TECHBRIEF

Portland Cement Concrete (PCC) Partial-Depth Spall Repair

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Background

Spalling—cracking, breaking, chipping, or fraying of concrete slab edges at joints and cracks—is a common distress in jointed concrete pavements. Spalling reduces pavement serviceability, and if left unrepaired, it can become hazardous to highway users.

Spalling is caused by high-compressive stresses that develop in the concrete when joints or cracks cannot properly close because incompressible materials are present.The depth of spalling in a concrete slab can vary from a few millimeters to the full depth of the slab. Once begun, spalls tend to grow or propagate under repeated thermal stresses and traffic loadings.

Most spalls are treated before they extend below the top third of the slab. Repairs of this nature are commonly referred to as "partial depth." Highway maintenance crews spend a large amount of time and money each year repairing partial-depth spalls, for both temporary and permanent fixes.

To examine the merits and deficiencies of current spall repair materials and practices, the Strategic Highway Research Program (SHRP) and the Federal Highway Administration (FHWA) sponsored one of the most extensive partial-depth patching investigations ever undertaken.

Objectives

The primary aim of the partial-depth spall repair study was to determine the most effective and economical materials and procedures for placing quality, long-lasting partial-depth patches in jointed concrete pavements. A secondary objective of the study was to identify any performance-related material tests that would enhance the material selection process and provide a better guarantee of patch performance.

Key Benefits of This Research

The benefits of this study include service life estimates for various spall repair materials and procedures, more cost-effective maintenance operations, less exposure of highway workers to traffic, and fewer maintenance delays for the traveling public.

The FHWA Pavement Technology Program is a comprehensive and focused set of coordinated activities. These activities are grouped under five major areas—Asphalt; Portland Cement; Pavement Design and Management; Advanced Research; and Long-Term Pavement Performance. The goal of the program is the development, delivery, and utilization of a broad spectrum of improved technologies that will lead to better-performing and more cost-effective pavements. The program is product and end-result oriented with the intent of significantly advancing and improving pavement technology and pavement performance.

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Experiment Design

Beginning in March 1991, more than 1,600 partial-depth patches were placed in four moderate- to high-volume four-lane highways:

- PA 28—Kittanning, Pennsylvania
  Wet-freeze region
- I-15—Ogden, Utah
  Dry-freeze region
- I-20—Columbia, South Carolina
  Wet-nonfreeze region
- I-17—Phoenix, Arizona
  Dry-nonfreeze region

Eleven materials were used with five different repair procedures. For each combination of material and procedure at a location, 20 to 30 patches were placed (see Table 1).

Most of the procedures were performed under normal conditions. However, spalls must sometimes be patched under adverse conditions. To determine whether a cost-effective material could be found for this situation, three materials were tested under adverse conditions using the clean-and-patch procedure. Adverse conditions were defined as an ambient air temperature below 4°C at the time of patching and a substrate that is surface saturated.

Evaluations

Once the experimental patches were placed, they were monitored for performance through onsite visual evaluations. At each site, an immediate inspection was performed to record the development of drying shrinkage cracks and any construction-related failures. Additional evaluations were then conducted at approximately 1, 3, 6, 12, and 18 months following the date of installation. Thereafter, annual evaluations were performed between the fall of 1993 and spring of 1998. These evaluations mainly entailed a visual examination of the patches to determine if failure had occurred and, if not, to record the type, severity, and density of various patch distresses.

For cementitious and polymer patches, the distresses and conditions observed included spalling, cracking, wearing, oxidizing, edge fraying, patch-adjacent deterioration, pavement corner cracking, joint sealant condition, faulting, and patch debonding. For bituminous patches, distresses and conditions observed included dishing, raveling, and shoving.

Each repair was evaluated for the various distresses (spalling, cracking, faulting, etc.). The areas, lengths, severity, and other characteristics of the distresses were measured and recorded on a form. This procedure varied somewhat depending on what the distress was. For example, the procedure for evaluating cracking was different from that for evaluating joint sealant condition.

Key Findings

- Table 1 contains a summary of repair survival ratios after the final site inspections. In general, 3 of the 4 sites experienced very good performance of all repair types, with 88 percent survival at the Arizona test site, 90 percent at the South Carolina site, and 91 percent at the Utah site. The 61 percent survival at the Pennsylvania test site appeared to be related to the condition of the overall pavement, which was poorer than conditions at the other three sites.
- The distresses most often observed during the field inspections of the spall repair test sites consisted of cracking of the patches and delamination of the rigid and two-part epoxy repairs from the underlying PCC material. Deterioration of repair edges, aging, and raveling of material, cracking, and loss of material pieces were the predominant distresses observed for the bituminous repairs. In many instances, the distresses developed during the first year after placement and worsened over time as climate and traffic continued to wear on the repairs.
- Annual cost figures for each site were primarily a factor of the initial material and installation cost.
- In all 28 situations where a repair material was placed using both the saw-and-patch and the chip-and-patch procedures, annual costs for the chip-and-patch repairs were lower than for the saw-and-patch repairs. This was the result of similar performance characteristics observed for all of the repairs placed and the lower installation costs associated with the chip-and-patch procedure.
- Type III PCC performed as well or better than other more expensive rigid repairs at all sites.
- The waterblast-and-patch procedures provided good results when the equipment was operating properly and by personnel

familiar with its use. The same level of good performance could not be expected for a maintenance crew first using the device.

Recommendations

- The needed duration of repair survival should be factored into decisions on which material and methods should be used. For situations where only 2 to 3 years of performance are needed because of impending overlay or rehabilitation plans, different repair types will be dictated than in situations where repairs are expected to last 10 to 12 years.

- Based on the cost-effectiveness of the different operations, the chip-and-patch procedure is recommended over the saw-and-patch procedure for the majority of the materials evaluated. The higher productivity and reduced equipment needs make the chip-and-patch procedure more desirable.

- Partial-depth spall repairs placed on both sides of existing pavement joints should have joints formed in the repair to match the underlying pavement. This is true even for flexible pavement repairs.

References

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Table 1. Summary of Repair Survival at Final Site Inspection

		Pennsylvania		Utah		South Carolina		Arizona	
Repair Material	Repair Method[1]	% Surviving at 87 Months	Observed Mean Patch Life (Months)	% Surviving at 86 Months	Observed Mean Patch Life (Months)	% Surviving at 68 Months	Observed Mean Patch Life (Months)	% Surviving at 51 Months	Observed Mean Patch Life (Months)
Type III PCC	Saw	68	71.2	100	86.0	100	68.0	100	51.0
	Chip	67	78.9	100	86.0	100	68.0	100	51.0
	Mill	85	77.6	-	-	-	-	-	-
	Waterblast	-	-	100	84.1	-	-	-	-
Duracel®	Saw	-	-	95	85.2	100	68.0	95	50.4
	Chip	-	-	84	81.8	90	62.8	95	50.4
Set-45®	Saw	80	83.0	100	86.0	85	60.8	80	43.1
	Chip	65	63.7	100	86.0	90	64.2	95	50.4
	Mill	85	83.5	-	-	-	-	-	-
Five Star® HP	Saw	70	73.7	100	86.0	100	68.0	95	51.0
	Chip	80	77.8	100	86.0	100	68.0	100	51.0
	Mill	70	70.9	-	-	-	-	-	-
MC-64	Saw	80	78.0	100	86.0	100	68.0	100	51.0
	Chip	35	58.0	100	86.0	90	64.8	100	51.0
	Mill	-	-	-	-	-	-	100	51.0
SilkaPronto® 11	Saw	81	82.8	100	86.0	85	61.3	100	51.0
	Chip	35	64.5	100	86.0	80	60.1	100	51.0
Percol FL	Saw	95	86.3	100	86.0	100	68.0	50	32.0
	Chip	95	86.3	100	86.0	70	50.3	90	49.7
	Mill	60	73.3	-	-	-	-	80	44.8
	Clean	60*	70.1	-	-	-	-	-	-
Pyrament® 505	Saw	89	78.2	-	-	-	-	-	-
	Chip	50	67.2	-	-	-	-	-	-
	Mill	-	-	-	-	-	-	100	51.0
	Clean	33*	52.2	-	-	-	-	-	-
UPM Cold Mix	Chip	0	38.0	0	47.0	65	62.3	30	42.2
	Clean	5*	42.4	-	-	-	-	-	-
Penatron®	Saw	-	-	-	-	-	-	65	43.2
Spray-injection	Chip	10	55.2	-	-	90	65.3	-	-

[1] Five repair methods were used: saw = saw and patch; chip = chip and patch; mill = mill and patch; waterblast = waterblast and patch; clean = clean and patch under adverse conditions.

*Observed for 91 months.

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Availability: The publication from which this TechBrief was developed—"LTPP Pavement Maintenance Materials: SHRP PCC Partial-Depth Spall Repair Experiment, Final Report" (Report no. FHWA-RD-99-153, October 1999)— is available from the National Technical Information Center, 5285 Port Royal Road, Springfield, VA 22161. A limited number of copies are available from the R&T Report Center, HRD-11, FHWA, 9701 Philadelphia Court, Unit Q, Lanham, MD 20706, Telephone: (301) 577-0818, Fax: (301) 577-1421.

Key Words: Chip-and-patch, cracking, faulting, edge fraying, joint sealant condition, mill-and-patch, oxidizing, partial-depth spall repair, patch-adjacent deterioration, patch debonding, pavement corner cracking, saw-and-patch, spalling, waterblast-and-patch, wearing.

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