Evaluation and Selection Guide of Method of Repair for Routine Maintenance

For TxDOT Maintenance Engineers

Product 0-5821-P3

Project 0-5821

Project Title: Develop Guidelines for Routine Maintenance of Concrete Pavement

Performed in cooperation with the Texas Department of Transportation
and the Federal Highway Administration

Submitted: April 2008

Published: November 2008

TEXAS TRANSPORTATION INSTITUTE

The Texas A&M University System, College Station, Texas 77843-3135

Training Session for Engineers

- Purpose :
  - Provide training to identify the distresses
  - Provide guidelines to select the appropriate methods of repairs

Outline of Presentation

- Pavement Condition Evaluation Techniques
- Routine Maintenance Strategy Guidelines
- Repair Decision Flowcharts
- Routine Maintenance Repair Details

Pavement Condition Evaluation Techniques

- Visual Survey
- Ground Penetration Radar (GPR)
- Falling Weight Deflectometer (FWD)
- Dynamic Cone Penetrometer (DCP)
- Coring

Visual Survey

- General Information about Pavement
  - Age
  - Aggregate type
- Condition Record Information
  - Recent visual and deflection information
- Condition of Joint or Crack Sealing
- Surface and Subsurface Drainage Condition
  - Possible locations for GPR and DCP testing

Visual Survey (cont.)

- Functional Conditions
  - Factors affecting ride quality (roughness)
  - Possible locations for FWD, GPR, and DCP testing
- Structural Conditions
  - Factors affecting premature failure
  - Possible locations for FWD, GPR, and DCP testing
- Identification of Distressed Areas for FDR

Visual Survey Check list

No.	Check list	Notes	Further inspection
1	Pavement age (yr.)		
2	Aggregate type (hard or soft)		
3	Year of recent pavement distress survey (yr.)		
4	Year of recent pavement deflection survey (yr.)		
5	Joint sealant age (yr.)		
6	Sealant damage of transverse joint or crack (%)		
7	Sealant damage of longitudinal joint or crack (%)		
8	Sealant damage of sealed crack (%)		
9	Trapped surface water in depressed area		
10	Standing water or slab staining		GPR, DCP
11	Pumping with or without staining		GPR, DCP
12	Bump (stable or unstable, depth, in.)		GPR, DCP
13	Settlement (stable or unstable, depth, in.)		GPR, DCP

Visual Survey Check list (cont.)

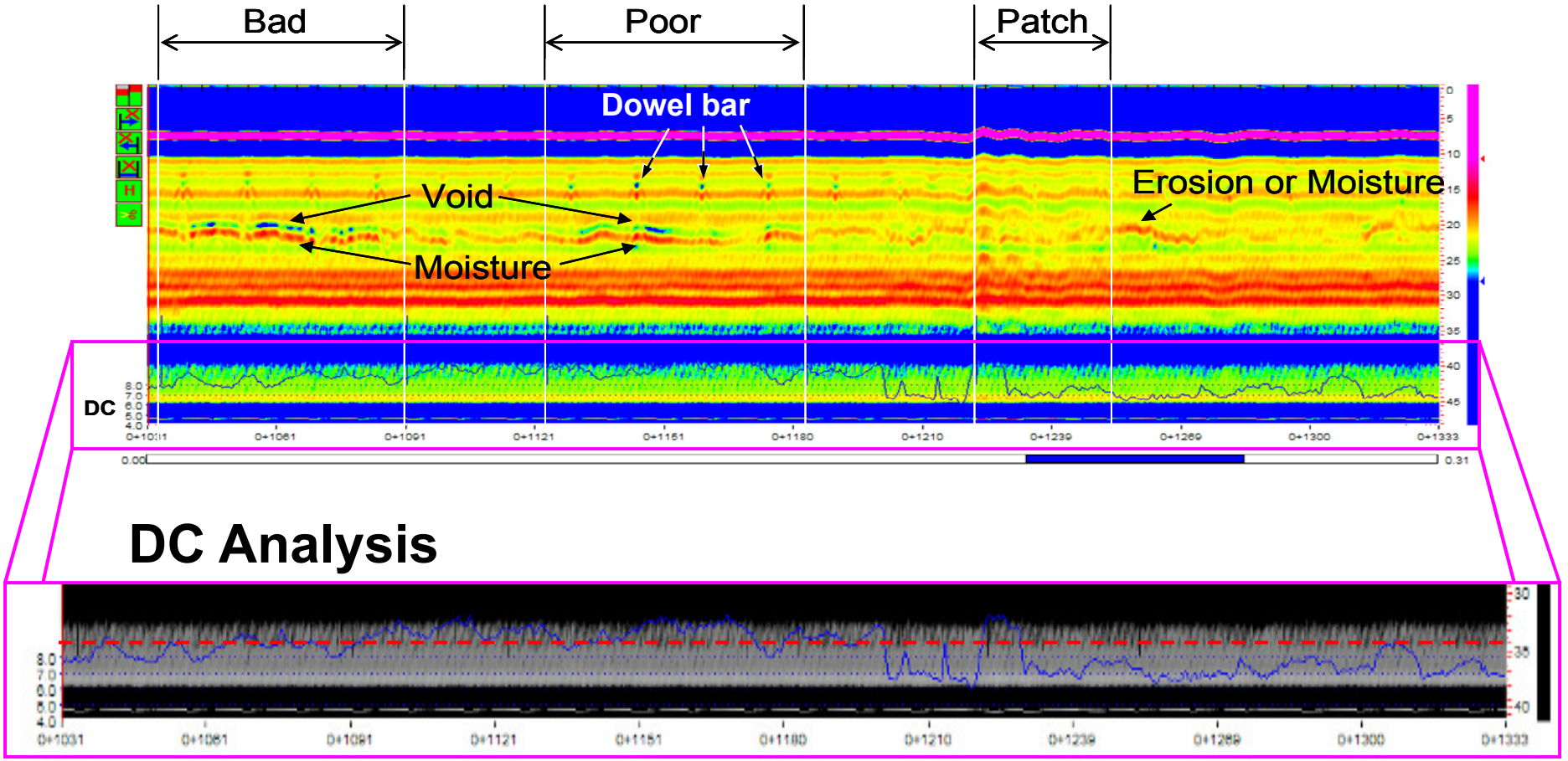
No.	Check list	Notes	Further inspection
14	Joint Spall (width, depth, % of joint spall > 2 in.)		FWD
15	Crack Spall (width, depth, % of crack spall > 2 in.)		FWD
16	Deep spall (depth, in.)		FWD, GPR, DCP
17	Patching (number/mile)		FWD, GPR, DCP
18	Faulting (depth, in.)		FWD, GPR, DCP
19	Transverse crack (width, number/slab)		FWD, GPR, DCP
20	Longitudinal crack (width, number/slab)		FWD, GPR, DCP
21	Shoulder separation (width, in.)		FWD, GPR, DCP
22	Corner break (spall width, fault depth, % of slab)		FWD, GPR, DCP
23	Faulted crack or deep delamination (depth, in.)		Steel corrosion
24	Punchout (spall width, fault depth, % of slab)		FWD, GPR, DCP
25	Reflection crack in ACOL (spall width, fault depth, number/mile)		FWD, GPR, DCP

Ground Penetration Radar

- Image Analysis
  - Void, ground water, dowel bar detection
- Dielectric Constant (DC) Analysis
  - DC value > 9 ⇨ Check drainage/wet condition

Ground Penetration Radar (cont.)

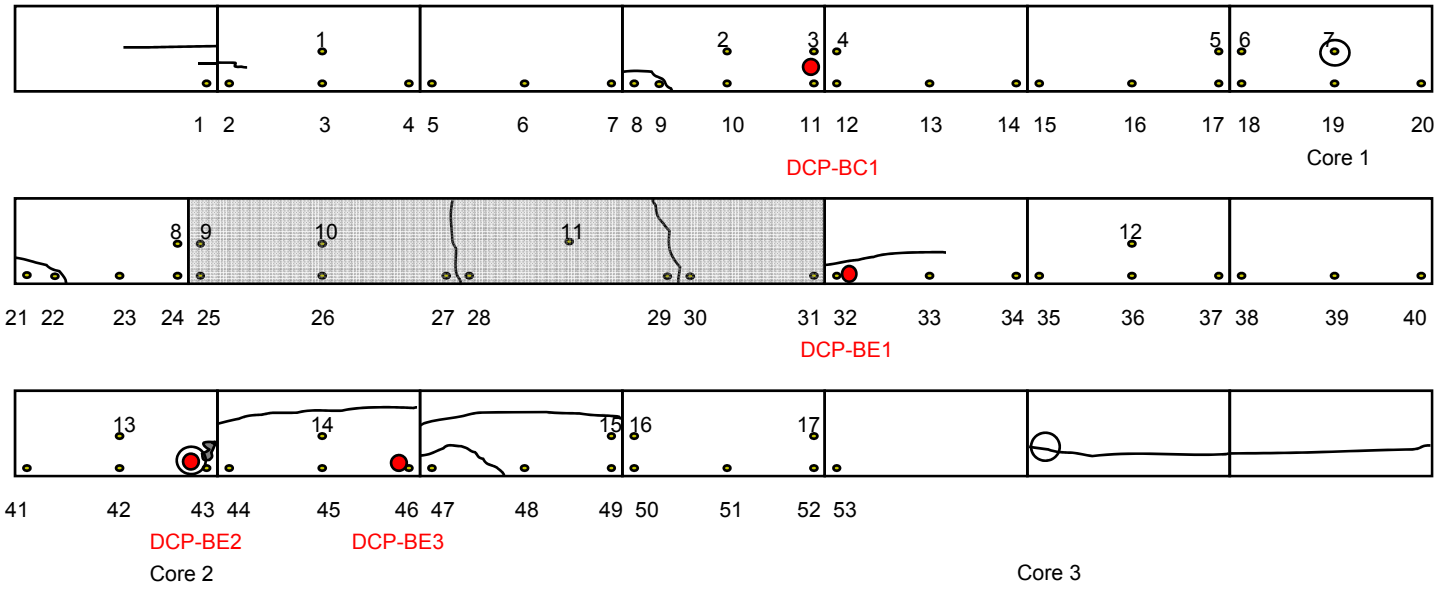
Image Analysis



DC Analysis

Falling Weight Deflectometer

- Load Transfer Efficiency (LTE)
- Deflection (Basin Area)
- Overall Structural Capacity (Effective Thickness)

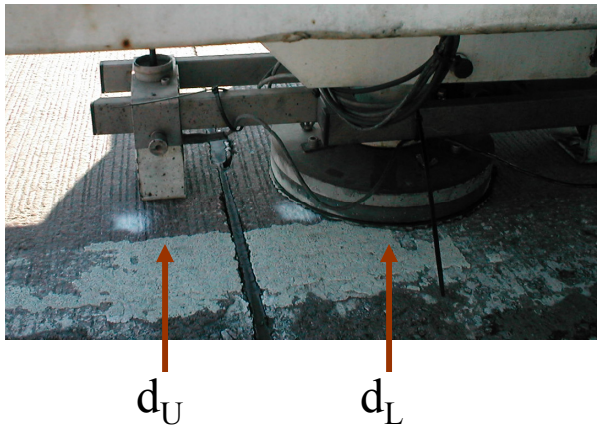


Example of FWD Testing Locations

Falling Weight Deflectometer (cont.)

- LTE Testing
  - Measure of independent action

$$LTE = \frac{d_U}{d_L} \times 100$$



Where, LTE = Load transfer effectiveness, percent

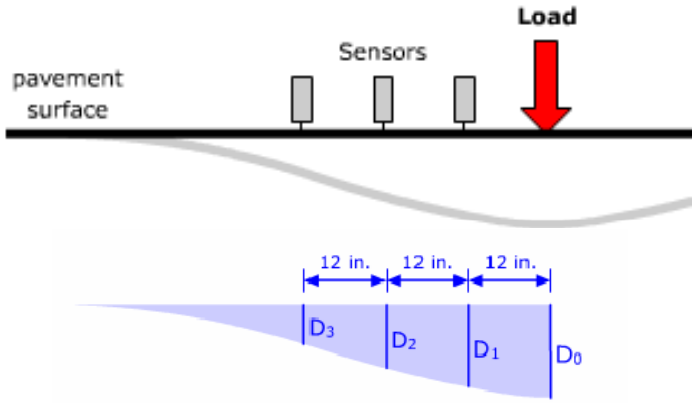
d_U = Deflection on the unloaded side of the joint or crack, mils

d_L = Deflection at the loaded side of the joint or crack, mils

LTE < 70% ⇨ Retrofit load transfer

Falling Weight Deflectometer (cont.)

- Deflection Testing



$$AREA = \frac{6(D_0 + 2D_1 + 2D_2 + D_3)}{D_0}$$

Where, *AREA* = FWD deflection parameter, in.

D_0 = Deflection at the loading position, mils

D_1 = Deflection at 12 in. from the loading position, mils

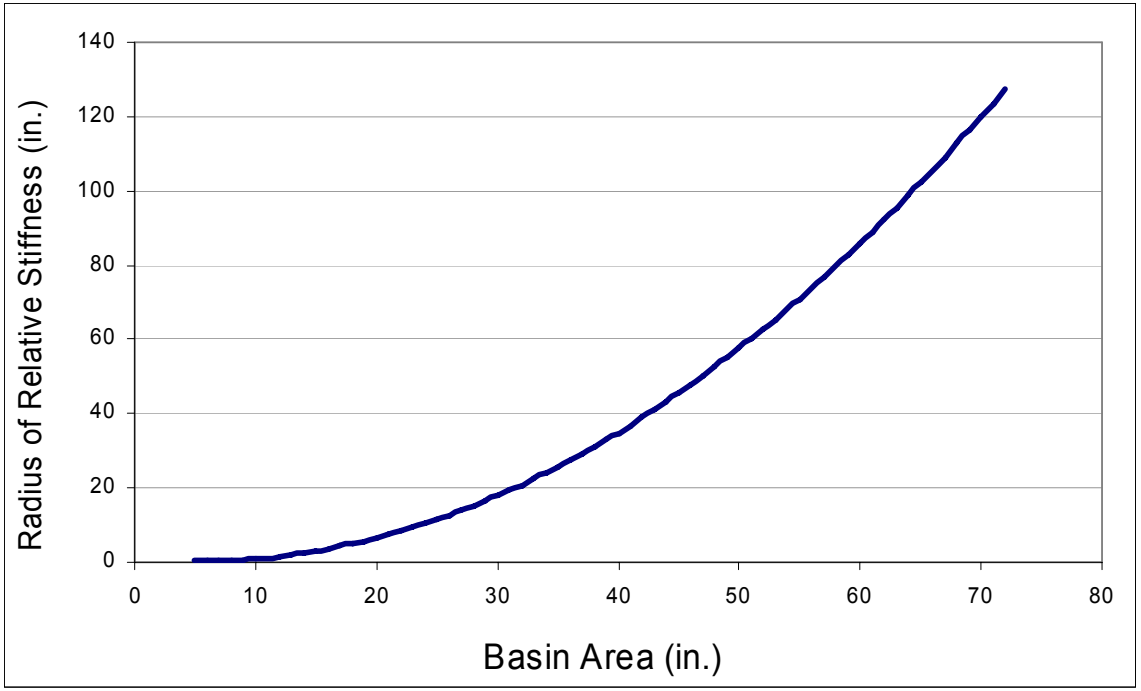
D_2 = Deflection at 24 in. from the loading position, mils

D_3 = Deflection at 36 in. from the loading position, mils

Basin area < 25 ⇨ Check base/subgrade support

Reference: Ioannides, A. M. "Dimensional Analysis in NDT Rigid Pavement Evaluation," Journal of Transportation Engineering, Vol. 116, No. 1, July 1990, pp. 23–36.

Radius of Relative Stiffness vs. Basin Area



$$BA = 6\frac{d_1 + 2(d_2 + d_3 + d_4 + d_5 + d_6) + d_7}{d_1}$$

BA = Basin area of seven sensors (in.)

d_i = Deflection of i^{th} sensor (mils)

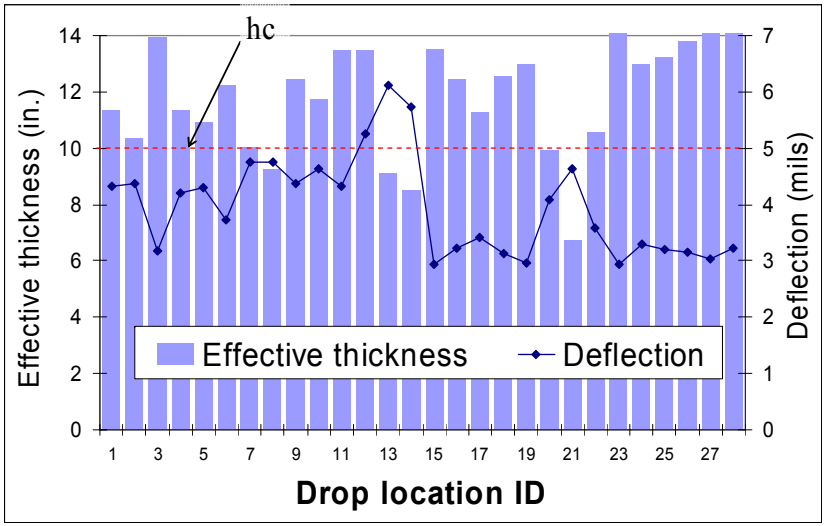
$$\ell = 0.0284 \cdot BA^2 - 0.2891 \cdot BA + 0.992$$

ℓ = Radius of relative stiffness (in.)

Falling Weight Deflectometer (cont.)

- Effective Thickness
  - Measure of structural capacity

$$h_e = \left[\ell^4 \cdot \frac{12\left(1-\nu^2\right)k_{dyn}}{E_c} \right]^{\frac{1}{3}}$$



Where, *h*e = effective slab thickness (in.)

ℓ = radius of relative stiffness (in.)

ν = Poison's ratio of the concrete

k_{dyn} = dynamic modulus of subgrade reaction (psi/in.)

E_c = elastic modulus of the PCC layer (psi)

he < hc ⇨ Check base/subgrade support

Dynamic Cone Penetrometer

- Base/Subgrade Strength
- Soil Modulus
- Penetration Ratio (PR, mm/blow)
  - Typical flexible base
    - E_{base} = 60 ~ 80 ksi or
    - PR_{base} of = 1 ~ 2 mm/blow
  - Soft subgrade or low strength
    - $E_{subgrade}$ < 6 ksi or
    - $PR_{subgrade}$ > 50 mm/blow (= 2 in./blow)

Dynamic Cone Penetrometer (cont.)

- Modulus of Soils

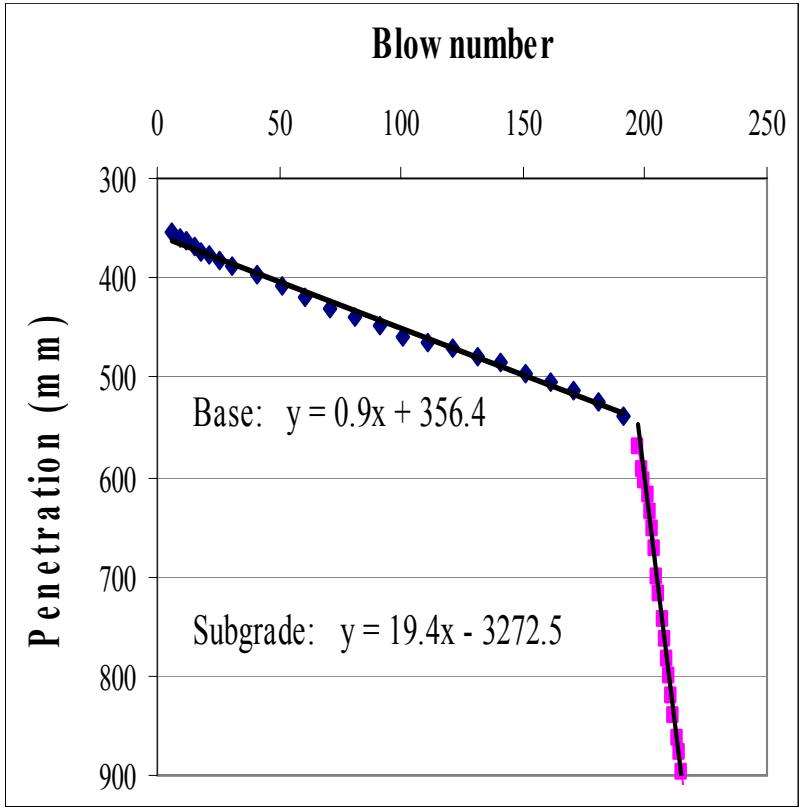
$$E = 2550 \times CBR^{0.64}$$

$$CBR = 292 / PR^{1.12}$$

Where, E = Elastic modulus, psi

CBR = California bearing ratio

PR = Penetration ratio, mm/blow



Coring

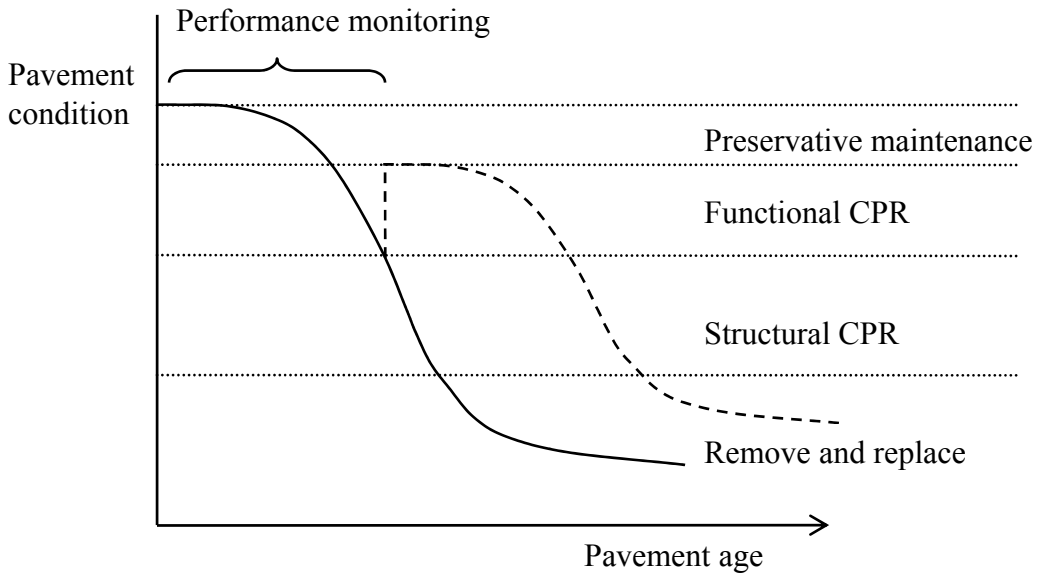
- Void, Erosion Detection
- Concrete Strength

Routine Maintenance Strategy Guidelines

- Performance Monitoring
- Preservative
- Functional CPR
- Structural CPR
- Remove and Replace

Maintenance Strategy

- As pavement condition degrades,
  - Repair costs and time of repair go up
  - Future renewal options become limited
- Preservative maintenance extend pavement life cost effectively



Performance Monitoring

Type of Activity	Type of Condition	Quantifiable Condition Factors	Repair Type and Notes
Conduct **Distress** Survey	Pavement age; PCC >10 years ACOL > 2 years	Pavement age	Monitor age for more than 10 year old PCC pavements or 2 year old ACOL pavements.
Conduct **Distress** and **FWD** Survey	Pavement deflection data > 3 years	Recent FWD data	Conduct FWD testing based on visual survey results.
Conduct **FWD** and **GPR** Survey; **DCP** Testing	• Pumping with or without staining • Missing joint seal material • Edge drop off	• Pumping • Joint seals condition • Surface DC of GPR • PR of DCP	• Conduct selected FWD and DCP testing based on visual and GPR survey results, PR > 2 in./drop indicates soft subgrade materials, soil modulus < 6000 psi. • GPR is useful to detect subsurface moisture and voided areas, DC > 9 indicates presence of subsurface water.

Preservative

Type of Activity	Type of Condition	Quantifiable Condition Factors	Repair Type and Notes
Crack sealing (**CS**)	Working cracks	Crack width > 0.03 in.	Crack sealing for working crack in CRC pavement
Reseal joints and cracks (**JS**)	Visible sealant damage on transverse and longitudinal joints and sealed cracks	• Sealant age • Visible sealant damage; cracking and debonding	• Keep joint well width < 1 in.; widened joint wells may be noisy. • Trapped subsurface water should be removed before re-sealing operations.
Transverse grade re-profiling (**TGP**)	Trapped surface water in depressed areas	Trapped surface water in depressed areas	• Depressed area degrade riding quality and cause impact loading • Trapped surface water can cause safety problem.
Retrofit edge drains (**RED**)	• Standing water • Trapped surface water • Saturated base layer and subgrade	• Presence of standing water • Slab staining • Surface DC • Subgrade strength	Edge drain is not recommended if the base is unstabilized, the base contains > 15% fines, or the pavement structure is undrainable.

Functional CPR

Type of Activity	Type of Condition	Quantifiable Condition Factors	Repair Type and Notes
Partial depth repair (**PDR**)	Spalled joint/crack	Density and width of spalling	• Spalling depth less than 1/3 thickness of the slab and no reinforcing steel exposure • Spalling 1/2 thickness of the slab and if remaining slab is strong with no other distress and steel is not corroded
Diamond grinding (**DG**)	• Rough and noisy patches • Faulting • Bump	• Density of patching • Depth of faulting	Restore load transfer before grinding if structurally defected
Thin **ACOL**	• Rough and noisy patches • Faulting • Hard aggregate • Settlement	• Density of patching • Depth of faulting • Aggregate type	• Employ for hard aggregate pavements • Restore load transfer before the overlay if structurally defected •Use crack attenuating mix and good aggregate

Structural CPR

Type of Activity	Type of Condition	Quantifiable Condition Factors	Repair Type and Notes
Restore load transfer (**RLT**)	• High deflection • Low LTE • Reflection crack in ACOL	• Faulting • Deflection • LTE • Crack width and density of spalling in ACOL	• Dowel bar retrofit • Check the deflection basin area and LTE of joint/crack • Employ RLT when 2 in. wide spalled joint in ACOL > 20%
Cross Stitching (**CST**)	• Longitudinal crack • Separated shoulder joint • Low LTE	• Width of the crack or shoulder joint separation • Lane to shoulder LTE • Pumping	• Cross stitching and joint seal when shoulder joint separation is between 1/2 in. and 1 in. • Slab undersealing where pumping and void detected
Slab undersealing (**SU**)	• Water-filled voids at or under joints • Settlement	• Presence of voids • Slab staining	GPR is recommended to locate holes in a way that will ensure good grout distribution and void filling

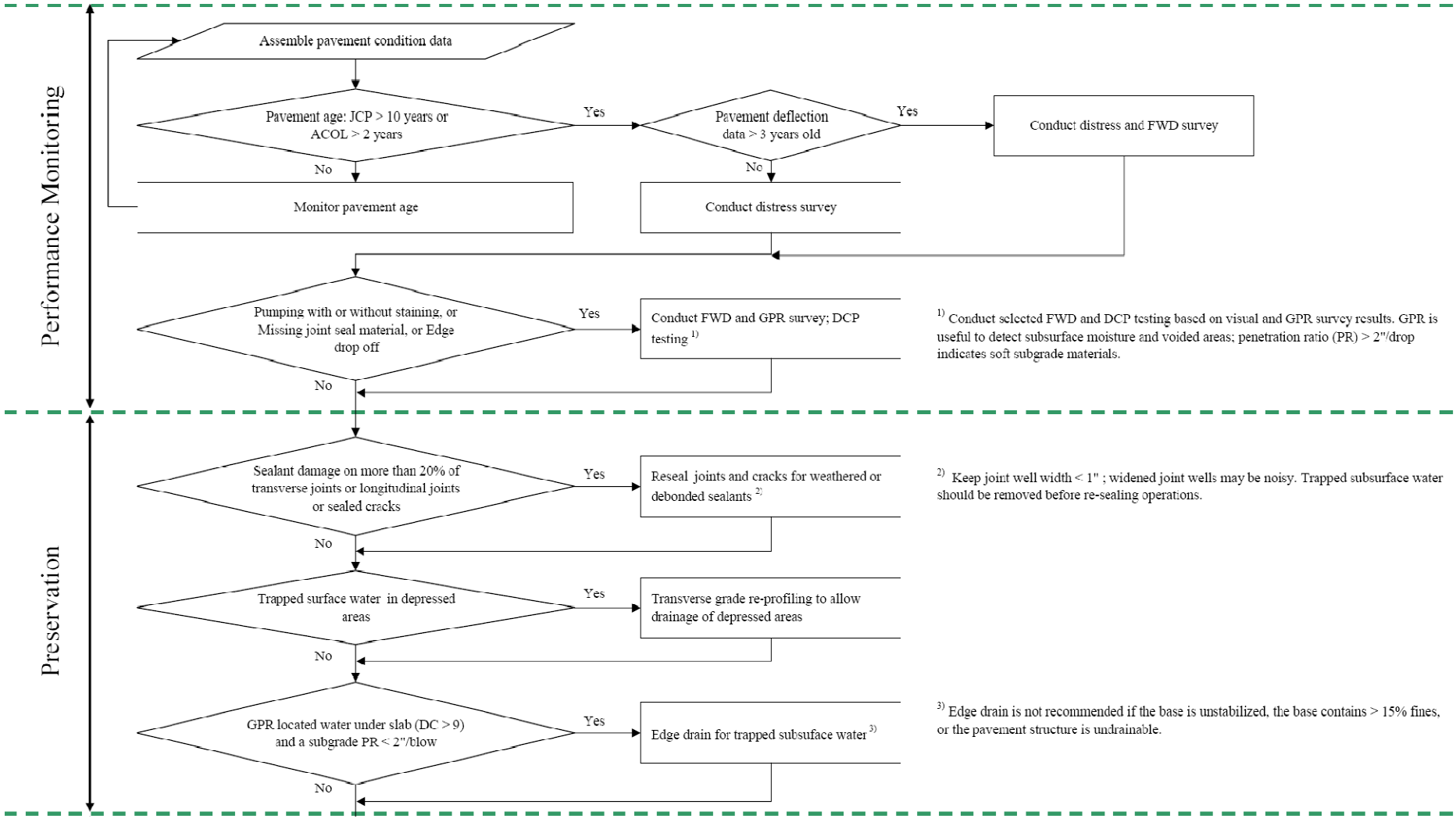
Remove and Replace

Type of Activity	Type of Condition	Quantifiable Condition Factors	Repair Type and Notes
Full depth repair (**FDR**)	• Corner break • Shattered slabs • Punchouts • Broken cluster area	• Severity and number of cracks • Spalling • Faulting	• Soft subgrade materials may require removal • Full depth repair for broken cluster should be extended to 1/2 of crack spacing between next cracks

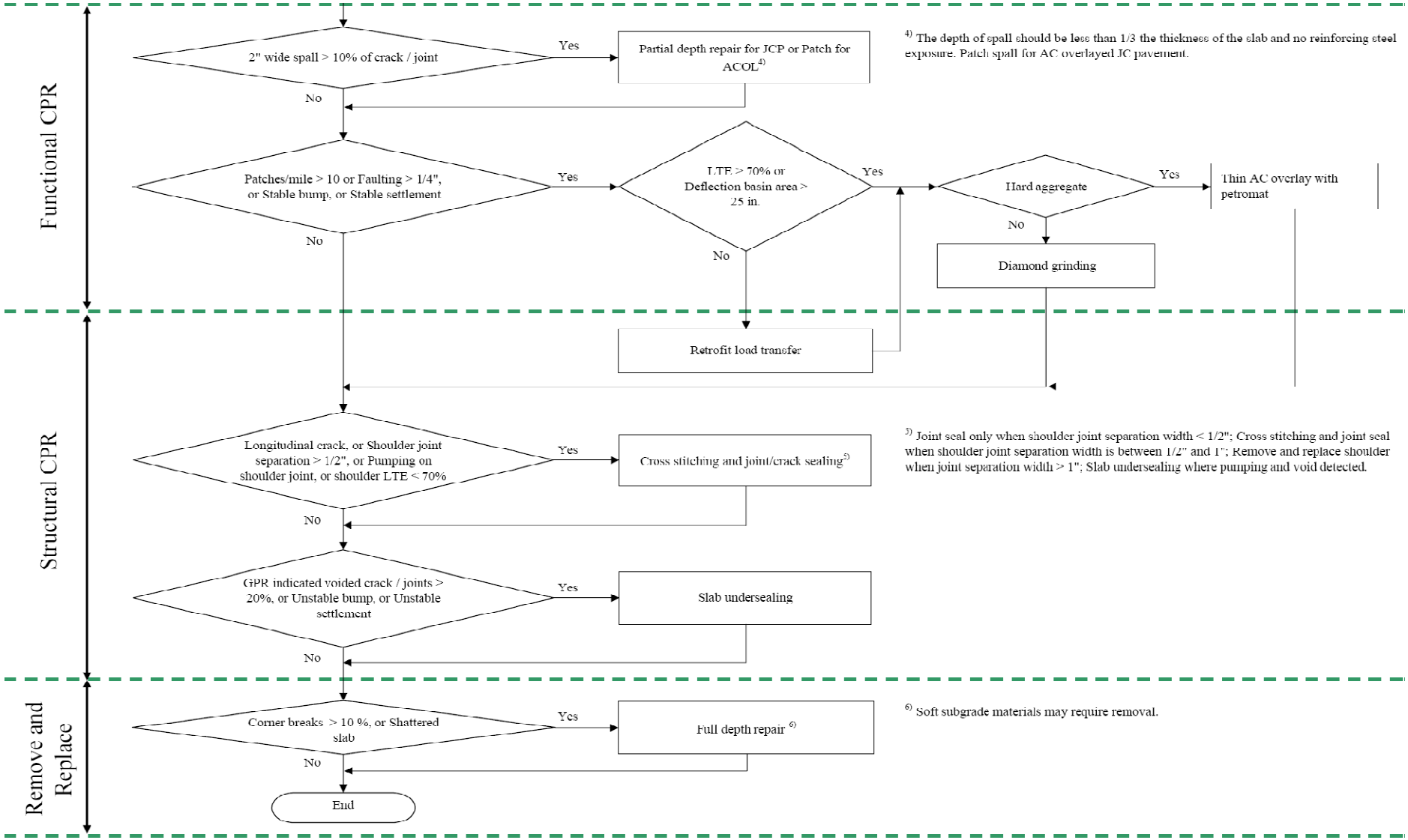
Repair Decision Flowcharts

- AC/Non AC Overlayed Jointed Concrete Pavement
- AC/Non AC Overlayed Continuously Reinforced Concrete Pavement
  - Based on the pavement condition evaluation
  - Decision flowchart is self explanatory
  - Provides guidance for effective routine maintenance

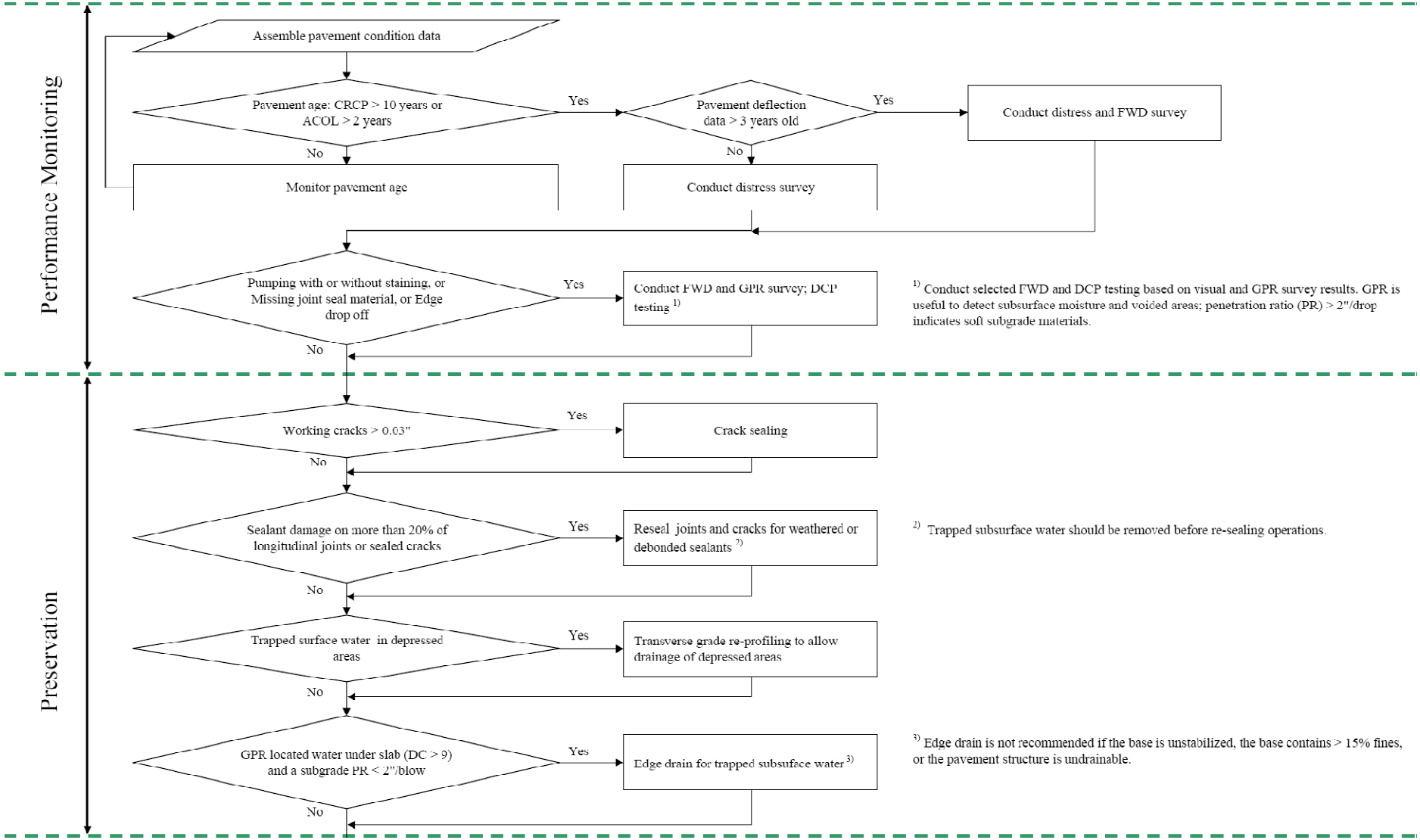
Decision Flowchart for AC/Non AC Overlayed JCP Routine Maintenance



Decision Flowchart for AC/Non AC Overlayed JCP Routine Maintenance (cont.)



Decision Flowchart for AC/Non AC Overlayed CRCP Routine Maintenance

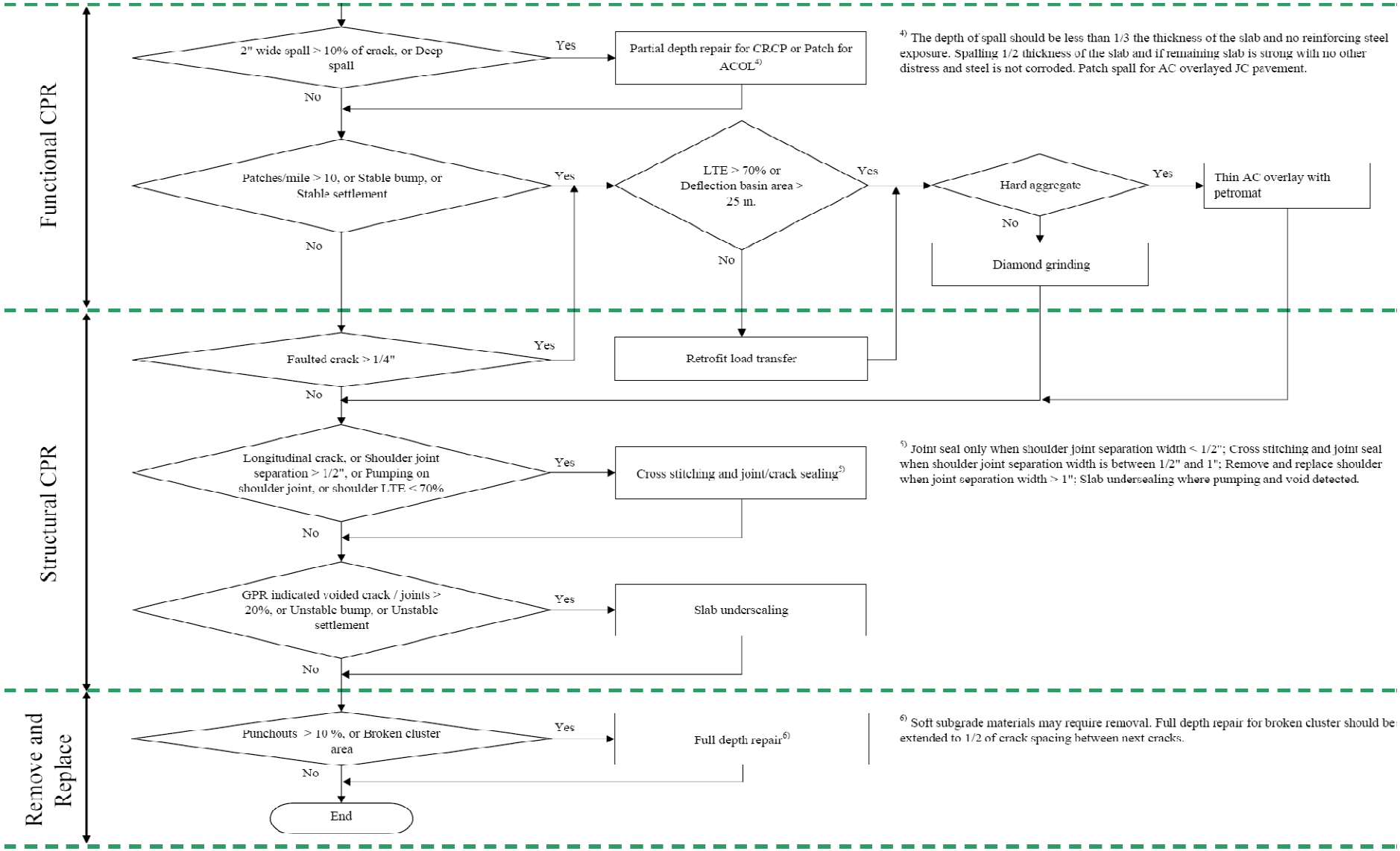


1) Conduct selected FWD and DCP testing based on visual and GPR survey results. GPR is useful to detect subsurface moisture and voided areas; penetration ratio (PR) > 2"/drop indicates soft subgrade materials.

2) Trapped subsurface water should be removed before re-sealing operations.

3) Edge drain is not recommended if the base is unstabilized, the base contains > 15% fines, or the pavement structure is undrainable.

Decision Flowchart for AC/Non AC Overlayed CRCP Routine Maintenance (cont.)

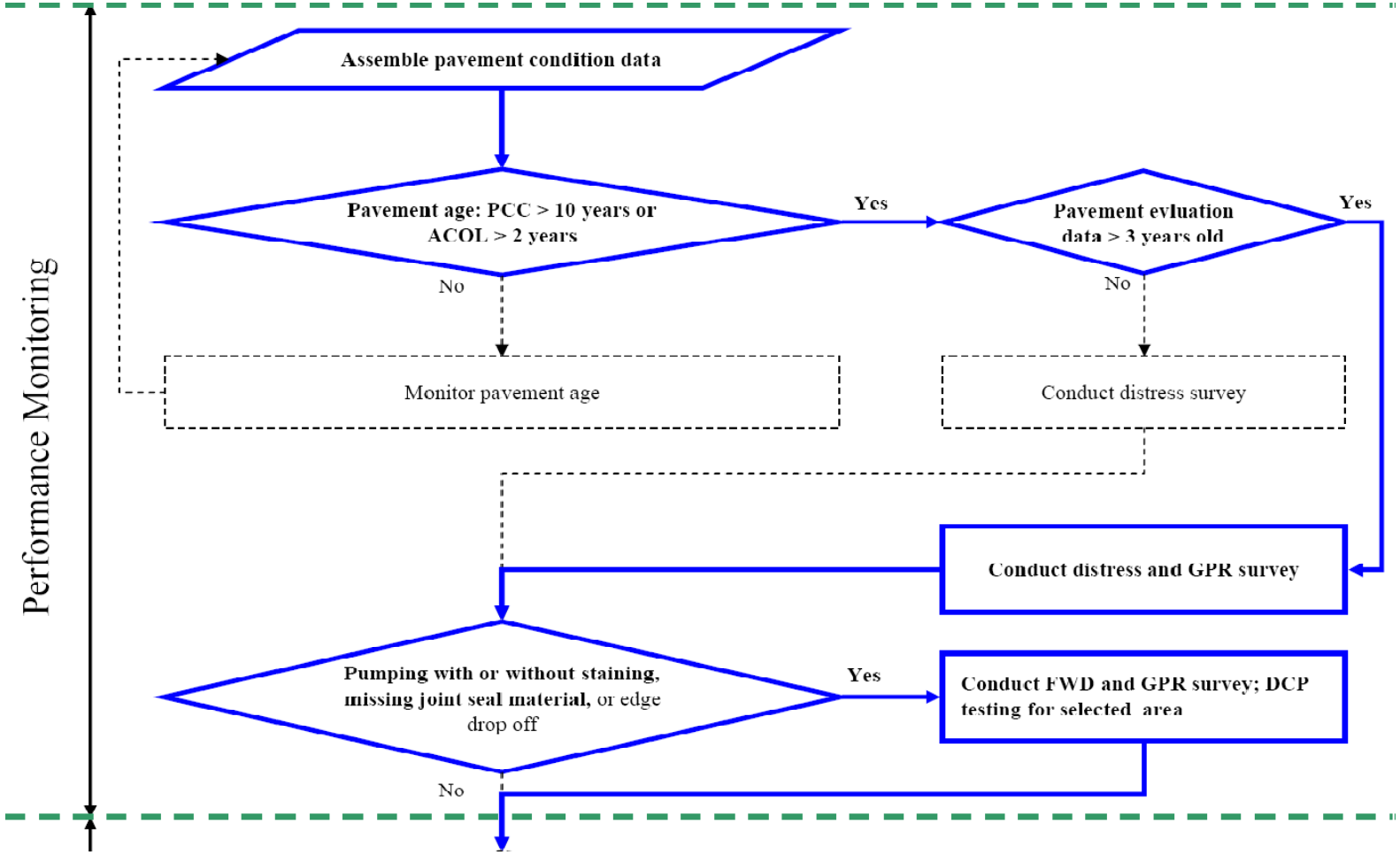


[4] The depth of spall should be less than 1/3 the thickness of the slab and no reinforcing steel exposure. Spalling 1/2 thickness of the slab and if remaining slab is strong with no other distress and steel is not corroded. Patch spall for AC overlayed JC pavement.

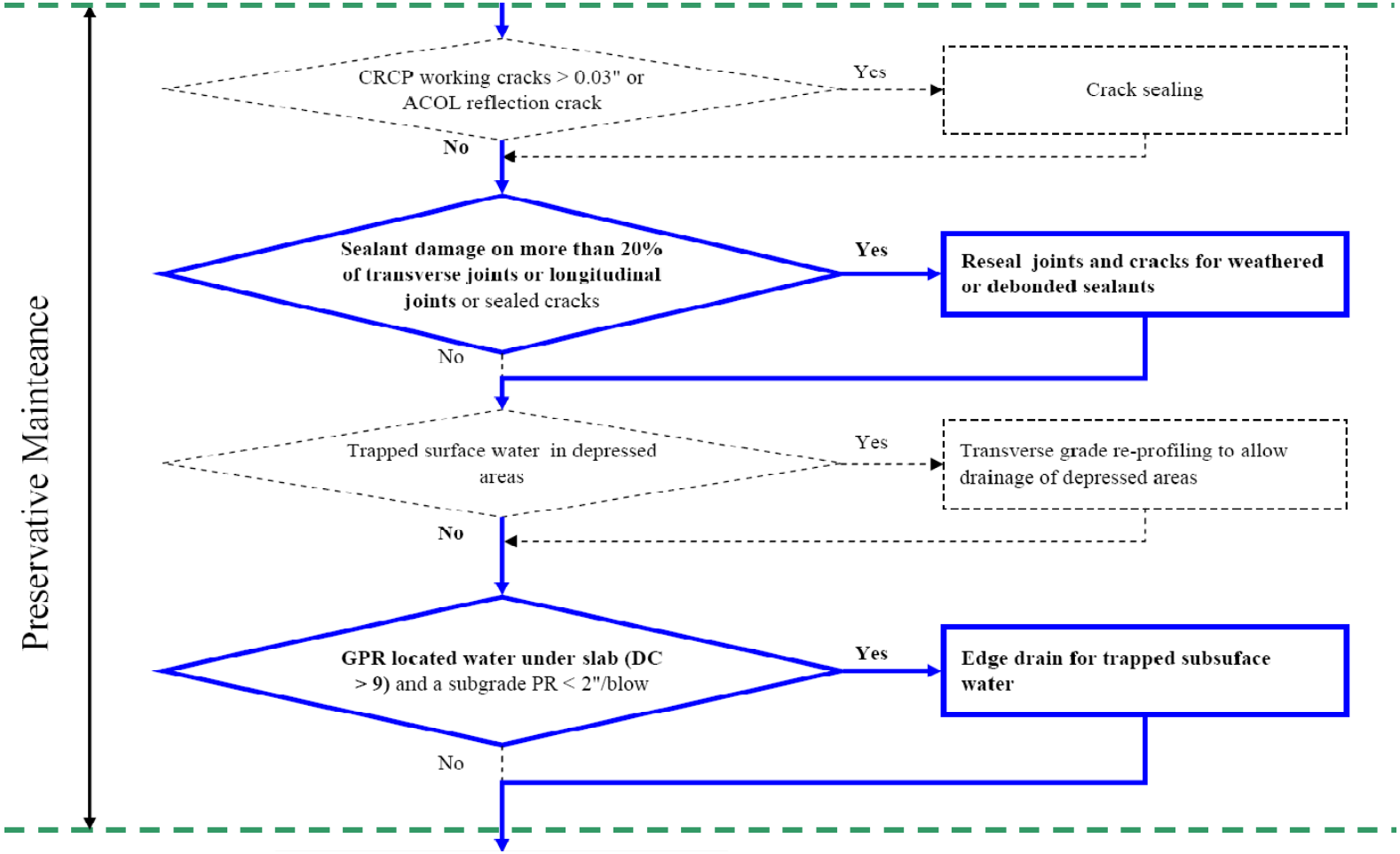
[5] Joint seal only when shoulder joint separation width < 1/2"; Cross stitching and joint seal when shoulder joint separation width is between 1/2" and 1"; Remove and replace shoulder when joint separation width > 1": Slab undersealing where pumping and void detected.

[6] Soft subgrade materials may require removal. Full depth repair for broken cluster should be extended to 1/2 of crack spacing between next cracks.

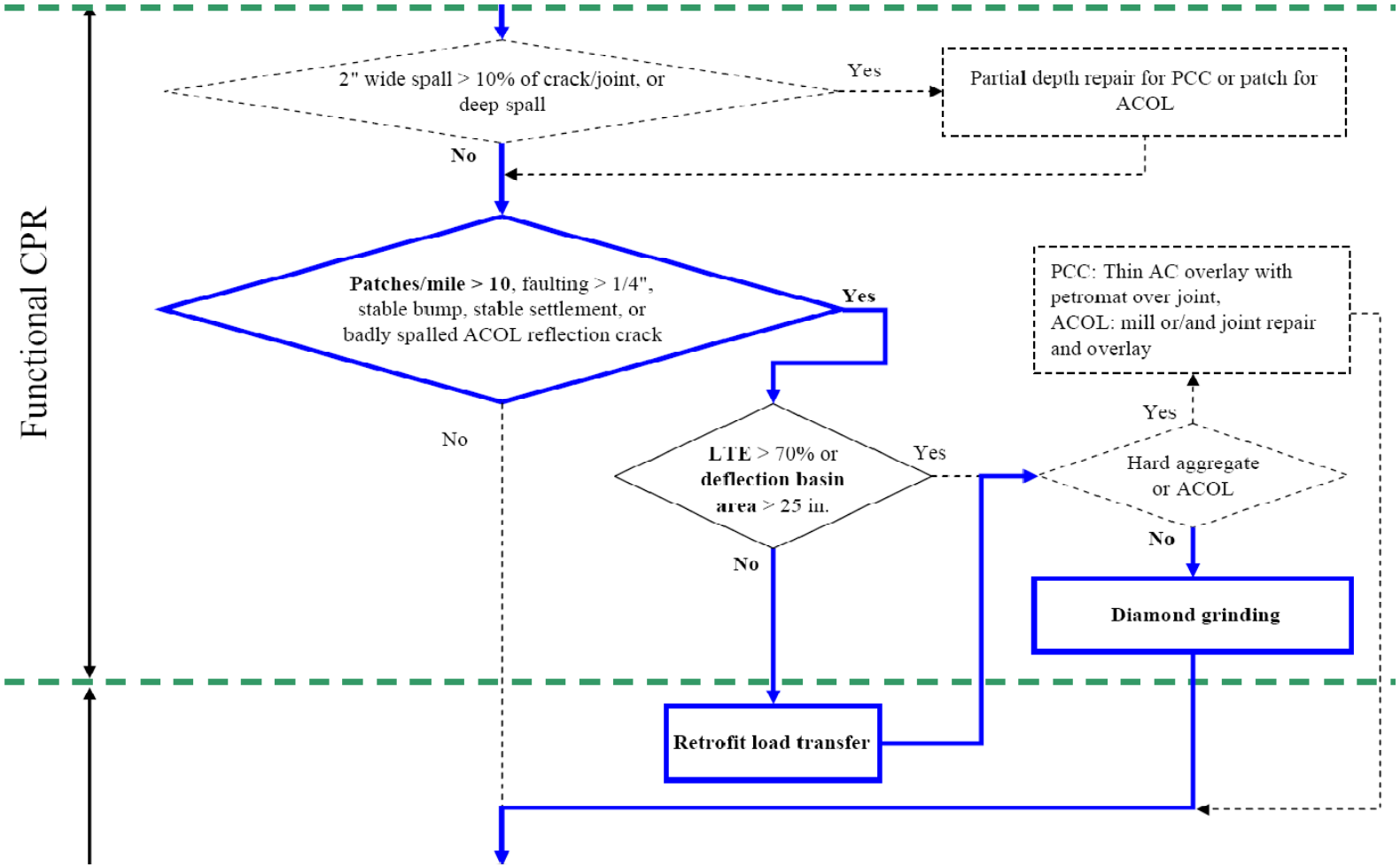
Decision Flowchart Example - Performance Monitoring Stage



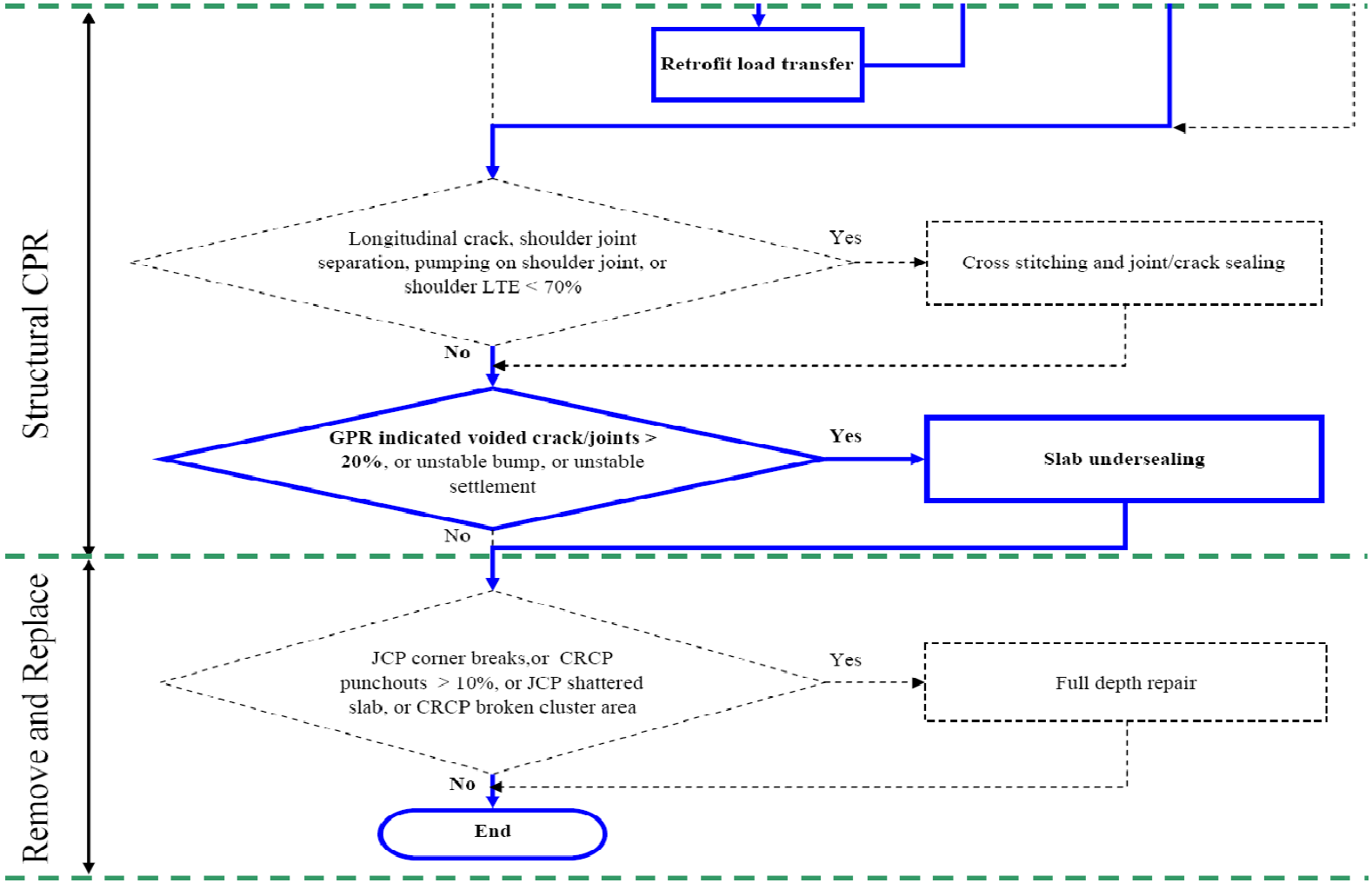
Decision Flowchart Example (cont.) - Preservative Maintenance



Decision Flowchart Example (cont.) - Functional CPR



Decision Flowchart Example (cont.) - Structural CPR, Remove and Replace



Routine Maintenance Repair Details

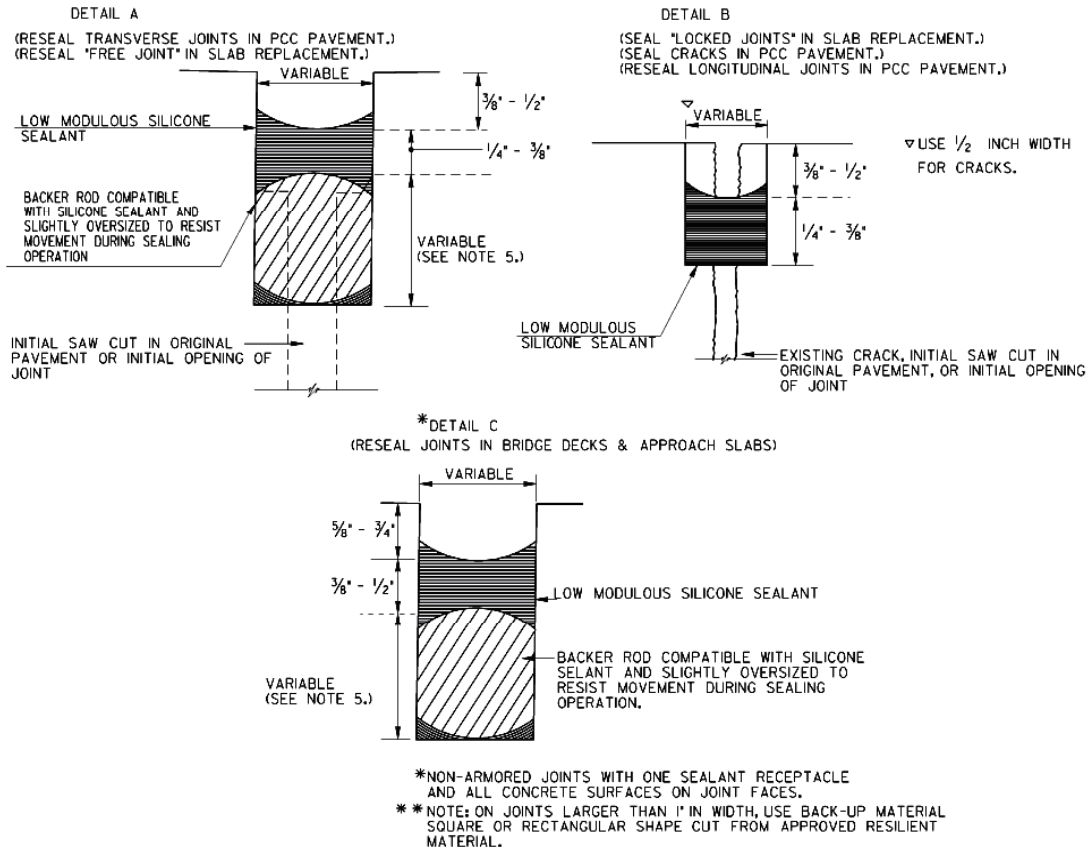
- **Preservative**
  - Seal joint and cracks
  - Retrofit edge drains
- **Functional CPR**
  - Partial depth repair
  - Diamond grinding
- **Structural CPR**
  - Retrofit load transfer
  - Cross stitching
  - Slab undersealing
- **Remove and Replace**
  - Full depth repair

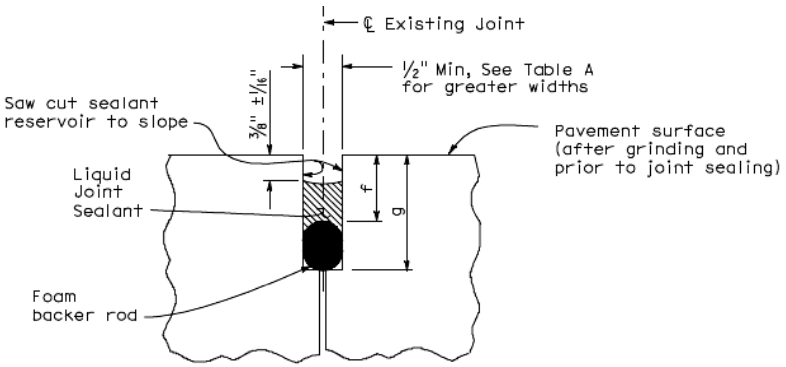
Seal Joint and Cracks

- **Object of repair**
  - Reduce infiltration of moisture and incompressive material, Reduce pumping and faulting
- **Limitations**
  - Questionable for long-term effectiveness
- **Unit repair cost ***
  - $0.75 - 1.25/ft (hot pour), $1.00 - $2.00/ft (silicon)
- **Expected life extension**
  - 3 - 8 years
- **Typical repair work time**
  - 5,000 ft / day (hot pour)
- **Recommendations**
  - Select proper sealing material based on temperature and moisture conditions

* Reference: Hoerner, T. E., K. D. Smith, H. T. Yu, D. G. Peshkin, and M. J. Wade. “PCC Pavement Evaluation and Rehabilitation,” Reference Manual, NHI Course 131062. National Highway Institute, Arlington, VA, 2001.

Seal Joint and Cracks – GA, CA DOT





LIQUID SEALANT TYPE R

Retrofit Transverse and Longitudinal Joints

TABLE A (TYPE R JOINT)

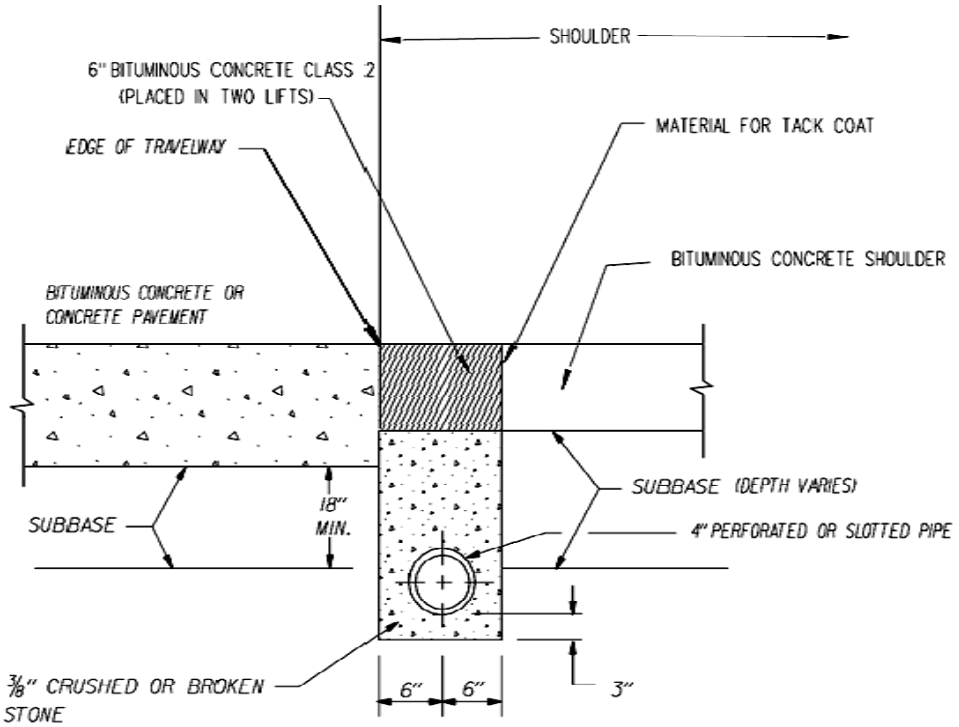
Sawn Joint Width	Backer Rod Diameter ± 1/16"	DIMENSION "f"	DIMENSION "g"
1"	1 5/16"	7/8"	2 1/4"
7/8"	1 3/16"	13/16"	2"
3/4"	1"	3/4"	1 3/4"
5/8"	7/8"	11/16"	1 1/2"
1/2"	11/16"	5/8"	1 1/4"

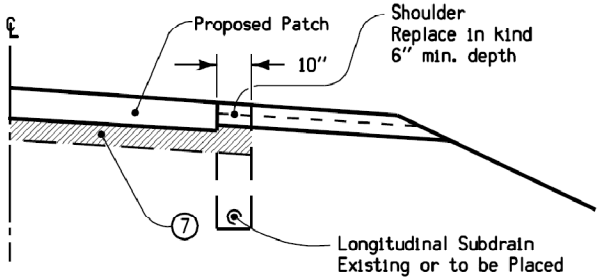
Retrofit Edge Drains

- **Object of repair**
  - Provide drainage of surface water, reduce pumping, faulting, and other moisture damage
- **Limitations**
  - May accelerate deterioration if not maintained well, Not recommended if no base or base contains excessive amount of fines (>15% passing No. 200 sieve)
- **Unit repair cost ***
  - $2.00 - $4.00/ft
- **Expected life extension**
  - Life of existing pavement
- **Typical repair work time**
  - 1 mile / day
- **Recommendations**
  - Proper design, construction, and maintenance is essential

* Reference: Hoerner, T. E., K. D. Smith, H. T. Yu, D. G. Peshkin, and M. J. Wade. “PCC Pavement Evaluation and Rehabilitation,” Reference Manual, NHI Course 131062. National Highway Institute, Arlington, VA, 2001.

Retrofit Edge Drains – CT, IA DOT

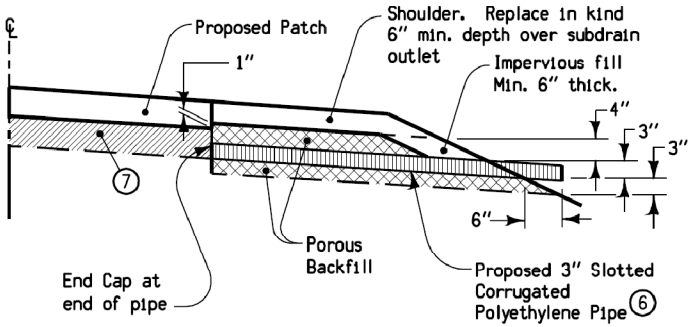




GRANULAR SUBBASE AND SUBDRAIN

(WHEN REQUIRED BY PLAN)

IF LONGITUDINAL SUBDRAIN IS PRESENT OR IS TO BE PLACED



GRANULAR SUBBASE AND SUBDRAIN

(WHEN REQUIRED BY PLAN)

WITHOUT LONGITUDINAL SUBDRAIN

Construct edge drain out side of shoulder if PCC shoulder

(6) If longitudinal subdrain (shoulder) is not to be placed or if not present on side of roadway to be patched, then place proposed 3 inch slotted corrugated pipe at low end of patch.

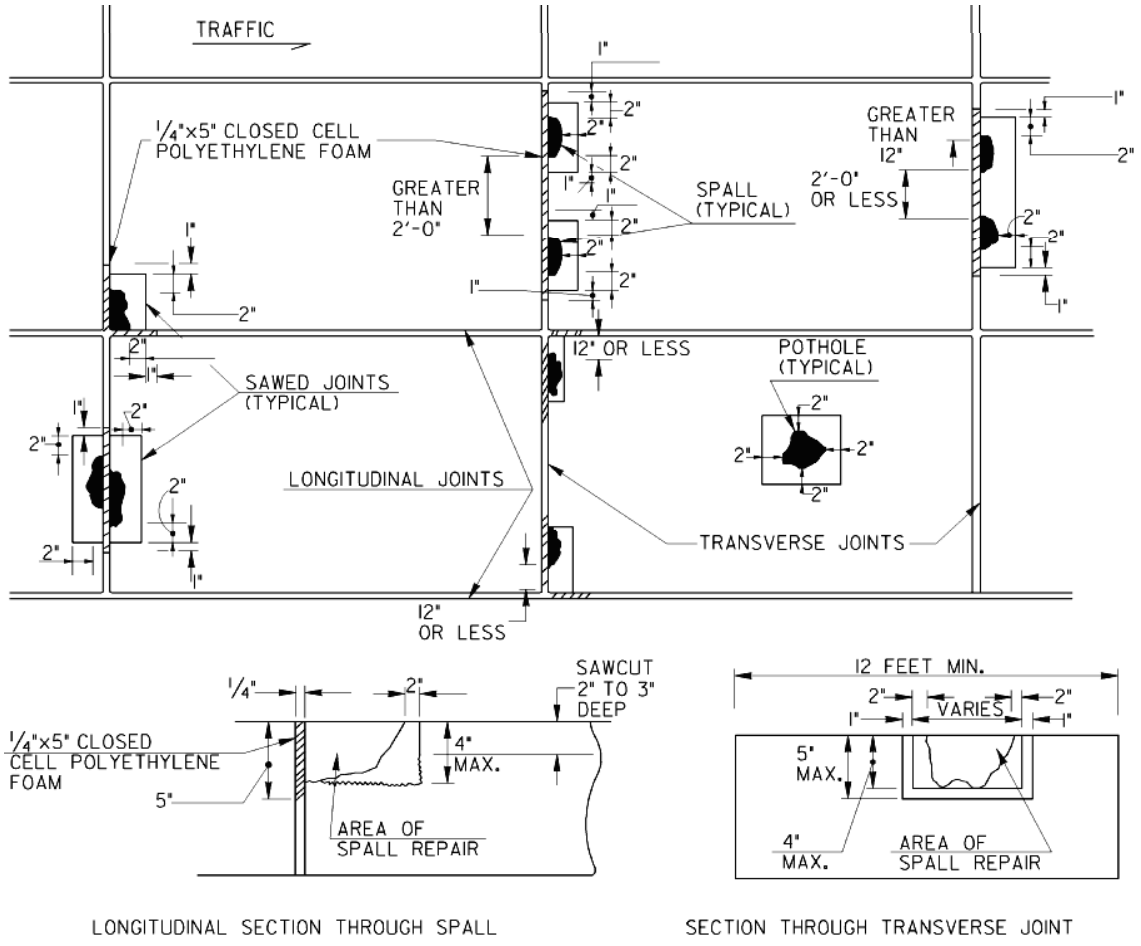
(7) 6 inches granular subbase if required by plan. When placed, granular subbase should extend over longitudinal subdrain, if present.

Partial Depth Repair

- **Object of repair**
  - Repair spall and distress without removing entire slab
- **Limitations**
  - Full-depth repair is needed if the damage extends below 1/3 the slab thickness
- **Unit repair cost ***
  - $325 - $500/yd^3
- **Expected life extension**
  - 3 - 10 years
- **Typical repair work time**
  - 4 to 12 repairs / hr, curing time not included
- **Recommendations**
  - Partial depth repairs should restore the joint face, and joint should be sealed properly

Reference: Hoerner, T. E., K. D. Smith, H. T. Yu, D. G. Peshkin, and M. J. Wade. "PCC Pavement Evaluation and Rehabilitation," Reference Manual, NHI Course 131062. National Highway Institute, Arlington, VA, 2001.

Partial Depth Repair – GA DOT



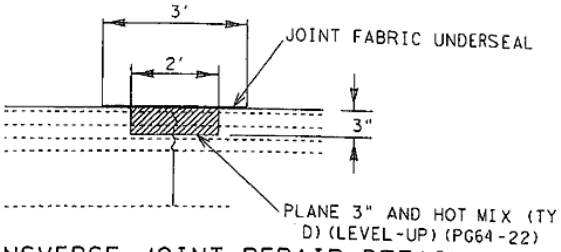
LONGITUDINAL SECTION THROUGH SPALL

SECTION THROUGH TRANSVERSE JOINT

Partial Depth Repair – TxDOT Lufkin

Inside lane

Unit repair cost: $ 7.26 /ft



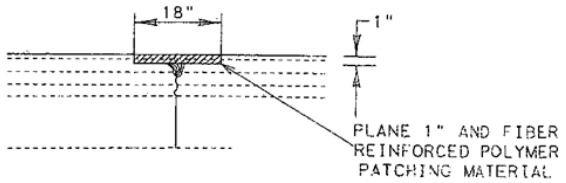
TRANSVERSE JOINT REPAIR DETAIL

STA 360+26.82 TO STA 428+64.00

NOTE:
TRANSVERSE JOINT REPAIR SHALL BE CLEANED OF ALL LOOSE MATERIAL

Outside lane

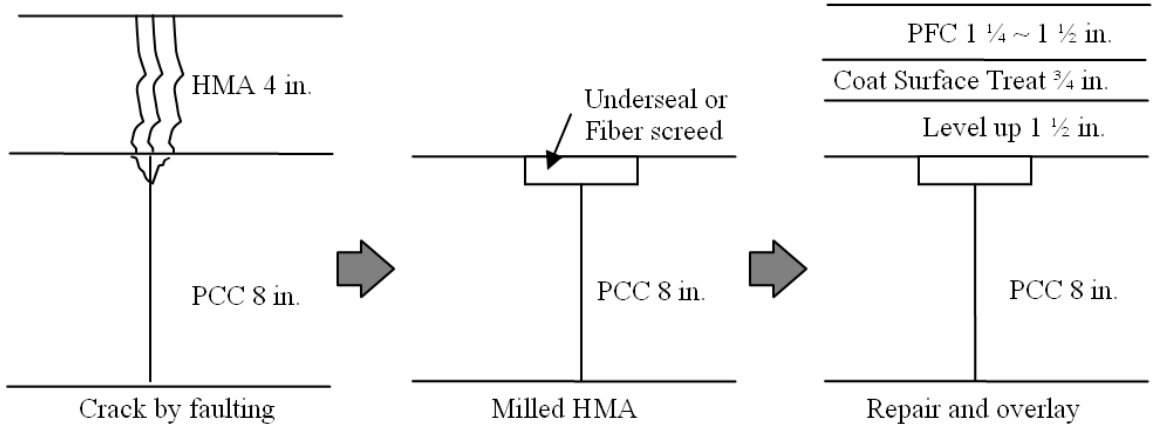
Unit repair cost: $ 2.17 /lb



TRANSVERSE JOINT REPAIR DETAIL

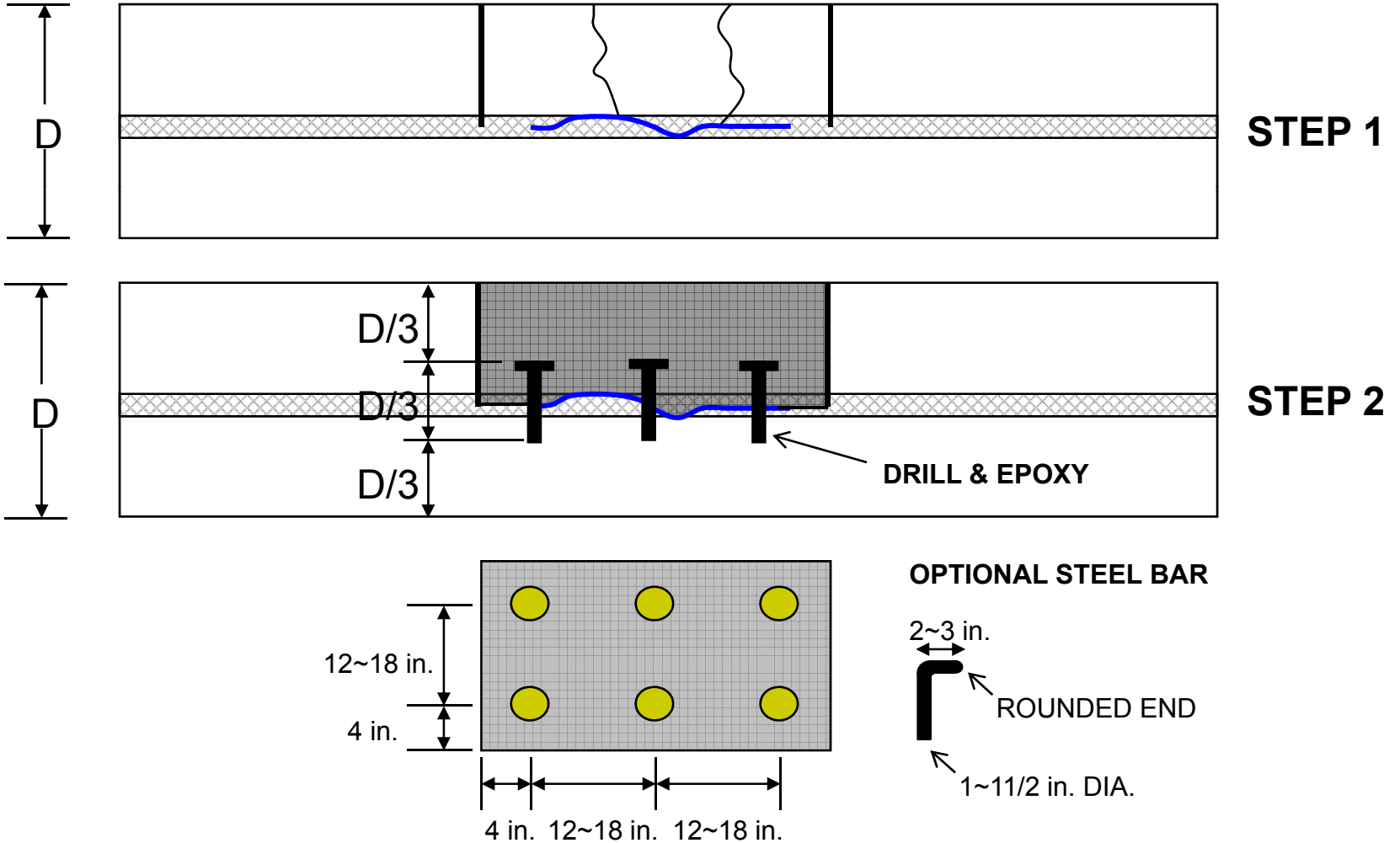
STA 299+96.64 TO STA 360+26.82

NOTE:
TRANSVERSE JOINT REPAIR SHALL BE CLEANED OF ALL LOOSE MATERIAL



Deep Partial Depth Repair

Proposed by Dr. Moonchul Won and Detailed by TTI

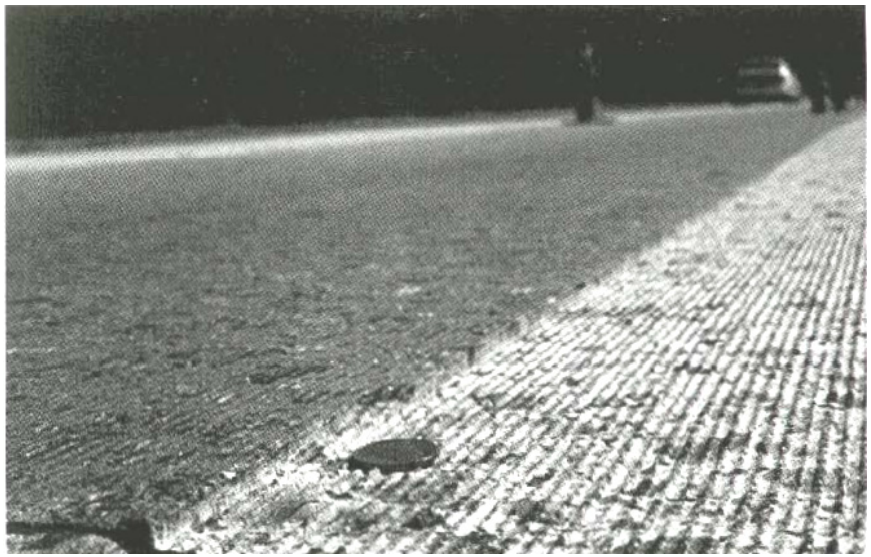


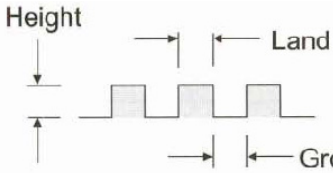
Diamond Grinding

- **Object of repair**
  - Provide smooth riding surface with good texture, reduce noise
- **Limitations**
  - Roughness will return if underlying causes not addressed
- **Unit repair cost ***
  - $1.80 - $7.80/yd^2
- **Expected life extension**
  - 8 - 12 years
- **Typical repair work time**
  - 2,500 yd^2/day
- **Recommendations**
  - Grinding should not be employed on pavements with material problems

* Reference: Hoerner, T. E., K. D. Smith, H. T. Yu, D. G. Peshkin, and M. J. Wade. “PCC Pavement Evaluation and Rehabilitation,” Reference Manual, NHI Course 131062. National Highway Institute, Arlington, VA, 2001.

Diamond Grinding – ACPA





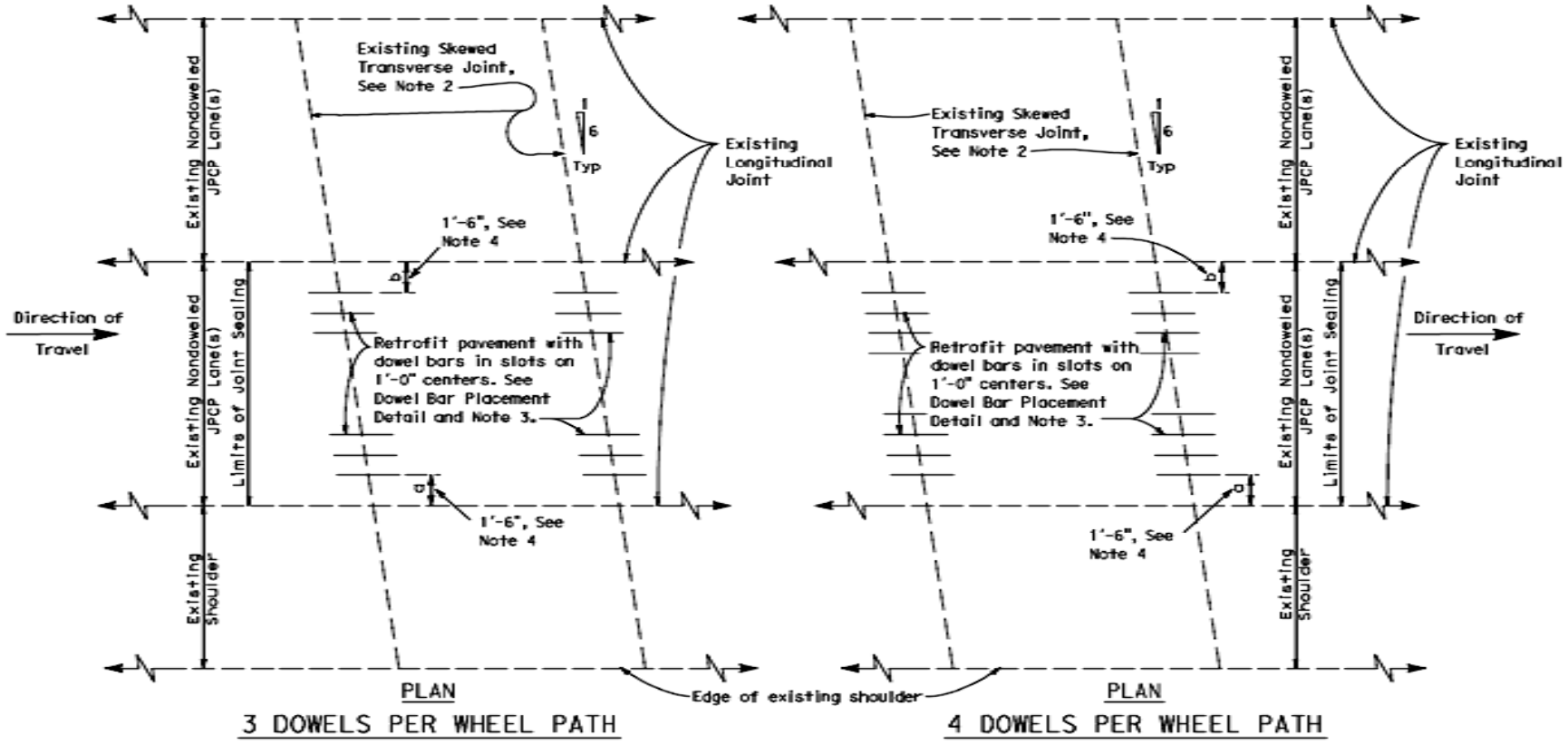
	Range	Hard Aggregate	Soft Aggregate
Grooves	2.25-3.75 mm	2.50-3.75 mm	2.50-3.75 mm
Land Area	1.50-3.25 mm	2.00 mm	2.50 mm
Height	1.50 mm	1.50 mm	1.50 mm
Grooves/m	164-197	174-197	164-177

Retrofit Load Transfer

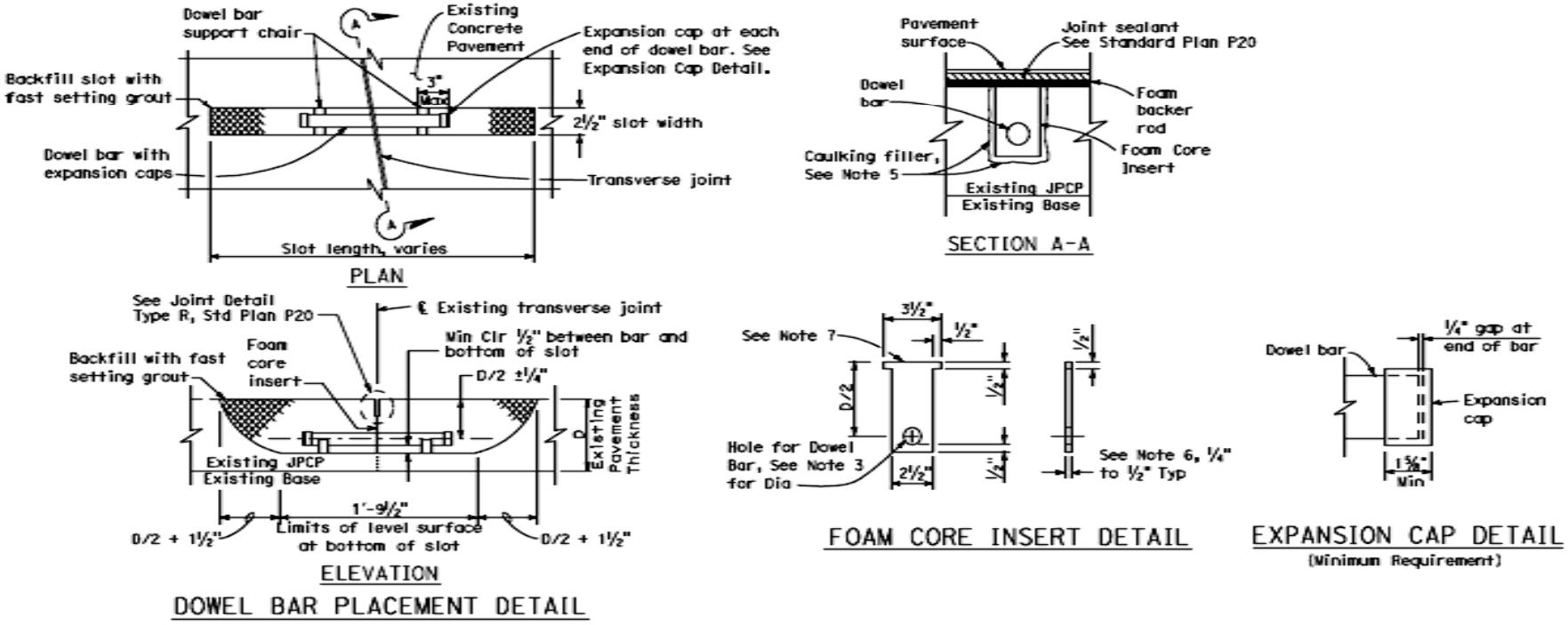
- **Object of repair**
  - Restore load transfer to reduce faulting, pumping, and crack/joint deterioration
- **Limitations**
  - Pavements exhibiting material related distresses such as D-cracking or reactive aggregate are not good for dowel bar retrofitting
- **Unit repair cost ***
  - $25 - $35/dowel
- **Expected life extension**
  - 10 - 15 years
- **Typical repair work time**
  - 150 joint / day
- **Recommendations**
  - Diamond grinding is needed to remove existing faulting, and Slab stabilization is needed to address loss of support

* Reference: Hoerner, T. E., K. D. Smith, H. T. Yu, D. G. Peshkin, and M. J. Wade. "PCC Pavement Evaluation and Rehabilitation," Reference Manual, NHI Course 131062. National Highway Institute, Arlington, VA, 2001.

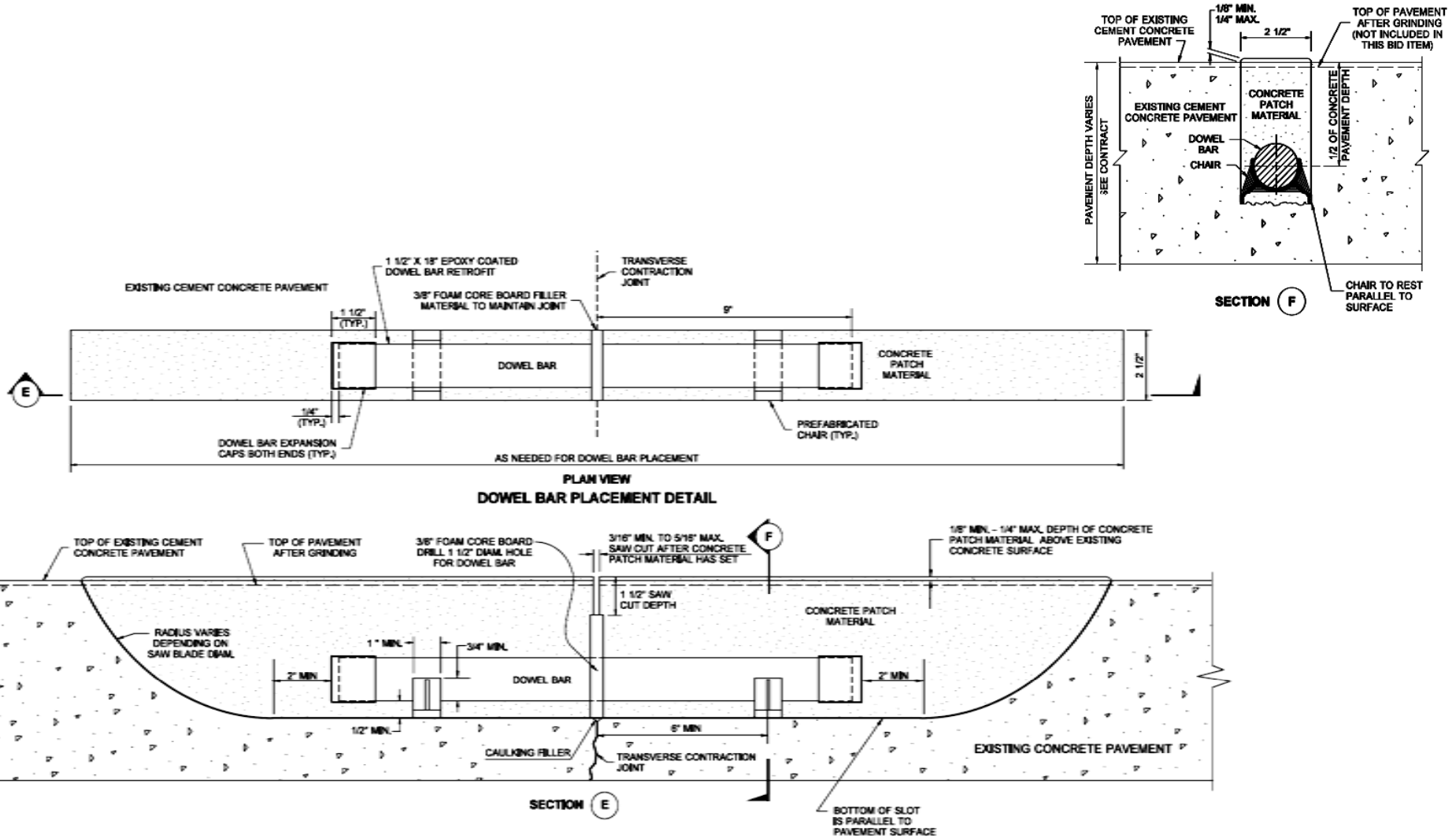
Retrofit Load Transfer – CA DOT



Retrofit Load Transfer – CA DOT



Retrofit Load Transfer – WA DOT

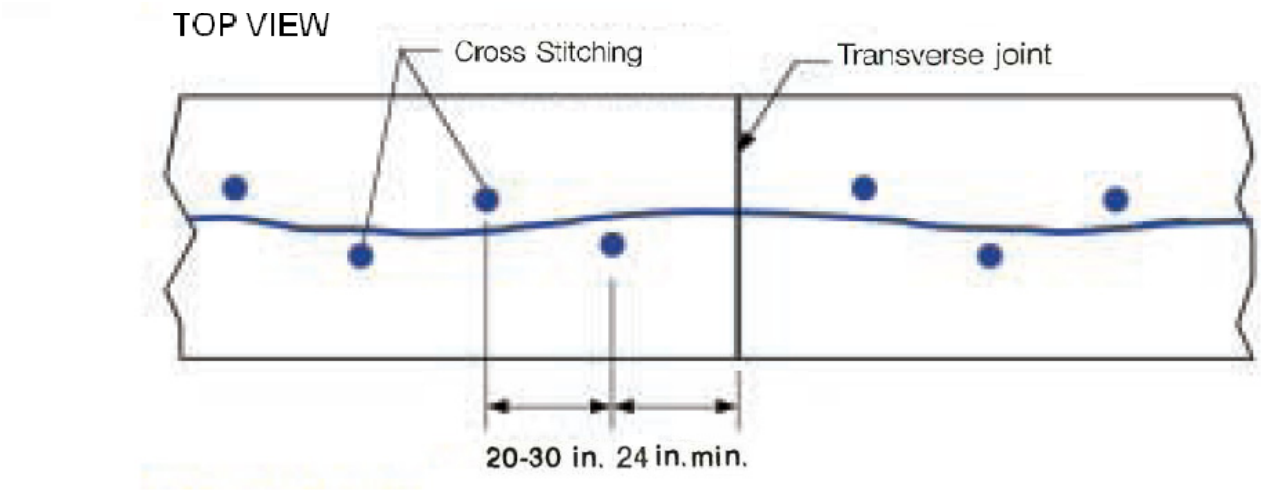


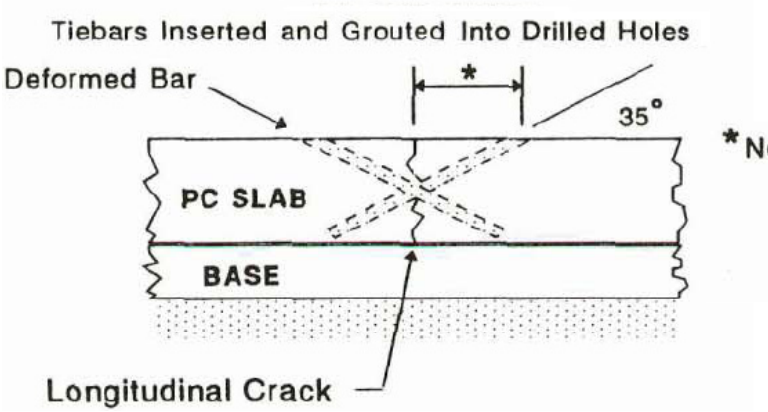
Cross Stitching

- **Object of repair**
  - Hold longitudinal crack or joint together and prevent opening of crack or joint
- **Limitations**
  - Applicable for fair condition and may not prevent secondary cracking or crack propagation
- **Unit repair cost ***
  - $9 - $10/bar
- **Expected life extension**
  - 3 - 6 years
- **Typical repair work time**
  - 1,500 ft / day
- **Recommendations**
  - Cross stitching and joint seal when shoulder joint separation is between ½ in. and 1 in.
  - Rehabilitation is required when secondary cracks develop

* Reference: Hoerner, T. E., K. D. Smith, H. T. Yu, D. G. Peshkin, and M. J. Wade. "PCC Pavement Evaluation and Rehabilitation," Reference Manual, NHI Course 131062. National Highway Institute, Arlington, VA, 2001.

Cross Stitching – ACPA





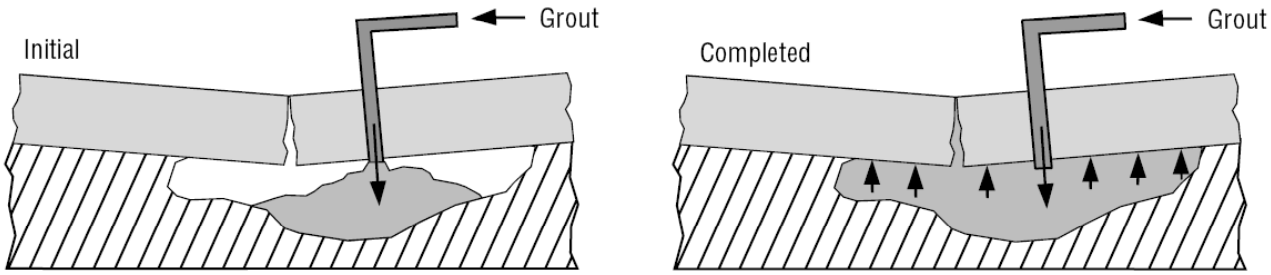
*Note: Holes are alternated to each side of the crack spaced 20-30 in. on center. Must start hole proper distance from crack to get intersection at mid-depth.

Slab Undersealing

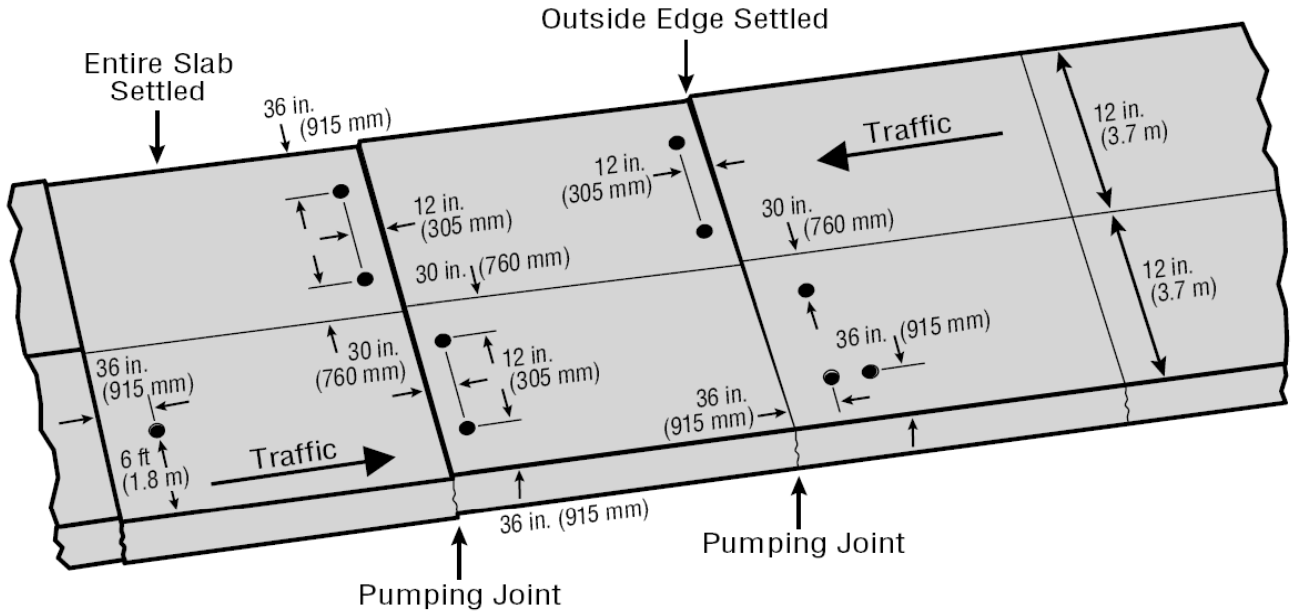
- **Object of repair**
  - Restore uniform support by filling void and reduce corner deflection, pumping, and faulting
- **Limitations**
  - Difficult to identify poorly supported area, restrictions on climatic condition, Can increase damage if slab is lifted
- **Unit repair cost ***
  - $1.30 - $1.40/yd^2
- **Expected life extension**
  - 3 - 6 years
- **Typical repair work time**
  - 100 slab / day
- **Recommendations**
  - Experienced contractor and proper inspection are essential

* Reference: Hoerner, T. E., K. D. Smith, H. T. Yu, D. G. Peshkin, and M. J. Wade. “PCC Pavement Evaluation and Rehabilitation,” Reference Manual, NHI Course 131062. National Highway Institute, Arlington, VA, 2001.

Slab Undersealing – ACPA



Grout will fill void under pavement without lifting it



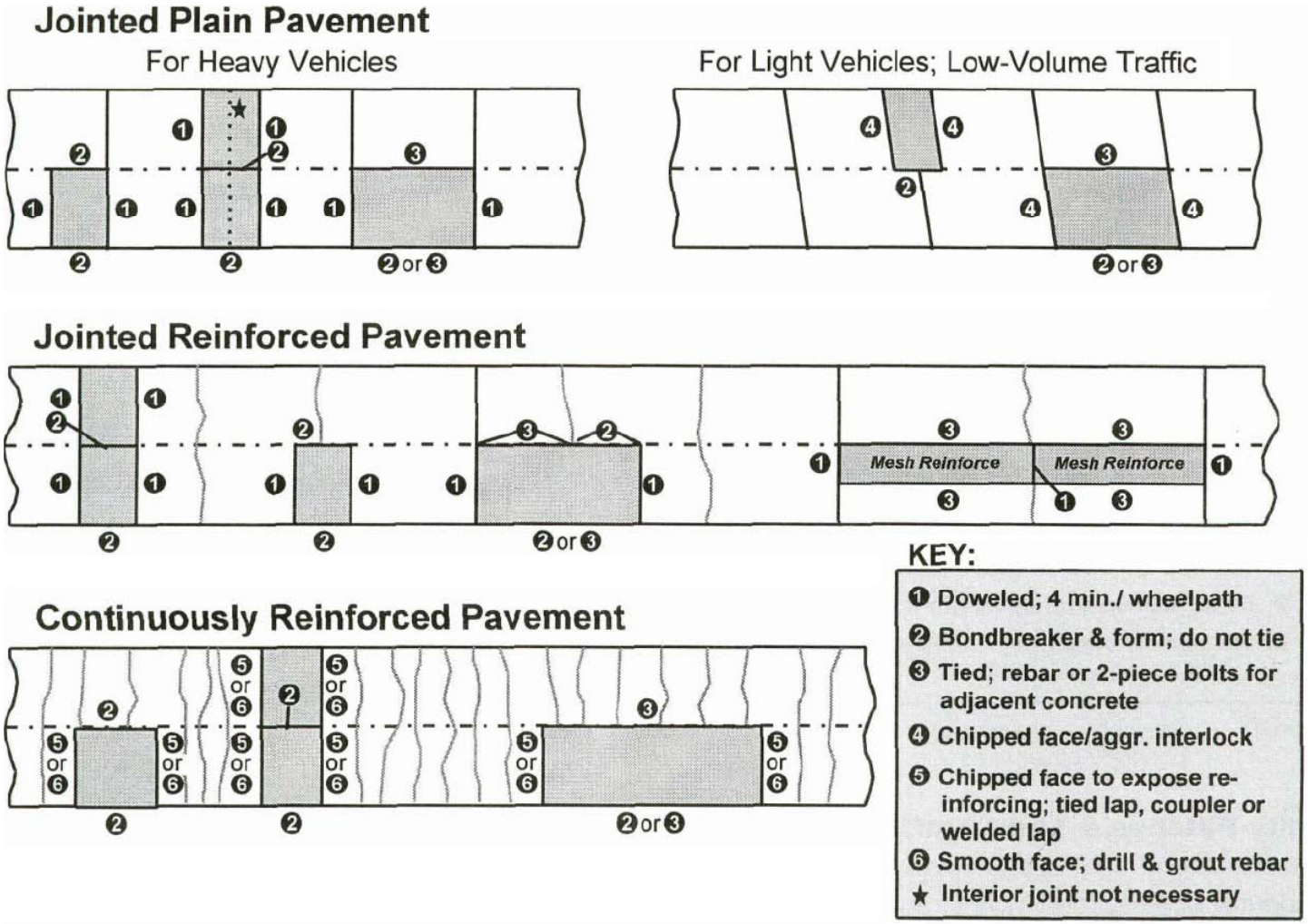
Location of Holes Varies for Defect to be Corrected

Full Depth Repair

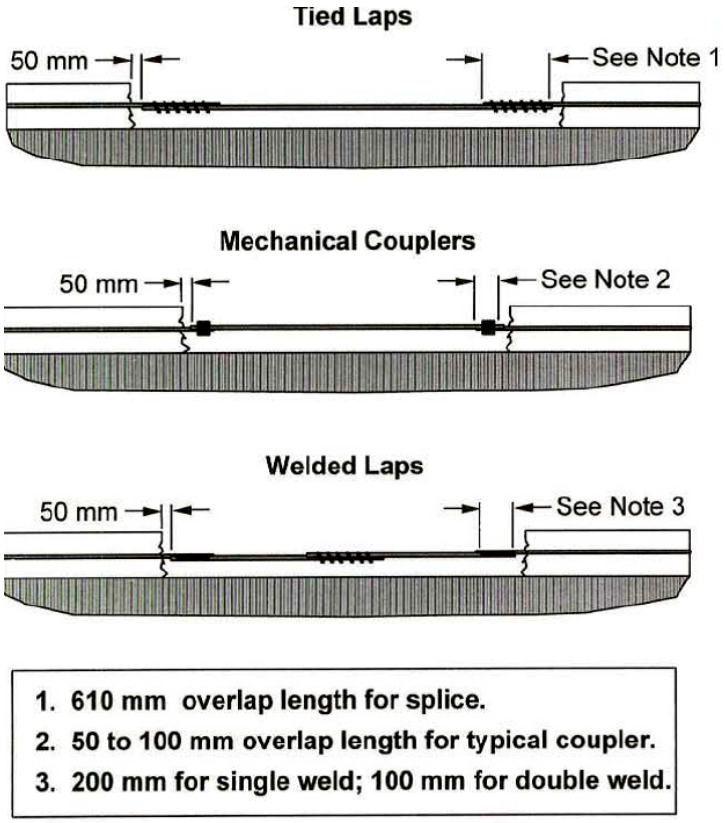
- **Object of repair**
  - Remove all deterioration in the distressed area, restore load transfer at joints and cracks
- **Limitations**
  - Additional joints introduced by full-depth repairs may add to the pavement roughness
- **Unit repair cost ***
  - $90 - $100/yd^2
- **Expected life extension**
  - 5 - 15 years
- **Typical repair work time**
  - 4 to 6 repairs / hr, curing time not included
- **Recommendations**
  - If the deterioration is widespread over the entire project length, an overlay or reconstruction may be more cost effective

* Reference: Hoerner, T. E., K. D. Smith, H. T. Yu, D. G. Peshkin, and M. J. Wade. “PCC Pavement Evaluation and Rehabilitation,” Reference Manual, NHI Course 131062. National Highway Institute, Arlington, VA, 2001.

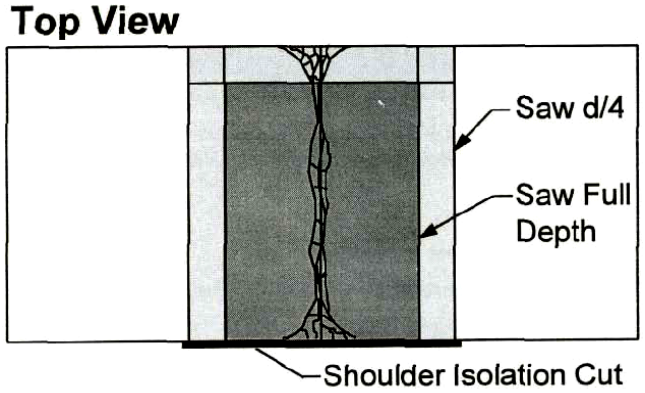
Full Depth Repair – ACPA

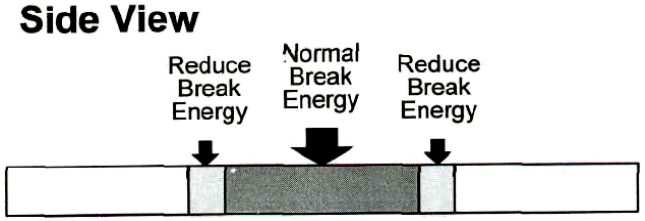


Full Depth Repair – ACPA



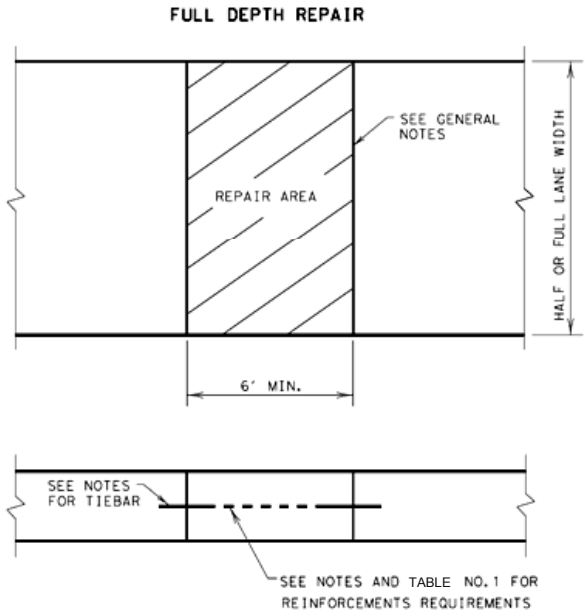
1. 610 mm overlap length for splice.
2. 50 to 100 mm overlap length for typical coupler.
3. 200 mm for single weld; 100 mm for double weld.





PATCH TYPE	MINIMUM OFFSET
CRCP with tied steel splice	600 mm (24 in)
CRCP with welded steel splice	100–200 mm (4–8 in)
CRCP with mechanical steel splice	50–100 mm (2–4 in)
Low-volume aggregate interlock or utility	50 mm (2 in)

Full Depth Repair – TxDOT



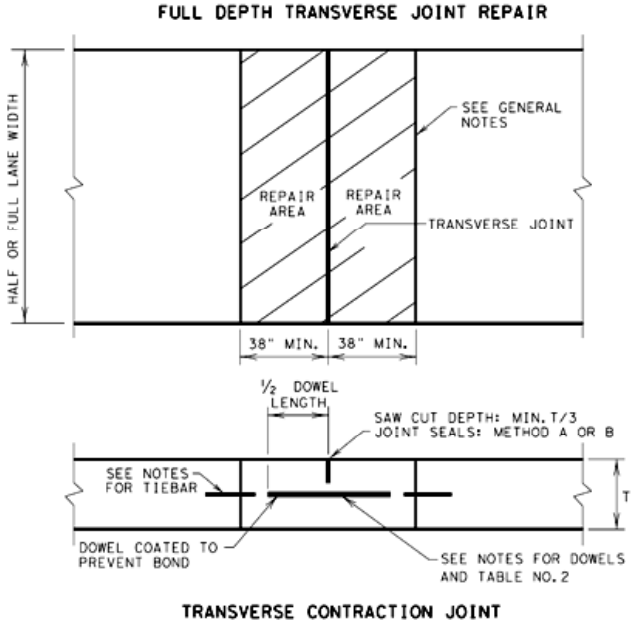


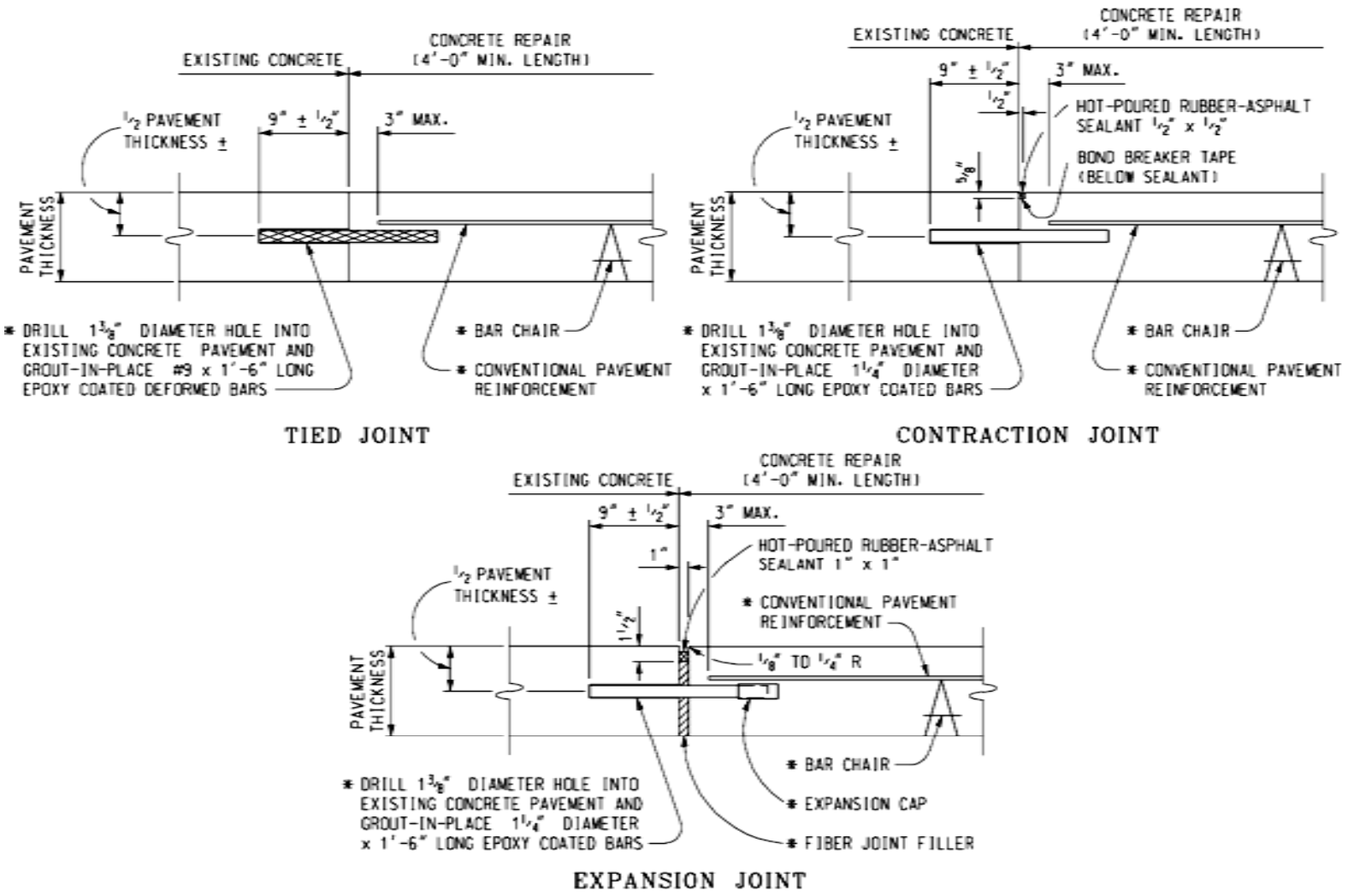
TABLE NO. 1 STEEL BARS SIZE AND SPACING

TYPE OF REINFORCEMENTS	TYPE PAVEMENT	PAVEMENT THICKNESS (INCHES)	TIEBARS		REGULAR REBARS		ALL BARS
			SIZE BAR (BAR NO.)	BAR SPACING (INCHES)	SIZE BAR (BAR NO.)	SPACING (INCHES)	FIRST & LAST SPACING AT END OR SIDE (INCHES)
TRANSVERSE BARS	CRCP JRCP	ALL	#6	24	#6	24	12
	JCP (CPCD)	ALL	#6	24	NONE	NONE	12
LONGITUDINAL BARS	CRCP	8	#6	9	#6	9	12
		9	#6	8	#6	8	12
		10	#6	7	#6	7	12
		11	#6	6.5	#6	6.5	12
		≥ 12	#6	6	#6	6	12
	JRCP	ALL	#6	12	#6	24	12
	JCP (CPCD)	ALL	#6	12	NONE	NONE	12

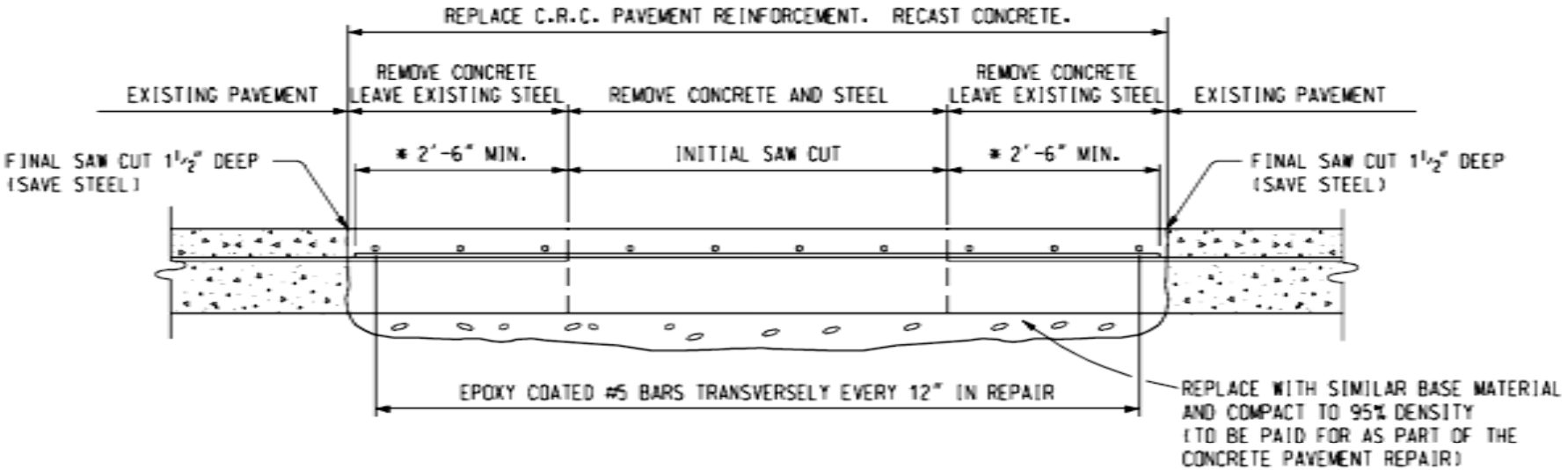
TABLE NO. 2 DOWELS (SMOOTH BARS)

PAVEMENT THICKNESS (INCHES)	SIZE AND DIA.	LENGTH (INCHES)	SPACING (INCHES)
8	#8 (1 IN.)	18	12
9	#9 (1⅛ IN.)		
≥10	#10 (1¼ IN.)		

Full Depth Repair – MI DOT



Full Depth Repair – MI DOT



* NOTE: IF EXISTING REINFORCEMENT LAPS ARE ENCOUNTERED IN THIS AREA. FINAL SAW CUT MUST BE MOVED BACK TO PROVIDE MINIMUM 2'-6" LAP OF PAVEMENT REINFORCEMENT.

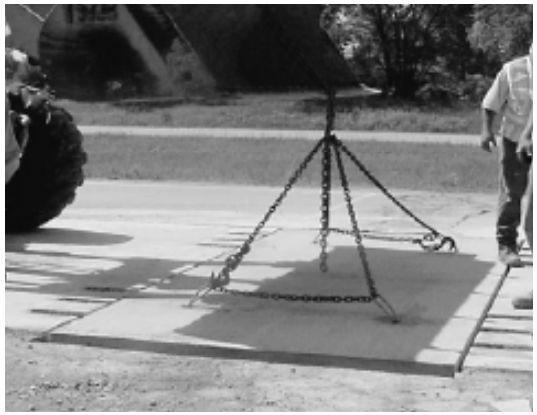
Precast Concrete Full Depth Repair

1. Precast PCC panel

2. Slab removal

3. Dowel slots

4. Flowable fill



5. PCC panel Installation

6. Finishing

Summary

- Pavement condition evaluation
  - Visual survey - identify concrete pavement surface conditions and select further NDT testing areas
  - GPR - analyze images of the base conditions and DC values for voids and underlying water
  - FWD - evaluate structural conditions of system, LTE of joint/crack, and loss of support below the slab
  - DCP - evaluate the in situ strength of base and subgrade soils
- Step by step repair method decision process
  - Simple decision tree by criteria based on visual survey and NDT information

Summary (cont.)

- Routine maintenance stages
  - Preservative maintenance - minor treatment to keep away from possible moisture damage

  ⇨ Reseal joint and cracks, Retrofit edge drains

  - Functional CPR - fix localized distresses or overall riding quality

  ⇨ Partial depth repair, Diamond grinding, Thin AC overlay

  - Structural CPR - eliminate the cause of structural distresses and restore structural capacity

  ⇨ Retrofit load transfer, Cross stitching, Slab undersealing

  - Remove and replace - early strength concrete or precast concrete panel are highly recommended

  ⇨ Full depth repair

Questions ?