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Pavement Repair Guidelines for Longitudinal Joints

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Pavement Repair Guidelines for Longitudinal Joints

1.1 Problem description

As concrete highways of Texas age beyond their original design/service life expectations, one type of distress has become more common on Texas highways — longitudinal separation and faulting. This distress leads to uneven roadway surfaces; which have the potential to result in serious accidents at highway speeds. Also, the depressed slab is below design grade and collects water that could cause hydroplaning or ice formation in freezing temperatures.

Implementation Project 5-5444-01, “Pilot Implementation of Pavement Repair Guidelines for Longitudinal Cracks and Joints,” applies the lessons and recommendations from the previous Texas Department of Transportation (TxDOT) funded Center for Transportation Research (CTR) Research Project 0-5444, “Rehabilitation Procedures for Longitudinal Cracks and Joints Separation in Concrete Pavement,” which investigated the causes and repairs of longitudinal joint separations and faulting.

1.2 Why does this type of separation and faulting happen?

Separation and faulting occur primarily due to environmental reasons as described in the subsequent paragraphs. To prevent the problems of separation and faulting, deformed steel reinforcement bars are used to tie longitudinally adjacent slabs together. These bars are typically ½-in. to ¾-in. in diameter by approximately 4 ft long and spaced approximately 3 ft apart along the longitudinal joint. Concrete slabs are usually cast in such manner as to ensure the two laterally adjacent slabs are locked very tightly together, preventing them from moving independently from each other—laterally by the tie bars and vertically by the interface friction (and tie bars). This ensures that slab edges near the wheel path are reinforced by the adjacent slab allowing very good load transfer across the joint.

Over time environmental changes due to temperature and moisture cause curling and warping in the slab. In areas with poor drainage and expansive soils, differential movement of the pavement lowers or lifts the outside edge of the shoulder slab, creating a lever arm that is restrained by the tie bars (Figure 1.1). These cyclic changes allow free water and non-compressible debris into the joint, increasing the stress on the tie bar with every significant cycle. Meanwhile, the free moisture in the joint continues to slowly corrode the tie bar until its reduced section ruptures or pulls out of the concrete. Once several tie bars in a row have failed, the slabs are free to move apart from each other. This can allow more water into the joint, resulting in a softening of the sub-base support.

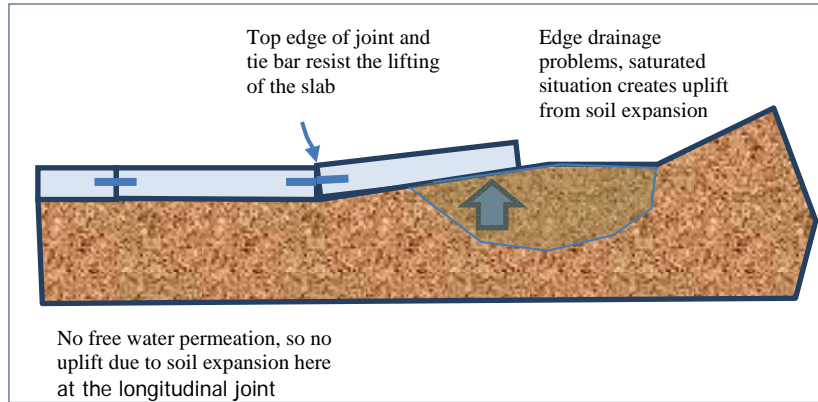


Figure 1.1: Edge drainage issues influence on tie bar failure

After vertical friction is lost between the two slabs at the longitudinal joint, the slabs will no longer effectively transfer wheel loads across the joint. Then, as traffic wheel loads cross the longitudinal joint, the two adjacent slabs will move independently. The slab carrying most of the wheel loads will deflect more than adjacent slabs, creating a pumping action from traffic in wet weather. As water infiltrates the failed, separated joint, pumping removes waterborne fines from the sub-base, replacing them with more water. This cycle continues until enough sub-base is softened and removed to create a large enough void beneath that the pumping slab begins to permanently subside, or fault (Figure 1.2).

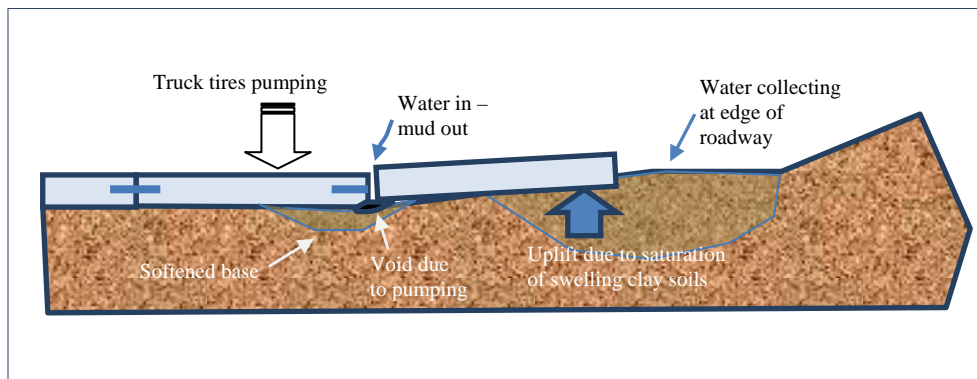


Figure 1.2: Failed joint has separated and faulted

1.3 What can be done to correct longitudinal separation and faulting?

CTR Project 0-5444, "Rehabilitation Procedures for Longitudinal Cracks and Joints Separation in Concrete Pavement," recommended a three-stage procedure to correct longitudinal separations and faulting.

1.3.1 Stage 1

Where faulting is deeper than ½ inch, the loss of support under the faulted slab must be repaired to eliminate the potential for further pumping. This is most economically done by under-sealing. Under-sealing involves drilling or coring holes, or ports, through the slab along the longitudinal joint to any voids (Figure 1.3) in the base and filling these voids and holes with a low strength mortar or grout. Care must be exercised in maintaining enough pressure to fill the voids while avoiding any lifting of the slab (Figure 1.4).



Figure 1.3: Unfilled voids mostly under unfaulted slab on the right.

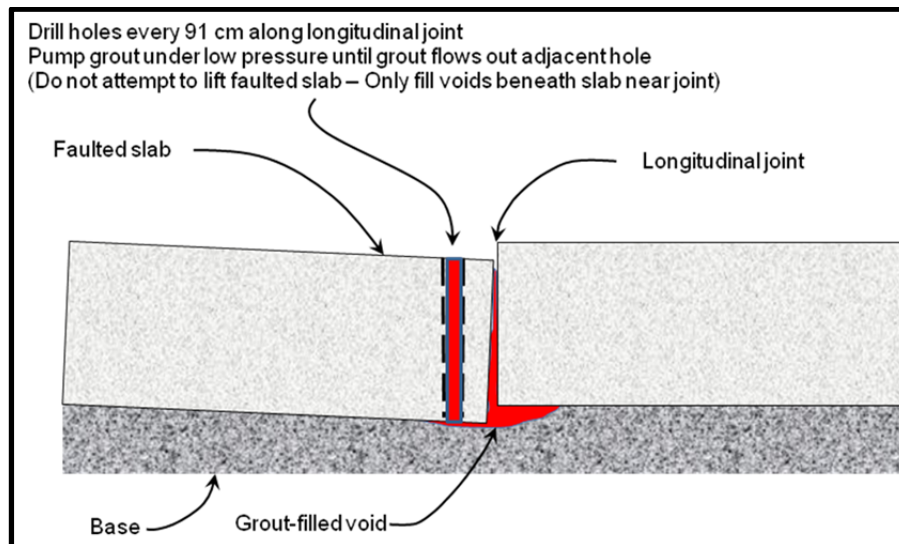


Figure 1.4: Sectional view of under-sealing beneath failed longitudinal joint

1.3.2 Stage 2

To keep the slabs from moving independently from each other and to restore load transfer, tie bars must be retrofitted at appropriate spacing along the faulted joint. This is best accomplished by “slot-stitching”. In this method slots are sawed transversely through the failed longitudinal joint to just below mid-depth of the slab. These slots are wide enough to allow a minimum of 1-inch of flowable concrete (max 3/8 in C.A.) or grout (specify minimum of 4500 psi) to surround the bars placed into slots at mid-depth of the slab. No attempt is made to maintain a longitudinal joint, since the intent is to permanently lock the two adjacent slabs together at this joint. The slot is filled level to the slab top surface (Figure 1.5).

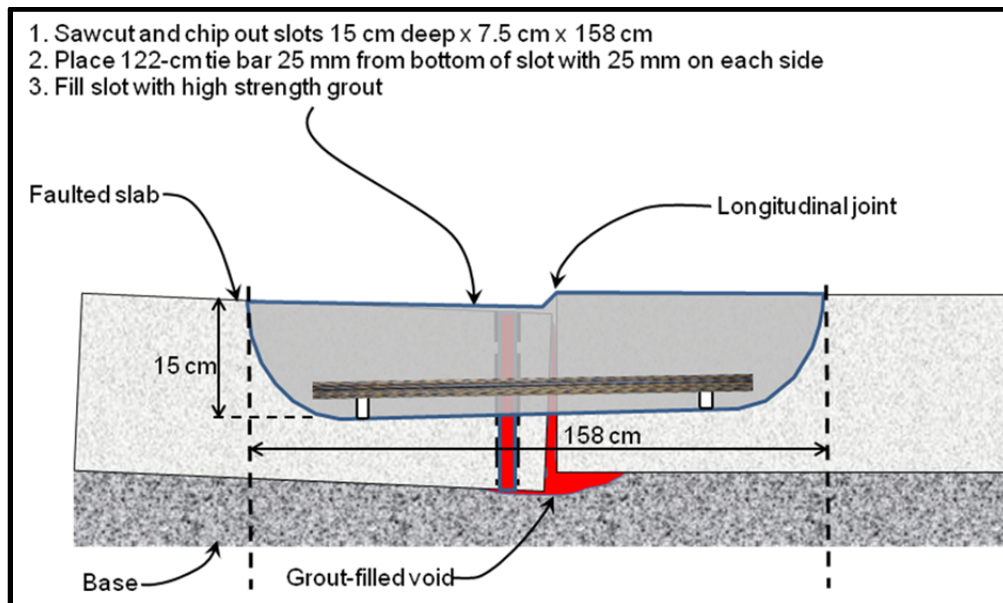


Figure 1.5: Slot-stitch section

1.3.3 Stage 3

The final step is to level the faulted slabs, so that the pavement surface has the designed grade to properly drain water off the roadway and provide a smooth transition for traffic across the longitudinal joint. This is accomplished by milling one-half the surface of the faulted slab extending from the depressed edge at the failed longitudinal joint to the center of the faulted slab and applying a thin bonded concrete overlay finished flush with the unfaulted slabs (Figure 1.6). The slabs are milled deeply enough to allow at least 1 ¼ inch depth for the overlay. After shot blasting, this surface is kept wet and overlaid. It is recommended that the overlay be wet-mat cured.



Figure 1.6: The depressed half of the faulted slabs was milled and overlaid

1.4 Who was involved in the implementation?

The implementation team consisted of engineers and inspectors from the Sherman Area Office of TxDOT's Paris District and researchers from CTR both in construction materials and in pavement design. The team was led by Dr. Dar Hao Chen of the TxDOT Construction Division Pavement Branch. After the specifications and construction details for the job and materials were completed and approved, the contractors for each of the two rehabilitation projects (southbound and northbound) had key personnel work closely with the implementation team in making the repairs.

1.5 Where did this implementation take place?

Engineers in the Sherman Area Office had previously identified several areas of faulting on US 75 in North Texas between Sherman and Denison, Texas. Researchers investigated and found many places along US 75 where implementation trials could be conducted. The plan of the implementation was to let the first contract for under-sealing, slot-stitching, and thin bonded concrete overlay to rehabilitate failed longitudinal joints on US 75. After monitoring all the rehabilitation project activities, a second revised set of plans, specifications, and details was submitted and approved for a second, improved rehabilitation project for failed longitudinal joints. This implementation project was a well-coordinated effort from many personnel in TxDOT, CTR researchers, and the contractors.

The first rehabilitation job took place summer 2009 on the southbound outside lanes of US 75 from Loy Lake Road Overpass south to the Exit 64 gore area. The second rehabilitation job occurred spring 2010 on the northbound outside lanes of US 75 from Loy Lake Road north to Crawford Street.

1.6 What was learned from the first rehabilitation project?

The site for the first project was chosen by the Paris District for its ease and safety in traffic control issues. These failed sections were not as severe as in many other locations, but they were clearly faulting. Ideally, it is much more cost effective to address the longitudinal separations and faulting at the earliest stages before pumping is evident. Caught early enough, the repair may only require slot-stitching, avoiding the need to under-seal and overlay. The implementation project, however, was intended to evaluate all three stages of the rehabilitation strategy, and all were performed on this rehabilitation contract.

1.6.1 Under-sealing

Coring to inject the grout for under-sealing was done according to specifications, but observations indicated that no grout penetrated into the voids or sub-base, indicating that the under-sealing was not successful on this job. A modification was made to allow more water, making a very “soupy” mix to ensure flow of the grout into sub-grade voids. High strength is not important in grout for under-sealing.

1.6.2 Slots

The original specifications required that the slots be only slightly longer than the 48-in. tie bars. The radius of the blade was large enough that the length at the top of the slot was increased to 62 inches to accommodate 48-inch long bars at the bottom of the slot, where the tie bar was laid (Figure 1.7).

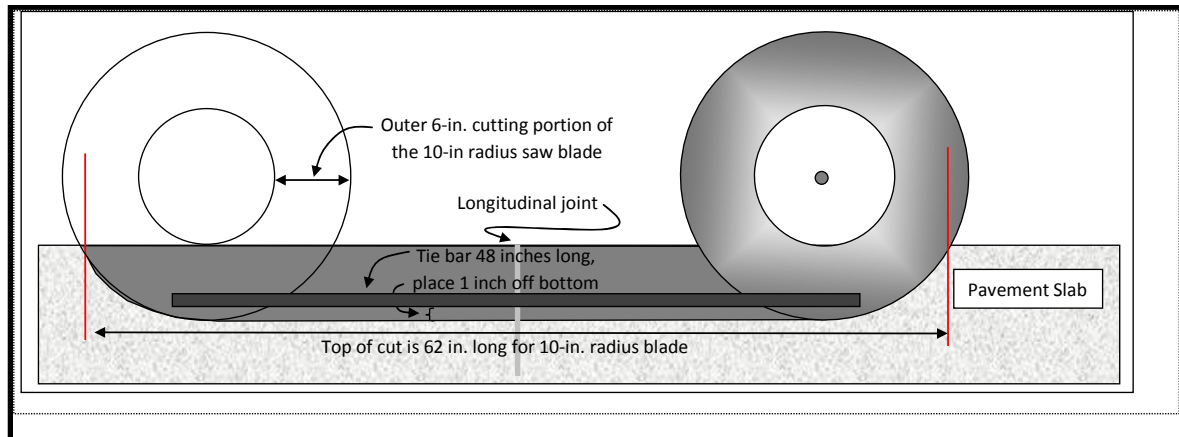


Figure 1.7: Section through pavement showing saw cut and tie bar placement

1.6.3 Slots

Because they were sawed and chipped out, the slots needed to be inspected closely and often re-chipped to get the whole bottom of each slot at the required depth.

1.6.4 Overlay

A latex-modified concrete overlay was specified to improve bond and cohesiveness of the thin mix. This material has special need to be mixed and cured

properly because the latex emulsion can cause foaming and will form a film that can shrink faster than the fresh concrete can restrain, causing many early cracks in the overlay. Original specifications called for a portable volumetric mixer truck and wet mat curing. The contractor negotiated the elimination of these items, and the ready mix supplier had trouble with providing a workable mix. There was confusion as to what properties to enforce in the LMC overlay, in spite of the fact that the properties in question are detailed in the TxDOT Standard Specifications Book Item 421. The concrete overlay cracked badly in several areas (Figure 1.8). Clearly specifications and enforcement need to be better covered in the construction documents and preconstruction meetings when dealing with such an unfamiliar material. It was agreed to replace the LMC with a conventional “concrete overlay” from Item 421 for the next project.



Figure 1.8: Early cracking in LMC overlay on southbound US 75

1.7 Lessons from the second rehabilitation project

After the southbound project, district personnel were more comfortable with the sequencing and the importance of each stage of the process. Consequently the sections for the second project on the northbound lanes were chosen for their severity of faulting with many slabs faulted as much as two inches. Lessons from the first project resulted in changes that were applied to the second project.

1.7.1 Under-sealing

The diameter of the core barrel was increased to two inches, and the inspectors used a tapered spike, called a depth gage (used for asphalt and base), to punch a one-inch extension from the bottom of the core hole toward the joint. This was enough to provide a better path to the voids under the slab. Also, pressure was maintained with a seal around

the injection tube at the opening of the core hole. The pressure was maintained until grout flowed out of adjacent ports or joints. A high-strength grout was used, but it was watered down to make it much more fluid. A fluid grout is needed, but a much weaker, less-expensive material could be used. For simple bearing support of the slab edge and an anti-eroding matrix, a flowable fill material with a maximum size aggregate passing a 1/2-inch sieve and with 28-day compressive strengths between 200 and 500 psi are all that are required. Some quality control of the flowable material is required to make sure it is both flowable and will reach an acceptable strength. The use of a simple flow cone test is recommended and included in the appendix of this document. The trial mix verifying strength goals should also specify flow cone diameter.

1.7.2 Slot-Stitching

Slot-stitching went as planned until the contractor ran out of the approved high-strength grout and the supplier said it could not be made available for at least two more weeks. Even though a substitute was found and verified to reach adequate strength in the laboratory, the field cured companion specimens never reached 3000 psi. This discrepancy can be avoided in the future by matching flow cone diameters with strengths for each material. Each batch must then meet the specified flow before being placed. Although there are many prepackaged high strength grouts that will meet the needs for this application, TxDOT Departmental Material Specification **DMS – 4655 CONCRETE REPAIR MATERIALS types A-2, B, or D** would work well for this application.

The contractor found a large plastic washer to use for a chair support for the tie bar. The outside diameter of the washer matched the slot width, and the washer hole matched the tie bar, so the tie bar stayed centered in the slot while the grout was poured (Figure 1.9).



Figure 1.9: Plastic discs used for self-centering tie bar chairs

1.7.3 The overlay

Milling damaged the transverse seals and slightly spalled the tops of the transverse joint edges. The contractor removed the remnants of joint filler and unsound top edges of joints. After cleaning the milled area by shot blasting, the area was overlaid and the contractor was asked to re-saw the transverse joints and seal them. This should be itemized in future job specifications.

The milled edge in the center of the slab spalled and raveled, thus sawing the edge definitely better defined the milled area and prevented ragged edge spalling of the overlay. This should be itemized in future job specifications.

The special thin concrete overlay worked very well. The contractor used a rolling screed (Figure 1.10) that provided much better compaction and a denser riding surface than is possible when using a vibrating bridge screed (Figure 1.11) on such a thin overlay. The finished northbound overlay was wet cured using wet burlap, followed by wet mats, and finished with a polyethylene film.



Figure 1.10: Rolling screed used on the northbound overlays worked well



Figure 1.11: Bridge screed used to place thin application of concrete in southbound overlays did not work well on such thin overlays

1.8 Finite element results

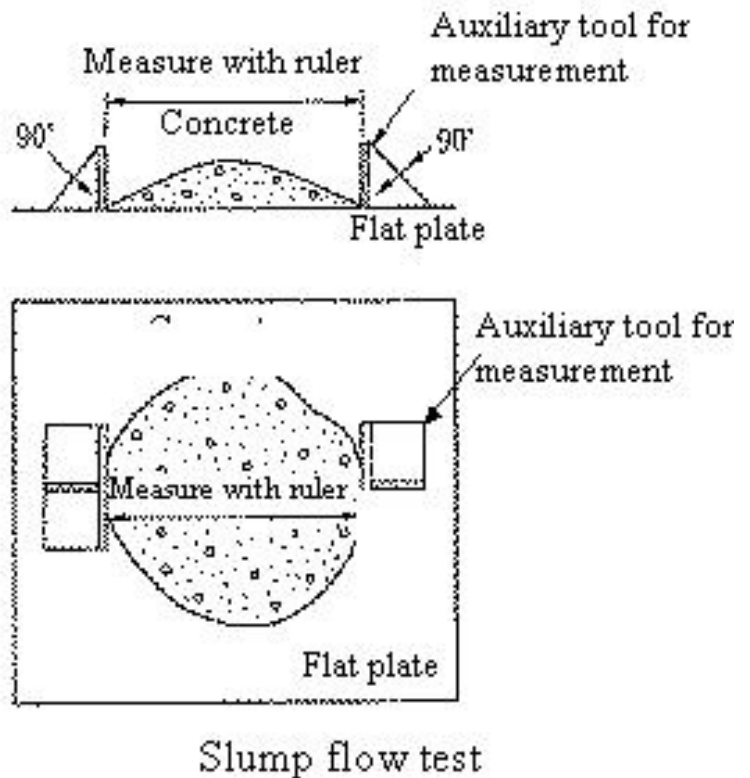
Through finite element modeling and analysis, Dr. Moon Won and his research team from Texas Tech University in Lubbock evaluated several tie bar scenarios to determine optimum use of slot-stitching. Variables in his modeling included pavement depth, tie bar diameter, and longitudinal spacing. Limited analysis of these scenarios shows that the effect of tie bar spacing on slab deflections is larger for thin slabs than for thick slabs. This is as expected, since thicker slabs will resist against slab deflections better than thinner slabs do, and the effect of tie bars diminishes as slab thickness increases. Also, the rate of decrease in slab deflections with reduced tie bar spacing becomes less as tie bar spacing decreases. There was very little difference in deflections of slabs with 1-ft and 2-ft tie bar spacing, whereas the decrease in slab deflections from tie bar spacing of 4-ft to 3-ft was noticeable. It indicates the 2-ft spacing of the tie bars, which is the new requirement in TxDOT, is quite reasonable from performance and cost standpoint.

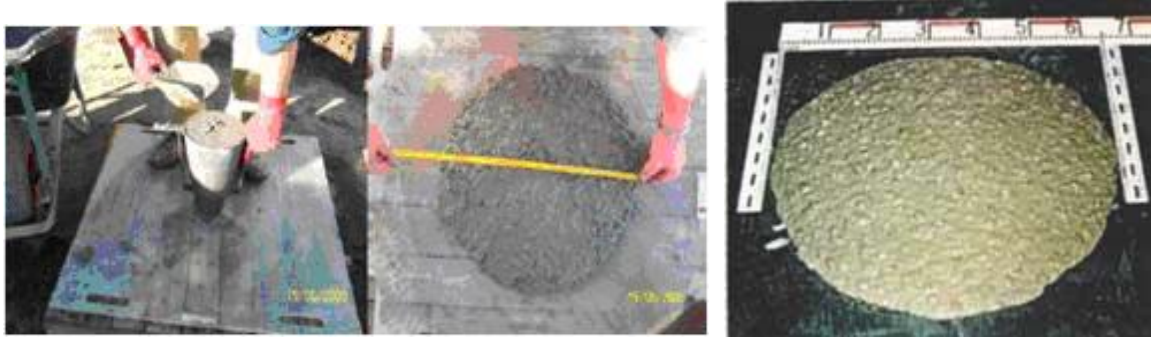
Appendix A

The Slump Flow Test

The following is a simple field test method that could be adopted by TxDOT for quality control of grout on the job. As long as the strength verification mixture has the given flow diameter as the mixture in field, the water content is probably adequate for that mix design. This test method is from “Self Compacting Concrete: Test Methods for fresh SCC” at the <http://www.concretebasics.org/articlesinfo/scc12.php> website.

The Slump Flow Test: This is a test method for evaluating the flowability of SCC, where the slump flow of SCC with coarse aggregates having the maximum size of less than 40 mm is measured. The basic equipment is the same as for the conventional slump test. However, the concrete placed into the mold is not rodded. When the slump cone has been lifted and the sample has collapsed, the diameter of the spread is measured rather than the vertical distance of the collapse.





Slump Flow Test. A technician lifts the slump cone and measures the diameter of the SCC Spread: (Source: Vic roads: Geo Pave)

Slump flows for an SCC mix can range from 18 inches to more than 30 inches. Observations of the flow should look for no separation of grout from the mix, no fringe of water at the edge or on the surface, and an even distribution of aggregate in the patty. The greater the slump flow, the higher the level of "flowability" of the concrete.

Appendix B

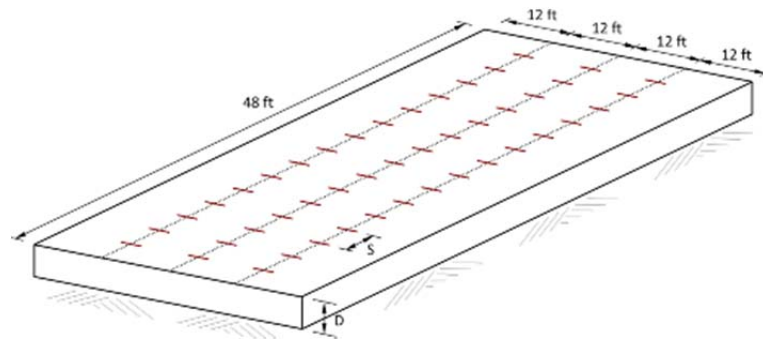
Finite Element Data

Chapter 1. CRCP Deflection Analysis

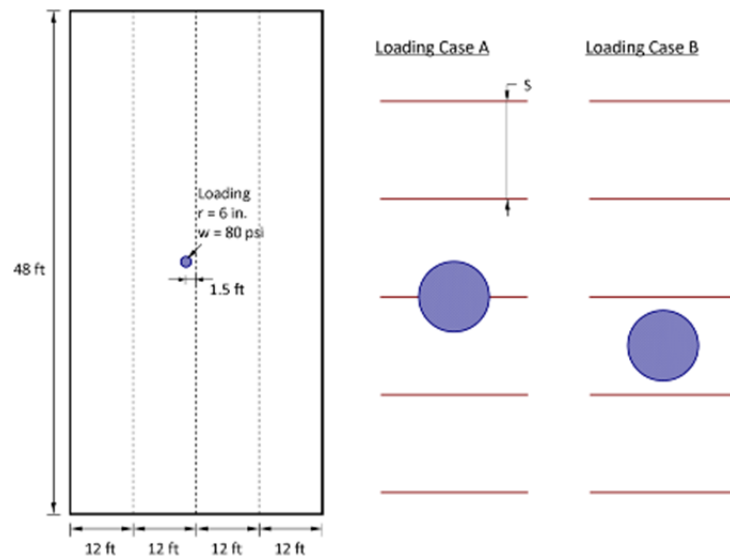
1.1. Mechanistic Modeling

1.1.1 Overview

To evaluate the effect of some design parameters on the deflection of continuously reinforced concrete pavements (CRCP), a 48 ft long four-lane slab was analyzed as shown in Figure B1. The dimension of the slab was determined based on the results from a preliminary analysis which showed that a length extending 24 ft on each side of the loaded area with no boundary constraints is adequate to consider the structural characteristics of CRCP.



(a) Geometric configuration of a concrete pavement



(b) Loading conditions

Figure B1: Analysis description and conditions

A 9-kip single-wheel loading was uniformly distributed over a circle with a radius of 6 in. at a distance of 1.5 ft from the middle longitudinal construction joint (LCJ). The material properties were assumed to be linear elastic and to have the properties as follows: (1) the elastic modulus and Poisson's ratio are 5×10^6 psi and 0.15 for concrete and 2.9×10^7 psi and 0.30 for tie bars, respectively; and (2) the moduli of subgrade reaction are 300 and 150 psi/in. for vertical and horizontal directions, respectively. The diameter and length of tie bars were assumed to be 0.75 and 50 in., respectively. Tie bars were assumed to be placed at mid-depth.

The evaluations were conducted for different slab thicknesses, tie bar spacings, and wheel loading positions. Ten levels of slab thickness were considered: 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15 in. Four levels of tie bar spacing were selected: 1, 2, 3, and 4 ft. Two types of loading position were taken into consideration as shown in Figure B1(b): the loading whose center is above a tie bar (loading case A) and the loading whose center is above the middle of two tie bars (loading case B).

1.1.2 Finite element modeling

The analysis was performed with the aid of the commercial finite element analysis program DIANA (DISplacement method ANALyser) ver. 8.1.2. DIANA is a general purpose finite element code, based on the displacement method. Civil, mechanical, biomechanical, and other engineering problems can be solved with the DIANA program. Its most appealing capabilities are in the fields of concrete and soil.

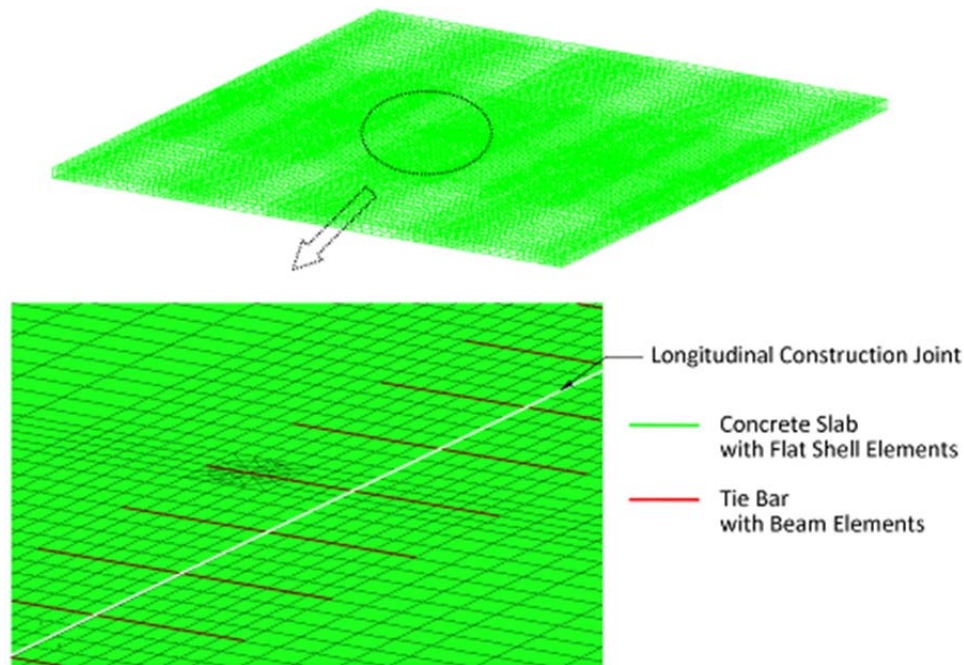


Figure B2: Finite element mesh model

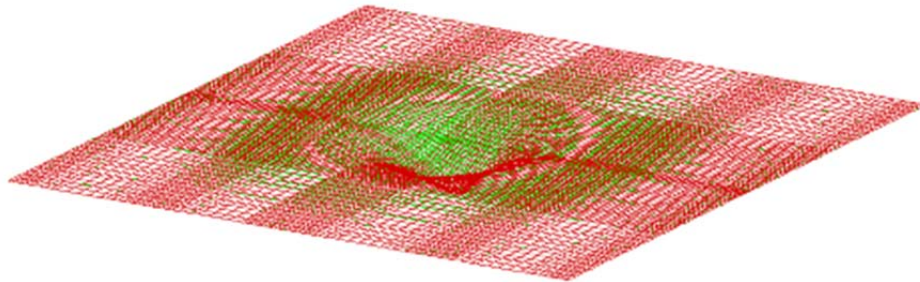
Figure B2 describes the finite element mesh model of the slab with a tie bar spacing of 1 ft and loading case A. The slab was modeled in three dimensions. Eight-node

quadrilateral isoparametric flat shell elements and six-node triangular isoparametric flat shell elements were used in the mesh representation of concrete. Subgrade was modeled in a smeared sense by means of linear elastic bedding with 8+8-node plane quadrilateral interface elements and 6+6-node plane triangular interface elements. Three-dimensional beam elements were used to model tie bars. It was assumed that aggregate interlock does not exist, which means that the wheel loading is transferred only through tie bars across LCJ. Perfect bond between tie bars and surrounding concrete was assumed.

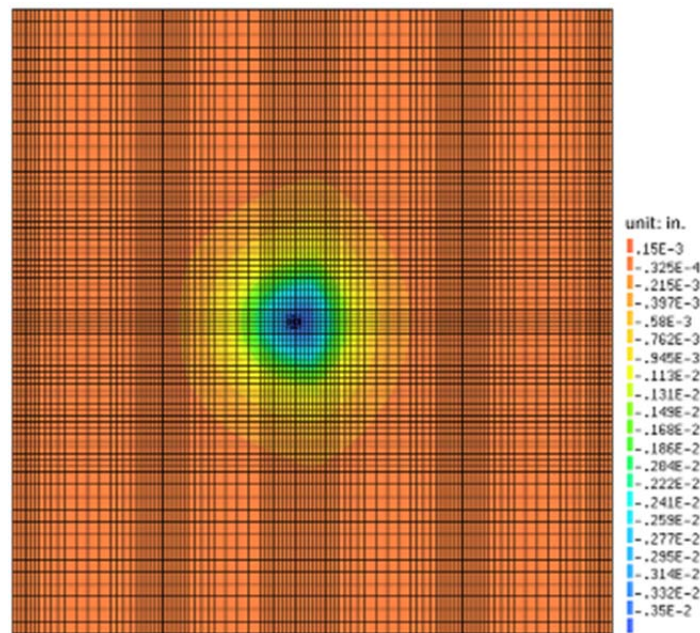
1.2. Analytical Results

1.2.1 Deformed shape

Figure B3 shows the deformed shape—magnified 13,000 times—and the contour of surface deflection for the 10-inch thick slab with a tie bar spacing of 2 feet under loading case A. The maximum surface deflection occurs directly below the center of wheel loading. Little surface deflection occurs as it gets farther away from the loading.



(a) Deformed shape

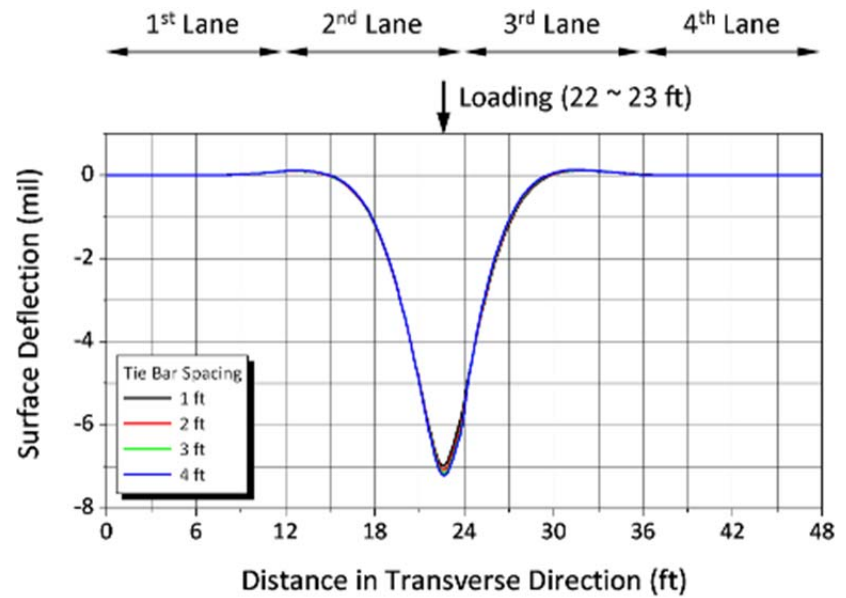


(b) Contour of surface deflection

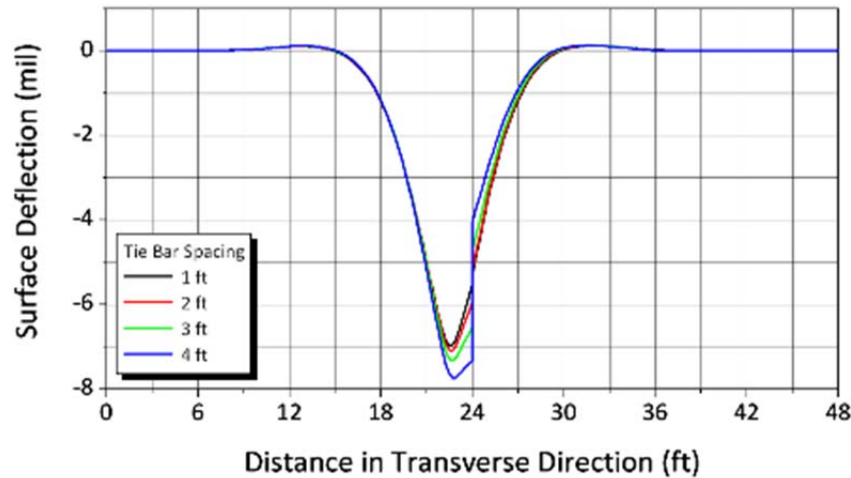
Figure B3: Deformed shape and surface deflection

1.2.2 Surface deflection

Figures B4~6 show the surface deflections along a transverse line passing through the center of the wheel loading in 6, 10, and 14-inch-thick slabs, respectively. The abscissa represents the distance from one of two slab edges which is closer to the loading. If one of two outermost lanes which is closer to the loading is denoted as lane number 1, the second lane is the loaded lane as shown in Figure B4. Figures B7~9 show the surface deflections near the loading in 6, 10, and 14-inch-thick slabs, respectively.

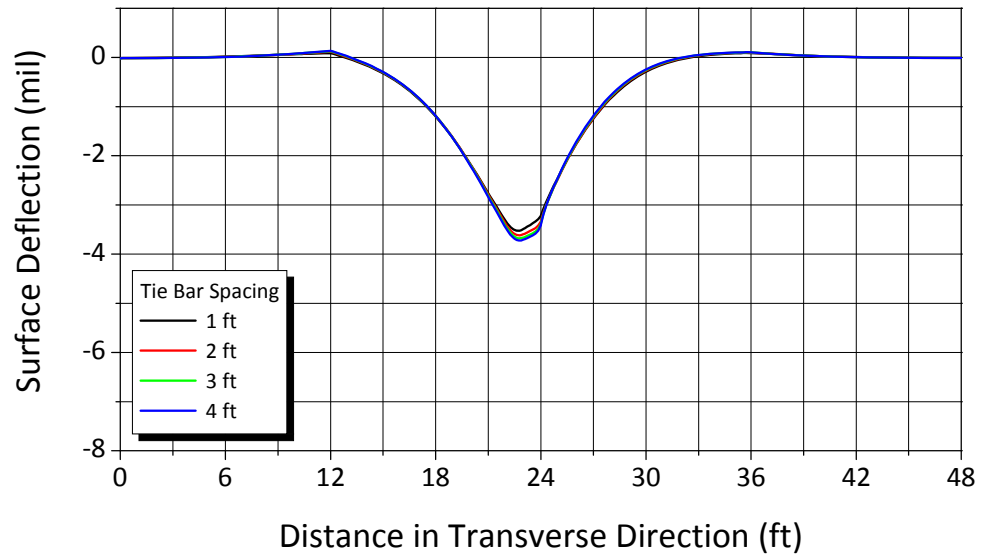


(a) Loading case A

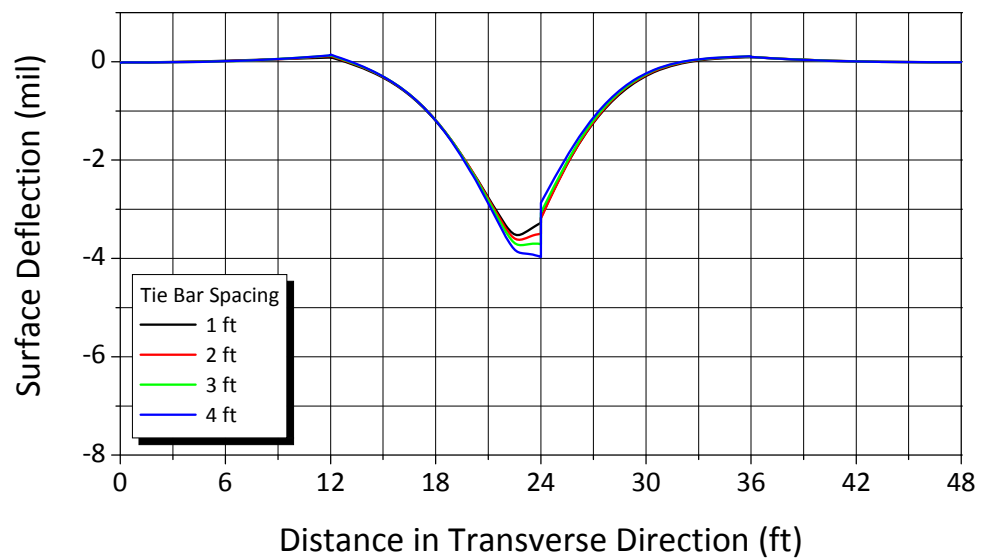


(b) Loading case B

Figure B4: Surface deflection along a transverse line in 6-inch-thick slabs

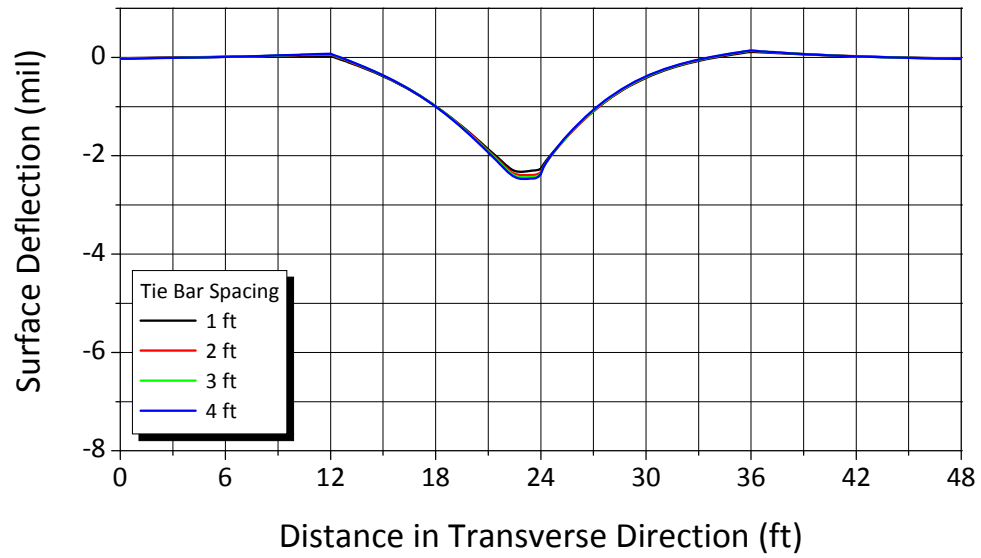


(a) Loading case A

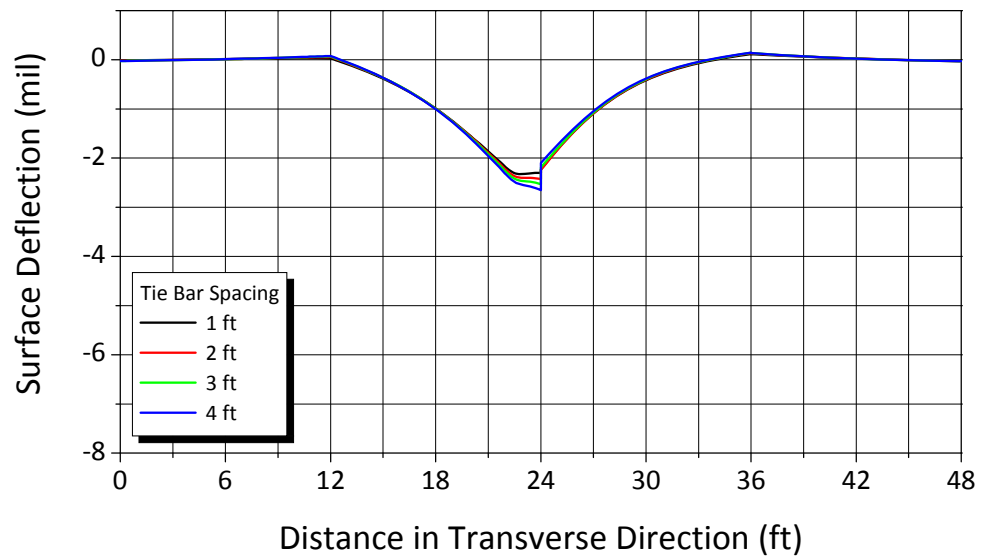


(b) Loading case B

Figure B5: Surface deflection along a transverse line in 10-inch-thick slabs

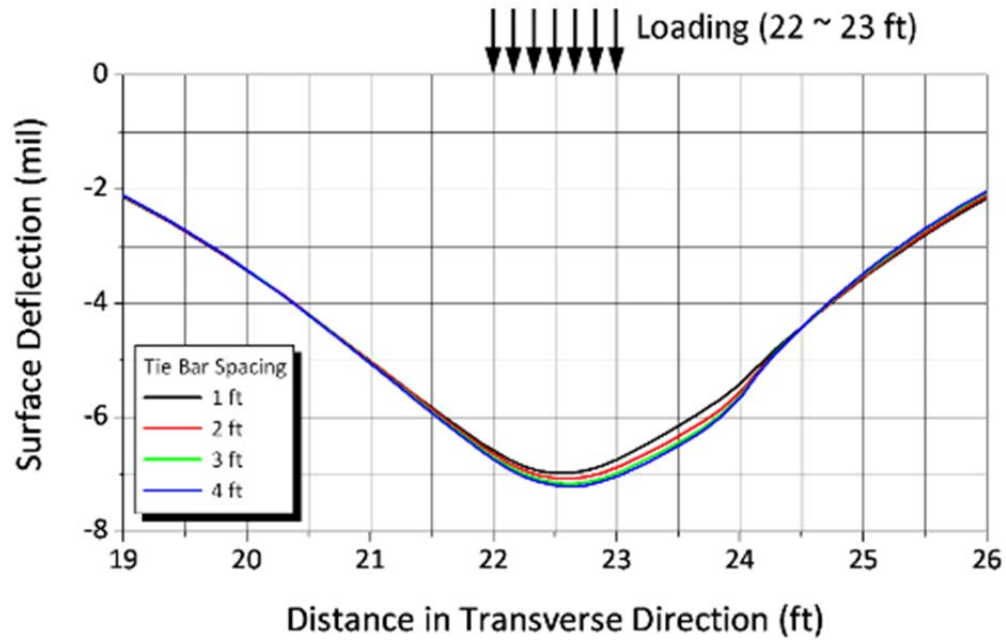


(a) Loading case A

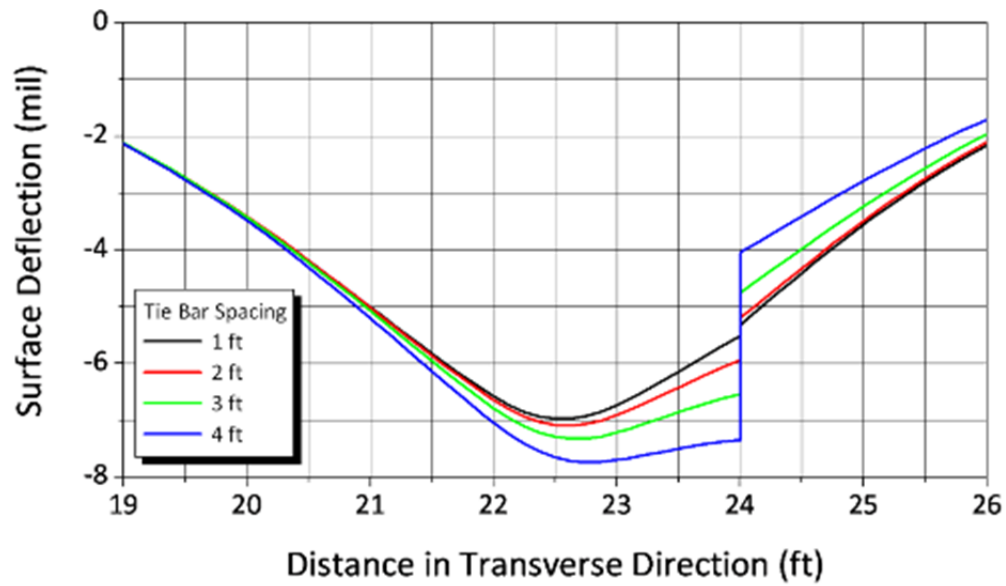


(b) Loading case B

Figure B6: Surface deflection along a transverse line in 14-inch-thick slabs

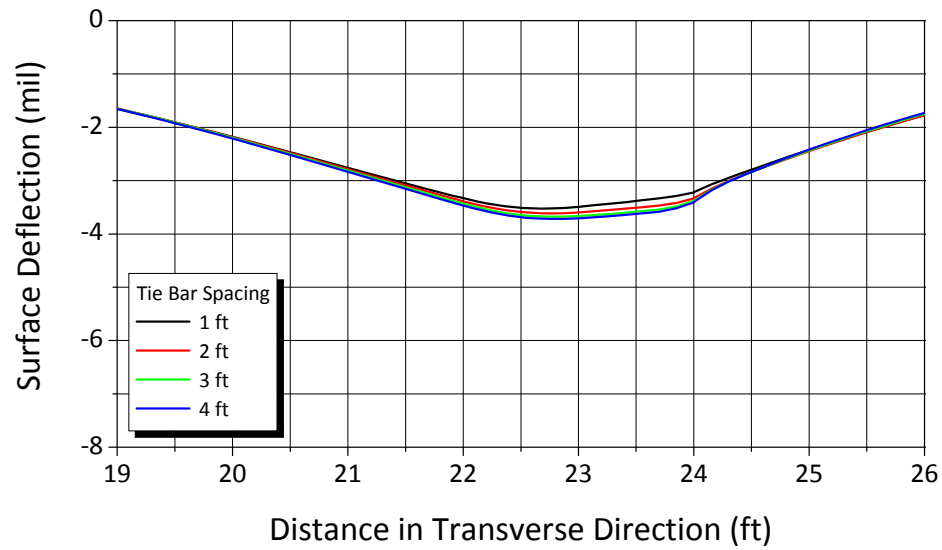


(a) Loading case A

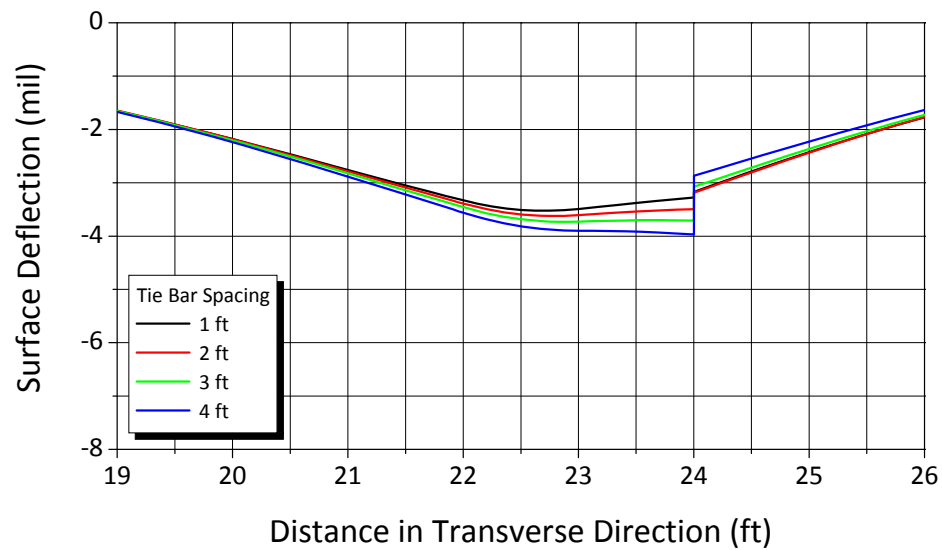


(b) Loading case B

Figure B7: Surface deflection near wheel loading in 6-inch-thick slabs

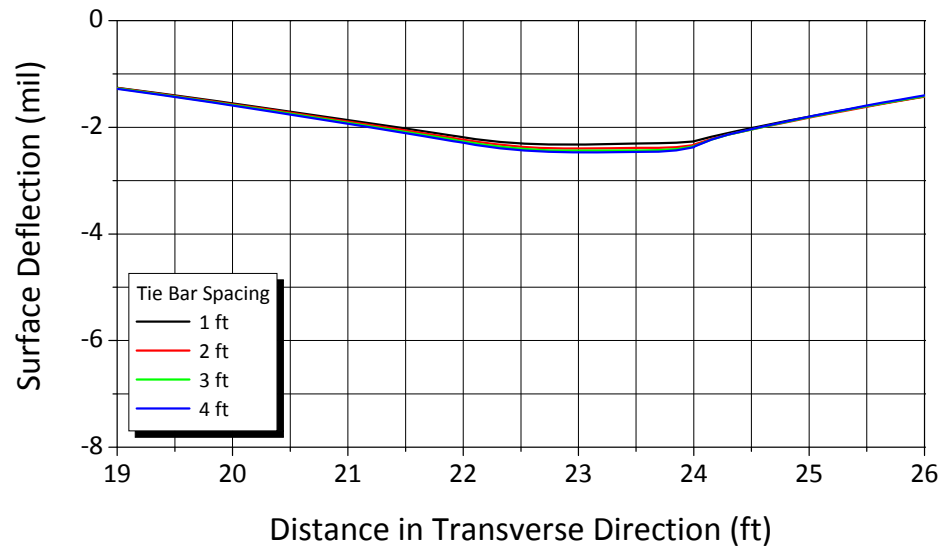


(a) Loading case A

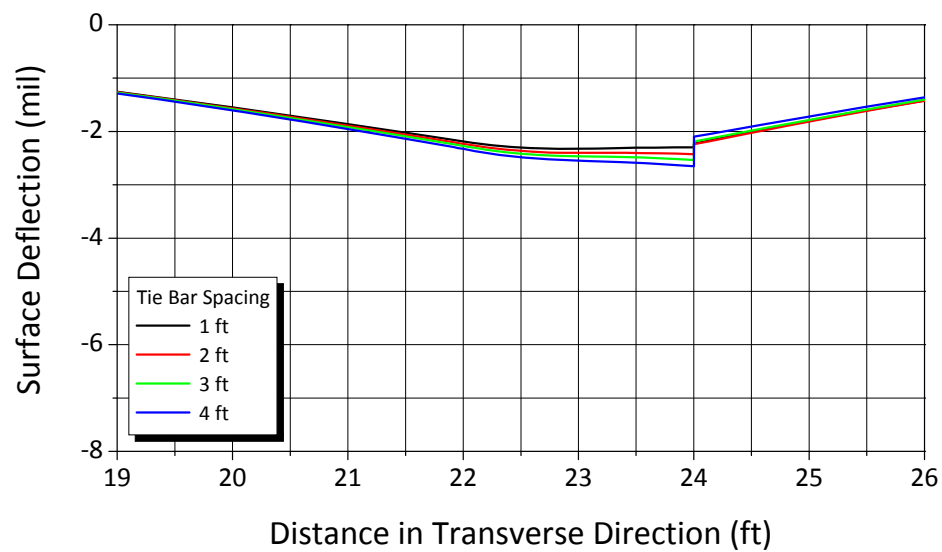


(b) Loading case B

Figure B8: Surface deflection near wheel loading in 10-inch-thick slabs



(a) Loading case A



(b) Loading case B

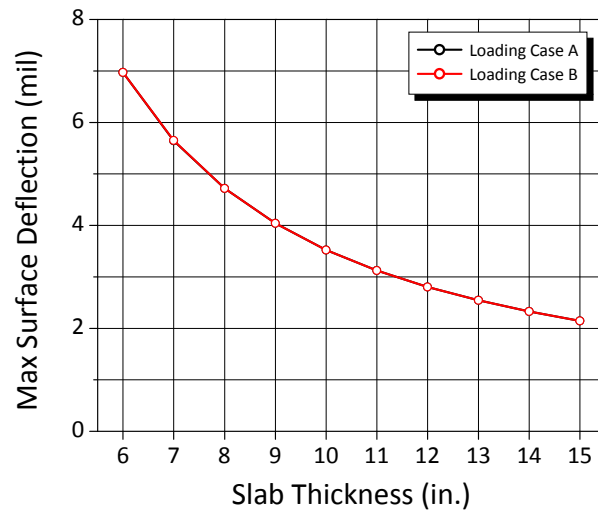
Figure B9: Surface deflection near wheel loading in 14-inch-thick slabs

As shown in Figures B7~9, the maximum surface deflection occurs below the wheel loading in thin slabs, but its location moves toward the middle LCJ as the slab is thicker. The surface deflection curve is continuous at the middle LCJ when the center of loading is above a tie bar (loading case A), but has a discontinuity when the center of loading is above the middle of two tie bars (loading case B). The jump in surface deflection at the middle LCJ increases as the slab is thinner and the tie bar spacing is larger. The maximum surface deflections are summarized in Table B1.

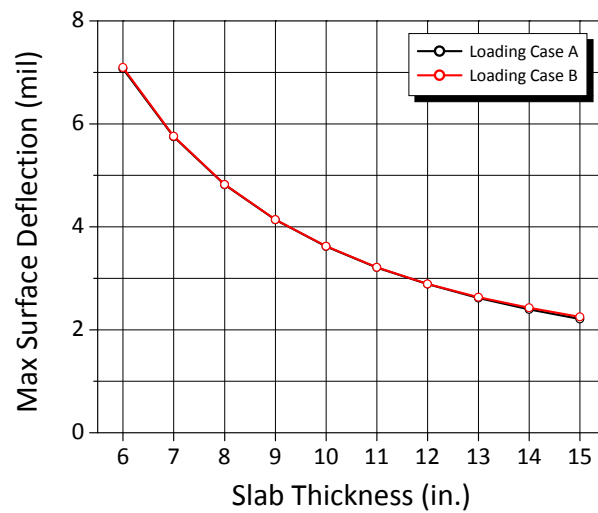
Table B1: Maximum surface deflections

Slab Thickness (in.)	Maximum Surface Deflection (mil)							
	Loading Case A				Loading Case B			
	Tie Bar Spacing (ft)				Tie Bar Spacing (ft)			
	1	2	3	4	1	2	3	4
6	7.0	7.1	7.2	7.2	7.0	7.1	7.3	7.7
7	5.6	5.7	5.8	5.9	5.6	5.8	5.9	6.3
8	4.7	4.8	4.9	4.9	4.7	4.8	5.0	5.2
9	4.0	4.1	4.2	4.3	4.0	4.1	4.3	4.5
10	3.5	3.6	3.7	3.7	3.5	3.6	3.7	4.0
11	3.1	3.2	3.3	3.3	3.1	3.2	3.3	3.5
12	2.8	2.9	2.9	3.0	2.8	2.9	3.0	3.2
13	2.5	2.6	2.7	2.7	2.5	2.6	2.8	2.9
14	2.3	2.4	2.4	2.5	2.3	2.4	2.5	2.7
15	2.1	2.2	2.3	2.3	2.1	2.3	2.3	2.4

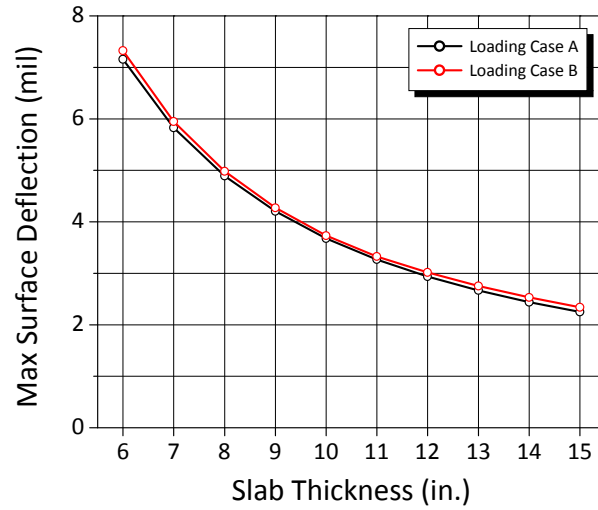
Figure B10 shows the maximum surface deflection with respect to the slab thickness. The maximum surface deflection decreases exponentially as the slab is thicker. The loading position has little influence on the maximum surface deflection when the tie bar is placed closely (Figure B10(a)), but its influence gets larger as the tie bar spacing is larger (Figure B10(d)). Larger maximum surface deflection occurs under the loading case B. However, the decreasing tendency of maximum surface deflections is little affected by the loading position and tie bar spacing.



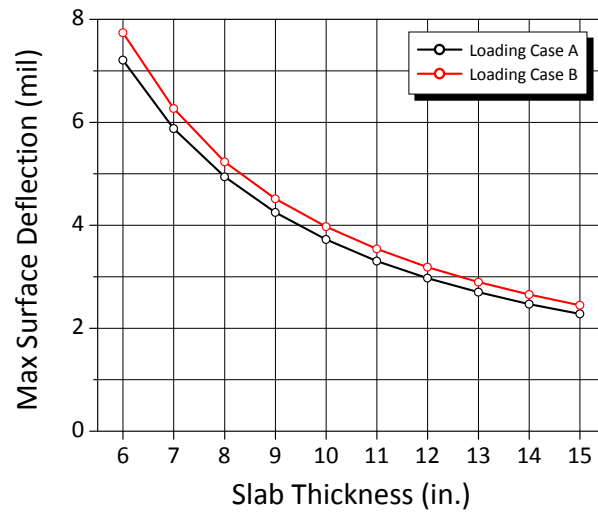
(a) Tie bar spacing of 1 ft



(b) Tie bar spacing of 2 ft



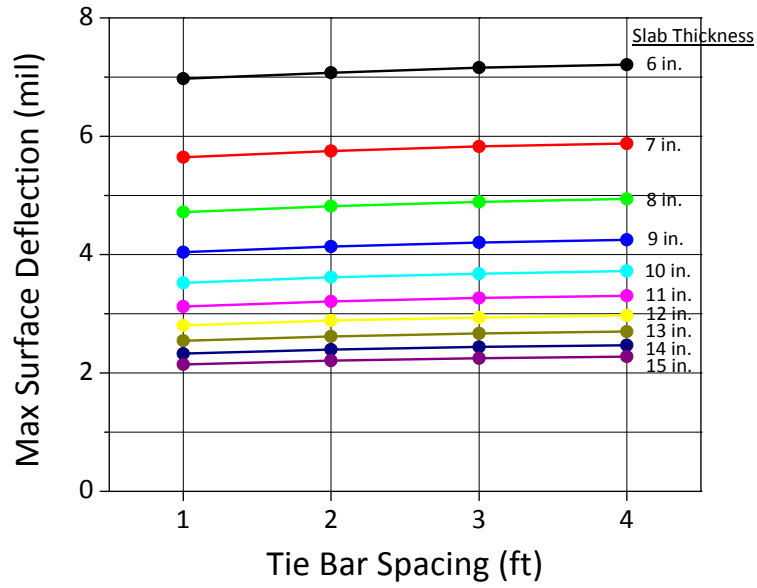
(c) Tie bar spacing of 3 ft



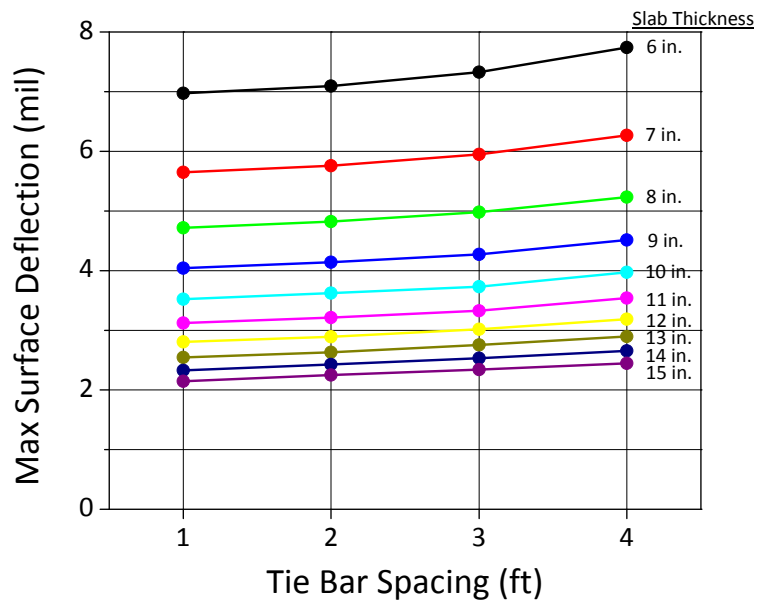
(d) Tie bar spacing of 4 ft

Figure B10: Influence of slab thickness on maximum surface deflection

Figure B11 shows that the maximum surface deflection increases with an increase in tie bar spacing. The influence of tie bar spacing on the maximum surface deflection gets greater as the slab is thinner and under the loading case B: the slope of the graph is 0.043 mil/ft in case of the 15-inch-thick slab under loading case A and 0.257 mil/ft in case of 6-inch-thick slab under loading case B.



(a) Loading case A



(b) Loading case B

Figure B11: Influence of tie bar spacing on maximum surface deflection

Appendix C: Guidelines and Specifications for Repair of Longitudinal Cracks and Joint Separations

Implementation Results 5-5444 Recommended Repair Guide: Details and Specifications For Longitudinal Joints August 29, 2008

The following guide details recommended practices for repair of failed longitudinal joints on concrete pavements.

As a result of the findings in Project 0-5444 and the implementation efforts in Project 5-5444 the first recommendation pertains to maintenance and prevention. Of the few contributing factors to the failure of longitudinal joints on concrete roadways, poor drainage along the edge of the shoulder, especially where the roads are built over expansive clay sub bases, is usually a factor. Good designs for drainage must include a well-conceived system of long-term maintainable slopes, bar ditches, and culverts to carry water away from the roadway. Before any plans for repairs to the failed longitudinal joints are made, a detailed inspection should be made to ensure that proper drainage is achieved. Regular attention to this potential problem could save the districts many years of service before any need for tie bar retrofits and slab replacements.

When a single longitudinal tie bar fails, there is a loss in load transfer at that tie, but there are no immediate issues demanding urgent corrective action from TxDOT. Once several tie bars in row fail, the longitudinal joints begin to fail. Soon after, at least one of two more obvious symptoms begin to insist on some type of repair considerations.

The most common problem is the separation of the longitudinal joint, and this normally occurs between the outside traffic lane and the outside shoulder. Once the tie bar is broken or debonded from either slab, the only lateral restraint is the friction between the free slab and the base. When water flows into the separating joint under traffic-induced vibrations, the free slab can begin to drift away. Typically the concerns are raised when the joint opens to approximately an inch. It becomes an obvious road hazard when it opens wide enough to allow motorcycle tires to fall into the joints, but deterioration of the roadway occurs long before it opens an inch in width.

When the pavement is new and the tie bars are properly performing, the adjoining slabs are locked so tightly together that water cannot enter the joint. Once the tie bars fail and the slabs begin to separate rain water enters the joint, corroding the steel and softening the base or sub base under the joint. This softening and separation allows downward deflections of the free edge of the slabs when heavy wheel loads occur along these edges. Soon traffic-induced pumping of base or sub base materials creates small voids that can allow the unsupported edge to drop, or fault, resulting in an uneven roadway along the

longitudinal joint. Localized lower elevations allow precipitation to collect along the joints creating skid hazards. Faulting frequently progresses to vertical differences of one inch or more before the edge drop alone creates a road hazard significant enough to require attention beyond constant temporary applications of cold patch into the faulted joint to ramp tires over the longitudinal vertical change.

Responsible long-term repair strategies should address the causal factors first and follow with solutions to the more obvious symptoms of interest. The objective for this guide, however, is to provide the user with tools to write specifications for successful repairs of failed longitudinal joints.

The following items are included:

1. Typical construction sequence and materials estimates for longitudinal repairs
2. Details, construction specifications and material specifications for filling the sub-slab voids with grout
3. Details, construction specifications, tie bar specifications and grout specifications for filling retrofit tie-bar slots
4. Details for milling and preparing surface for bonded concrete (inlay) overlay (BCO), details for placement of BCO with construction and materials specifications for installation of the BCO overlay for leveling faulted slabs. (Also a copy of the ASTM C 1583 Pull-off test method for bond strength).

1. Construction Sequence

1. Wherever longitudinal joints are pumping as indicated by pumping stains and falling weight deflection reading, and wherever faulting exceeds ½ inch, larger base voids are likely. Lasting repairs in these areas require the re-establishment of uniform edge support through simple low-pressure pumping of grout into the voids along these joints. This item eliminates further pumping and faulting.

Only where indicated on the site plans, fill the voids along edges of faulted slabs, to provide more uniform support along the joint and prevent further pumping. Low pressure grouting (10 to 20 psi) using hydraulic cement grouts will be used such that slabs will not be lifted during grouting.

2. Lock the slabs laterally with retro-fitted tie bars, using slot-stitching to prevent further separation and to provide load transfer across the joint. The longitudinal joint will be filled at each slot during the installation of the tie bars. This longitudinal joint should be tightly locked wherever practical to prevent differential vertical deflections between the two slabs. All transverse joints, however, must remain unlocked and able to open or close as slab temperatures change.

3. Return the local faulted slab elevation near the joint to original grade by overlaying the depressed pavement sections with bonded concrete. This item will result in restoration of ride quality. Milling will be required to (1) provide a clean, rough surface to bond the BCO and (2) to provide a minimum thickness of 1 ½ inch for the BCO.

2. Materials Estimates for Longitudinal Joint Repairs

Estimates for each material are for treating 20 each 15-ft. long slabs.

Under-Sealing Grout = 3 cu. Ft.

This estimate is for under-sealing all 20 slabs, but the actual number where under-sealing is really required, based on pumping or depth of faulting, will be listed on plans.

Estimate: average 3 in. wide x 3/8-in. deep x 15 ft. long x 20 slabs = 2.5 cu. ft.
plus 20% contingency and waste = 3.0 cu. ft.

Tie bars- (No. 6, deformed, 48 inches long) = 110 each

Estimate: 5 per slab x 20 slabs = 100 plus 10% contingency = 110 tie bars

High Strength/ Rapid Setting (HSRS) Grout- 64 cu. ft.

Estimate: volume of slot for tie bar = 2-3/4 in. wide x 6 in. deep x 57* in. = 941 cu. in.

Vol. of tie bar = 48 in. long x (3/8 in.)² x 3.14 = 21.2 cu. in.

Volume to be filled with HSRS grout = 941 – 21 = 920 cu. in.

100 slots x 920 cu. in. / slot = 92,000 cu. in. or 54 cu ft. Order 64 cu. ft. (includes 20% contingency and waste)

*57 is average width of trapezoid 50-in. bottom, 64-in. top.

Rapid-Setting Portland Cement Mortar = 11 cu. yd.

Estimate: 20 slabs (6 feet wide x 15 feet long x 1 ½ inch thick)

= 225 cubic feet (8.5 cubic yards). Order materials for 11 cu. yd.

(includes 30% overage for priming, QC testing, and waste)

3. Filling and Under-Sealing Sub-Slab Voids with Low-Pressure Grouting

1. Special Specification for Filling and Under-Sealing Base Voids with Low-Pressure Grout
2. Grouting Detail before Slot-Stitching (Figure A 1.)

SPECIAL SPECIFICATION
AAAA (typical for large jobs)

Filling and Under-Sealing Base Voids with Low-Pressure Grout

- 1) **Description.** This Item shall govern for the filling and sealing of existing voids under the concrete pavement at locations shown on the plans or designated by the Engineer. This work shall include coring injection holes, placement of under-sealing material, monitoring to avoid lifting slabs, clean-up and other related work.
- 2) **Special Requirements.** The Contractor shall use a crew experienced and competent in the work of pressure grouting and pavement under-sealing. The crew and equipment furnished by the Contractor shall have satisfactory production capabilities in the judgment of the Engineer.
- 3) **Materials.** The materials shall consist of a mixture of Type I, II or III Portland cement, a fluidifier, fly ash and water. All materials shall be furnished by the Contractor.

Type I, II or III Portland cement shall conform to the requirements of DMS-4600, "Hydraulic Cement".

The fluidifier shall be a cement dispersing agent possessing such characteristics that will inhibit early stiffening of the pumpable mortar, tend to hold the solid constituents of the fluid mortar in suspension and prevent completely all setting shrinkage of the grout.

Water shall conform to Item 421, "Hydraulic Cement Concrete".

Use fly ash that meets the requirements of DMS-4610. Select the fly ash from an approved source. The Materials and Pavements Section of the Construction Division maintain a list of approved sources.

- 4) **Equipment.** The equipment used shall be that used in coring concrete pavements and that customarily used in the pressure grouting of earthen embankments or pressure grouting of concrete pavement. It shall consist of at least the following:
 - (1) Stand-mounted coring rigs for vertical coring of concrete pavements. These shall be equipped with core barrels that will core 2-in. diameter (or any diameter approved by the Engineer) holes at 3-ft. intervals and through the full depth of the slabs plus base at indicated pavement sections.
 - (2) A minimum 2-ft. long, 1-in. diameter, tapered steel depth probe as typically used for determining depth of hot-mixed asphalt or bases.
 - (3) Cylindrical wooden plugs or other approved plugs that satisfactorily plug

holes until the grout has set.

- (4) Equipment for accurately measuring and proportioning by volume or weight the various materials composing the grout.
- (5) A colloidal mixer that is capable of operating in a range from 800 rpm to 2,000 rpm and thoroughly mixing the various components of the grout in an approved manner.
- (6) A positive action pump that is capable of forcing grout through a drilled hole into voids and cavities beneath the pavement slab. The pump shall be capable of supplying a varying pressure up to a maximum of one hundred pounds per square inch at the end of the discharge pipe, when pumping grout of the specified consistency. The injection pump shall be capable of continuous pumping at rates as low as 1/2 gallon per minute.

The discharge line shall be equipped with a positive cut-off valve at the nozzle end, and a bypass return line for recirculating the grout back into a holding tank or mixer unless otherwise approved by the Engineer.

- (7) A stop watch and flow cone conforming to the dimensions and other requirements of Test Method Tex-437-A, "Method of Test for Flow of Grout Mixtures (Flow-Cone Method)".

- 5) **Proportioning Grout Mixture.** The mixture used in low-pressure grouting, herein referred to as "Grout Slurry", shall consist of proportions of Portland cement, fly ash, fluidifier and water.

The Contractor shall furnish the Engineer the proposed mix design meeting the following requirements:

- The grout slurry shall remain fluid and not exhibit a resistance to flow for a minimum of one hour.
- The time of efflux from the flow cone shall be between 10 and 20 seconds. Perform the flow test in accordance with Test Method Tex-437-A, "Method of Test for Flow of Grout Mixtures (Flow-Cone Method)."
- The grout slurry shall achieve initial set in less than 4 hours. Do not allow the grout slurry to carry traffic until which time it has set to the satisfaction of the Engineer; or until which set time, as determined with Test Method Tex-302-D, "Time of Setting of Hydraulic Cement by Gillmore Needles", has been reached.
- The 7 day compressive strength of the grout slurry shall not be less than 200 psi. The compressive strength shall be determined in accordance with Test Method Tex-307-D, "Compressive Strength of Hydraulic Cement Mortars".

- 6) **Deflection Testing.** Each joint and slab on the project or within designated areas of the project is subject to be tested by the Engineer in cooperation with the Contractor

using the Falling Weight Deflectometer (FWD). Test joints in question before and after pressure grouting. If the deflection testing is done after grouting, then it will be done the next day before 11:00 a.m. All testing shall be limited to the hours between daylight and 11:00 a.m. The Engineer will use the deflection data to determine where re-grouting is necessary. A maximum of 2 properly performed grouting injections will be required. The Engineer will determine the specific joints that are to be tested.

- 7) **Construction Methods.** Core 2- in. diameter (or other approved diameter) holes through the concrete pavement at the locations indicated on the plans or designated by the Engineer. Core these holes to a depth sufficient to penetrate any stabilized base and into the subgrade. Subgrade penetration shall not exceed 3 in. For holes marked near the edges of the slab, the joints or a major crack, a maximum of 1 in. from the precise marked location is considered to be reasonable. Core vertically to avoid cracking the pavement or disturbing vertical joint face of the slab and to provide satisfactory holes of the proper diameter for effective operations in pressure grouting. Whenever coring, the core barrel shall be held as nearly perpendicular as possible to the pavement surface. Irregular or unsatisfactory holes which cannot be satisfactorily used in pressure grouting shall be filled with grout and new holes shall be drilled. The Contractor shall exercise sufficient precautions during all operations to insure that slabs are not broken or cracked. Any slab that develops a crack that extends through the drill hole will be considered to have been damaged during the process of the work and it shall be repaired or replaced at no cost to the Department. Repair or replacement will be in accordance with techniques approved by the Engineer. No more holes shall be drilled during a day's operations than can be grouted during the same day, unless specific approval is given by the Engineer.

After drilling the holes, lower a pipe connected to the discharge hose on the pressure grout pump into the holes. The discharge end of the pipe shall extend below any overlays which might exist, but not below the lower surface of the concrete pavement.

To fill all voids, pumping of grout will be required in holes designated by the Engineer. During the sub-sealing operation, no lifting of the slab will be allowed. No upward movement of the pavement is allowed, unless directed by the Engineer. Pump each hole until maximum pressure is built-up, grout is observed flowing from hole-to-hole, out of adjacent joints or as directed by the Engineer. Maximum allowable pressure shall not exceed 20 psi., except for the allowance of a short surge to 30 psi when starting to pump.

Monitor the pressure by an accurate pressure gauge in the grout line that is protected from the grout slurry. Water displaced from the void structure by the grout shall be allowed to flow out freely, but shall not interfere with adjacent traffic. Excessive loss of grout through cracks, joints, or from backpressure in the hose or in the shoulder area shall not be tolerated.

Do not perform low-pressure grouting when pavement surface temperatures are below 35°F or if the subgrade and/or base course material is frozen.

After the completion of grouting in any 1 hole, withdraw the discharge pipe from that hole and plug the hole immediately. Temporary plugs may be used since additional grout may be placed in particular holes to complete the required work in that area.

Remove temporary plugs when sufficient time has elapsed to permit the grout to set sufficiently so that back pressure will not force it through the hole, fill the space occupied by the plug with a reasonably stiff grout or an approved concrete mixture, and then compact.

In the event the Engineer determines that continued grout injection at any specific location is no longer economically feasible, he may direct the Contractor to cease grout injection at that location.

The Engineer may modify the construction methods outlined above, for sufficient justification, as field conditions dictate.

The Contractor shall use such approved measures as are necessary to keep all pavement surfaces adjacent to the actual grouting operation in progress reasonably clean of excess grout and other materials at all times.

Prior to the placement of traffic on the work area, clean the pavement (including adjacent shoulders) to the satisfaction of the Engineer.

Keep all traffic off the grouted slab until last mix grout sample has set, unless otherwise directed by the Engineer.

- 8) **Measurement.** Drilled holes will be measured by each drilled hole actually drilled and filled as necessary to accomplish the work provided herein.

The under-sealing grout slurry, mixed and placed as specified herein, will be measured by the cubic foot (dry measure) of each material (cement and fly ash) incorporated into the under-seal, prior to mixing.

- 9) **Payment.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Cored Holes" and "Grout Slurry."

These prices shall be full compensation for all work covered by this Item, including but not limited to, drilling, temporary plugging and final sealing of holes in the concrete slabs; for securing and furnishing all materials including fluidifier and water; including all royalty, freight and storage involved; for mixing, proportioning and pumping the under-sealing slurry grout into the voids under the concrete slabs; for cleaning up and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

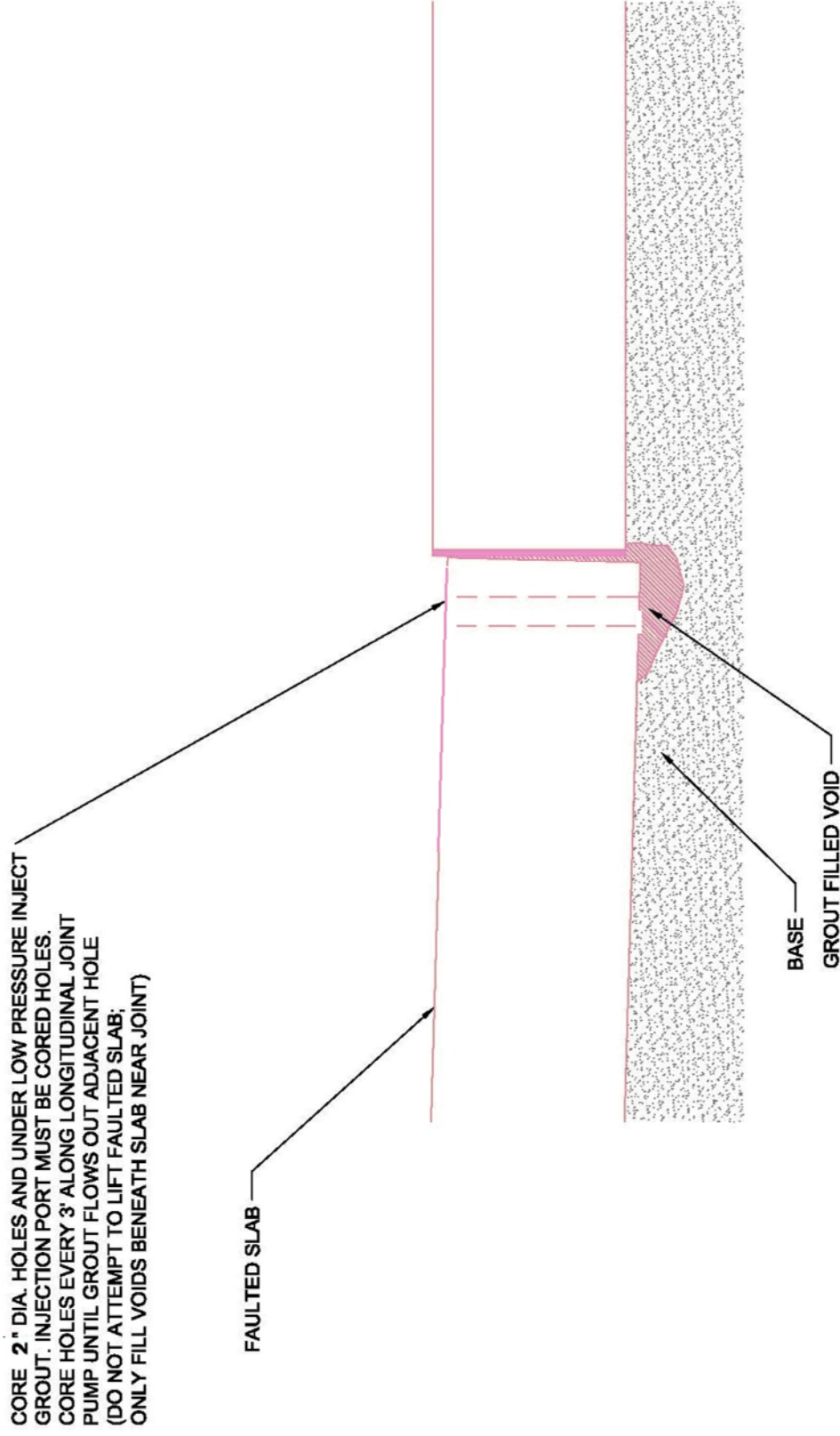


Figure A 1  **GROUTING DETAIL BEFORE SLOT STITCHING**
FOR FAULTED SLABS

3. Slot-Stitching

1. Special Specification for Slot-Stitching Longitudinal Joints in Concrete Pavement
2. Plan View of Sawing Detail for Slot-Stitching (Figure A 2.)
3. Slot-Stitching Plan View (Figure A 3.)
4. Slot-Stitching Section for Unfaulted Slabs (Figure A 4.)
5. Slot-Stitching Section for Faulted Slabs (Figure A 5.)

SPECIAL SPECIFICATION

BBBB

Slot-Stitching Longitudinal Joints in Concrete Pavement

1. **Description.** Install tie bars across longitudinal joints in concrete pavement in accordance with the details shown on the plans and the requirements of this item.
2. **Materials.** Furnish the following materials, unless otherwise shown on the plans or directed by the Engineer:
 - a. **Concrete.** Provide Class HES concrete conforming to Item 421, “Hydraulic Cement Concrete,” with the following exceptions or additions:
 - i. Design concrete mix with a maximum water to cement ratio of 0.40, and a minimum average compressive strength of 3500 psi at the age of 24 hours. Test according to Tex-418-A, “Compressive Strength of Cylindrical Concrete Specimens.”
 - ii. Provide washed aggregate with 100% passing the 1/2 in. sieve. No more than 15% of the mix must be of any one size of aggregate.
 - iii. Use shrinkage reducing or compensating admixtures, or water reducing admixtures as approved to achieve a fluid non-segregating mixture. Do not use retarding admixtures. When using any admixtures, document the type, quantity, and location of mix placement on a copy of the final plans.
 - iv. The use of proprietary, high strength, rapid setting mixes may be approved when the materials demonstrate the satisfied performance. Obtain approval for the materials and proportions before using. Document the placement locations and material properties of proprietary materials on a copy of the final plans.
 - b. **Steel Tie Bars.** Provide 48-in. long No. 6 deformed steel tie bars in accordance with Section 360.2.B, “Reinforcing Steel.”
 - c. **Membrane Curing Compound.** Provide membrane curing compounds that conform to the requirements of DMS-4650, “Hydraulic Cement Concrete Curing Materials and Evaporation Retardants”, Type 2, Class A.

3. **Construction Methods.** Demonstrate slot-stitching work for approval of all the equipment and procedures. Provide tie bars at locations and spacing as detailed in the plans.

a. **Slot Formation.**

- i. Provide slots using multiple saw cuts made with a diamond impregnated saw blade to a depth of 6 ½ in. This depth will provide the needed clearance under the tie bars for the support devices and for encasing the tie bars in the repair material.
- ii. The slot is 2 ¾ in. minimum and at most 3 ½ in. wide.
- iii. Provide enough length of the cut to allow the tie bar to be placed at the mid-depth of the slab with a 1-in. space between the ends of the tie bar and the ends of the slot. This typically makes a slot that is 62 to 64 inches long at the top of the slab and 50 long at the bottom of the cut, due to saw radius equal to or greater than 10 inches.
- iv. Use lightweight jackhammers less than 30 lb. or hand tools to remove the “fins” formed by sawing.
- v. Do not spall or fracture concrete adjacent to the slots. Repair damages to concrete pavement caused by Contractor’s operation without any additional compensation. Repair in accordance with Item 361, “Full-Depth Repair of Concrete Pavement” or Item 720, “Repair of Spalling in Concrete Pavement” if spalls are 0.25 to 3 in. in depth, or as approved.

b. **Tie Bar Placement.**

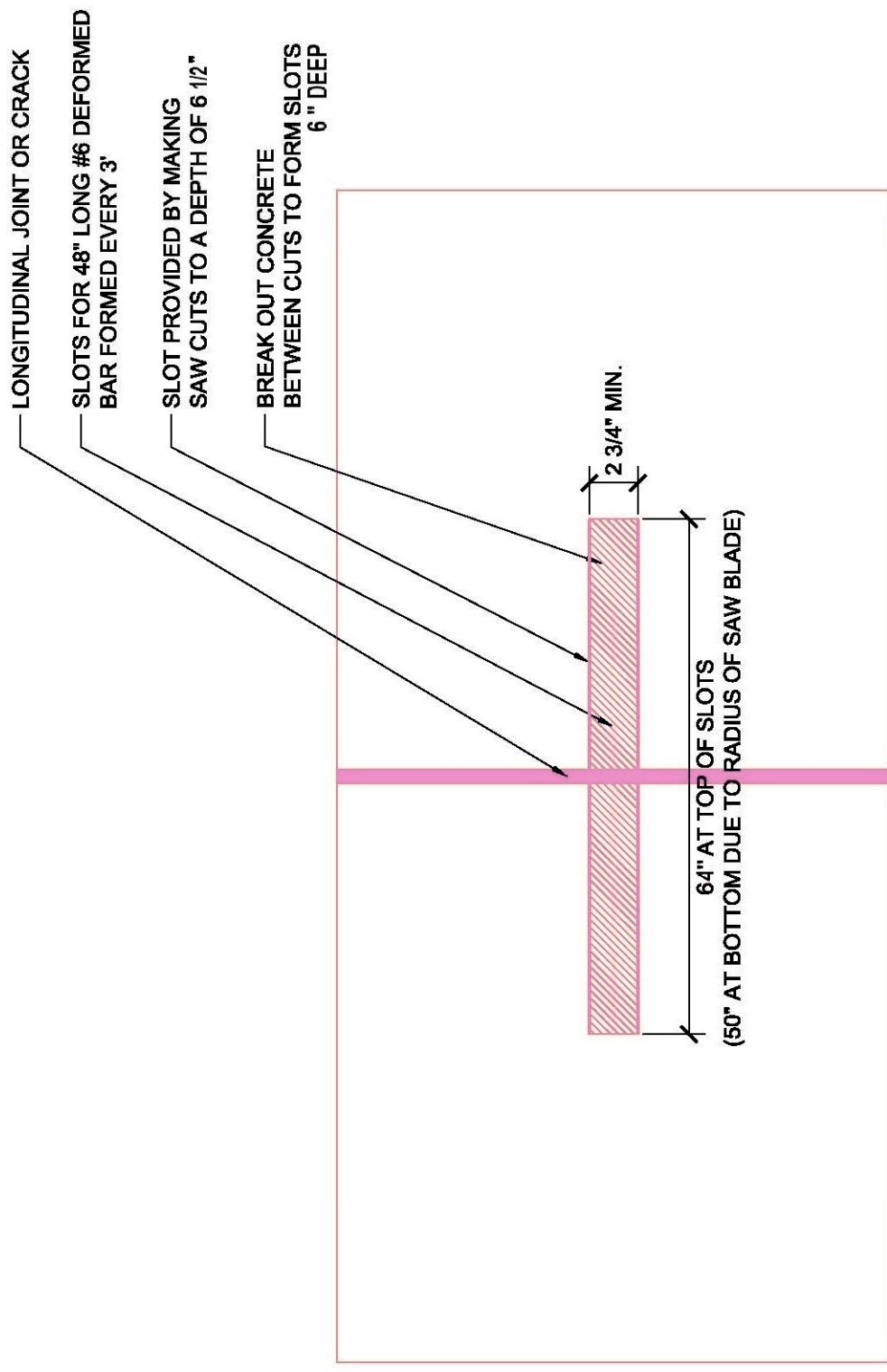
- i. Rinse the slot with potable water to remove cutting slurry, sand blast to provide better texture for bond to sawed faces, and blow clean and dry with high pressure oil-free air to remove sand, water and dust.
- ii. Place tie bars at locations and spacing as detailed in the plans. Place the tie bars on support chairs so that the tie bars rest horizontal at the mid-depth of the slab.

c. **Repair Material Placement.**

- i. Do not place concrete when the air temperature is below 65°F. Use a vibrator head at most 1 in. in diameter to consolidate the concrete repair material. Do not dislodge or move the tie bar out of position, but the repair material must fill the space under and around the bar.
- ii. Finish the repair material level with the existing slab surfaces.
- iii. Cure the repair surface in accordance with Section 360.4.I. If a

proprietary mix is used, use manufacturer's curing procedure.

- iv. Use insulation blankets to facilitate curing and the strength gain of repair areas when needed. Provide insulating blankets with a minimum thermal resistance (R) rating of 0.5 hour-square foot °F/BTU and in good condition.
 - v. Make and cure concrete compressive strength test specimens as directed.
- d. **Opening to Traffic.** The pavement may be opened to traffic after all tie bars have been installed at a joint and the concrete has obtained a minimum average compressive strength of 3500 psi or as directed by the Engineer. Determine the compressive strength in accordance with Tex-418-A by using concrete specimens cured at the job site under the same conditions as the pavement. Opening the pavement does not relieve the Contractor from his responsibility for the work in accordance with Item 7, "Legal Relations and Responsibilities." Seal all joints and clean the pavement before opening the pavement to traffic.
4. **Measurement.** This Item will be measured as each completed and accepted tie bar complete in place.
5. **Payment.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Slot-Stitching Longitudinal Joints in Concrete Pavement". This price is full compensation for furnishing all materials, tools, labor, equipment and incidentals necessary to complete the work. No payment will be made for extra work required to repair damage to the adjacent pavement that occurred during sawing.



PLAN OF SAWING DETAIL FOR SLOT STITCHING

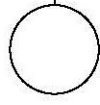


Figure A 2

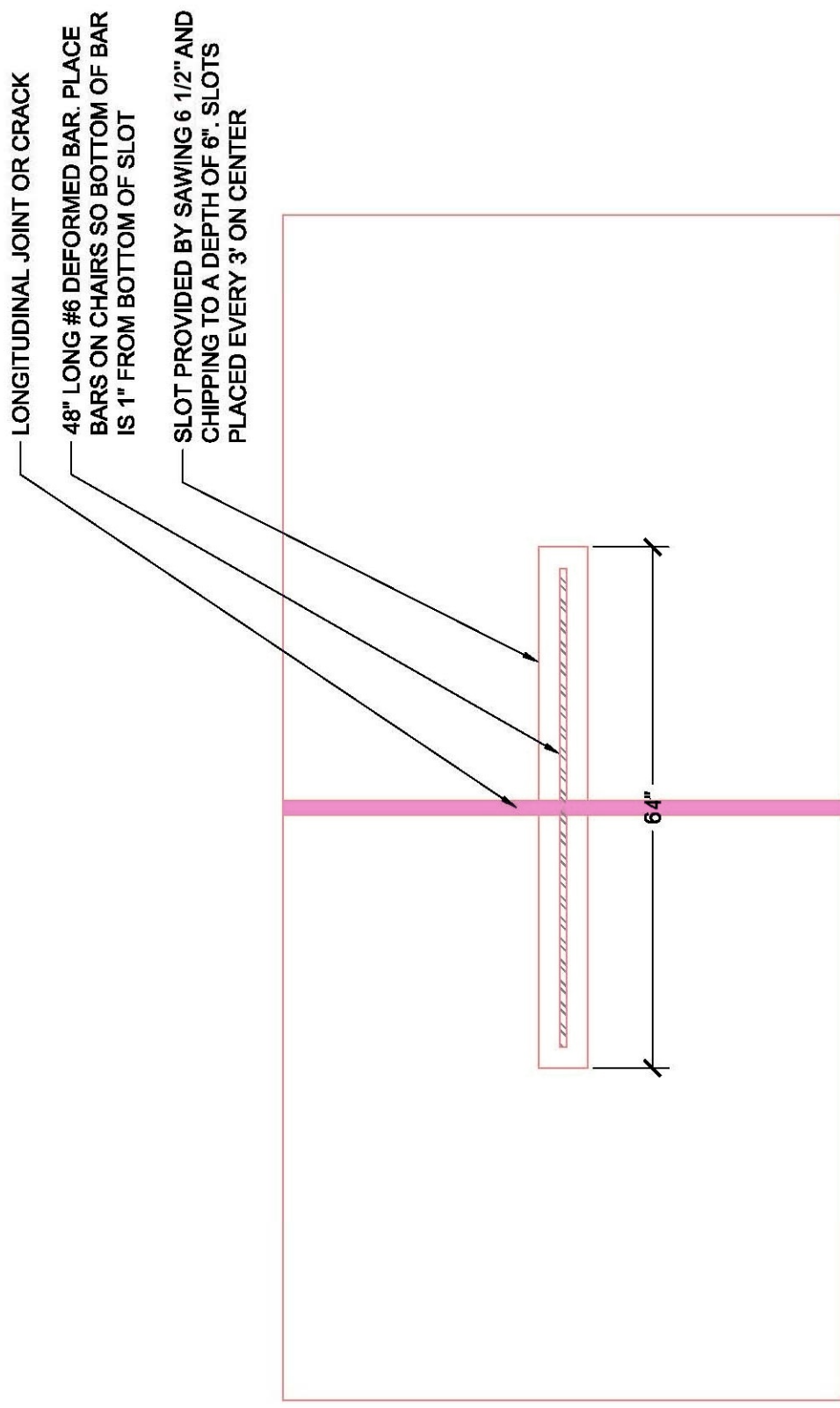


Figure A 3

SLOT STITCHING PLAN VIEW

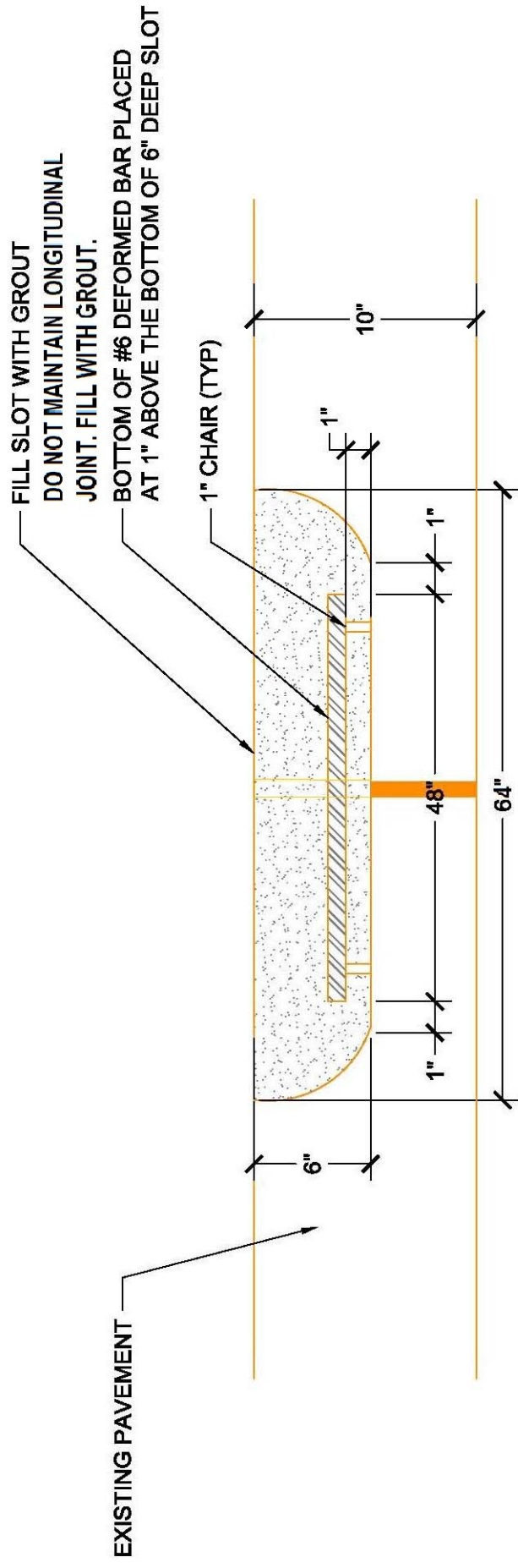
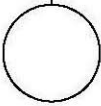
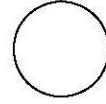


Figure A 4  **SLOT STITCHING SECTION**
FOR UN-FAULTED SLABS - NO OVERLAY REQUIRED



FOR FAULTED SLABS



4. Restoring Grade for Faulted Slabs

1. Special Specification for Cold Milling Concrete Pavement Prior to Overlay
2. Milling Detail (Figure A 6.)
3. Special Specification for Cleaning Milled Concrete Pavement
4. Special Specification for Bonded Concrete Overlay
5. Slot-Stitching Detail with BCO for Faulted Slabs (Figure A 7.)

SPECIAL SPECIFICATION

CCCC

Cold Milling Concrete Pavement for Bonded Concrete Overlay

1. **Description.** Cold milling shall consist of removing a portion of the existing concrete substrate as shown in the plans. Any non-portland cement concrete overlay materials shall be milled off completely and the concrete surface shall be milled to create an area to place a rapid-setting concrete inlay or overlay. The concrete surface shall be milled down to a uniform depth in specified areas shown in the plans or described in the special provisions.
2. **Materials.** Essentially all of the milled material shall be pulverized to pass a 1-inch sieve.
3. **Equipment.** The milling shall be done with a commercially manufactured machine able to perform this work to the Engineer's satisfaction. The milling machine shall be self-propelled and shall have sufficient power, traction, and stability to maintain an accurate depth of cut.
 - a) The cold milling machine shall be equipped with automatic controls for establishing profile grades at each edge of the machine. The reference shall be the existing pavement or taut reference lines erected and maintained by the Contractor true to line and grade. A single reference may be used if the machine can maintain the designated transverse slope.

When referenced from existing pavement, the cold milling machine shall be controlled by a self-contained grade reference system provided by the machine's manufacturer for that purpose. The sensing point shall react to compensate for 25 percent of the actual change in elevation due to a hump or dip that is 3 feet or less in length. The self-contained grade reference system shall be used at or near the centerline of the roadway. On the adjacent pass with the milling machine, a joint matching shoe may be used.
 - b) Broken, missing, or worn teeth shall be replaced if the machine is unable to maintain the surface texture requirements.
 - c) The machine shall be equipped with a loading elevator to remove the milled material from the roadway surface.
 - d) The machine shall be equipped with means to effectively control dust generated by the cutting operation.

4. **Construction Methods.** Before beginning work on roadway demonstrate the milling machine to assure proper condition and operation of equipment to the satisfaction of the engineer.
- a) The milled surface shall not be open to traffic.
 - b) When milling removes pavement markings, the Contractor must place temporary pavement marking before opening the road for public use.
 - c) The texture produced by the cold milling operation shall be uniform, and continuous longitudinal striations will not be allowed.
 - d) When milling is done under traffic maintained conditions, the Contractor shall uniformly mill the partial-lane width with one machine.
 - e) The milling must result in a vertical longitudinal face between 1-1/2 inch and 2-1/2 inch in depth between the lanes. At the end of each day, no milled surface will be present to vehicular traffic. Work shall be scheduled so that the milled surface will not be present between traffic lanes over weekends, holidays, or other extended periods when work is not being performed.
 - f) Transitions between milled and unmilled surfaces will not be feathered either by milling or with wedges of bituminous material (maximum slope 1 horizontal to 4 vertical).
 - g) Surfacing material that cannot be removed by cold milling equipment because of physical or geometric constraints may be removed by other methods approved by the Engineer.
 - h) If traffic has been detoured from the milled area, the surface shall be swept once per day. When milling is performed under traffic maintained conditions, the milled surface shall be inlaid or overlaid with rapid-setting portland cement concrete that has achieved at least 3600 psi compression strength before traffic is placed on it.
 - i) The Contractor shall mill curbs in accordance with the plans.
 - j) The Contractor shall prepare stockpile sites by removing all vegetation on the portion of the site on which the material will actually be placed. The stockpile area shall be graded so that water will drain away from the stockpiled material. Unsurfaced areas upon which material is stockpiled shall be smoothed and rolled so that the salvaged material may later be removed with a minimum of loss.
 - k) The Contractor shall stockpile salvaged material for the Department at the locations shown in the plans or special provisions.
 - l) The Engineer shall locate each stockpile. The maximum height of stockpiles is 10 feet. Equipment shall not be driven over the stockpiled material.
 - m) Concrete millings from inlays will not be salvaged but shall be disposed of in

accordance with the specified removal requirements.

5. **Method of Measurement.** The bid proposal "Schedule of Items" shall indicate whether the milling will be measured for payment by the ton, station, or square yards of completed and accepted work.
- a) Roadways that are measured by the station (100 feet) shall be measured horizontally along the project centerline between the beginning and ending points of the work.
 - b) Areas outside the typical cross section shown in the plans will be measured in equivalent stations based on one station's area for the immediately adjacent roadway.
 - c) Since the entire roadway width is not milled, the length of the milled roadway shall be added for the payment.
 - d) Each milled slab will be measured separately in stations of 20 feet without regard to width. Stations will be measured horizontally along the project centerline between the beginning and ending points.
 - e) Roadways that are measured by the square yard shall be measured to ± 1 SY.
 - f) Areas outside the typical cross section shown in the plans will also be measured to ± 1 SY.
 - g) Deductions will be made for all areas greater than 1 SY that are not milled.
 - h) Measurement of temporary traffic control devices will be made in accordance with Section 422.
 - i) Milling concrete for inlays will be measured for payment by the each.
 - j) Milling concrete curb is measured in linear feet along the back face of the curb.

6. Basis of Payment

- a) Pay Item Pay Unit
Concrete Surface Milling Station (Sta)
Concrete Surface Milling Square Yard (SY)
Milling Concrete for Inlays Each (ea)
Payment for temporary traffic control devices will be made in accordance with Section 422.
- b) Payment is full compensation for all work prescribed in this Section.

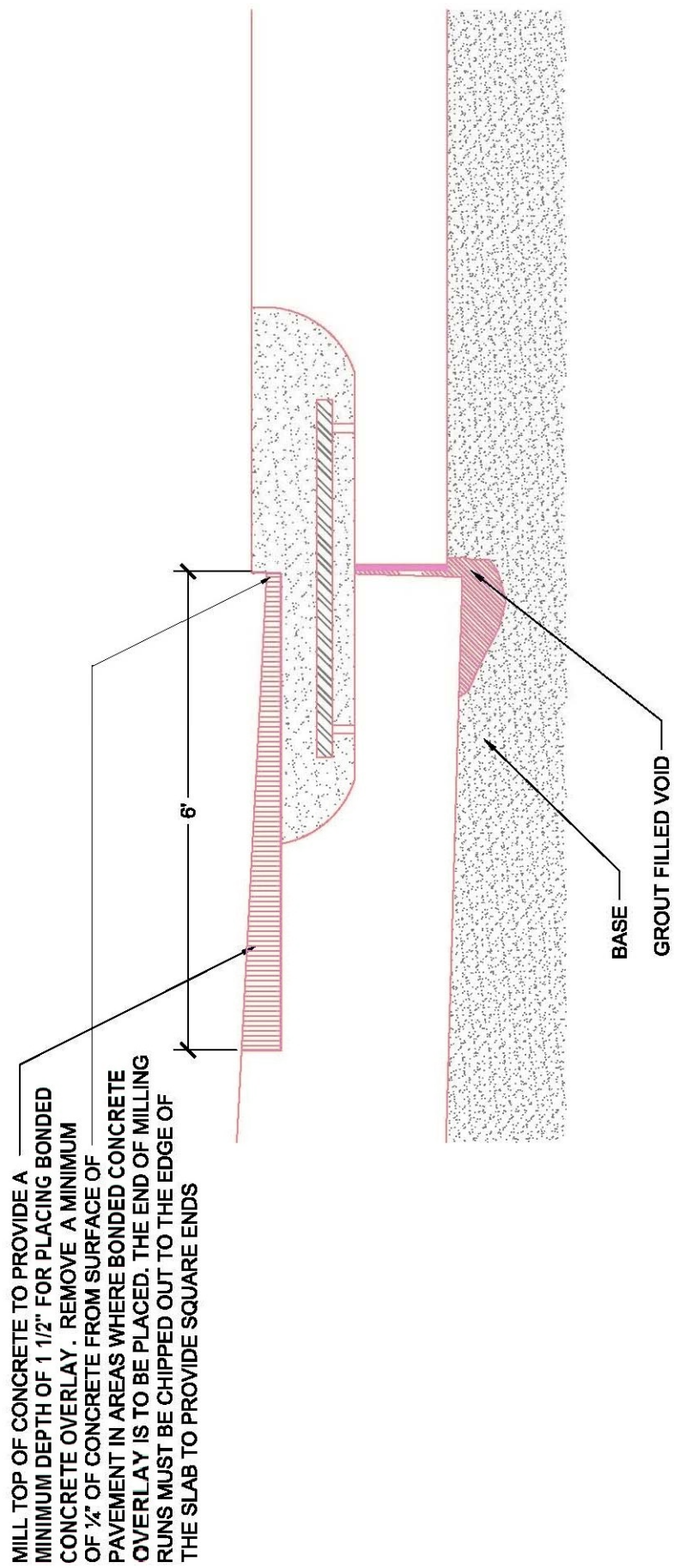


Figure A 6  **MILLING DETAIL**
FOR FAULTED SLABS

SPECIAL SPECIFICATION

3049

Cleaning Milled Concrete Pavement

1. **Description.** This Item shall govern for the cleaning by steel shot abrasion media of existing hydraulic cement concrete pavement surfaces at the locations shown on the plans or as directed by the Engineer and in accordance with the requirements herein.
2. **Equipment.** The abrasion cleaning shall be done by a machine designed and built for high production pavement texturing. Each machine shall have a minimum average production rate of 1200 sq. yd. per hour for concrete surfaces. The machine shall employ the HVIM (High Velocity Impact Method) by hurling steel abrasive media at high velocity to abrasively clean and texture the surface. The machine shall be capable of varying the velocity of the steel abrasive as well as the speed of the machine to provide the desired surface texture. Utilization of radial blades in multiple centrifugal wheels shall produce a continuous, minimum six-foot wide swath. This is synchronous to the recycling of the abrasive and vacuuming of surface materials into a self-contained vacuum unit of 6 cu. yd. or more, meeting or exceeding all environmental quality standards. No objectionable dust shall be emitted during the work. The machinery shall direct the velocity of abrasion in a bi-directional fashion, giving uniform abrasion to the surface. When transverse curves are present, the abrasion will be at an angle transverse to the grooves to give equal texture to the grove edges.

On-board controls capable of providing and monitoring uniform velocity and direction will be required. Self-contained lighting for night operations will be required.

A generator driven electromagnet equal in width and production to the texturing machine will be available on the project. It will be used to pick up any steel abrasive left behind the machine if deemed necessary by the Engineer.

Verifiable proof of prior major pavement texturing, in accordance with the specification, or satisfactory test sections performed at the Contractor's expense will be necessary before the equipment will be approved.

3. **Construction.** Steel blast abrasion cleaning shall be done on the areas indicated on the plans. It shall be performed in a continuous operation of consecutive passes up to 6 ft. in width (if necessary), parallel to the centerline, so that one 12 ft. lane can be completed in a maximum of 2 passes. The cleaned surface shall have a uniform surface appearance and be devoid of machine product streaks, ruts or overlapping grooves which will inhibit the free flow of water. It shall have a non-directional texture. Following the abrasive cleaning operation, the electromagnet shall pass over

the entire surface if deemed necessary by the Engineer.

The abrasion cleaning shall not encroach on the existing centerline stripes, lane stripes, traffic arrows, cross bar stripes, traffic buttons or other traffic markings unless approved by the Engineer. The distance from the edge of traffic markings to the texture shall be a maximum of 3 in. The longitudinal area between dashed lane markings need not be textured.

All surfacing materials removed during the abrasion cleaning process shall be collected and stored in the vacuum unit until it can be removed from the project and disposed of by the Contractor. No on-site transfer of, or storage of, the materials will be permitted. No loose material will be left on the roadway or swept off to the side of the roadway.

4. **Testing.** The Engineer will require the following testing procedure.

ICRI Concrete Surface Profile (CSP) When cleaning first begins close visual inspection of cleaned surface should closely compare to the minimal texture of molded ICRI (International Concrete Repair Institute) coupons CSP1-3. This level of surface cleaning must remain similar throughout the cleaning of each milled slab, and each cleaned slab will be visually compared to the ICRI CSP coupons to the satisfaction of the inspector before an overlay is placed.

5. **Measurement.** This Item will be measured by the square yard of surface area. Square yard calculations will be based on the neat dimensions shown on the plans or as adjusted by the Engineer.
6. **Payment.** The work performed in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Texturing Portland Cement Concrete Pavement." This price shall be full compensation for texturing the pavement surface as well as vacuuming, hauling, unloading and satisfactory storing or disposing of the material, for all labor, equipment, supplies and incidentals necessary to complete the work.

SPECIAL SPECIFICATION

DDDD

Ultra-Thin, Rapid-Strength, Bonded Concrete Overlay (BCO)

1. **Description.** Construct an ultra thin, rapid-strength-gain, bonded concrete overlay (BCO) of a portland cement concrete pavement surface in accordance with the details shown on the plans and the requirements of this Item.
2. **Materials.**
 - a) **BCO.** Provide portland cement concrete in accordance with Item 439.4.C.1, “Concrete Overlay.” Unless otherwise shown on the plans or directed by the Engineer, design the concrete mix with a maximum water cement ratio of 0.40, TxDOT Grade No.6 coarse aggregate, a minimum average compressive strength of 2,500 psi at 24 hours and 4500 psi at 28 days (tested according to Tex-418-A, “Compressive Strength of Cylindrical Concrete Specimens.”) and bond strengths of 120 psi at 24 hours (tested according to ASTM C 1583 Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)). (Instead of early compression tests, flexural strengths at 24 hours must reach a minimum of 580 psi when tested in accordance with Tex-427-A.).
 - b) **Joint Sealants and Fillers.** Provide joint sealants and fillers in accordance with Section 360.2.F, “Joint Sealants and Fillers” for transverse joints only.
 - c) **Curing Materials.** Provide moist curing materials and procedures conforming to Section 439.4.E, “Curing.”
 - d) **Reinforcing Fibers.** When shown on the plans, provide Synthetic Fibers, ASTM C 1116-03 Type III, Polypropylene or Nylon, 3/4” to 1 1/2” in length. Mix 3 lb. synthetic fibers for each cubic yard concrete as per manufactures recommendation.
3. **Equipment.** Equipment as per Item 439.3, “Concrete Bridge Deck Overlays, Equipment,” but roller screeds have performed best for overlays less than 2 inches thick.
4. **Construction.** Submit a paving plan for approval before beginning pavement construction operations. Include details of all operations in the concrete paving process, including construction method and sequence of construction operation, construction and contraction joint layout, sawing plan and sequence, curing, other details and description of all equipment.
 - a) **Preparation of Surface.**
 - i) Where shown on the plans, mill 1/2 the (transverse) width of the surface of the depressed slabs to the depth specified on the plans, in accordance with Item 354, “Planing and Texturing Pavement,” so that no milled portion of the overlay area is less than 1 1/2 inch from the projected overlay surface. (BCO must be minimum of 1 1/2

inch in thickness).

- ii) Adjust the screed to provide an approved grade line and overlay thickness, as specified on the plans. To identify areas with deficient thickness prior to concrete placement, use the following or other approved methods. Attach a filler block having a thickness 1/4 in. less than the overlay thickness to the bottom of the screed and pass the screed over the area to be overlaid. Correct areas which have deficient thickness by adjustments of the screed and/or rail system or by chipping or scarifying of the milled concrete substrate prior to the BCO as approved by the Engineer.
 - iii) Immediately prior to BCO placement, prepare by shot blasting the pavement surface such that the surface is free of all contaminants and material detrimental to achieving an adequate bond between the original concrete substrate and the bonded concrete overlay.
- b) **Placing and Removing Forms.** When needed, place and remove forms in accordance with Section 360.4.E, "Placing and Removing Forms."
 - c) **Concrete Proportioning, Mixing, and Delivery.** Batching, mixing, and delivering concrete will be done on site with a mobile continuous mixing facility in accordance with Section 439.3.B.4, "Proportioning and Mixing Equipment."
 - d) **Temperature Restrictions for Concrete Placement.** Place BCO on days when 24-hour forecast temperatures will be above 60F and below 95F. With the approval of the Engineer wet cotton batting under white polyethylene film may be used to insulate overlays from maximum temperatures above 95F and thus allow overlay placement each day before ambient rises above 95F.
 - e) **Spreading and Finishing.** Spread and finish concrete in accordance with Section 360.4.H, "Spreading and Finishing."
 - f) **Construction Joints.** Saw and seal all construction joints using a Class 5 joint seal, in accordance with Section 360.2.F, "Joint Sealants and Fillers." When placing of concrete is stopped, install a bulkhead of sufficient cross sectional area at a planned transverse contraction joint location and remove the excess of concrete. Place the bulkhead at right angles to the centerline of the pavement, perpendicular to the surface and at the required elevation. Saw and seal this joint.
 - g) **Curing.** Moist cure concrete in accordance with Section 439.4.E, "Curing."
 - h) **Saw Cutting Contraction Joints.** Saw joints to the full depth of the overlay at existing contraction joints. Saw cuts in lines that are perpendicular and parallel to the centerline of the travel lanes. Saw cuts perpendicular to the surface of the overlay. Saw joints for radii as detailed in the plans. Use a chalk line, offset string line, sawing template or other approved methods to provide a true joint alignment. Remove all debris after sawing, and seal the saw cuts. The Contractor is fully responsible for the timing and order of the saw cutting to prevent uncontrolled cracking, spalling, or raveling. If excess spalling or raveling occurs at the top of the saw cuts or the intersection of saw cuts, or if uncontrolled cracking occurs before opening to traffic, remove and replace all damaged

concrete overlay sections without any additional compensation.

- i) **Deficient Thickness.** The Engineer will determine the overlay thickness in accordance with Test Method Tex-423-A, “Determining Pavement Thickness by Direct Measurement,” at selected locations. If the thickness of the overlay measured is deficient by more than 0.40 in. of the plan thickness, the Contractor may verify the thickness by cores taken in accordance with Test Method Tex-424-A, “Obtaining and Testing Drilled Cores of Concrete,” at the locations selected by the Engineer. Remove and replace any concrete panel deficient by more than 0.40 in. of plan thickness without any additional compensation.
 - j) **Opening to Traffic.** The completed overlay may be opened to traffic after the concrete has been cured for 36 hours and has obtained a minimum compressive strength of 3,000 psi or as directed by the Engineer. Determine the compressive strength in accordance with Tex-418-A, “Compressive Strength of Cylindrical Concrete Specimens” using concrete cylinders cured at the job site under the same conditions as the pavement, or in accordance with Tex-426-A, “Estimating Concrete Strength by the Maturity Method”.
 - k) **Ride Quality.** When shown on the plans, achieve ride quality in accordance with Item 585, “Ride Quality for Pavement Surfaces,” Type A.
5. **Measurement.** This Item will be measured by the square yard of surface area in place.
6. **Payment.** The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Bonded Concrete Overlay” of the thickness specified. This price is full compensation for materials, equipment, labor, tools, and incidentals.

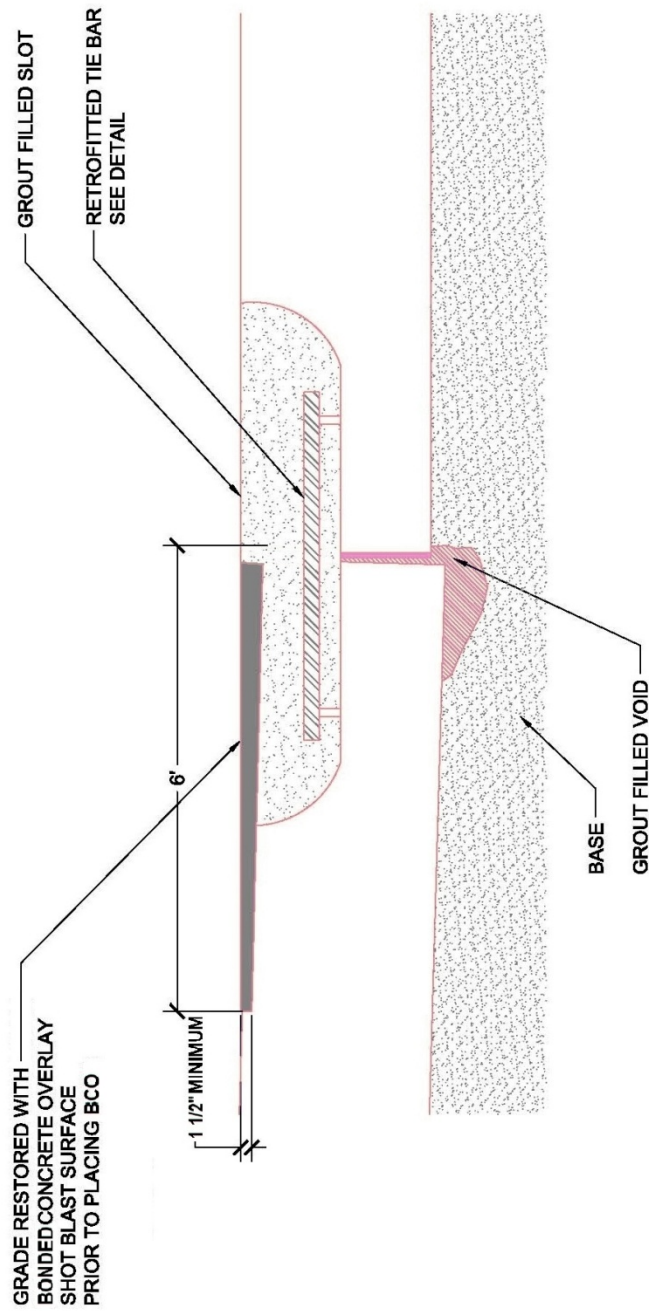


Figure A 7 **SLOT STITCHING DETAIL WITH BCO**
FOR FAULTED SLABS