less than 0.70 indicate poor load transfer however, Load Transfer greater than 0.70 does not necessarily indicate good joints. If the pavement is warm, the joints may be locked up and showing better load transfer than actually exists. Load Transfer is the W(12) sensor divided by the W(0) sensor, both from the joint approach reading.

When cracks are tested, Load Transfer from one side of a crack to the other is calculated and analyzed in the same manner as joints.

502.2.4 Joint Support Ratio

The Joint Support Ratio is another measure of a joint's effectiveness. Joint Support Ratio is the W(0) sensor from the joint leave reading divided by the W(0) sensor from the joint approach reading. Joint Support Ratios between 0.50 and 1.50 are considered good. Ratios outside this range indicate probable voids under the joint. Voids are also likely anytime the W(0) sensor measurement is above 1.0.

When mid-panel transverse cracks are tested, a Crack Support Ratio is calculated and analyzed the same as the Joint Support Ratio.

502.3 Factors Affecting Deflections

The major factors that influence deflections include loading, climate, and pavement conditions. These factors must be carefully considered when conducting nondestructive tests and analyzing the results.

502.3.1 Loading

The magnitude and duration of loading have a great influence on pavement deflections. It is desirable that the NDT device applies a load to the pavement similar to the actual design load, e.g., a 9000 pound (4086 kg) wheel load. This is achieved with the FWD utilized by ODOT for deflection measurements.

502.3.2 Climate

Temperature and moisture are the two climatic factors that affect pavement deflections. For asphalt pavements, higher temperatures cause the asphalt binder to soften and increase deflections. For concrete pavements, temperature, whether ambient or thermal gradient within the slab, has a significant influence on deflections near joints and cracks. Concrete expands in warmer temperatures causing tighter joints and cracks and resulting in greater efficiency of load transfer and smaller deflections. Curling of the slabs due to temperature gradients can cause a large variation in measured deflections. Measurements taken at night or early morning, when the top of the slab is colder than the bottom, will result in higher corner and edge deflections than those taken in the afternoon, when the top of the slab is much warmer than the bottom.

The season of the year has a great effect on deflection measurements. In winter, when the subgrade is frozen, deflections are reduced. In the spring there may be increased moisture in the subgrade and deflections increase. ODOT attempts to mitigate the seasonal effects the testing season.

502.3.3 Pavement Conditions

Pavement conditions have significant effects on measured deflections. For asphalt pavements, deflections obtained in areas with cracking and rutting are normally higher than those free of distress. For concrete pavements, voids beneath the concrete slabs will cause increased deflections, and the absence or deterioration of load transfer devices will affect the deflections measured on both sides of the joint.

503 Overlay Design Procedure

503.1 Introduction

The overlay design procedure for minor rehabilitations requires a great deal of preparatory work before analyzing the deflection measurements. The FWD measurements must be available (Section 502), traffic projections must be completed (Section 202), and the history of the pavement must be known.

The history is required to determine the actual buildup of the pavement at the time the FWD measurements were collected. Sources for pavement history include such things as the pavement management system or looking up historical plans. On past overlay projects where the asphalt surface was planed, it is necessary to determine the depth of planing as deflection analysis requires the total thickness of asphalt and/or concrete at the time the measurements were taken. If the thickness or pavement type changes within the project, the deflection measurements will be analyzed separately for each of the different thicknesses or pavement types.

Once all the required information is collected, the Office of Pavement Engineering will process and analyze the deflection measurements. Most of the overlay design inputs for deflection analysis are common to all pavement types: the design traffic input comes from the ESAL11 program (Section 202.3), reliability factors are given in Figure 201-1, the traffic standard deviation is always 0.10, and initial and terminal PSI are always 4.5 and 2.5, respectively. Overlay design inputs specific to each pavement type are discussed in the following sections. The information given here is not intended to fully explain the deflection measurement and analysis procedure.

All of the overlay design inputs and outputs are exclusively in English units.

503.1.1 Design Period

The design period is the number of years over which the pavement is expected to deteriorate from its initial condition to its terminal serviceability. It is the number of years the ESALs are predicted for. The design period is established in Section 102.

503.2 Rigid Pavements

Rigid pavement refers to all types of exposed concrete pavement with no asphalt on top. The minimum overlay thickness for rigid pavements is three inches. Pavements that require an overlay of about one inch or less are candidates for diamond grinding instead of an overlay.

Most of the rigid pavement overlay design inputs for deflection analysis use recommended default values, such as Poisson's Ratio, elastic modulus, initial PSI, terminal PSI, modulus of rupture, and the drainage coefficient shown in Figure 503-1. The thickness of the existing pavement is obtained from the history. The load transfer coefficient (J) is dependent on the specifics of the existing pavement. A list of J-factors for existing pavements is given in Figure 503-1. A rigid pavement with the majority of the joints replaced with flexible repairs should use a J-factor for a pavement with no load transfer at the joints (i.e. undoweled).

503.3 Flexible Pavements

Flexible pavements are made up entirely of asphalt with or without an aggregate or macadam base. Previously rubblized pavements are considered flexible pavement. Previous break & seat and crack & seat projects may be flexible pavement but are more likely acting as composite pavement. The Edwards Ratio can help in determining the appropriate pavement type for analysis in questionable cases.

Most of the overlay design inputs for flexible pavement require project specific values. Overlay design requires the whole thickness of flexible pavement above subgrade including any aggregate base, macadam base, or rubblized concrete, plus the entire thickness of asphalt.

Overlay design requires the surface asphalt layer thickness for temperature adjustment. It is not a sensitive input and may use a default value of 3.5 inches (90 mm). Best practice is to use the thickness of the existing surface and intermediate courses combined. Pavement surface temperature is recorded during FWD testing and stored on the computer in the tow vehicle. Where fluctuating temperatures were recorded for the same data, a weighted average should be used.

Overlay design also requires the 5-day mean air temperature. This should be obtained from meteorological records available on the internet. If temperature records cannot be obtained, the morning pavement surface temperature should be used as the basis for the 5-day mean temperature. Some adjustment is allowed if the designer is aware of specific temperature conditions in the days just prior to the FWD measurements.

503.4 Composite Pavements

Composite pavements are concrete overlaid with asphalt. Most in-service break & seat and crack & seat pavements should be analyzed as composite pavements. Any asphalt-surfaced road with concrete underneath that is acting like a rigid pavement according to the Edwards Ratio, should be analyzed as a composite pavement.

The overlay design inputs for composite pavement are nearly identical to rigid pavement with the addition of asphalt on top (Section 503.2). The thickness of the existing asphalt concrete layer on top of the concrete is required for overlay design. Overlay design uses recommended default values for Poisson's Ratio, resilient modulus of the asphalt, new concrete elastic modulus, initial PSI, terminal PSI, new concrete modulus of rupture, and drainage coefficient. The thickness of existing PCC slab used for overlay design is obtained from the history or coring. The load transfer coefficient (J) is dependent on the specifics of the existing pavement. A list of J-factors for existing pavements is given in Figure 503-1. A composite pavement with the majority of the joints replaced with flexible repairs should use a J-factor for a pavement with no load transfer at the joints (i.e. undoweled).

503.4.1 Brick Base Pavements

Most brick pavements in Ohio were built on a concrete base and have since been overlaid with asphalt and thus are a special kind of composite pavement. The Edwards Ratio can help the user decide which pavement type to use to analyze the brick.

Since brick base pavements occur mostly in urban areas, there are likely to be geometric constraints such as curb reveal, driveways, etc. One method to increase the structural capacity while possibly minimizing elevation changes involves removing the bricks. This should be considered only if the section has been cored to determine the condition and thickness of the underlying concrete. A crack and seat design (see Section 600) is used to determine the new thickness of asphalt to be placed after the old asphalt and bricks have been removed. The actual cracking and seating operation should not be performed as the concrete is likely already well cracked. This method eliminates the need for deflection analysis on a brick base pavement.

504 Minor Rehabilitation Strategies

As stated before, minor rehabilitations generally consist of some combination of planing, repair, and overlay. The structural overlay thickness needed for priority system routes is determined from the FWD measurements by the Office of Pavement Engineering. Even if no additional structure is needed, an overlay may still be required to correct functional deficiencies. The thickness of a functional overlay is selected based on factors such as planing depth, lift thickness requirements, vertical clearance, curb reveal, etc. A functional overlay with planing should never result in thinner pavement than existed beforehand. The other minor rehabilitation actions are at the designer’s discretion based on the condition of the pavement. The actions selected should be those required to reach the full design period for minor rehabilitation projects.

504.1 Asphalt Considerations

All asphalt items used in minor rehabilitation overlays should conform to the guidelines given in Section 400. High stress areas should be identified and treated in accordance with the guidelines in Appendix B. Prior to completion of the plans, all asphalt items specified should be discussed with the District Engineer of Tests or designee. This is important to ensure proper binder grades and mix specifications are specified.

A minimum of 3 inches (75 mm) of asphalt is required over any concrete or brick surface.

504.2 Pavement Planing

Item 254 Pavement Planing, Asphalt Concrete is always recommended prior to placing a new asphalt overlay on an old asphalt surface. A planed surface allows for mechanical interlock between the old pavement and the overlay which helps prevent rutting and debonding. Planing removes the old, raveled, oxidized asphalt which, if left in place, would be a weak layer in the pavement structure and would tend to hold water due to the lower binder content. Planing reduces the overall elevation increase and thus helps reduce geometric problems. Planing removes ruts and other irregularities and provides a level surface for the contractor to achieve proper density when 446 acceptance is specified.

When old asphalt is removed, it is necessary to replace the structure removed with an equivalent structure of new asphalt. The structural ratio of new asphalt to old asphalt used in Ohio is 2:3. For example, if 3 inches (75 mm) of asphalt are removed, 2 inches (50 mm) of asphalt are required to replace the lost structure. Any required structural overlay from deflection analysis is then placed in addition to the 2 inches

(50 mm). This ratio should not be used to make major reductions in the pavement thickness. In virtually all cases, the pavement thickness after rehabilitation should be equal to or greater than the thickness prior to rehabilitation.

On composite pavements, including brick bases, if all the asphalt is removed down to the concrete or bricks, the minimum overlay thickness for rigid pavements of 3 inches (75 mm) applies.

When planing down to a concrete surface, scarifying the top of the concrete is recommended if the total overlay to be placed is less than 5 inches (125 mm) thick. The scarification should be specified by plan note. The roughened surface increases the bond between the asphalt and the concrete and helps reduce the chances of rutting and debonding.

504.2.1 Brick Base Pavements

When planing asphalt over a brick base, it is recommended to leave about two inches (50 mm) of asphalt on the bricks. Planing any closer can easily dislodge the bricks and pull them up with the asphalt. Dislodged bricks should be quickly repaired, preferably using asphalt concrete (Items 301 or 441 Type 2), to prevent adjacent bricks from moving. Repairs should be made prior to running any traffic over the area, including construction traffic.

504.2.2 Fine Planing

Supplemental Specification 897 Pavement Fine and Micro Planing, Class A for fine planing is available for use with single course thin asphalt concrete overlays to allow for proper compaction. Thicknesses of planing need to be carefully considered to minimize any scabbing. Scabbing occurs when the planing depth is slightly above the interface of two pavement layers and the entire top layer is pulled up in random spots. Fine planing is primarily for surface treatment projects and will not typically be used for minor rehabilitation projects.

504.2.3 Micro Planing

Supplemental Specification 897 Pavement Fine and Micro Planing, Class B for micro planing is available for short term friction remediation and is not intended to be used for minor rehabilitation projects.

504.3 Pavement Repair

504.3.1 Rigid and Composite Pavements

Full-depth repairs in rigid and composite pavements most often occur at transverse joints and cracks and are typically all referred to as joint repairs. Joint repairs can be made using either concrete or asphalt. The repairs can be at transverse joints, transverse cracks, or any other place that requires full-depth repair.

Rigid repairs according to BP-2.5 using Item 255 Full Depth Pavement Removal and Rigid Replacement are recommended in almost every case. Prior to performing rigid repair, coring is recommended to determine if solid concrete exists to dowel into. Where solid concrete does not exist, flexible repairs using Item 252 Full Depth Rigid Removal and Flexible Replacement are an option. Only coring can reveal if the concrete is solid, FWD analysis and visual inspection of the surface cannot reveal this. Cores should be extracted a minimum of three feet from the joint or crack, near the location of the expected saw cut for the repair.

Four classes of concrete exist for rigid repairs; QC 1, QC MS, QC FS, and RRCM. Class QC 1 is recommended if the repairs are in a closed lane and adequate time, typically 3 to 7 days, exists for curing. When quicker opening to traffic is needed, one of the other classes may be used. Class QC MS allows opening to traffic in 24 to 28 hours. Class QC FS allows opening to traffic in 4 to 8 hours. Class RRCM allows opening to traffic in 4 to 6 hours. Use of classes QC MS and QC FS has led to problems due to the rapid and significant drying shrinkage. Class RRCM was developed to overcome these problems. Class RRCM is recommended whenever a faster setting time is needed however, the testing requirements make this class impractical for small quantities.

Joint repair is considered economical for repair quantities up to ten percent of the pavement surface area. When more than ten percent repair is needed, a more thorough investigation is warranted. If not already done, the pavement should be cored to better determine exact repair needs. The required overlay thickness needs to be examined and the possibility of major rehabilitation should be considered. It should be remembered that minor rehabilitations are intended to last twelve years, not twenty. It may not be necessary to repair every joint, especially if the pavement is to receive a thick overlay.

When estimating repair quantities, it is important to correctly calculate the pavement sawing quantities. Transverse saw cuts are required across the pavement at the limits of the repair. A saw cut is also required along any tied longitudinal joint. For a typical six foot (1.8 m) repair in one twelve foot (3.6 m) wide lane on a four-lane divided highway with an asphalt overlay or tied concrete shoulders, the total sawing quantity would be 12 feet + 6 feet + 12 feet + 6 feet = 36 feet (3.6 m + 1.8 m + 3.6 m + 1.8 m = 10.8 m). In limited rare situations where the limits of repair encounter untied side(s), each untied side does not require a saw cut and the calculated quantity should exclude these lengths from the total sawing quantity. For example, a typical six foot (1.8 m) repair in one twelve foot (3.6 m) wide lane on a four-lane divided highway with concrete lanes and asphalt shoulders, the total sawing quantity would be 12 feet +12 feet +6 feet = 30 feet (3.6 m +3.6 m +1.8 m = 9 m).

If the existing concrete has skewed joints, best practice is to make the saw cuts perpendicular to the center line and spaced to encompass the skew and the dowels.

In the past, due to concerns over pressure in concrete pavements, Type D pressure relief joints (see BP-2.4) were sawed at approximately 1000-foot (300 m) intervals in many concrete pavements. This not only relieved the pressure in the pavements but allowed the mid-panel cracks to open up and lose aggregate interlock required for load transfer. These Type D joints should be repaired full depth with rigid joint repairs whenever they are encountered. As long as a method to relieve pressure exists at the bridges, there is rarely a need for any additional pressure relief joints in a concrete pavement.

Some concrete pavements have had joints repaired with full depth flexible repairs. These asphalt repairs tend to hump up as the concrete expands, forming mini speed bumps which can be very detrimental to the ride and can be a maintenance headache. When a majority of the joints have been repaired with asphalt, it is generally impractical to re-repair them with concrete. However, if there are only a few flexible repairs or if the concrete is in excellent condition except for the flexible repairs, it may be practical to replace all the flexible repairs with rigid repairs.

Partial depth repairs in concrete pavement are specified using Item 256 Bonded Patching of Portland Cement Concrete Pavement. Bonded patches are most commonly used to repair surface spalling along joints. Repairing all or a portion of the asphalt on a composite pavement is done using Item 251 Partial Depth Pavement Repair.

504.3.2 Flexible Pavements

Flexible pavements may require full-depth repair due to potholes, wheel track cracking, transverse thermal cracks, etc. Full-depth repairs in flexible pavements are done using Item 253 Pavement Repair. As with rigid and composite pavements, when full-depth repair quantities exceed about ten percent, further investigation is warranted and major rehabilitation should be considered. For construction purposes, the minimum practical repair size is 2 feet by 2 feet (0.6 m x 0.6 m).

Transverse thermal cracks are similar to transverse joints in concrete pavement. As flexible pavements expand and contract with temperature, if the binder is too stiff the pavement will crack. These cracks can be random or can be regularly spaced just like joints in concrete. Thermal cracks are full-depth cracks through the entire thickness of the pavement and, if they are to be repaired, must be repaired full depth to correct them.

Partial depth repairs in flexible pavement are specified using Item 251 Partial Depth Pavement Repair. Partial depth repairs are typically used to correct areas of debonding or localized severe raveling.

504.3.3 Brick Base Pavements

Brick base composite pavements built on a concrete base typically do not have joints but often require full-depth repair. Full-depth repairs should be made using Item 305 Concrete Base, As Per Plan to the top of the bricks. A plan note needs to be written to handle all project specific concerns. In general, the note should eliminate the need for dowels, tie bars, joint forming, joint sealing, and texturing requirements. This assumes the brick has an asphalt overlay or is going to receive one.

Full-depth repair of brick base composite pavements built on a flexible base should be made Item 253 Pavement Repair. Alternatively, the repairs may specify the depth of Item 304 Aggregate Base and/or Item 301 Asphalt Concrete Base to be placed.

As many brick pavements occur inside municipalities, the agency responsible for maintenance should be contacted regarding their repair standards. This is particularly true for exposed brick pavements that will remain exposed. ODOT does not have standards for building or repairing exposed brick pavements.

504.3.4 Pavement Coring

Coring is completed with a drill rig capable of extracting a minimum of 4 inch (100 mm) diameter cores the depth of the pavement layers. Cores are used primarily to determine or confirm in-place layer thicknesses and conditions before finalizing a repair strategy. Coring can be completed by either District forces where available or the Office of Pavement Engineering. Requests are handled on a first-come, first-served basis, subject to scheduling considerations.

504.4 Reflective Crack Control

Composite pavements develop reflective cracks in the asphalt over transverse or longitudinal joints or cracks in the concrete below. Reflective cracks are inevitable with composite pavements. Reflective cracks may also occur in flexible pavements, particularly over thermal cracks and the longitudinal joint formed when a pavement is widened. Other reflective crack control options may be available, however only details regarding sawing and sealing, fabrics and geogrids, and chip seal interlayers are discussed.

504.4.1 Sawing and Sealing

Sawing and sealing asphalt concrete pavement joints, Item 409, consists of making a partial-depth saw cut in the asphalt overlay finished surface directly over transverse joints in the underlying concrete pavement immediately after paving. After the saw cuts are made, they are filled with a hot applied joint sealer. Sawing and sealing can be effective in controlling the location and deterioration of reflective cracks. Properly locating and aligning the saw cuts is critical for the treatment to have any chance of success. Sawing and sealing should be considered anytime the concrete is exposed, either because it has never been overlaid or because any overlay has been removed.

504.4.2 Fabrics and Geogrids

Paving fabrics and geogrids have not been found to be <u>cost</u> effective in reducing transverse reflective cracking. Studies have shown that fabrics can delay and sometimes reduce reflective transverse cracking, but not to the extent that future maintenance needs are less costly or come at a later time. Paving fabrics effectiveness in reducing reflective cracks over longitudinal joints is currently being researched with no final conclusions to date. Fabrics may be considered for longitudinal joints, particularly widening joints and joints at concrete/asphalt interfaces; however these types of applications should include a control section to monitor performance. A minimum overlay thickness of 1.5 inches (38 mm) should be placed above fabric installations.

Due to each proprietary material having different specifications and a lack of cost effectiveness data for Ohio, a generic specification has not been developed.

504.4.3 Chip Seal Interlayer

Chip seal interlayers consist of placing an Item 422, Single Chip Seal prior to placing an asphalt concrete overlay. This treatment has been used many times however, conclusions regarding cost effectiveness have not yet been made. If this treatment is used, the project should include a control section to monitor performance.

504.5 Concrete Pavement Restoration

Concrete Pavement Restoration (CPR) generally consists of some combination of full- and partial-depth repair, load transfer retrofit, cross stitching, diamond grinding, joint resealing, undersealing, etc. Experience has shown that adding tied concrete shoulders where they don't already exist is not cost effective and is not recommended as part of a CPR. CPR is recommended as the first rehabilitation action for most exposed concrete pavements. CPR maintains the concrete surface and avoids the reflective cracking that comes with composite pavements. CPR is not recommended for pavements built with slag aggregate as they tend to deteriorate from the surface down and diamond grinding can speed this deterioration.

504.5.1 Load Transfer Retrofit

Load transfer can be established across transverse cracks by retrofitting dowel bars or deformed bars. Dowel bars are recommended when the crack extends across all tied concrete lanes and shoulders. Deformed bars are recommended when the crack exists in one lane but not the adjacent tied lane or shoulder. The choice of dowel or deformed bars should be shown in the plans or marked by the Engineer. It should never be left to the contractor to choose. All the bars across a crack are required to be the same type, never a mixture of dowels and deformed bars.

Dowel bar retrofit can be used to establish load transfer at undowelled joints however, most pavements in Ohio were constructed with dowels. Details on load transfer retrofit can be found in C&MS Item 258 and SCD BP-2.6.

504.6 Geometric Issues

Many times there are geometric deficiencies with the roadway such as vertical clearance, curb reveal, cross-slope, etc., that need to be addressed. Some geometric deficiencies can be easily corrected as part of the pavement rehabilitation. Cross-slopes can be adjusted with either variable depth planing or a layer of asphalt with variable thickness or in extreme cases a combination of the two. Other problems are not fixed so easily.

To meet at-grade bridges and provide minimum clearance requirements under overhead bridges, the overlay is often thinned down or the planing depth increased. The minimum overlay thickness on concrete must still be maintained. If the minimum overlay thickness cannot be maintained, pavement must be removed or bridges raised. These areas with thinner pavement structure may exhibit more extensive and severe distresses as they age and will require more maintenance than the surrounding pavement. In some cases where a thick structural overlay is required, thinning down is not recommended and the pavement should be replaced or bridges raised.

Curb reveal is often a problem in urban areas. The structural needs of the pavement should not be compromised to save old curb. Where there is insufficient curb height for the required overlay, the curbs should be replaced. When only a functional overlay is needed, then it may be practical to increase the planing depth at the face of the curb to provide the full overlay thickness while still maintaining the curb height.

504.7 Pavement Widening

When widening a pavement, the best practice is to design the widening for the traffic and soils conditions present. When traffic and soils information is not available, the designer should match the in-place pavement type, materials and thicknesses. Best practice is for the old pavement and the widening to meet at the same subgrade elevation. If necessary, the widening may be built thicker than the abutting pavement but should not be built thinner. The base under the widening should slope away from the old pavement and drainage should be provided for the widening. Drainage can be achieved with pipe underdrains or possibly aggregate drains. Pipe underdrains should be tied into the existing outlets, if any.

Pavement widening in this section refers to additional driving lane width, additional lanes, turn lanes, etc. Widening projects in excess of four lane-miles must follow the Pavement Type Selection process in Section 104.

When adding or widening paved shoulders only, asphalt pavement is typically used regardless of the driving lanes pavement type. Matching subgrade elevation and providing drainage is recommended.

504.7.1 Rigid Pavement

When widening rigid pavement with concrete, the new pavement should be the same type as the old (plain or reinforced) and should be tied to the old concrete using a Type D Longitudinal Joint according to BP-2.1. Prior to specifying a Type D joint, the concrete should be cored to determine soundness. Where coring discloses unsound pavement; pavement repair, pavement replacement, or the elimination of the Type D joint should be considered. Widening of concrete pavement without tying longitudinally may create separation or longitudinal faulting depending on traffic.

The most important consideration when widening and tying rigid pavement is that transverse joints in the widening must be of the same type, placed at the same location, and in the same alignment as the old concrete joints. Mismatched transverse joints will induce cracking. Longitudinal joints are to be located at lane lines however, in a widening situation this may not be possible. The worst location for a longitudinal joint is in the wheel path. If necessary, remove part of the old pavement to prevent locating a longitudinal joint in the wheel path.

Rigid pavements to be overlaid as part of the widening project should be considered composite pavements and follow the widening guidelines given in Section 504.7.3.

When widening a rigid pavement with another pavement type, the widening should be designed for the conditions at hand. If necessary, the base under the widening should be thickened so that the subgrade elevations will match. If the widening is thicker than the abutting pavement, the subgrade should be sloped away from the old pavement and drainage provided.

504.7.2 Flexible Pavement

When widening flexible pavement with asphalt, the best practice is to make a saw cut at the edge of a lane and remove the outside edge of the old asphalt. This not only removes the uncompacted asphalt at the edges, but ensures there will not be a longitudinal construction joint in the wheel path. When matching thickness with the in-place buildup, the exact buildup and lift thicknesses should follow the guidelines given in Section 406.

When widening a flexible pavement with another pavement type, the widening should be designed for the conditions at hand. If necessary, the base under the widening should be thickened so that the subgrade elevations will match. If the widening is thicker than the abutting pavement the subgrade should be sloped away from the old pavement and drainage provided.

504.7.3 Composite Pavement

When widening composite pavement with composite pavement, not only should the subgrade elevations match but the surface of the concrete must match as well. Because it will be overlaid immediately, use Item 305 Concrete Base for the concrete regardless what type the old concrete is. However, if the old concrete is reinforced, add a plan note requiring the 305 also be reinforced. Transverse joints should be the same location, alignment and type as the old concrete. Mismatched transverse joints will induce cracking. Tie the 305 to the old concrete using a Type D Longitudinal Joint according to BP-2.5. Prior to specifying a Type D joint, the concrete should be cored to determine soundness. If the concrete is too deteriorated at the edge, the widening should not be tied but simply butted up against. The longitudinal joint between the old and new concrete is to be located at a lane line however, in a widening situation this may not be possible. It is recommended that some of the old pavement be removed rather than placing the longitudinal joint in a wheel path.

When widening a composite pavement with another pavement type, the widening should be designed for the conditions at hand. If necessary, the base under the widening should be thickened so that the subgrade elevations will match. If the widening is thicker than the abutting pavement the subgrade should be sloped away from the old pavement and drainage provided.

504.7.4 Wheel Path Location

The location of the wheel path varies depending on lane width and traffic wander. Where the wheel path location is known, use known limits for these locations. In lieu of project specific details of traffic wander and wheel path location, typical lane widths of 10, 11 and 12 feet (3.05, 3.35, 3.66 m) have corresponding wheel paths assumed to be located at 42 to 60 inches (1.07 to 1.53 m), 41 to 61 inches (1.04 to 1.55 m) and 40 to 62 inches (1.02 to 1.58 m), respectively, from the center of lane. Generally, the wider the lane the more traffic wander and the larger the wheel path. If the longitudinal widening joint must be placed in the lane, locate it in the center of the lane or a maximum of 3 feet (0.91 m) from the center.

504.8 Shoulder Use for Maintenance of Traffic

When minor rehabilitation requires the use of shoulders for maintenance of traffic operations during construction, the structural integrity of the shoulders should be verified. Verification may include pavement history, coring, non-destructive testing, empirical calculations etc., to determine the feasibility of use. Shorter duration maintenance of traffic operations, typical of minor rehabilitations, may not require as detailed an investigation as required for longer operations.

504.8.1 Pavement for Maintaining Traffic

When the shoulders are deemed structurally inadequate for maintenance of traffic operations during construction, they may require replacement. The replacement pavement is typically constructed in accordance with Item 615 Roads and Pavements for Maintaining Traffic. If the replacement pavement will be left in place, design calculations should be performed to confirm that the proper thicknesses and materials are specified.

List of Figures

Figure	Date	Subject
503-1	July 2015	Overlay Design Inputs

Parameter	Recommended Default Value
Reliability - All	see Figure 201-1
Standard Deviation of Traffic - All	0.10
Initial PSI - All	4.5*
Terminal PSI - All	2.5
Poisson's Ratio - Asphalt	0.35
Resilient Modulus - Asphalt	450,000 psi
Poisson's Ratio - Concrete	0.15
Elastic Modulus - Concrete	5,000,000 psi
Modulus of Rupture - Concrete	700 psi
Drainage Coefficient - Concrete	1.0
Load Transfer Coefficient - Concrete	See below

* New rigid pavement design uses 4.2 as the Initial PSI, however when analyzing an exposed rigid pavement for overlay design an initial PSI of 4.5 should be used.

Load Transfer Coefficient (J)		
Existing Pavement	**Edge Support****	**No Edge Support**
Jointed Doweled	2.7	3.2
Jointed Undoweled	3.8	4.2
Continuously Reinforced	2.4	3.0

** Edge support includes tied concrete shoulders, integral curb, widened lane, etc. Widened lane refers to concrete slabs built 14 feet (4.2 m) wide or wider, but striped for a standard 12-foot (3.6 m) lane, leaving 2 feet (0.6 m) outside the traveled lane to provide edge support.