



Facilities Development Manual

Chapter 14 Pavements

Section 25 Pavement Rehabilitation

Wisconsin Department of Transportation

FDM 14-25-10 Concrete Pavement Rehabilitation Guidelines

Exhibit 10.1 Concrete Pavement Rehabilitation Manual

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Concrete Pavement Rehabilitation Manual

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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 to 416.3.9, 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.

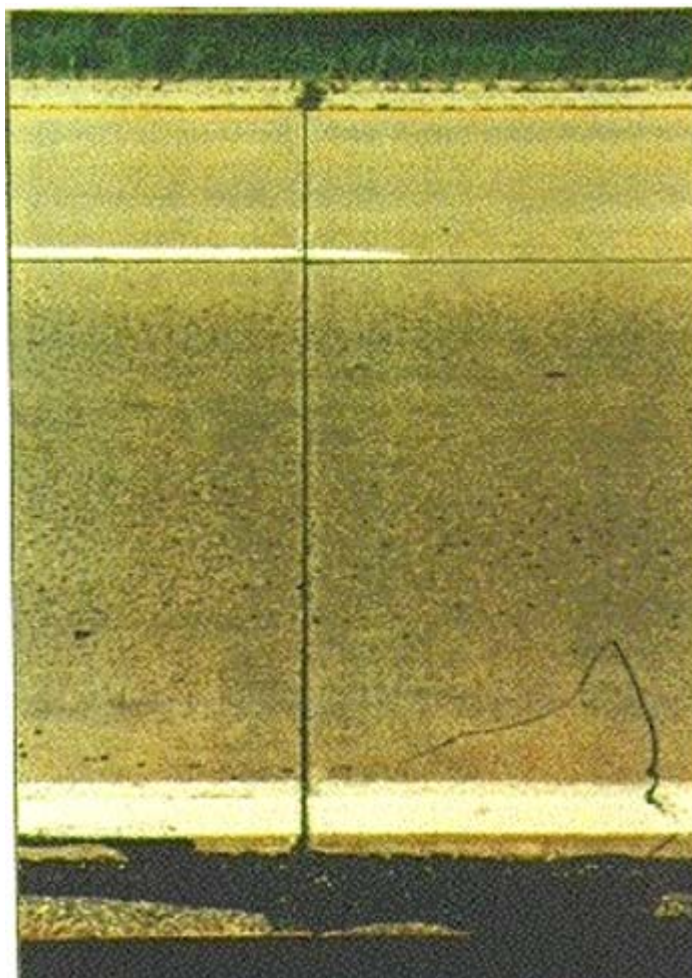
As part of the rehabilitation with resurfacing alternative, partial depth repairs can be considered, especially for longitudinal joints and spalling of mid-panel transverse cracks. The repair consists of grinding 2 to 3 inches deep (and going deeper if necessary with jack hammers to remove deteriorated 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

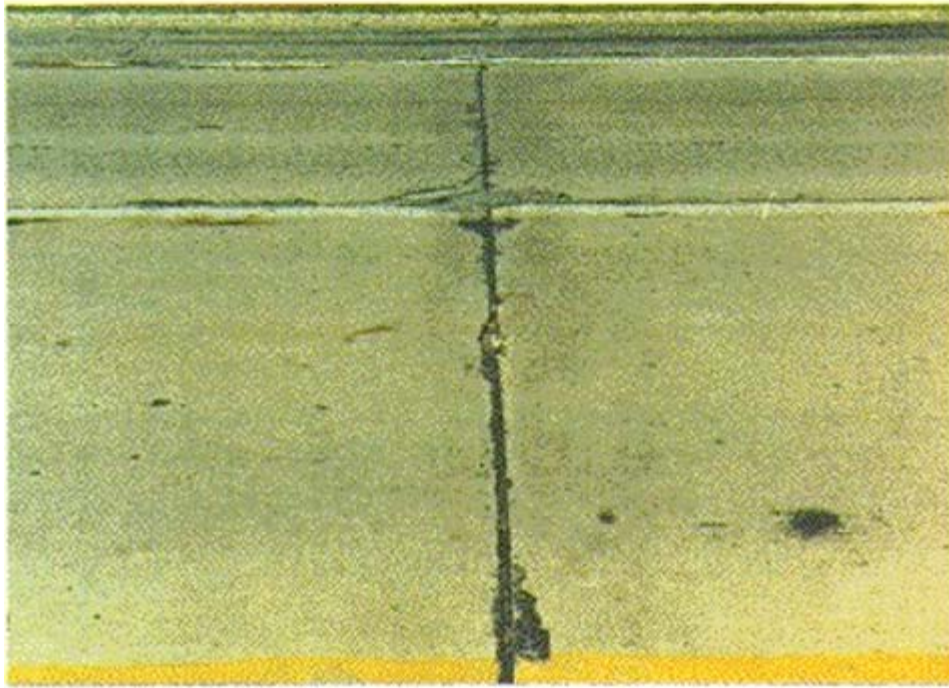
Joint is in excellent condition. No repair required.

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

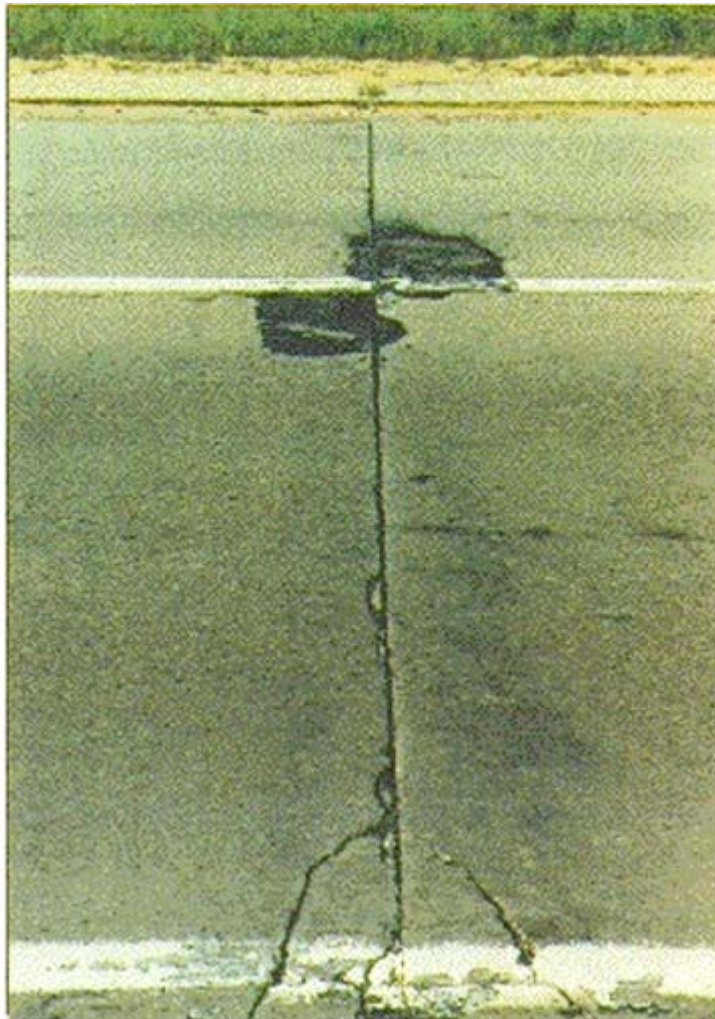
This joint is in a more severe state of distress with the deep spalling at and around the joint. Also, the asphalt patch at the centerline is a sign of additional deterioration at the joint. The asphalt patch would not be compatible with the grinding operation. This joint should be selected for a full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

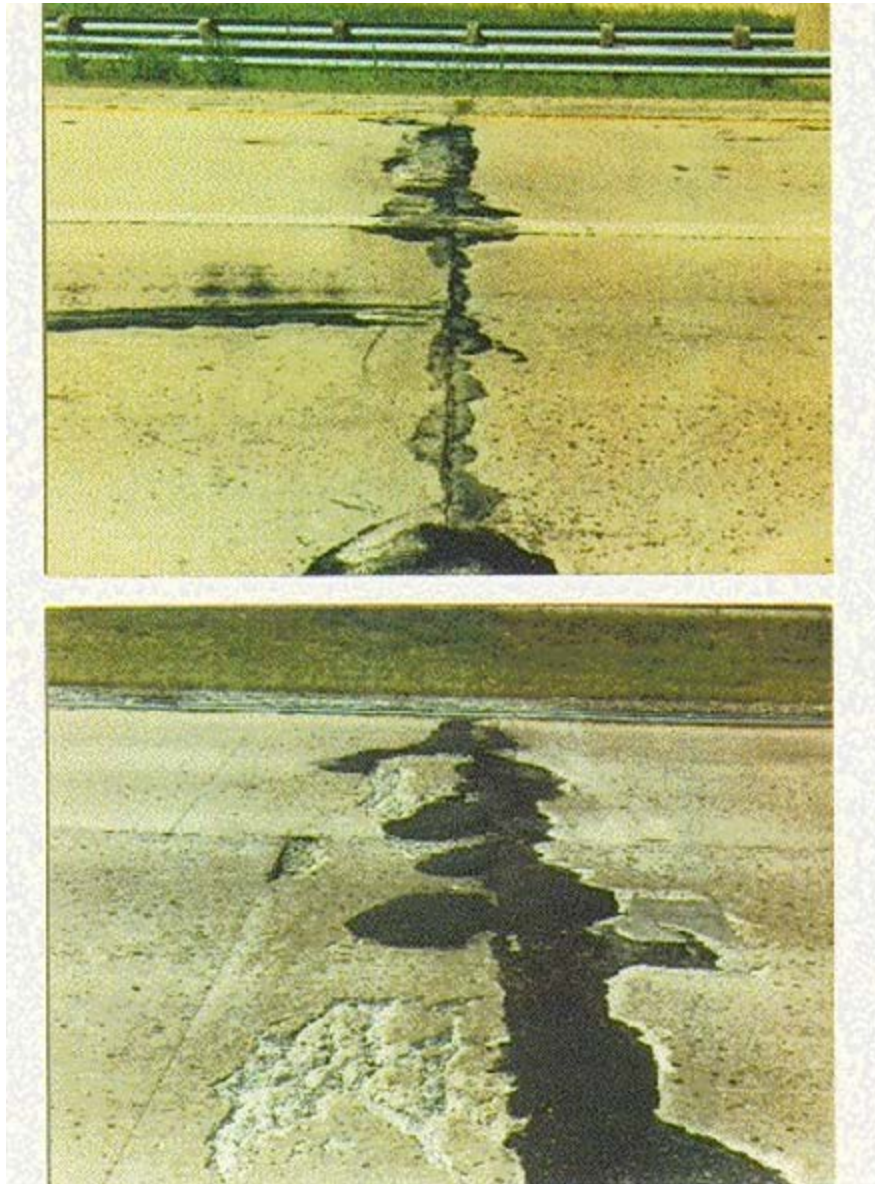
This joint should be repaired as part of the rehabilitation strategy. The broken pieces at the edge and center of the pavement are not compatible with the grinding operation.

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

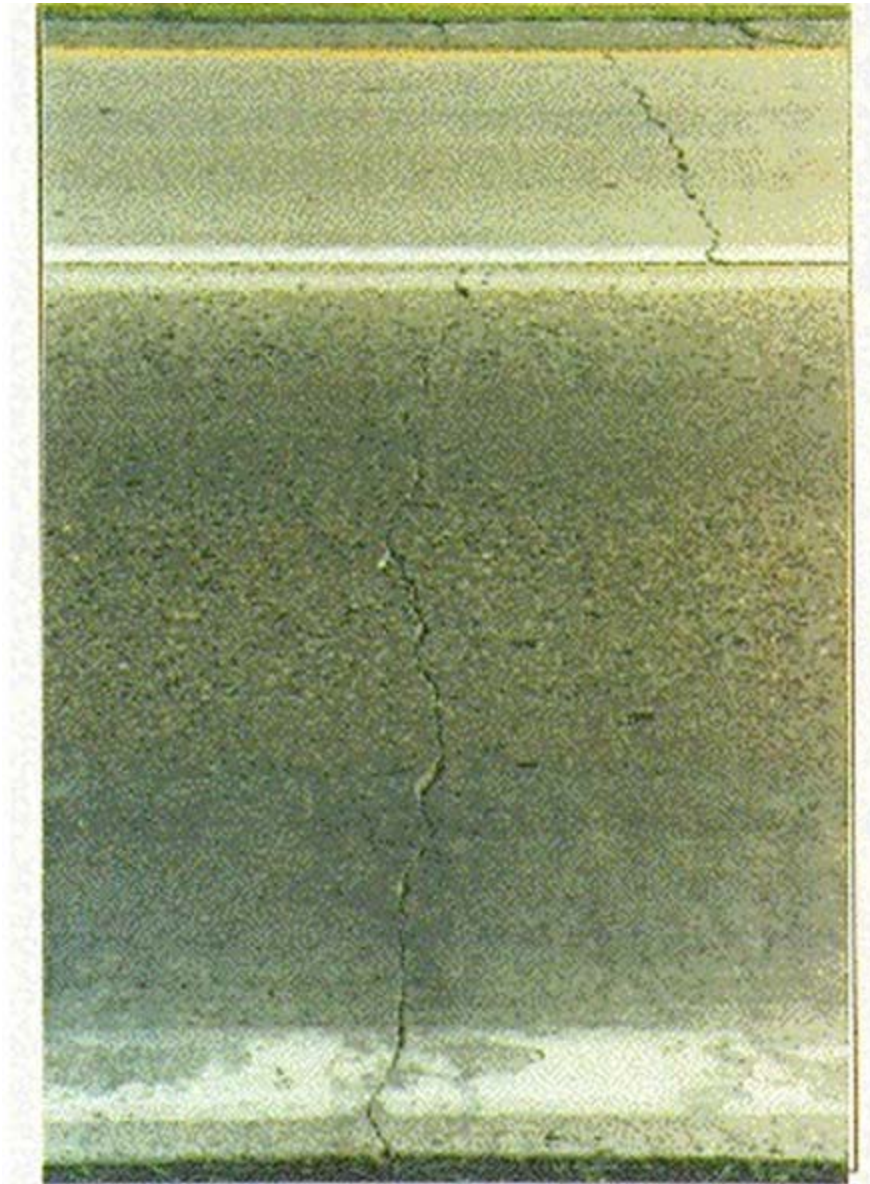
1. CRACK



This hairline crack requires no attention regardless of rehabilitation strategy.

Jointed Reinforced Concrete Pavement

1. CRACK



Repair and Grind

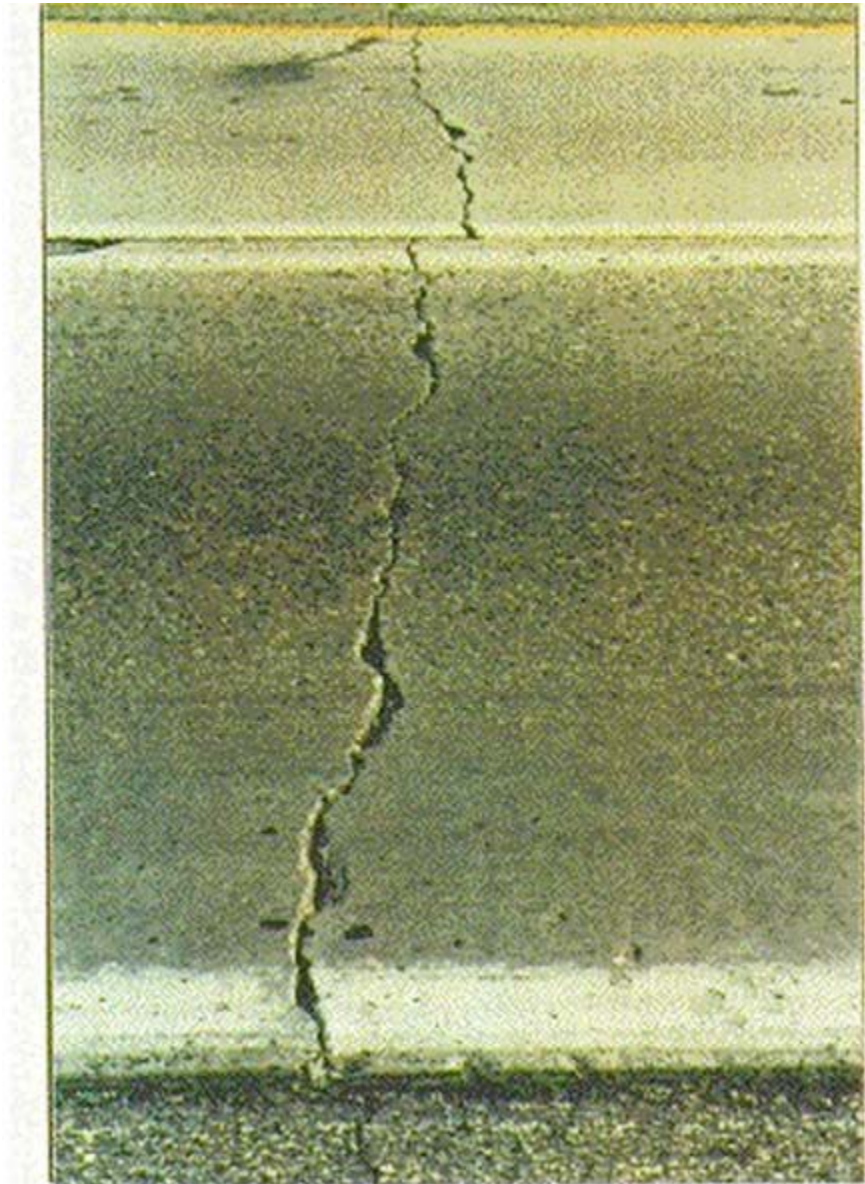
This crack is in good condition with a few minor spalls along the length of the crack. These spalls will be removed as part of the grinding operation.

Repair and Overlay

No treatment required prior to placement of the overlay.

Jointed Reinforced Concrete Pavement

1. CRACK



Repair and Grind

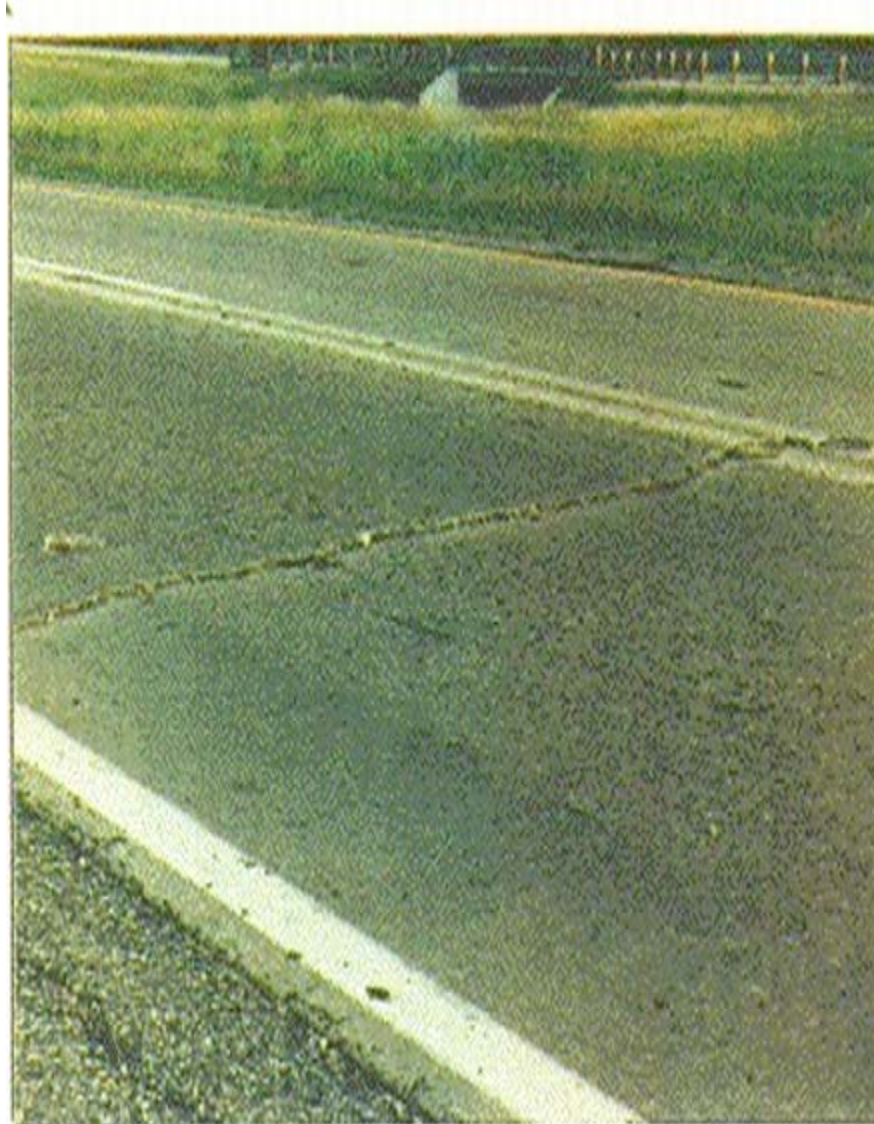
This crack has more severe spalling, but is not faulted. A careful inspection of the spalled areas needs to be made. If the depths of these spalls are significant (1-3 inches) and additional visible distress is evident, the pavement should be repaired. This particular crack shows no distress other than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

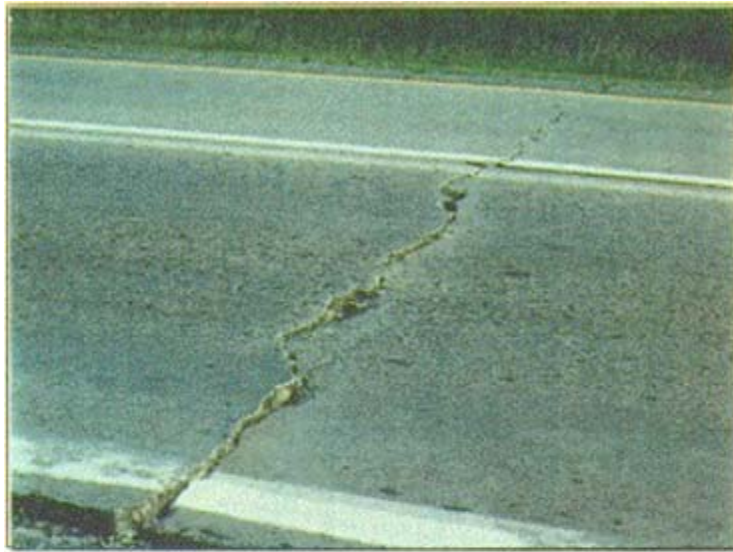
This crack is in good condition with exception of the faulting. No repair is required prior to the grinding operation

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

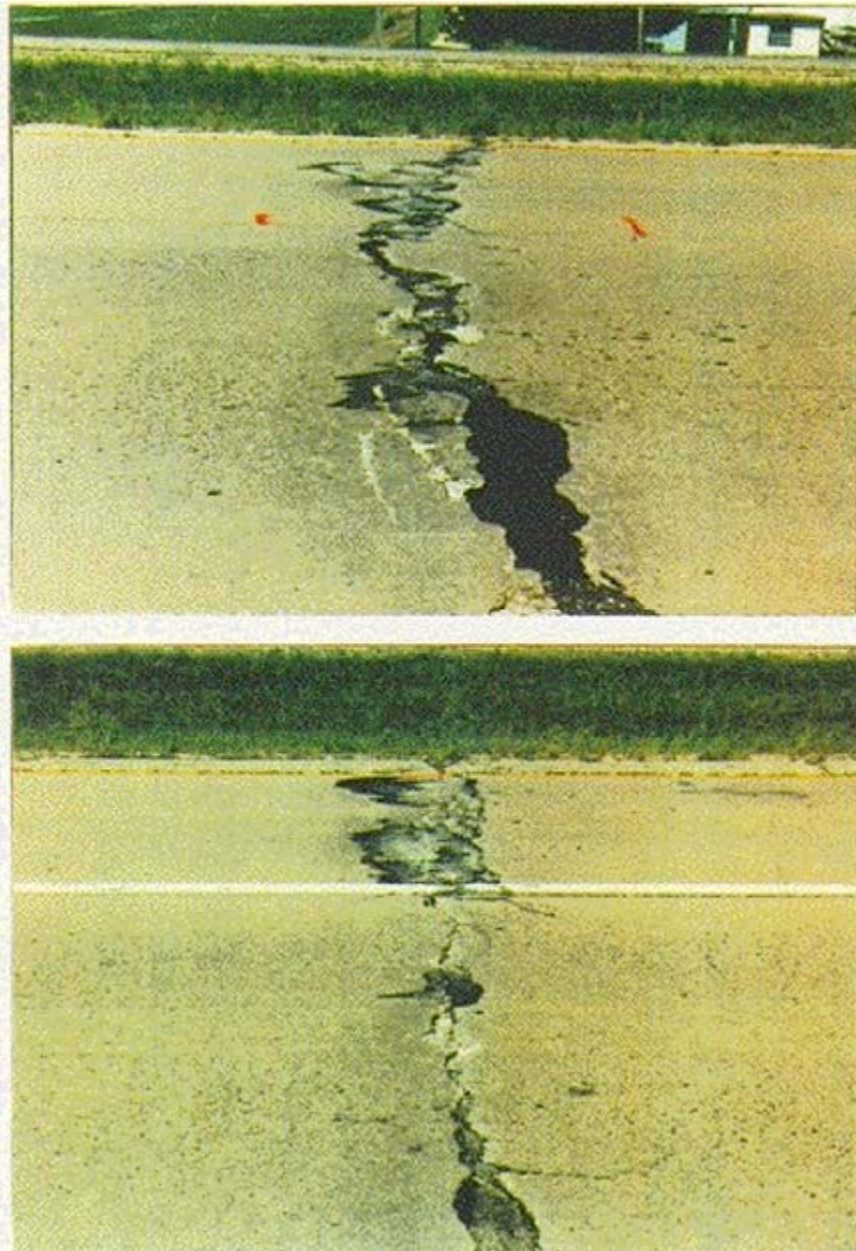
Both of these cracks have secondary cracking adjacent to them that have formed large pieces of concrete. These pieces would be dislodged during grinding and form a large void at the surface. The secondary cracking is also an indication that more advanced distress has occurred. This crack should be repaired.

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.

SECTION TWO: 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:

Repair

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.

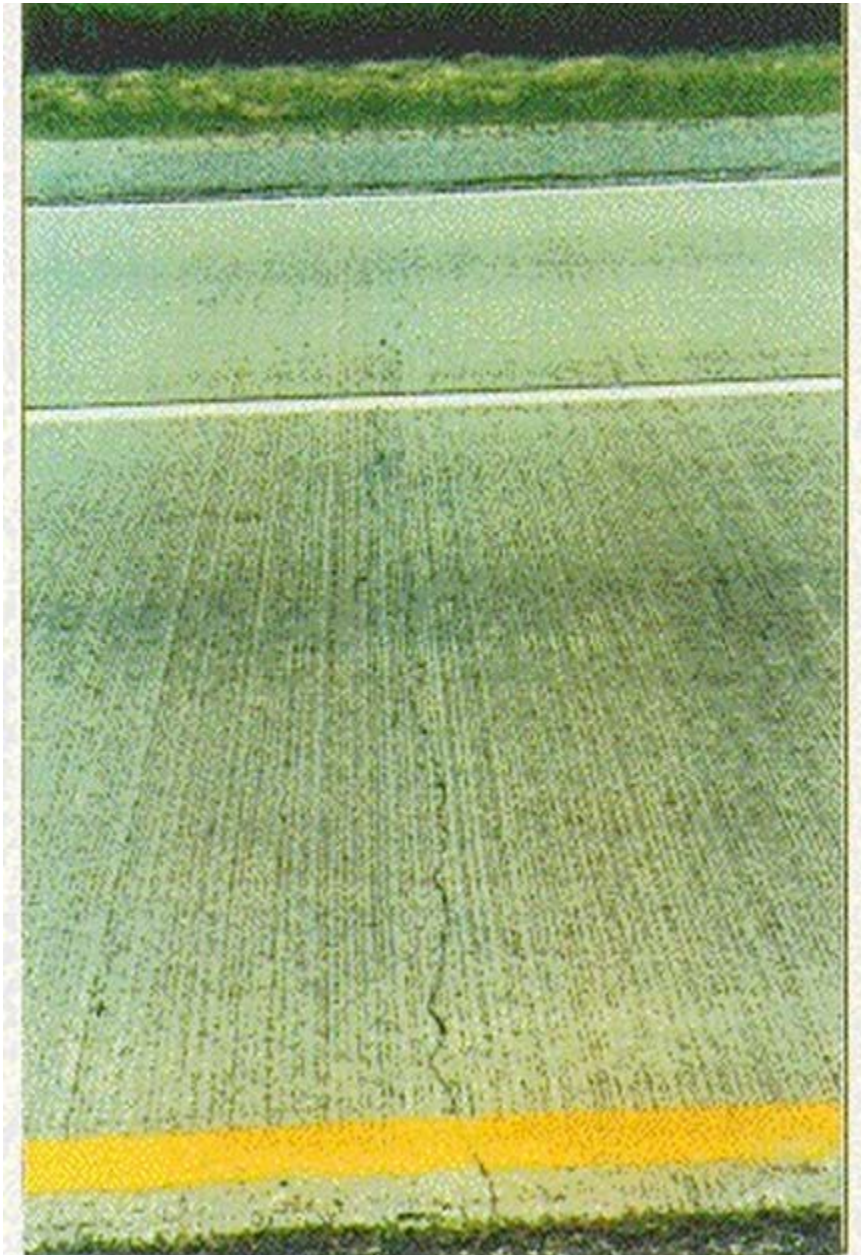
Repair and Overlay

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

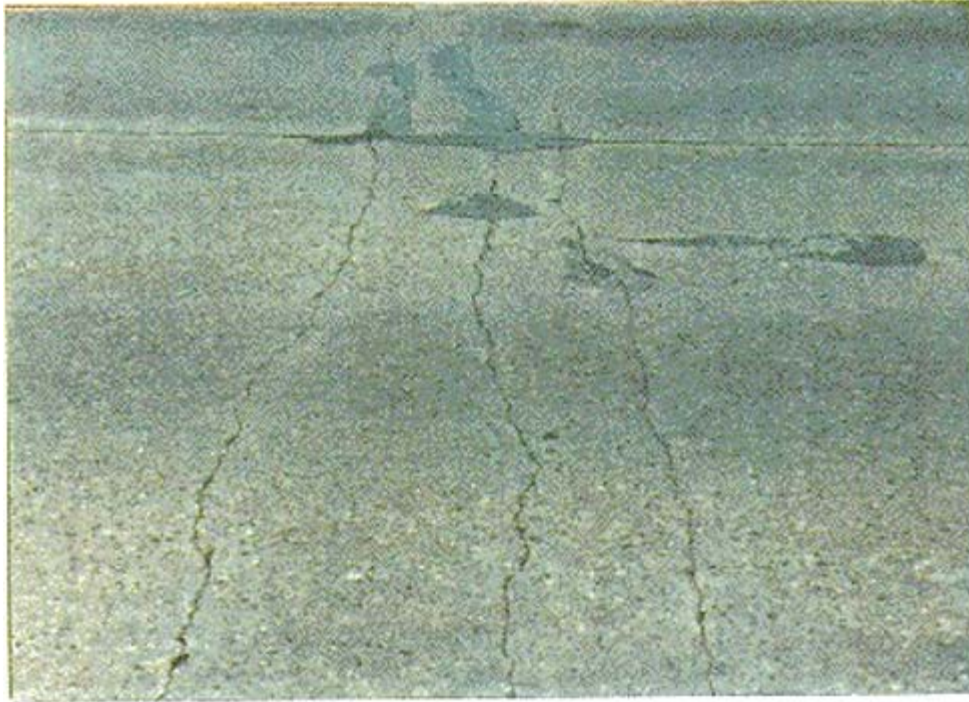
Both lanes require a full depth repair when using this rehabilitation strategy. It is obvious that the inside lane requires repair. However, the outside lane is not so obvious. As a general rule, any crack on a CRCP pavement with a crack width of $\frac{1}{4}$ inch or greater is an indication that the 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

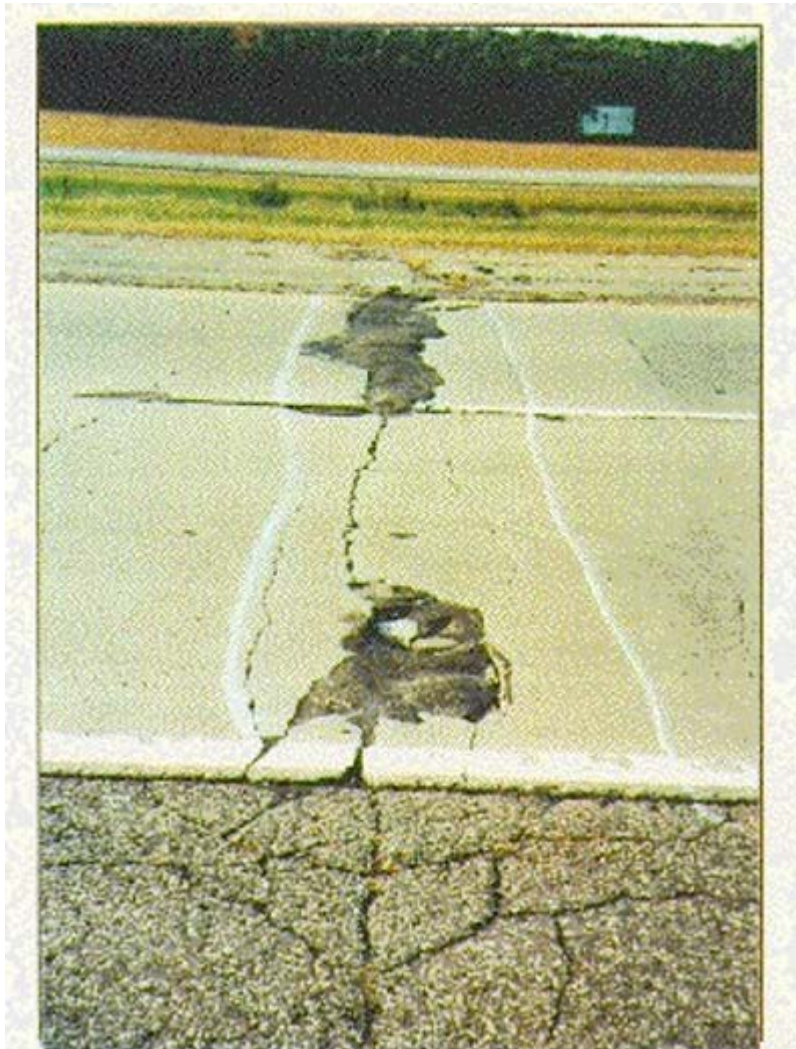
This series of cracks does not require repair. They are all still tight with insignificant spalling. Close inspection of the CRCP is required here. The presence of longitudinal cracking must be determined here. The confirmation of the existence or nonexistence of the longitudinal cracking is important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

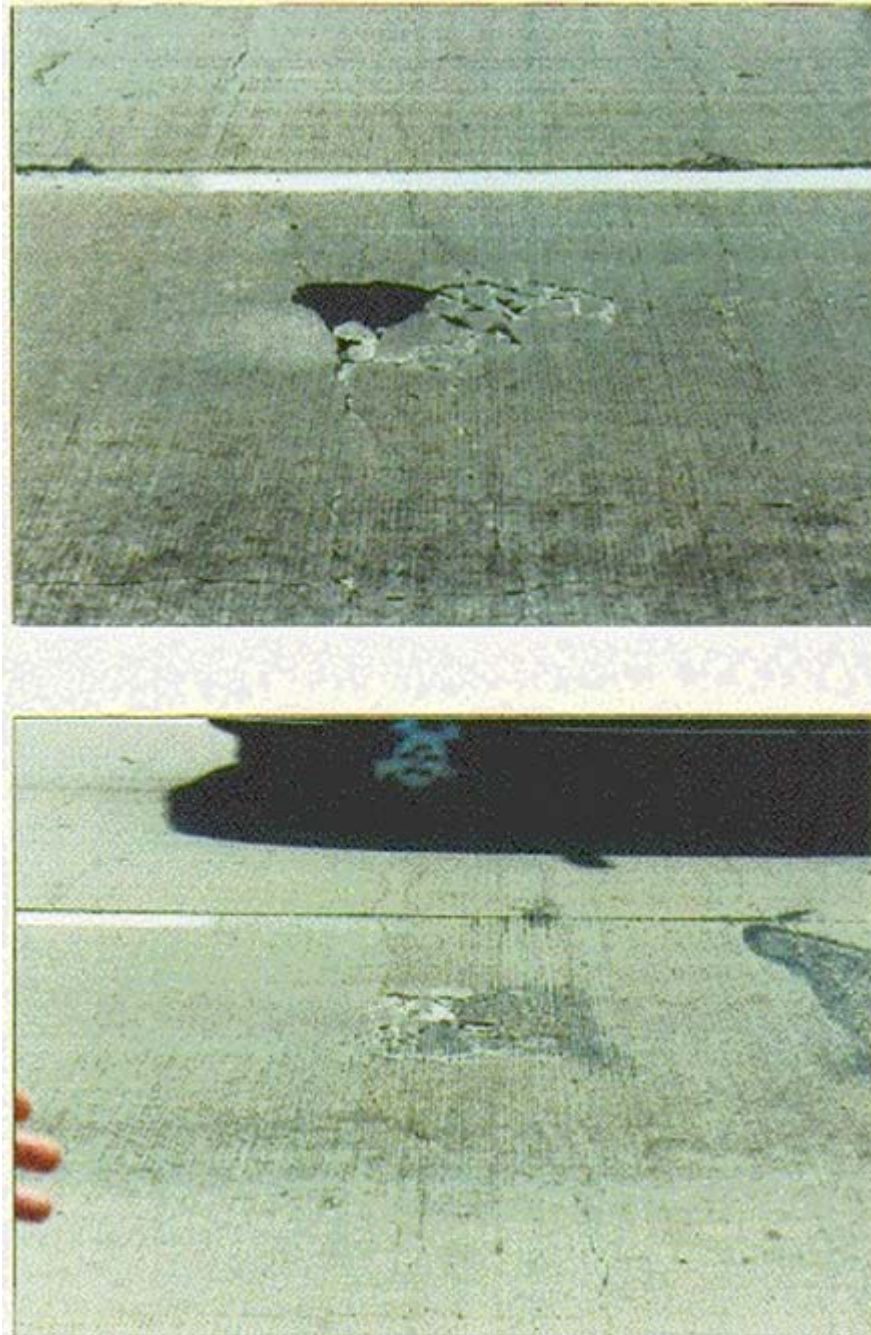
The distress that has taken place at this location between cracks requires a full depth repair as part of this rehabilitation strategy. The steel has ruptured at the cracks and additional deteriorated areas have formed adjacent to the crack.

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 picture 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.

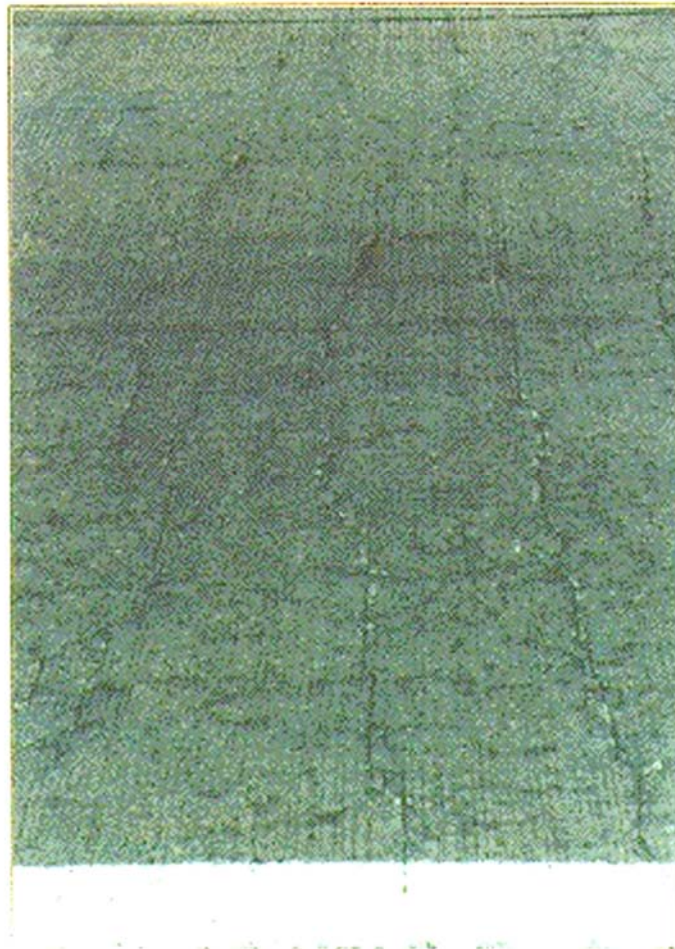
Repair and Overlay

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.

SECTION THREE: 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:

Repair and Grind

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.

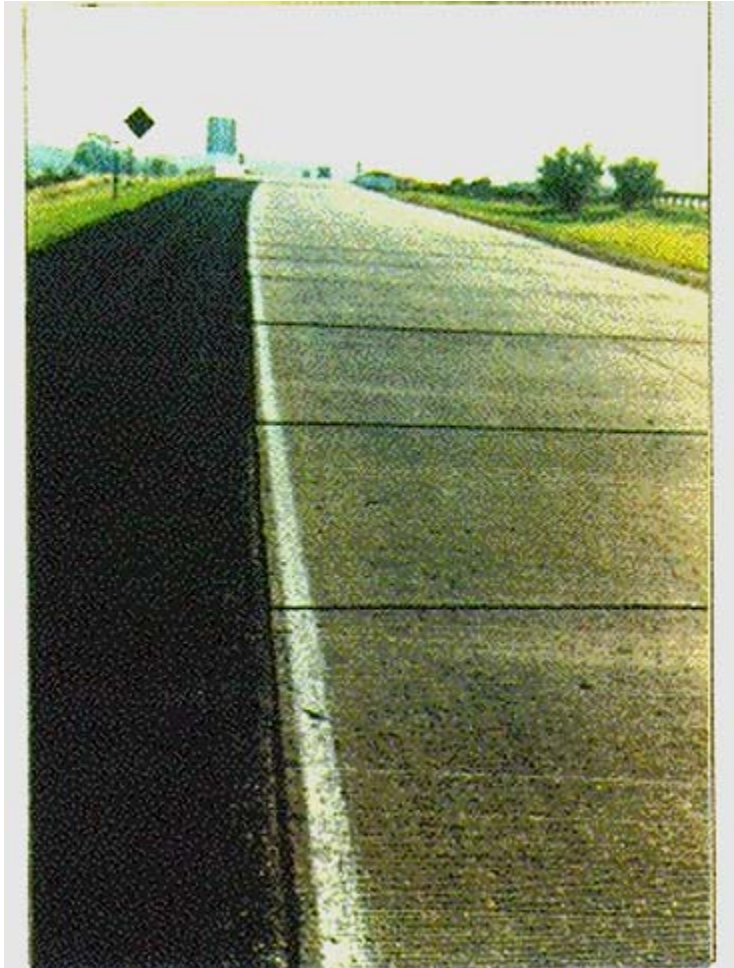
In general, a pavement that has faulting between $\frac{1}{4}$ and $\frac{1}{2}$ inch would be repaired as necessary and ground. If a slab is cracked, the decision to repair is consistent with the previously outlined criteria in the section on Jointed Reinforced Concrete Pavement. However, due to the short joint spacings any repair being performed should be completed by replacing the entire slab, rather than performing a six-foot long repair.

Repair and Overlay

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

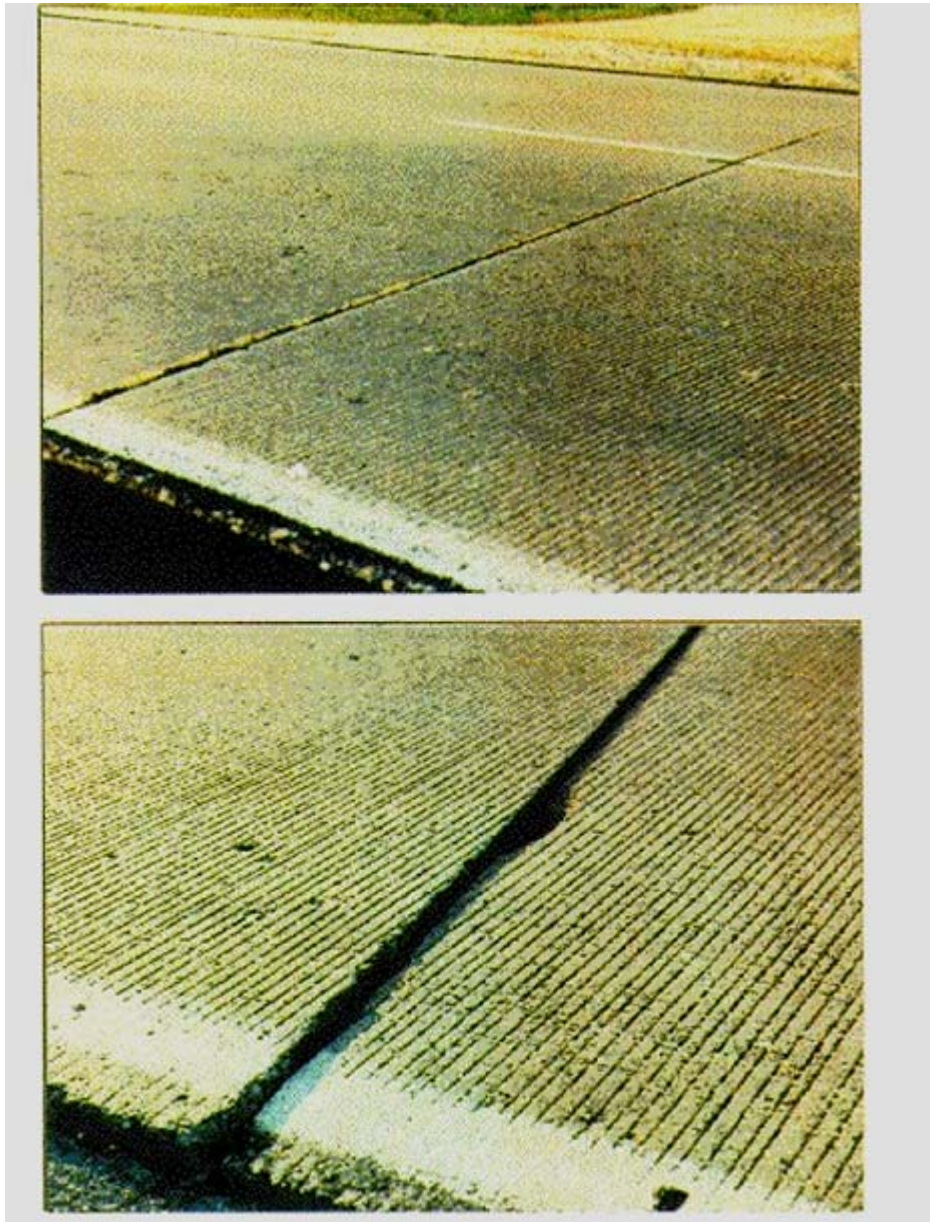


Repair and Grind

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 $\frac{1}{2}$ 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

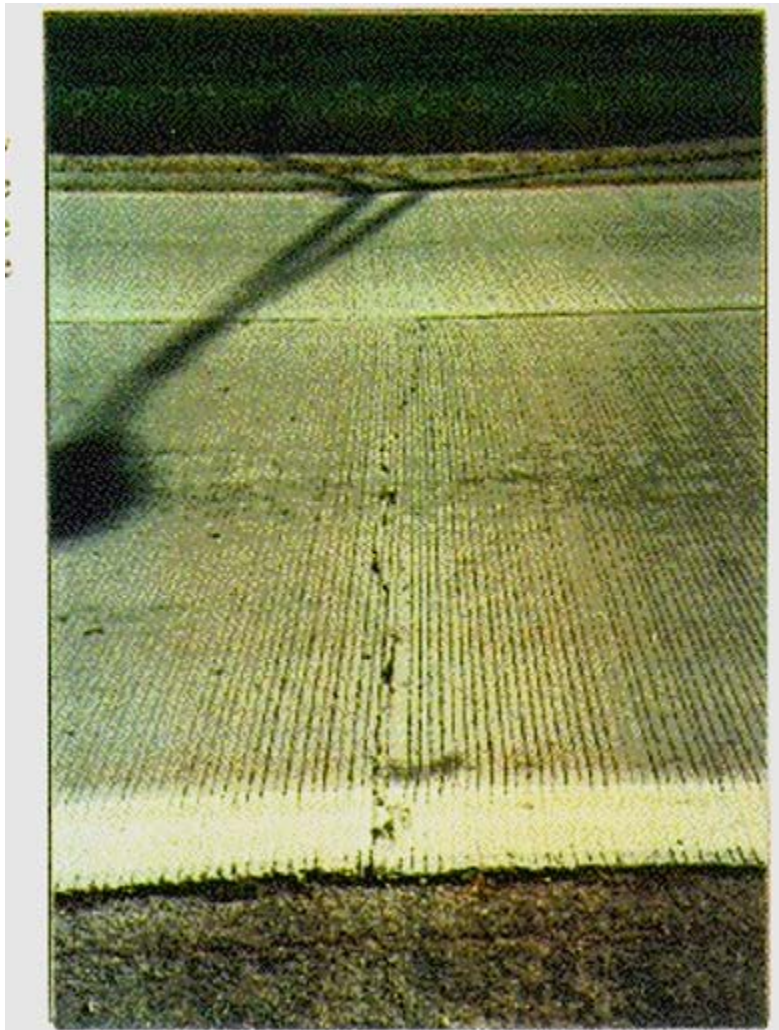


Repair and Grind

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

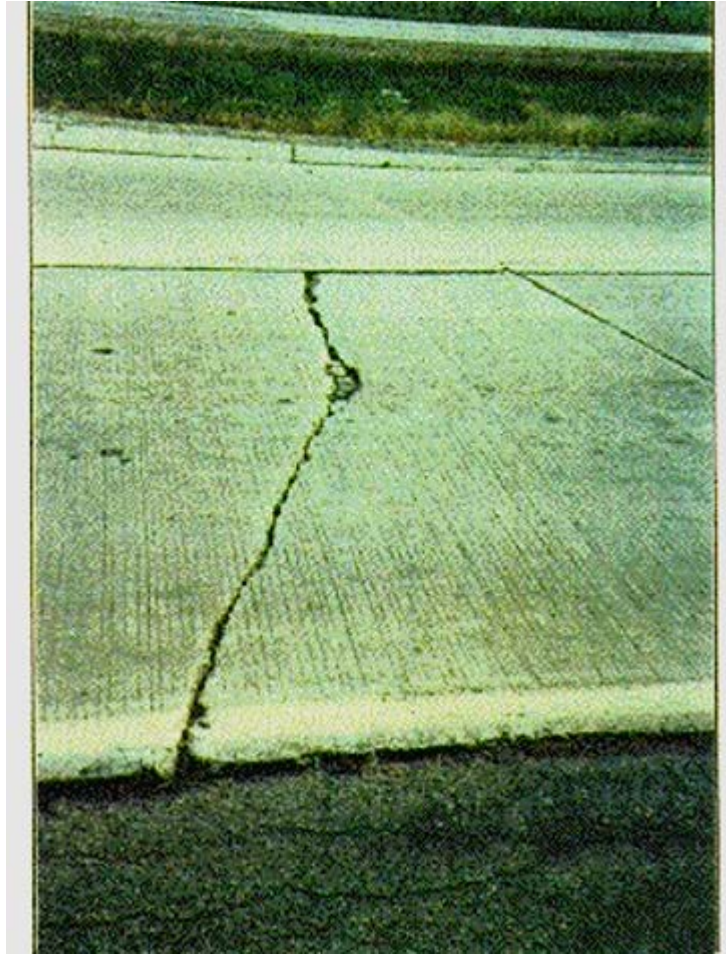


Repair and Grind

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

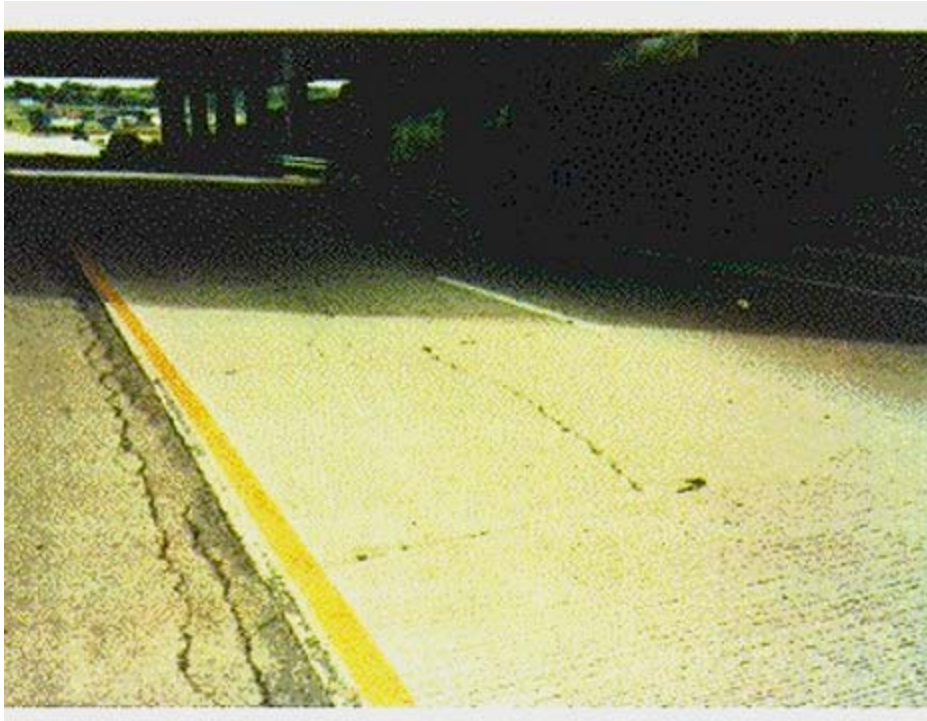


Repair and Grind

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.