Technical Report Documentation Page

1. Report No. FHWA/TX-08/0-5444-1	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Interim Repair Guidelines for Longitudinal Cracking and Joint Separations		5. Report Date September 2007 6. Performing Organization Code
7. Author(s) Moon Won, David Fowler, David Whitney, Taylor Crawford, Megan Stringer		8. Performing Organization Report No. 0-5444-1
9. Performing Organization Name and Address Center for Transportation Research The University of Texas at Austin 3208 Red River, Suite 200 Austin, TX 78705-2650		10. Work Unit No. (TRAIS) 11. Contract or Grant No. 0-5444
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Implementation Office P.O. Box 5080 Austin, TX 78763-5080		13. Type of Report and Period Covered Technical Report 9/1/2005-9/30/2005 14. Sponsoring Agency Code
15. Supplementary Notes Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration. Project Title: Rehabilitation Procedures for Longitudinal Cracks and Joints Separation in Concrete Pavement		
16. Abstract Interim Repair Guidelines for Longitudinal Cracking and Joint Separations		
17. Key Words Longitudinal Cracks, Joint Separation	18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161; www.ntis.gov	

19. Security Classif. (of report)	20. Security Classif. (of this page)	21. No. of pages	22. Price
Unclassified	Unclassified	18	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Interim Repair Guidelines for Longitudinal Cracking and Joint Separations

Moon Won
David Fowler
David Whitney
Taylor Crawford
Megan Stringer

CTR Technical Report:	0-5444-1
Report Date:	September 2007
Research Project:	0-5444
Research Project Title:	Rehabilitation Procedures for Longitudinal Cracks and Joints Separation in Concrete Pavement
Sponsoring Agency:	Texas Department of Transportation
Performing Agency:	Center for Transportation Research at The University of Texas at Austin

Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration.

Center for Transportation Research
The University of Texas at Austin
3208 Red River
Austin, TX 78705

www.utexas.edu/research/ctr

Disclaimers

Authors' Disclaimer: The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Federal Highway Administration or the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation.

Patent Disclaimer: There was no invention or discovery conceived or first actually reduced to practice in the course of or under this contract, including any art, method, process, machine manufacture, design or composition of matter, or any new useful improvement thereof, or any variety of plant, which is or may be patentable under the patent laws of the United States of America or any foreign country.

Engineering Disclaimer

NOT INTENDED FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES.

Project Engineer: Dr. David W. Fowler
Professional Engineer License Number: Texas No. 27859
P. E. Designation: Research Supervisor

Table of Contents

List of Figures

1. Interim Repair Guidelines

1.1 Approach in Deciding Repair Strategy

The Districts should monitor pavements carefully, taking note of visible longitudinal joint separations and longitudinal cracks. As soon as distress is identified, crack widths should be measured and dynamic cone penetrometer (DCP) evaluations of the base and sub grade should be performed. Catching distress symptoms earlier enables the engineer to select the least expensive strategies, while waiting until distress becomes critical typically leaves only the most expensive options.

Whenever most expensive solutions may be indicated, it would be beneficial to perform falling-weight deflectometer (FWD) tests on a representative sampling of locations, including the best and worst instances of distress. Whenever possible, FWD tests should be conducted at night or early in the morning to capture the worst possible load transfer performance. For similar reasons FWD readings in cooler months are also most advantageous. For separated longitudinal joints, FWD tests should also be performed on properly functioning joints for comparison.

1.1.1 Longitudinal Crack Repair

1.1.1.1 Longitudinal Cracking in CPCD:

- If crack width is greater than 1/4 in., and no faulting is present, check DCP values for the sub-grade, and, unless sub-grade modulus is below 5 ksi, prep and fill or seal crack.
- If crack width is greater than 1/4 in., and faulting is present or sub-grade modulus is below 5 ksi, perform slot stitching, and prep and fill the crack.
- If the crack width is less than 1/4 in., DCP testing of the base and sub-grade is required. (FWD could also be performed and load transfer efficiency (LTE) calculated.)
  - If sub-grade modulus is less than 5 ksi or LTE is less than or equal to 60%, slot stitching is required.
  - If sub-grade modulus is more than 15 ksi, only sealing the crack is required.
  - If sub-grade modulus is less than 15 ksi but more than 5 ksi, cross stitching is recommended.
- Before stitching longitudinal cracks, steps should be taken to ensure that the repairs do not cause cracking elsewhere in the pavement. The longitudinal warping joint should be cored in several locations to ascertain whether a crack is present beneath the saw cut. If the warping joint has cracked as intended, repairs should proceed. If no crack is present beneath the warping joint, the joint should be re-sawed to t/2 before proceeding with repairs.

1.1.1.2 Longitudinal Cracking in CRCP:

- Cracks should be sawed to at least 1 in. wide by 1 to 2 in. deep and filled with polymer concrete conforming to TxDOT DMS-6140 Type II polymer

concrete specifications. Surface preparation should conform to TxDOT Item 720.4.B.

1.1.2 Longitudinal Joint Repair

1.1.2.1 Longitudinal Joint Separations on CRCP and JCP:

- Where no faulting is present
  - If the sub-grade modulus is below 5 ksi (or LTE is less than or equal to 60%) and the joint is more than 1/4 inch wide, slot stitch and seal joint.
  - If the sub-grade modulus is above 15 ksi and the joint is more than 1/4 inch wide slot stitch (or staple where horizontal cracking or delams are present) and seal joint.
  - If the sub-grade modulus is above 15 ksi and the joint is less than ¼ inch wide cross stitch and seal joint.
  - If the sub-grade modulus is below 5 ksi and the joint is less than ¼ inch wide cross stitch and seal joint.
- When faulting is present
  - Pump with low pressure a cementitious grout under slab to restore desired grade. Then slot stitch and seal joint.

Or

  - Slot stitch and seal joint. Level up surface with micro-surfacing or multiple-lift polymer overlay. Diamond grinding a taper for the matching edge of adjacent, high slabs to match depressed slab edge is also possible.

1.1.3 Repair Details

1.1.3.1 Cross Stitching

- Stitch bars should be epoxy coated, #6 to #8 Grade 60 deformed bars.
- Bar size and spacing should provide at least 0.2 sq. in. of stitch bar cross sectional area per lineal foot of crack or joint[1].
- Minimum bar spacing is to be 24 in. (ACPA 2001).
- Minimum distance between stitch bar and transverse slab edge should equal 24 in. (ACPA 2001).
- Stitch bar holes are to be drilled at least 7 in. from longitudinal joint or crack.
- The drilling angle should be chosen such that the stitch bar crosses the joint or crack at mid-slab (tolerance is plus or minus 1 in.).
- A length of bar must be chosen to produce 1 in. recess between the top of the bar and the pavement surface. Recess is to be filled with rapid setting epoxy.

[1] Bar size and spacing subject to revision after field monitoring of tie bars is complete.

- Holes are to be filled with anchor bolt epoxy to meet the requirements of TxDOT DMS-6100 Type III Class A Adhesive. A dispenser nozzle capable of reaching the end of the drilled hole shall be used.
- The crack is to be saw cut to a width of at least 1 in. and a depth of 1 to 2 in. Joints are to be saw cut to a width such that fresh surfaces are exposed on each face of the joint. Depth of saw cuts must be chosen to provide a slot width to depth ratio between 1:1 and 1:2. The crack or joint is to be filled with polymer concrete conforming to TxDOT DMS-6140 Type I Elastomeric Concrete. Crack or joint surface preparation to conform to TxDOT Item 720.4.B.

1.1.3.2 Slot Stitching

- Stitch bars should be uncoated #8 to #12 Grade 60 deformed bars 48 in. long.
- Bar size and spacing are to provide at least 0.39 sq. in. of stitch bar cross sectional area per lineal foot of crack or joint. Spacing recommendations will be revised after the completion of field testing to determine the forces present in tie bars.
- Minimum bar spacing should equal 24 in. (ACPA 2001).
- Minimum distance between stitch bar and transverse slab edge should equal 30 in. (ACPA 2001).
- Bar length should equal 48 in. (similar to the required 50 in. length for tie bars in new pavement).
- Repair material used to fill slots must be a low shrinkage, fast setting rigid repair grout that conforms to the requirements in Appendix L.
- Joint or crack sealing procedures to follow the guidelines in the previous section for cross stitching.
- Stainless steel stitch bars may be used instead of uncoated (black) steel. If chosen, silicone or hot pour sealant conforming to TxDOT Detail JS 94 may be used.

1. Adhere to policy of regular pavement inspections (two-year intervals).
2. Investigate any reports indicating cracking or joint separations.
3. Look for faulting and determine crack/joint widths.
4. Perform full-depth DCP (TxDOT's Tex-132-E) tests (anvil resting on riding surface) on any sections showing distress to determine if sub-grade modulus is high (above 15 ksi) or low (below 5 ksi).
5. Follow recommended procedures (specifications attached) as indicated for the following distress determinations.

Longitudinal Cracking- Observations and Repair Recommendations

FIELD OBSERVATIONS			RECOMMENDED PROCEDURES
faulting?	crack width	DCP indications	
no faulting	tight crack(less than 1/4 in.)	high-modulus subgrade-	No repair needed, but monitor closely for changes in all future pavement inspections.
		low-modulus subgrade-	1. Cross stitch (specification). 2. Clean and fill open top of crack (specification).
	wide crack (more than 1/4 in .)	high-modulus subgrade-	1. No stitching, or cross stitch (specification). 2. Clean and fill open crack (specification).
		low-modulus subgrade-	1. Slot stitch (specification). 2. Clean and fill open crack (specification).
faulting (less than 3/16 in.)	tight crack (less than 1/4 in.)	high-modulus subgrade-	1. Cross stitch (specification), 2. Clean and fill open crack (specification) 3. Diamond grind (specification) where needed.
		low-modulus subgrade-	1. Slot stitch (specification), 2. Clean and fill open crack (specification) 3. Diamond grind (specification) where needed.
	wide crack (more than 1/4 in.)	high-modulus subgrade-	1. Slot stitch (specification). 2. Clean and fill open crack (specification). 3. Level up with polymer multiple-lift overlay (specification).
		low-modulus subgrade-	1. Clean and fill open crack (specification). 2.. Slot stitch (specification), 3. Level up with multiple-lift polymer concrete overlay (specification) or latex modified rapid-set overlay system (specification).
deep faulting (more than 3/16 in.)		- any subgrade -	**Initiate forensic investigation before attempting any repair strategy.**
spalled cracks (2 inches or wider)		- any subgrade-	1. Clean and prepare spalled areas (specification), 2. Prime as needed (per manufacturer's recommendation), and 3. Place preapproved elastomeric spall repair material (DMS specifications).
shattered slab (slab broken into more than four large pieces)			1. Remove shattered slab (specification), 2. Restore disturbed base with asphalt base (specification), 3. Side drill adjacent slabs for tiebars (specification), 4. Epoxy grout tie bars into place (specification), and 5. Cast full depth slab (specification).

Figure 1.1 Longitudinal Cracking

1. Adhere to policy of regular pavement inspections (two-year intervals).

2. Investigate any reports indicating cracking or joint separations.

3. Look for faulting and determine crack/joint widths.

4. Perform full-depth DCP (TxDOT's Tex-132-E) tests (anvil resting on riding surface) on any sections showing distress to determine if sub-grade modulus is high (above 15 ksi) or low (below 5 ksi).

5. Follow recommended procedures (specifications attached) as indicated for the following distress determinations.

Longitudinal Joint Separations- Observations and Repair Recommendations

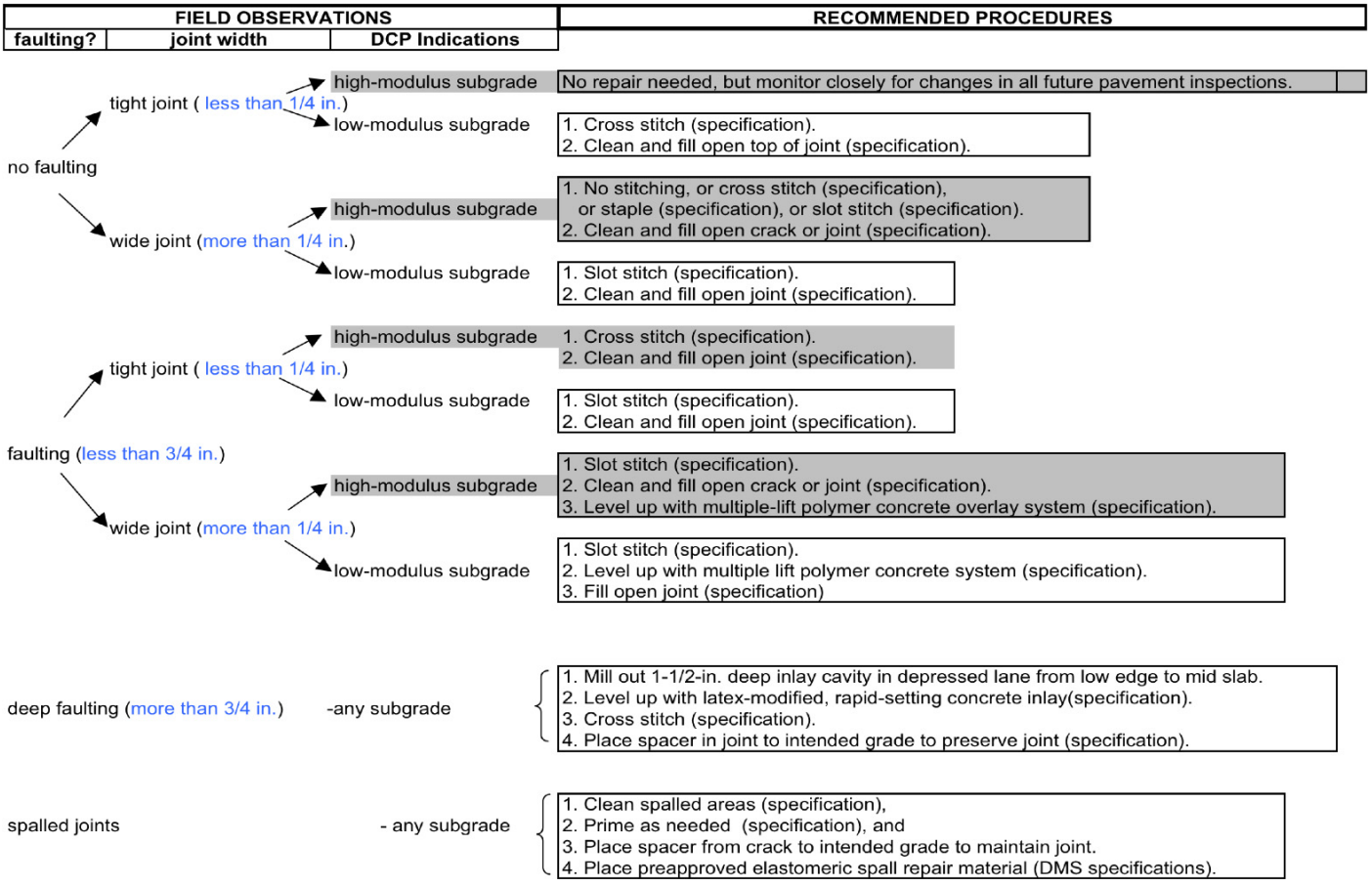

Figure 1.2 Longitudinal Joint Separations

2. Guidelines for New Construction

2.1 Multi-Piece Tie Bars

a. The spacing for tie bars shall be in accordance with governing design standards.
b. The precise locations of tie bars should be clearly marked, on top of the subbase, with brightly colored paint.
c. Female tie bars should be placed as closely to the slip-form edge as possible, without protruding.
d. The holes in the female tie bars should be covered with a plastic cover to prevent fresh concrete from entering.
e. Once the slip form paver completes the pass, the excess concrete over the tips of female tie bars should be removed so that the plastic covers become clearly visible. Squirting water and subsequent removal of fresh concrete is acceptable as long as the water squirting does not cause too much concrete to be damaged.
f. Clean the removed concrete from the subbase.
g. Once the concrete has sufficiently hardened, install male pieces of tie bars by screwing them into the female pieces with sufficient force.
h. Make sure that the other ends of male piece tie bars are within 1 inch vertically from mid-depth of the slab.

2.2 Single-Piece Tie Bars

a. The spacing for tie bars shall be in accordance with governing design standards.
b. The precise locations of tie bars should be clearly marked on top of the subbase with brightly colored paint.
c. When the slip-form paving is utilized, insert the tie bars as soon as the slip-form paver completes the pass.
d. While inserting tie bars, avoid excessive vibration or movements of the inserter to minimize the edge slump of the concrete.
e. Cover the exposed tie bars with appropriate materials, such as plastic tubes, completely before the curing operation is applied.