Dowel Bar Retrofit, Cross Stitching, and Slot Stitching

ConcreteState

ICPA

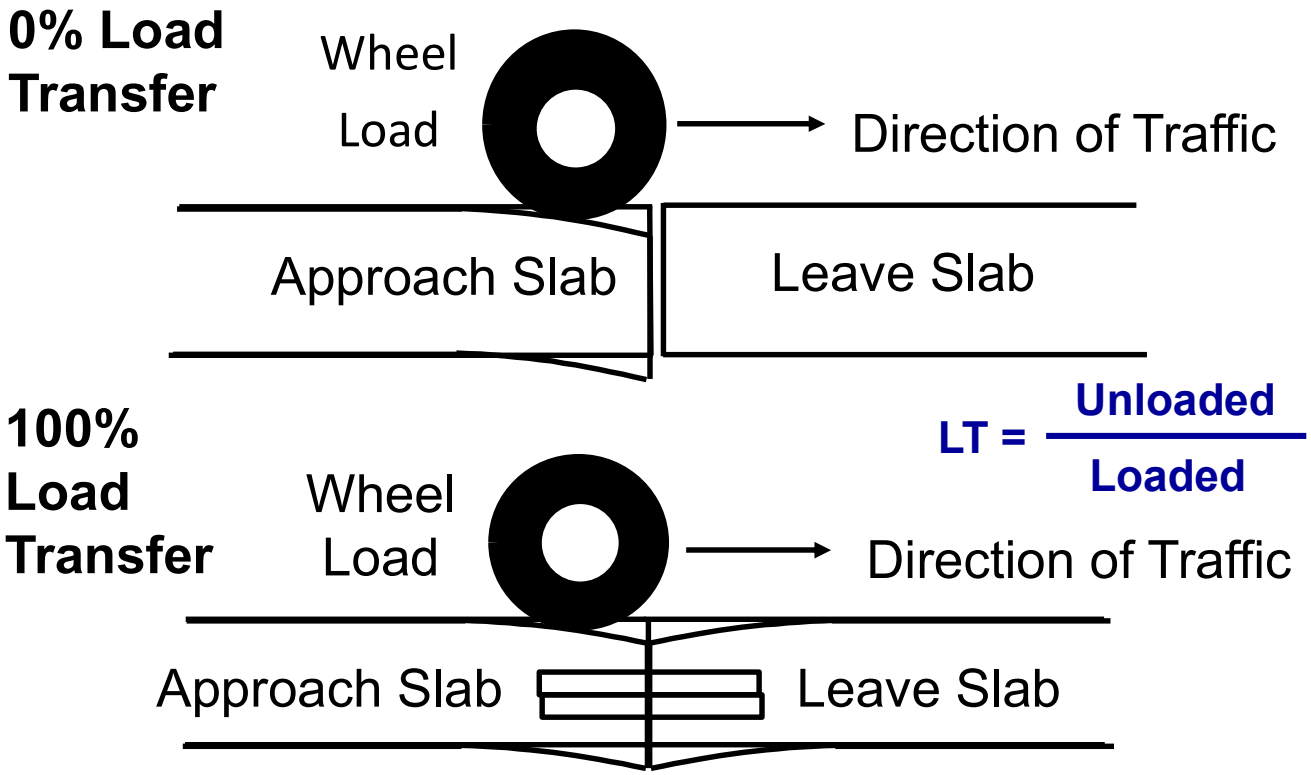
Introduction

- Three separate techniques, each with unique application
  - Dowel bar retrofit
  - Cross stitching
  - Slot stitching
- All three related to the load transfer efficiency at a joint or crack

Load Transfer

- Ability of a joint or crack to transfer a wheel load from one side to the other
- Accomplished through:
  - Mechanical devices (dowel bars)
  - Aggregate interlock
  - Foundation support
- Expressed in terms of load transfer efficiency (LTE)

Load Transfer Efficiency



Typical Causes of Poor Load Transfer

- Absence of load transfer devices
- Failed load transfer devices
- Poor aggregate interlock
- Poor pavement drainage
- Erodible base

Results of Poor Load Transfer

Pumping/Erosion/Loss of Support

Results of Poor Load Transfer

Transverse Joint Faulting

Results of Poor Load Transfer

Corner Breaks

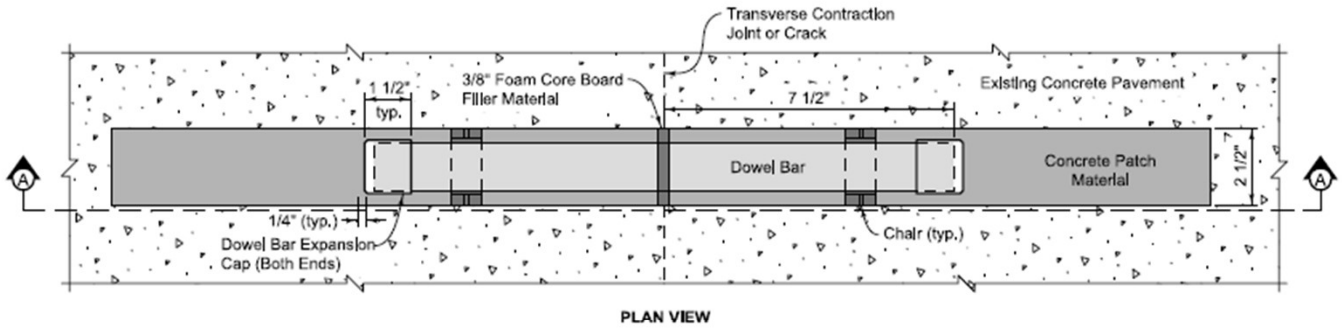
Results of Poor Load Transfer

Deteriorated Mid-Panel Cracks

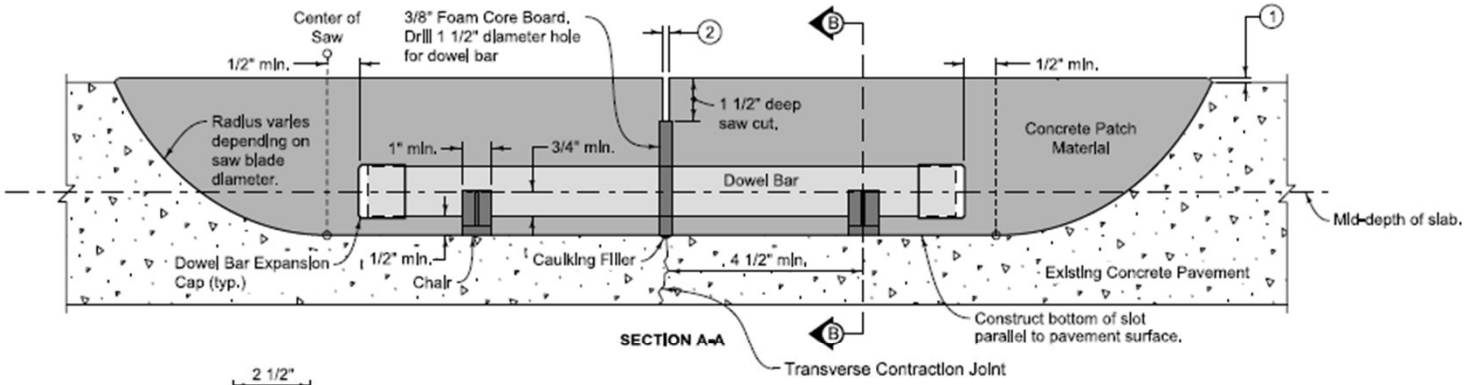
Dowel Bar Retrofit

Dowel Bar Retrofit

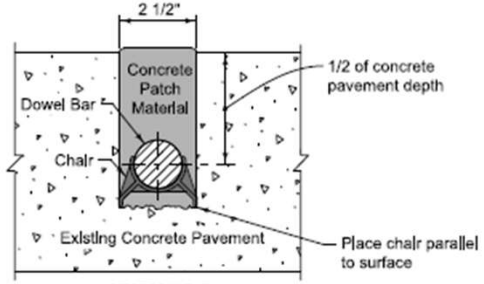
- Installation of dowel bars at existing transverse joints or cracks
  - Provide transfer of wheel loads across slabs
  - Reduce deflections
- Effective in reducing or eliminating pumping and faulting



PLAN VIEW



SECTION A-A



SECTION B-B

CHAIR DETAIL

1. Extend concrete patch material 1/8" above existing concrete surface for projects to be diamond ground; construct flush if diamond grinding is not required.
2. Sawcut joint width 3/16" min to 5/16" max. Saw after concrete patch material has set.

FIGURE 7040.106

SHEET 1 OF 1

SUDAS

REVISION: New 10-17-17

7040.106

SHEET 1 of 1

SUDAS Standard Specifications

DOWEL BAR RETROFIT

Dowel Bar Retrofit

Benefits

- Restores load transfer
- Reduces probability of pumping, faulting, and corner breaks
- Improves long-term rideability
- Increases service life

Limitations and Effectiveness

- Established preservation treatment
- Demonstrated experience in 26 State Highway Agencies
- Several projects > 20 years of performance
- Early issues
  - Application on project too deteriorated
  - Shrinkage/compatibility issues of patching material
  - Poor installation/workmanship
- Limited to pavements 8” or greater

Performance of DBR

- IA 163 Polk Co. both directions
- Pavement built 1964-65
- DBR & Diamond Grind in 2007
- Performing well

Candidate Projects

- Relatively good structural condition and with:
  - Poor load transfer (< 50–60%)
  - Faulting: 0.12 to 0.5 in
  - <10% slabs with multiple cracks
- Medium to heavy truck traffic
- Transverse cracks are also an option

Materials and Design Considerations

- Patching (backfill) materials
- Design
  - Dowel design
  - Assembly
  - Layout

Patching Materials

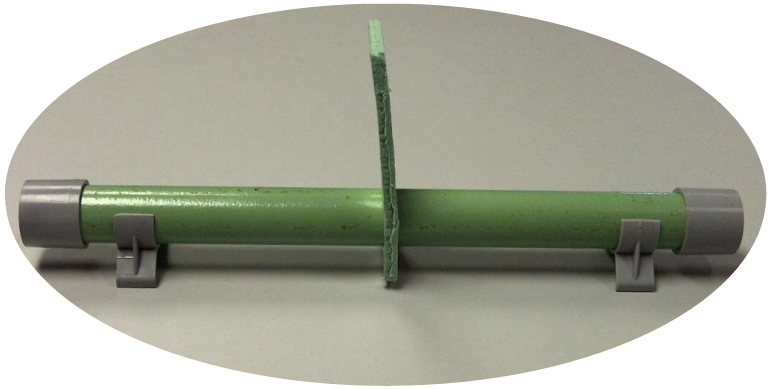
- Patching materials (Grout):
  - Rapid Set Patch Materials – Shrinkage compensated
    - IDOT IM 491.20 App B
- Extended with pea gravel according to manufacturer
- Do not retemper

Patching Materials

- Bulk cementitious materials
  - Same content as bag mix
- Pea gravel – Class 2 or better and Gradation No. 9
- 4110 Sand
- Do not retemper
- Compressive strength
  - 3000 psi 3 day
  - 5000 psi 24 hrs

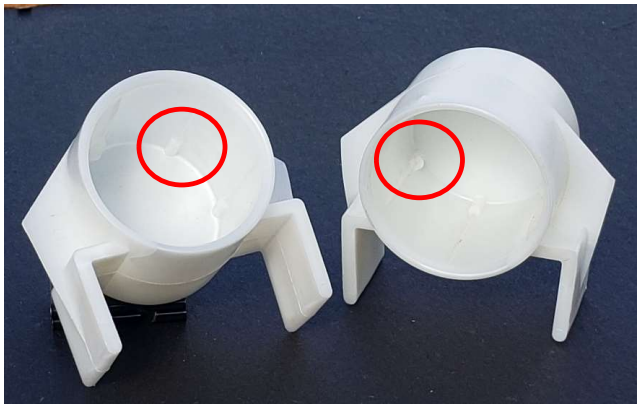
Dowel Bar Design

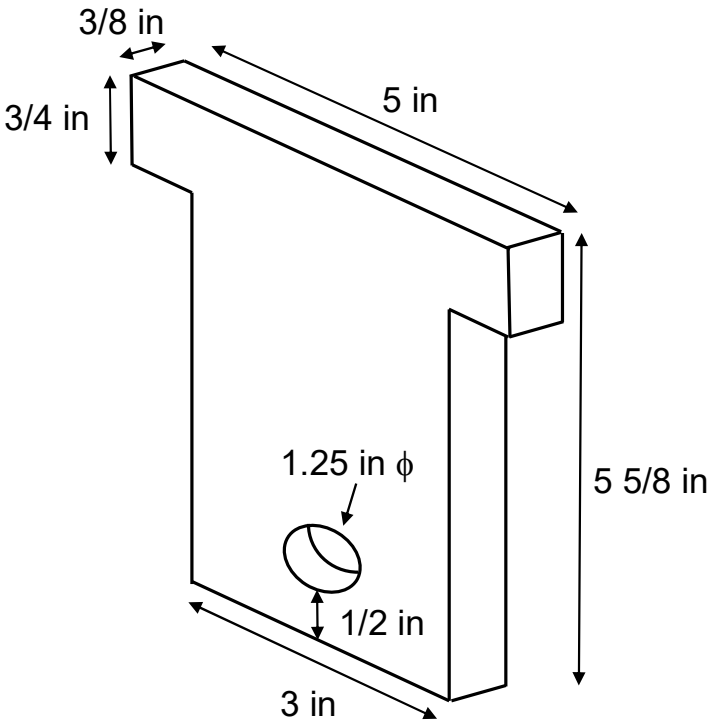
- Round, smooth steel bars
  - AASHTO M 31 or ASTM A615
  - Epoxy coated
- Recommended dowel bar dimensions and spacings:



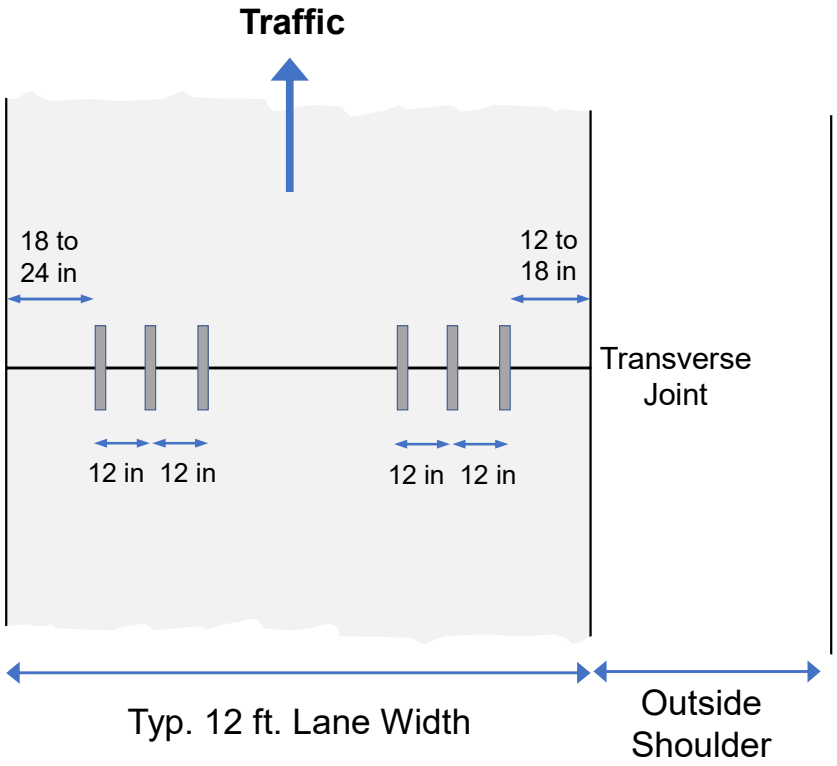
Slab Thickness, inches	Dowel Diameter, inches	Minimum Length, inches	Spacing, inches
≥ 8 to < 10	1.25	15	12
≥ 10	1.50	15	12

Dowel Bar Assembly





Dowel Layout



Construction

1. Test section
2. Slot creation
3. Slot preparation
4. Dowel bar placement
5. Patch material placement
6. Re-establish joint
7. Diamond grinding and joint sealing (as specified)

1. Process Control Plan

- IDOT Article 2556 requires a process control plan at least one week prior to retrofit work – Plan Includes
  - Materials and processes to achieve dowel bar alignment
  - Materials and processes to prevent grout from entering joints
  - Materials and processes to place and align foam inserts
  - Mix design and proportion control for grout

2. Slot Creation

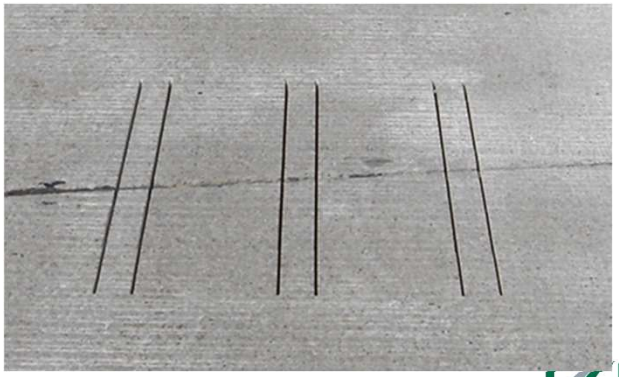
- Diamond-bladed slot cutting machines
  - Ganged sawblades for multiple cuts
- Slots parallel to pavement centerline
- Slot dimensions
  - Length: Typically 3 ft for 15-inch long dowel bar
  - Width: Typically 2.5 inches
  - Depth: Dowel at mid depth & 0.5 inch clearance below dowel
    - ~1.25 inches below mid depth

2. Slot Creation

Multi-Slot Cutting Machines

2. Slot Creation

Sawblades and Saw Cuts

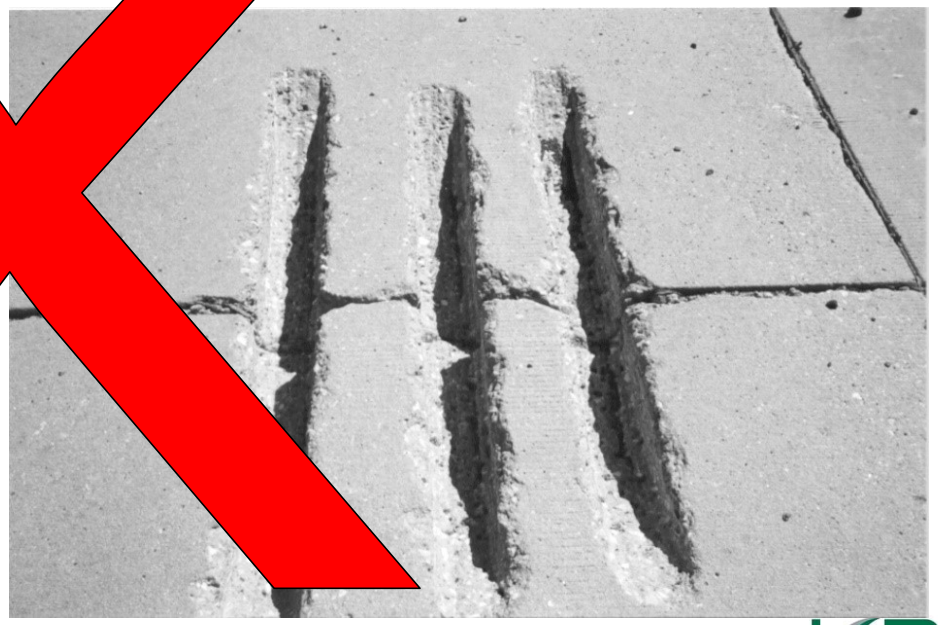


2. Slot Creation

Single Slot Cutting Machine

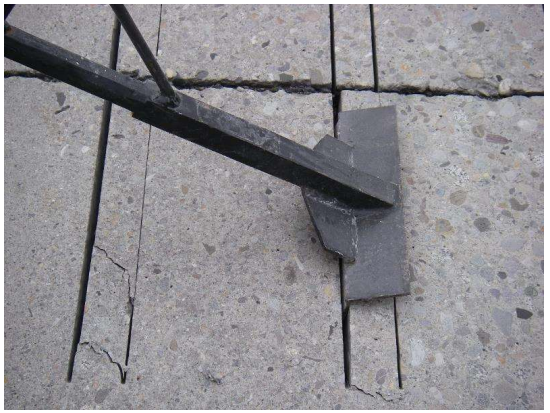
2. Slot Creation

Slot Cutting with Milling Machine



3. Slot Preparation

Material Removal



3. Slot Preparation

Material Removal

- Use jackhammers not larger than 30 pound class to remove concrete from slots.
- Prevent damage to pavement or vehicles traveling in the adjoining lane.
- Operate at 45 degree angle or less to prevent blowing bottom of slot

3. Slot Preparation

Checking Slot Depth

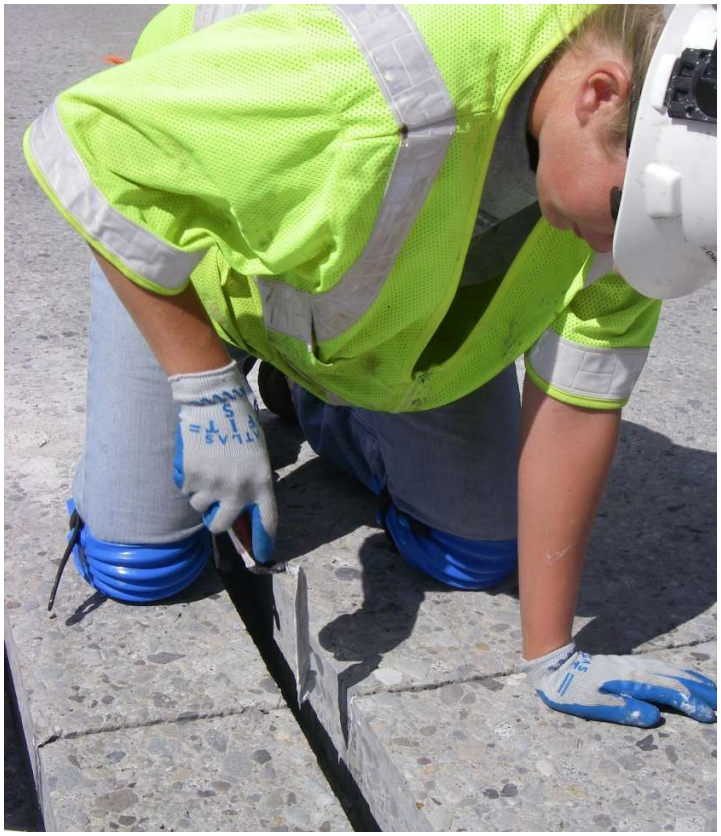
3. Slot Preparation

Sand Blasting Slots

Cleaned Slot

3. Slot Preparation

Sealing Slots After Sand Blasting



4. Dowel Bar Placement

- Apply bondbreaker to dowels
- Slip filler board onto dowel bar
- Attach non-metallic expansion caps to both dowel ends
- Place dowel on non-metallic chairs

4. Dowel Bar Placement

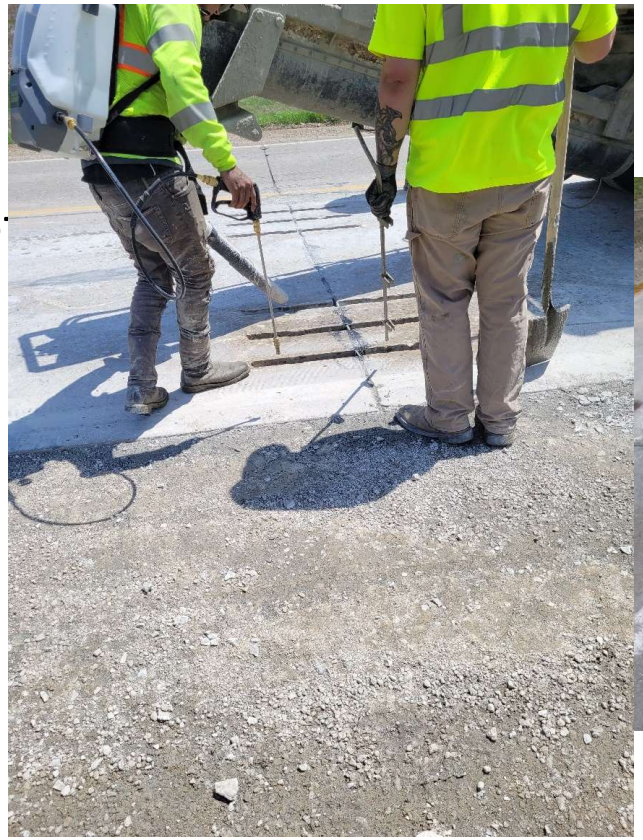
Inserting Prepared Dowel in Slot

- Place dowel bar assembly into the dowel bar slot
- Adjust filler board to align with joint/crack

4. Dowel Bar Placement

Inserting Prepared Dowel in Slot

- Blow out debris with leafblower
- Moisten sides and bottom of slot immediately prior to grout placement
- Remove excess with compressed air



5. Patch Material Placement

- Smaller project
- Mix material in small quantities
- Do not retemper

Portable drum mixer

Small mobile mixer

5. Patch Material Placement

- Larger projects typically use a mobile mixer
- Bulk cementitious materials
- Do not retemper

Volumetric mobile mixer

5. Patch Material Placement

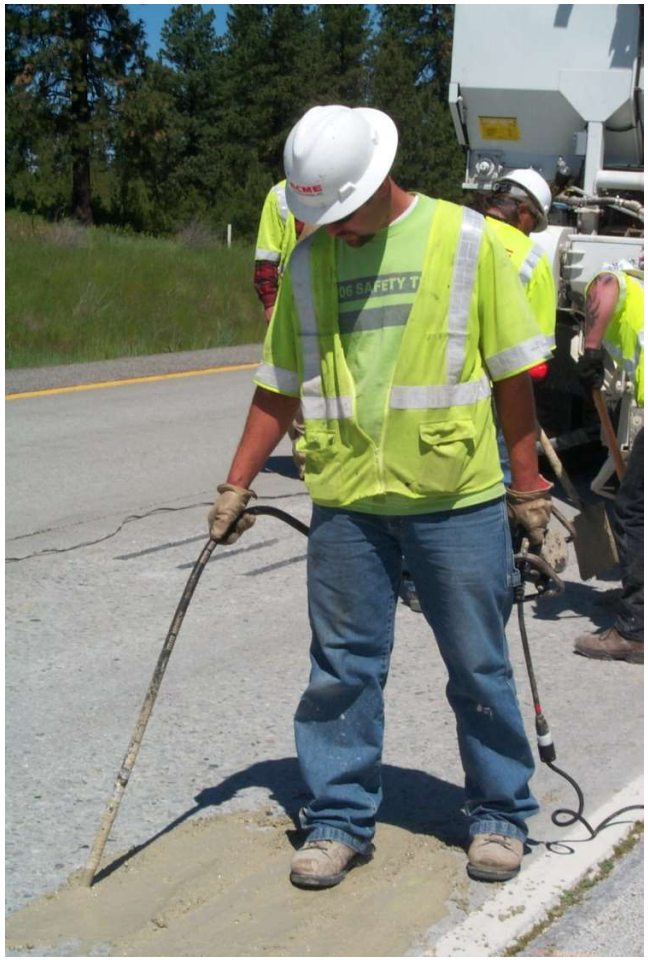
Backfilling

- Use care to avoid moving the dowels.
- Placing material on the surface adjacent to the slot and shovel into the slot provides the least dowel movement.

5. Patch Material Placement

Consolidation and Finishing

- Totally encase dowel bar
- Provide effective consolidation
  - Small 1 inch spud vibrator
  - Do not contact dowel bar assembly



5. Patch Material Placement

Consolidation and Finishing

- Do not overwork surface
- Finish flush if not diamond grinding
- Leave 1/8 inch above surface if diamond grinding

5. Patch Material Placement

Curing

- Immediately after placement, thoroughly coat grout with white pigmented curing compound.

6. Re-Establish Joint

- When grout has sufficient strength or withing 8 hrs., reestablish joint by sawing
- If foam board is visible, sawing is not required

7. Diamond Grinding and Joint Resealing (as specified)

Key Factors for Success

- Selection of proper candidates
- Proper dowel bar design and layout
- Cutting of dowel bar slots
- Proper preparation of dowel slots
- Proper placement of dowel bar assembly
- Selection of appropriate material
- Careful material placement and curing

Troubleshooting

What is wrong here?

Troubleshooting

What is wrong here?

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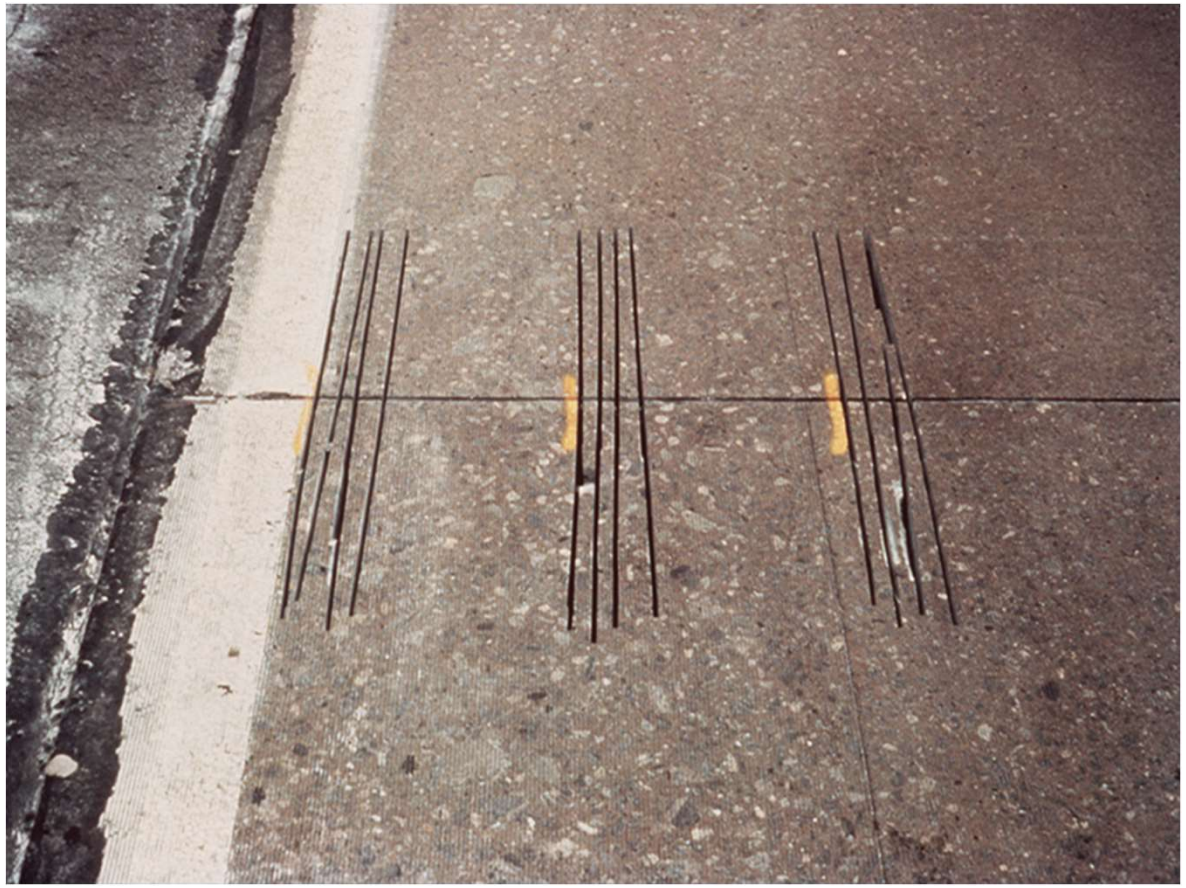
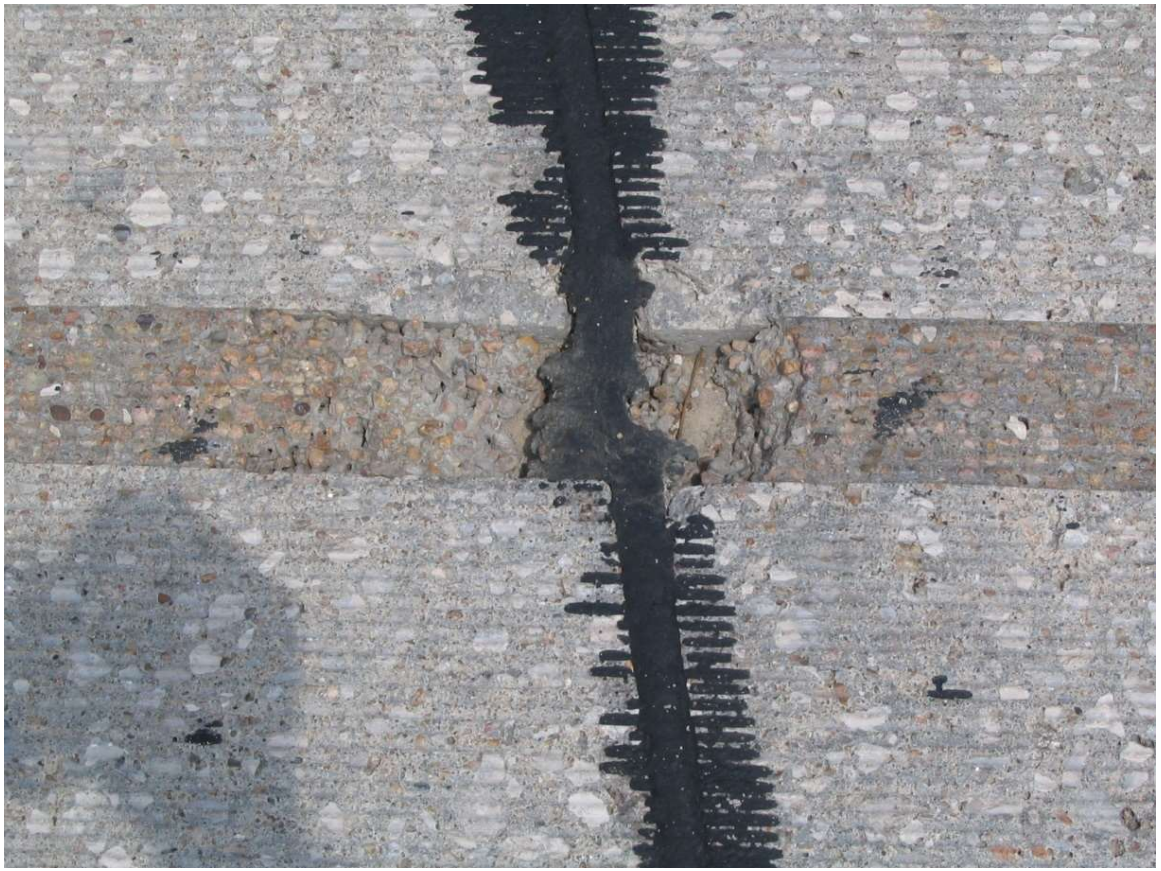


Troubleshooting

What is wrong here?



Troubleshooting

What is wrong here?

Troubleshooting

Things to watch for

Excessive depth of sawcut / weight of hammer

Remove water prior to patch material placement

Avoid longitudinal cracks

DBR Bid Prices

Letting Date	County	Proposal Low	Quantity	Proposal Bid Count
3/15/2022	SHELBY	$54.80	10,164 EACH	2 Bids
2/15/2022	MARSHALL	$52.00	7,800 EACH	3 Bids
7/20/2021	MONONA	$41.64	9,297 EACH	3 Bids
7/20/2021	OBRIEN	$49.00	2,292 EACH	2 Bids
2/16/2021	CARROLL CRAWFORD	$56.00	2,645 EACH	3 Bids
1/22/2020	LEE	$43.80	29,751 EACH	2 Bids
3/19/2019	MONONA	$35.25	8,502 EACH	3 Bids
12/18/2018	OBRIEN	$45.50	2,598 EACH	6 Bids

Cross Stitching

Cross Stitching

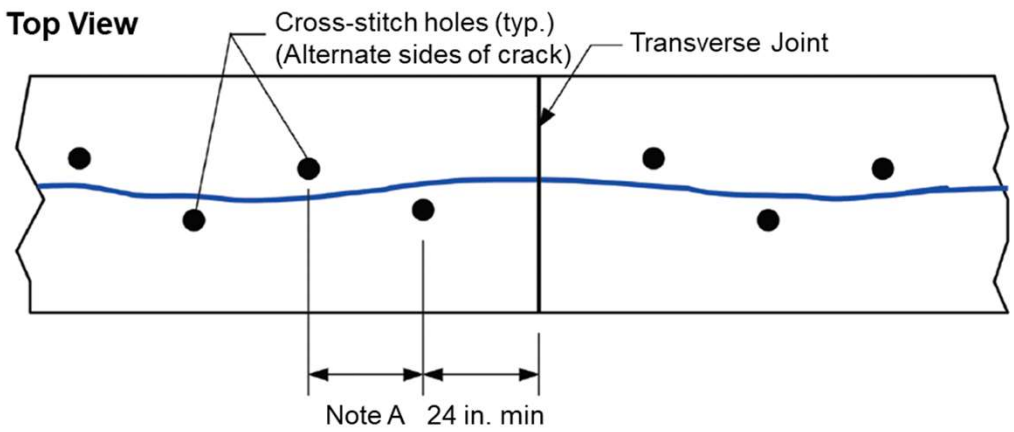
- Grouting of tiebars in holes drilled across nonworking longitudinal joints and cracks at an angle to the pavement surface
- Used to strengthen nonworking longitudinal joints and nonworking longitudinal cracks (in relatively good condition)

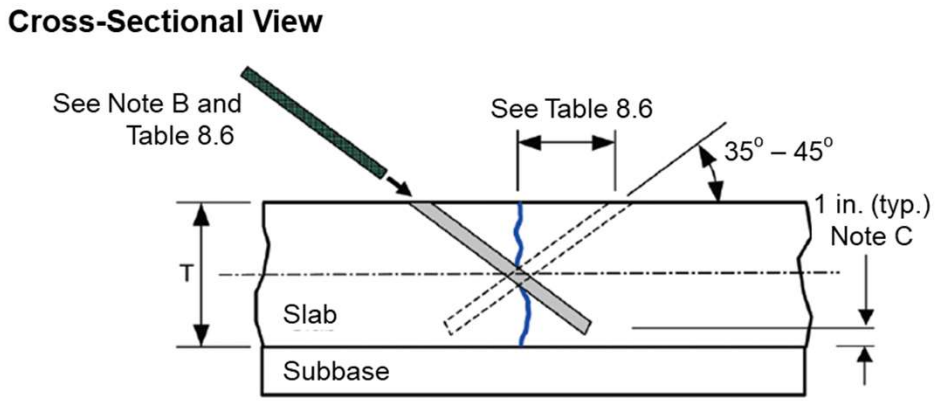
Cross Stitching

Applications and Benefits

- Prevent slab migration
- Maintain aggregate interlock
- Mitigate the effects of tie bars omitted during construction
- Tying roadway lanes or shoulders that are separating
- Tying centerline longitudinal joints that are starting to fault

Cross Stitching Schematic





Notes:

A. Distance between holes varies based on truck traffic levels; 20-in. spacings recommended for heavy traffic and 30-in. spacings for light traffic.

B. Epoxy deformed bar into hole. Provide 1 in. cover at surface and at bottom (as per Note C).

C. Do not drill hole completely through slab. Stop drilling so epoxy/grout will not run out of the bottom while backfilling.

Cross Stitching

Bar Dimensions, Angles, and Locations

Angle	Slab Thickness (T) inches				
	8	9	10	11	12
Distance from Joint to Hole (D) inches					
35º	5.75	6.50	7.25	7.75	8.50
40º	-	-	-	6.50	7.25
Length of Bar (inches)					
35º	9.50	11.00	12.50	14.50	16.00
40º	-	-	-	12.50	14.00

Cross Stitching

Drilling Holes

Pilot Hole

Drilling

Cross Stitching

Inserting Epoxy

Air blasting the hole

Inserting Epoxy

Cross Stitching

Bar Insertion

Cross Stitching

Completed Project

Cross Stitch Bid Prices

Letting Date	County	Proposal Low	Quantity	Proposal Bid Count
4/19/2022	JASPER	$21.00	480 LF	3 Bids
4/19/2022	POLK	$22.00	2,464 LF	1 Bid
4/19/2022	POLK	$14.00	18,390 LF	3 Bids
3/15/2022	POLK	$14.58	129 LF	2 Bids
2/15/2022	JASPER	$20.00	2,599 LF	5 Bids
2/15/2022	JASPER	$20.00	6,897 LF	5 Bids
1/19/2022	POWESHIEK	$22.00	1,157 LF	5 Bids
4/20/2021	POLK	$13.00	3,745 LF	2 Bids
3/17/2020	POLK	$20.00	385 LF	3 Bids
1/22/2020	POLK	$20.00	402 LF	6 Bids
6/18/2019	JASPER POWESHIEK	$18.00	460 LF	3 Bids
4/16/2019	FRANKLIN to STORY	$25.00	295 LF	2 Bids

Slot Stitching

Slot Stitching

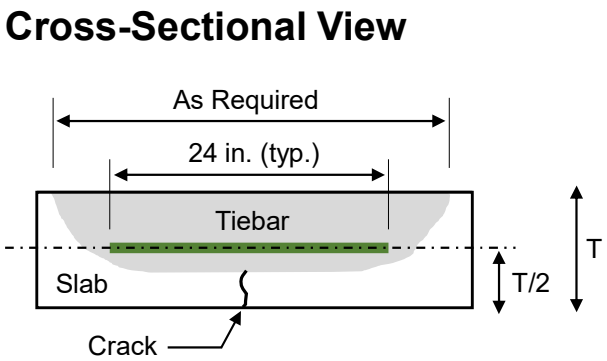
- Repair technique for longitudinal cracks and joints that grew out of the dowel bar retrofit technique
- *Except* uses deformed tie bars at longitudinal joints and cracks

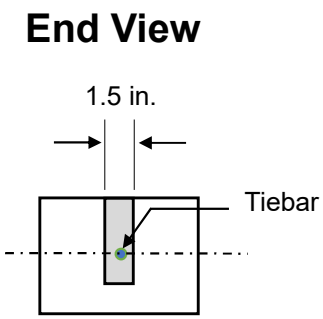
Slot Stitching

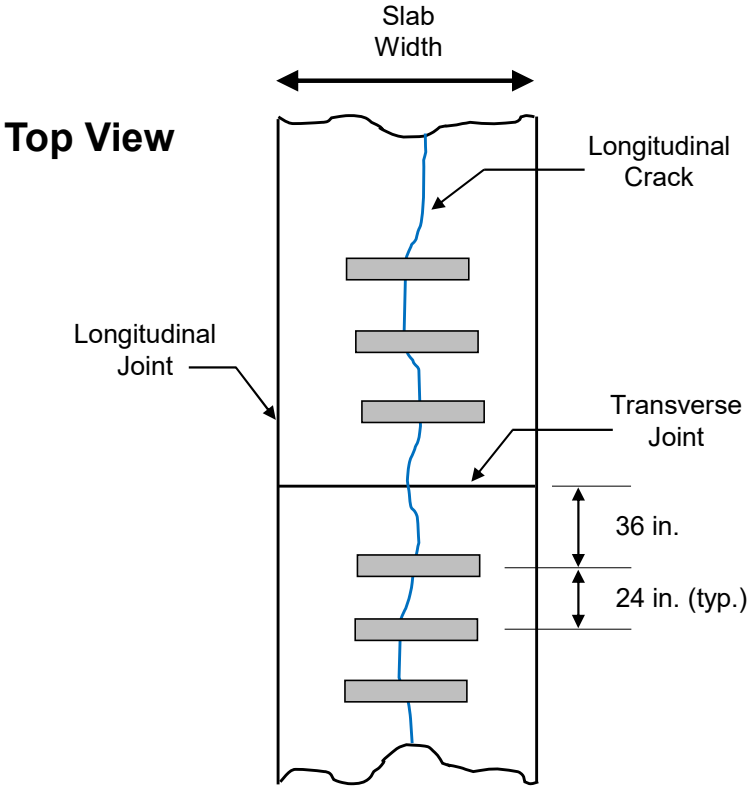
Applications and Benefits

- Hold together adjoining concrete slabs
- Maintain aggregate interlock
- Provide reinforcement and strength to the longitudinal joint or crack
- Generally applied to more severe cracks with wider widths

Slot Stitching Schematic







#11 deformed steel 24 inches long

Slot Stitching

Cutting Slots

Slot Stitching

Remove Material

Slot Stitching

Finished Cracks

Questions
DBR, Cross Stitching, Slot Stitching?

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