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UNIFIED FACILITIES CRITERIA (UFC)

CONCRETE CRACK AND PARTIAL-DEPTH SPALL REPAIR

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CONCRETE CRACK AND PARTIAL-DEPTH SPALL REPAIR

U.S. ARMY CORPS OF ENGINEERS (Preparing Activity)

NAVAL FACILITIES ENGINEERING COMMAND

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	**Date**	**Location**
1	16 May 2006	Revised Foreword

The format of this document does not conform to UFC 1-300-1; however, it will be reformatted at the next major revision.

FOREWORD

\1\
The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD(AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA.) Therefore, the acquisition team must ensure compliance with the more stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

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AUTHORIZED BY:

DONALD L. BASHAM, P.E.
Chief, Engineering and Construction
U.S. Army Corps of Engineers

DR. JAMES W WRIGHT, P.E.
Chief Engineer
Naval Facilities Engineering Command

KATHLEEN I. FERGUSON, P.E.
The Deputy Civil Engineer
DCS/Installations & Logistics
Department of the Air Force

Dr. GET W. MOY, P.E.
Director, Installations Requirements and
Management
Office of the Deputy Under Secretary of Defense
(Installations and Environment)

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Acknowledgment

This handbook was prepared by Mr. Richard E. Bradley, U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS, and is an update and revision of a version prepared by Dr. J. Kent Newman, U.S. Army Engineer Waterways Experiment Station. Funding for this project was provided by the Air Force Civil Engineer Support Agency (AFCESA/CESC), Tyndall Air Force Base, Florida, and the Naval Facilities Engineering Command (NAVFAC), Norfolk, VA. Monitor at AFCESA/CESC was Mr. Richard Smith, and monitors at NAVFAC were Messrs. Charlie Schiavino and Vince Donnally.

CHAPTER 1

INTRODUCTION

1.1. Preface. This handbook contains information on current practices (as of September 1998) for the repair of cracks and spalls in concrete pavements as well as on the selection of materials and equipment. This handbook is intended for use as a field handbook for airfield concrete pavement repair for all U.S. Navy, Army, and Air Force facilities; however, the techniques for repair can be used for other concrete pavements as well. References are provided for additional information on pavement repair practices not addressed in this manual. Tables 1.1. and 1.2. list applicable American Society of Testing and Materials (ASTM) specifications and American Concrete Institite (ACI) publications. **AF Records Disposition**. Ensure that all records created by this handbook are maintained and disposed of IAW AFMAN 37-139, "Records Disposition Schedule."

1.2. Safety Considerations. It is the responsibility of supervisory personnel to ensure worker safety by informing the workers of any potential hazardous practices. Occupational Safety and Health Administration (OSHA) guidelines must be followed at all times for hazardous practices such as sandblasting joints and cracks, airblasting for cleaning cracks, and working with chemicals. Workers are required to be informed of all hazardous materials and practices that may involve exposure to toxic materials in the workplace. Material Safety Data Sheets must be available to all wokers at the work site.

1.3. References.

1.3.1. Department of the Navy, Naval Facilities Engineering Command. "Concrete Pavement Repair Manual," MIL-HDBK-1102/7.2, Norfolk, Virginia.

1.3.2. Headquarters, Departments of the Army and Air Force. (1989). “Procedures for U.S. Army and U.S. Air Force Airfield Pavement Condition Surveys,” TM 5-826-6/AFM93-5, Washington, DC.

1.3.3. Department of the Navy, Naval Facilities Engineering Command. (1995). “Resealing of Joints in Rigid Pavement,” Guide Specification NFGS-02982, Norfolk, Virginia.

1.3.4. Air Force Civil Engineer Support Agency. (1994). “Silicone Joint Sealants for Pavements,” Engineering Technical Letter ETL 94-9, Tyndall Air Force Base, Florida.

1.3.5. Headquarters, Department of the Army. (1991). “Field Molded Sealants for Sealing Joints in Rigid Pavements,” Guide Specification for Military Construction CEGS-02760, Washington, DC.

1.3.6. Headquarters, Departments of the Army and Air Force. (1989). “Repair of Rigid Pavements Using Epoxy- Resin Grouts, Mortars, and Concrete,” TM 5-822-9/AFM 88-6, /Chapter 10, Washington, DC.

1.3.7. Evans, L. D., and Romine, A. R. (1993). “Materials and Procedures for the Rapid Repair of Joint Seals in Concrete Pavements,” SHRP-H-349, Strategic Highway Research Program, Transportation Research Board, Washington, DC.

1.3.8. Air Force Civil Engineer Support Agency. “Concrete Joint and Crack Repair,” Tyndall Air Force Base, Florida.

1.3.9. Air Force Civil Engineer Support Agency. “Concrete Repair Field Manual,” Tyndall Air Force Base, Florida.

1.3.10. Department of the Navy, Naval Facilities Engineering Command. (1995). “Patching of Rigid Pavement Partial Depth,” Guide Specification NFGS-02983, Norfolk, Virginia.

1.3.11. Headquarters, Department of the Army. (1989). “Patching of Rigid Pavements,” Guide Specification for Military Construction CEGS-02980, Washington, DC.

1.3.12. Evans, L. D. et al. (1993). “Materials and Procedures for Rapid Repair of Partial-Depth Spalls in Concrete Pavements,” SHRP-H-349, Strategic Highway Research Program, Transportation Research Board, WAshington, DC.

1.3.13. American Association of State Highway and Transportation Officals (AASHTO). (1991). “Burlap Cloth Made From AJute or Kenaf,” AASHTO M 182, Washington, DC.

1.3.14. U.S. Army Engineer Waterways Experiment Station. (1990). “Specification for Membrane-Forming Compounds for Curing Concrete,” CRD-C 300-90, Handbook for Concrete and Cement, Vicksburg, MS.

Table 1.1. American Society for Testing and Materials (ASTM) Specifications for Sealants, Joint Fillers, Patching Materials, etc.

Joint and Crack Repair	
ASTM C 603	(1990) Extrusion Rate and Application Life of Elastomeric Sealants
ASTM C 639	(1990) Rheological (Flow) Properties of Elastomeric Sealants
ASTM C 661	(1993) Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer
ASTM C 679	(1987; R 1992) Tack-Free Time of Elastomeric Sealants
ASTM C 719	(1993) Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement
ASTM C 792	(1993) Effects of Heat Aging on Weight Loss, Cracking, and Chalking of Elastomeric Joint Sealants
ASTM C 793	(1991) Effects of Accelerated Weathering on Elastomeric Joint Sealants
ASTM D 412	(1992) Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers - Tension
ASTM D 1751	(1983; R 1991) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)

Joint and Crack Repair	
ASTM D 1752	(1984; R 1992) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D 2628	(1991) Preformed Polychloroprene Elastomeric Joint Sealers for Concrete Pavements
ASTM D 2835	(1989; R 1993) Lubricant for Installation of Preformed Compression Seals on Concrete Pavements
ASTM D 3405	(1994) Joint Sealants, Hot-Applied, for Concrete and Asphalt Pavements
ASTM D 3406	(1995) Joint Sealant, Hot-Applied, Elastomeric-Type, for Portland Cement Concrete Pavements
ASTM D 3569	(1985, R 1991) Joint Sealant, Hot-Applied, Elastoimeric, Jet-Fuel-Resistant-Type for Portland Cement Concrete Pavements
ASTM D 5893	(1996) Cold-Applied, Single Component Chemically Curing Silicon Joint Sealant for Portland Cement Concrete Pavement
Spall Repair	
ASTM C 31	(1996) Making and Curing Concrete Test Specimens in the Field
ASTM C 33	(1993) Concrete Aggregates

Spall Repair	
ASTM C 39	(1993; Rev. A) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 94	(1994) Ready-Mixed Concrete
ASTM C 131	(1989) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(1996a) Sieve Analysis of Fine and Coarse Aggregate
ASTM C 143	(1990a) Slump of Hydraulic Cement Concrete
ASTM C 150	(1996) Portland Cement
ASTM C 171	(1995) Sheet Materials for Curing Concrete
ASTM C 173	(1994a) Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 231	(1991b; Rev. B) Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	(1994) Air-Entraining Admixtures for Concrete
ASTM C 309	(1993) Liquid-Membrane-Forming Compounds for Curing Concrete
ASTM C 494	(1992) Chemical Admixtures for Concrete
ASTM C 881	(1990) Epoxy-Resin-Base Bonding Systems for Concrete

Table 1.2. American Concrete Institute (ACI) Publications Pertaining to Spall Repair That Detail Good Practices for Concrete Repair Work

ACI 305R-88	Hot-Weather Concreting
ACI 306R-88	Cold-Weather Concreting
ACI 308-92	Standard Practice for Curing Concrete
ACI 548.1R	Guide for the Use of Polymers in Concrete

CHAPTER 2

SUMMARY OF CRACK REPAIR

2.1. Sealant Selection. Select the proper sealant material for the area being repaired (Chapter 6, “Crack Sealants”); however, the sealant selected must conform to appropriate specifications and be authorized by base engineers before use. Normally, it should match adjacent sealants. However, neoprene compression seals should not be used for cracks. The repair should be timed such that sawed-out cracks are not exposed for more than 24 hours before sealing. If the cracks get wet, the repair operation must stop until the cracks are completely dry. The cracks may be dried with a heat lance (Figure 9.3.).

2.2. Shape Factor and Recess. Saw or rout (Figures 9.1. and 9.2.) the crack to the proper width and depth to reach the desired shape factor and recess (Chapter 8, “Shape Factors”) recommended by the manufacturer of the sealant to be used. For silicone sealants, use of a backer rod in lieu of separating tape is recommended (Chapter 6, “Crack Sealants”). Small cracks may be sawed by hand (Figure 10.1.).

2.3. Sandblasting. Clean the crack faces by sandblasting using the multiple pass technique (Figure 10.3.). While standing to one side of the crack, pass the wand along the crack face at an angle to allow a strong blast on one crack face; then step to the other side of the crack and reverse direction.

2.4. Removing Loose Material. Blow debris out of the crack using compressed air; then clean the crack with high-pressure water (Figure 9.4.). There must be no loose material in the bottom of the crack.

2.5. Vacuuming. Clean the area around the crack with a broom or vacuum sweeper to prevent debris from reentering the crack before sealing (Figure 9.5.). Compressed air may be required to clean crack after the power broom is used.

2.6. Cleanliness. Remember that the cleanliness of both crack faces is extremely important! Dirty crack faces are a major cause of loss of adhesion of the sealant to the crack face and subsequent failure of the crack repair. Place the sealant within 24 hours after sandblasting. If sealant is not placed within 24 hours sandblast the face again, clean the crack with high-pressure water and air, sweep and vacuum the surface around the crack, and then seal. If a finger wiped along the joint face picks up dirt or dust, the joint or crack face is dirty and must be cleaned.

2.7. Backer Rod. Place the backer rod immediately prior to sealing the crack (Figure 9.6.). The backer rod must be at least 25 percent larger in diameter than the width of the crack and must be placed at the proper depth for the shape factor of the sealant being used (Figure 7.1.). Seal the crack from the bottom up and from beginning to end in one stroke without interruption, when practical (Figure 11.1.).

2.8. Foreign Object Damage. After the crack repair operation is complete, clean the surrounding pavement and sweep away all potential materials that may cause **F**oreign **O**bject **D**amage (FOD). Clean, lubricate, and properly store all equipment until the next repair operation.

CHAPTER 3

SUMMARY OF SPALL REPAIR

3.1. Selecting Repair Materials and Procedure. Refer to Figures 3.1. through 3.6. for details on spall repairs in various slab locations and spall repair boundaries. Refer to Table 3.1. for notes on Figures 3.1. through 3.6. Select the spall repair materials and the spall repair procedure (saw and patch is recommended). The recommended patch materials are discussed in Chapter 13; however, use of these materials (concrete, joint sealer, joint filler, etc.) must meet specifications and/or be authorized by base engineers. As with any repair operation, the cleanliness of the area to be patched is one of the most important factors in a long-lasting patch. Extra care must always be taken to ensure the repair area is clean before repair. The timing of the repair should be such that the prepared spall recess is not exposed to the elements for more than 24 hours without additional cleaning.

3.2. Removing Old Sealant. Remove any sealant present in the joint or crack adjacent to the spall as discussed in Chapters 5 and 9.

3.3. Boundaries. Cut a boundary around the area to a depth of at least 2 inches (50 millimeters) using a concrete or a hand saw (Figure 14.1.). The spall repair area should be sized as described in Chapter 12.

3.4. Concrete Removal. Remove the concrete inside the boundary to a depth of at least 2 inches (50 millimeters), or 1/2 inch (13 millimeters) into visually sound concrete, which ever is deeper. Use a light jackhammer (less than 30 pounds (14 kilograms)) equipped with a chipping hammer (Figure 14.2.), scarifier, or high-pressure water blaster (Figure 9.4.). If a dowel is exposed during the concrete removal, it must be replaced (References 1.3.1., 1.3.6., or 1.3.9. for details on dowel replacement). If more than 90 degrees of the perimeter of reinforcement is exposed, a space at least 1/2 inch (13 millimeters) completely around the bar or wire must be exposed.

3.5. Concrete Soundness. Visually check the underlying concrete for soundness and remove any concrete found to be unsound.

3.6. Cleaning. Clean out the spall recess using high-pressure water and compressed air.

3.7. Sweeping. Sweep the area to prevent debris from reentering the spall repair area.

3.8. Joint Filler. Install preformed joint filler to provide a rigid boundary next to the joint or crack and to retain the shape of the joint. This filler must extend the full length of the joint or crack for the full depth of the spall repair area.

3.9. Bonding Agent. If required for the repair material, apply bonding agent to the spall repair surface (Figure 16.1.). Always ensure that the spall repair is clean before adding bonding agents or any repair material. If the spall repair area is large and portland cement concrete (PCC) is the repair material to be used, be sure to place the grout rapidly so areas do not begin to dry prior to filling the area. Place the spall repair material (Figure 16.2.), finish the surface (Figure 16.3.), and follow the curing procedure recommended by the manufacturer of the repair material or refer to the guidelines outlined in Chapter 16, “Spall Repair Procedures.”

3.10. Sawing. Where the spalled area abuts a joint, an insert or other bond-breaking medium shall be used to prevent bond at the joint face. After the curing is complete, a reservoir for the joint sealant shall be sawed with a small-diameter saw blade to the dimensions required for other joints, or as required to be routed for cracks. Sandblast each face of the fresh sawcut, wash with high-pressure water, airblast, and sweep the area. Place the proper width backer rod at the required depth for the sealant. Place the sealant from the bottom up and in one smooth operation from the beginning to the end of the joint or crack.

3.11. Cleanup. After the spall operation is complete, clean and sweep the surrounding pavement of all potential materials that may cause FOD. In addition, clean, lubricate, and properly store all equipment until needed.

Figure 3.1. Plan of spall repairs (Notes for figures are found in Table 3.1.; notes 1 through 5 apply to this figure)

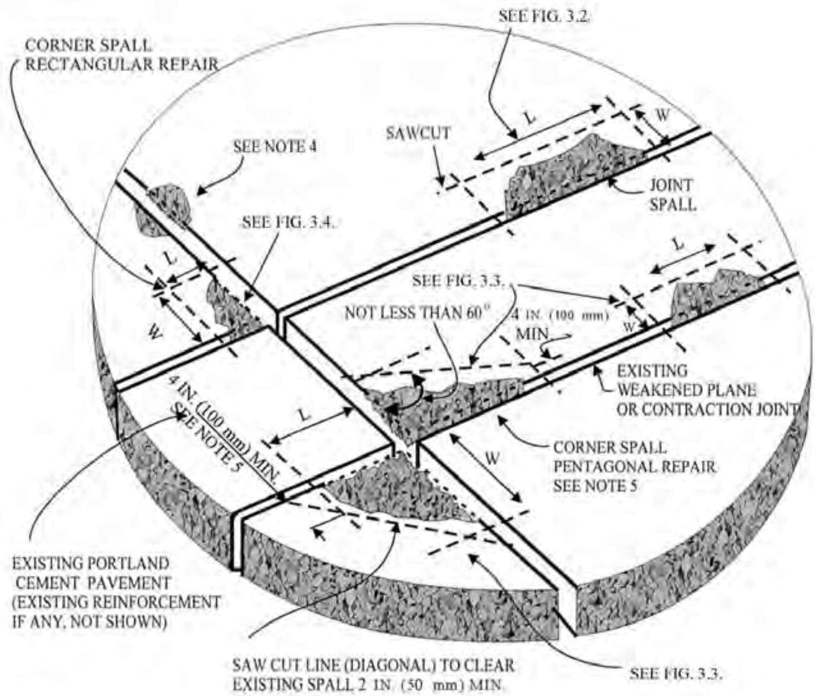


Figure 3.2. Spall repair at keyed construction joint

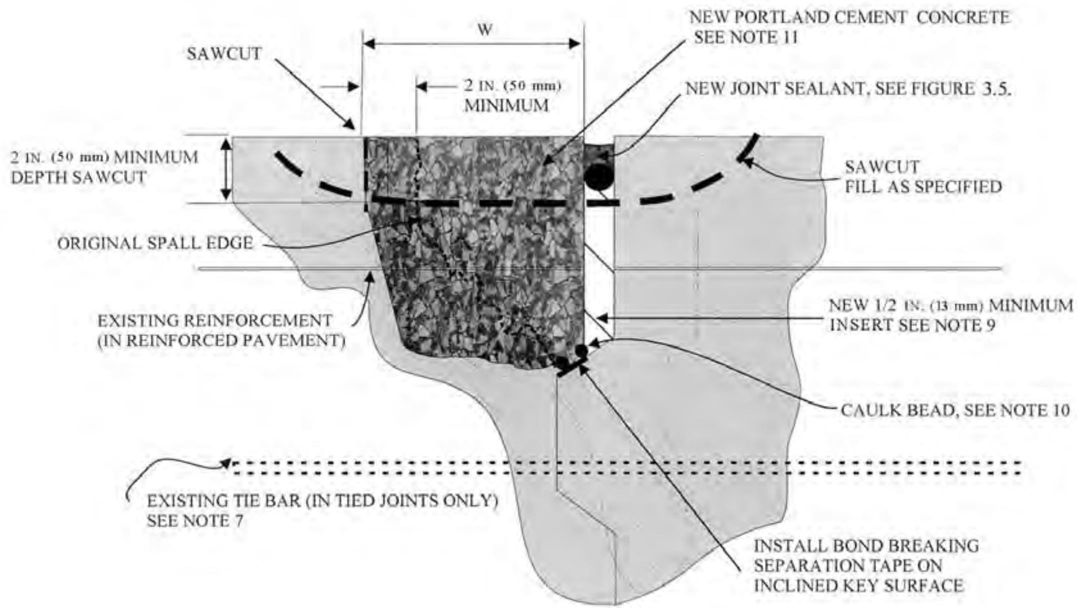


Figure 3.3. Spall repair at weakened plane or contraction joint

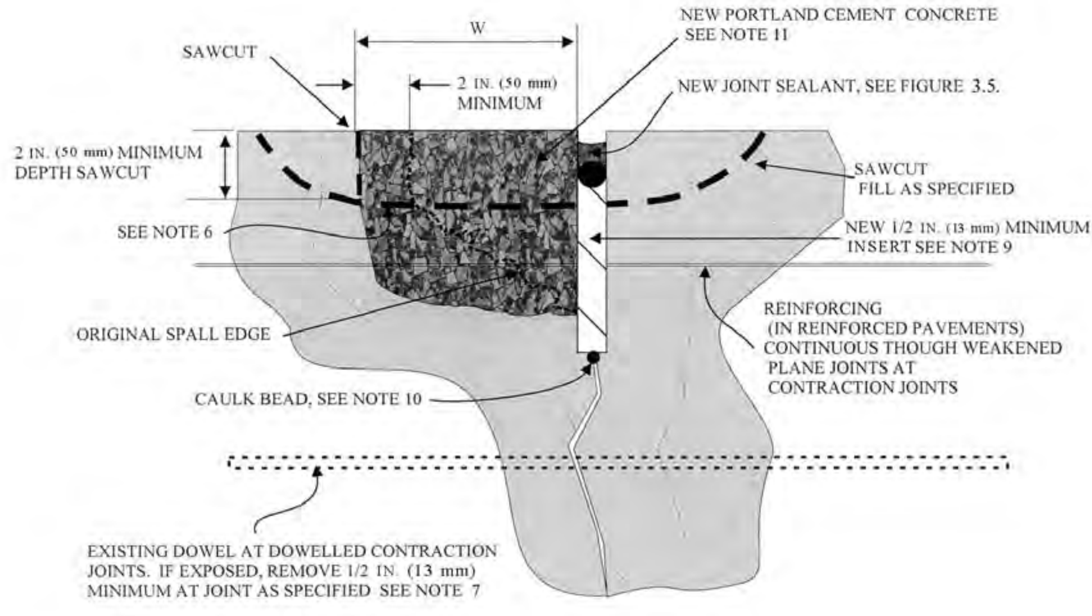


Figure 3.4. Spall repair at expansion joint

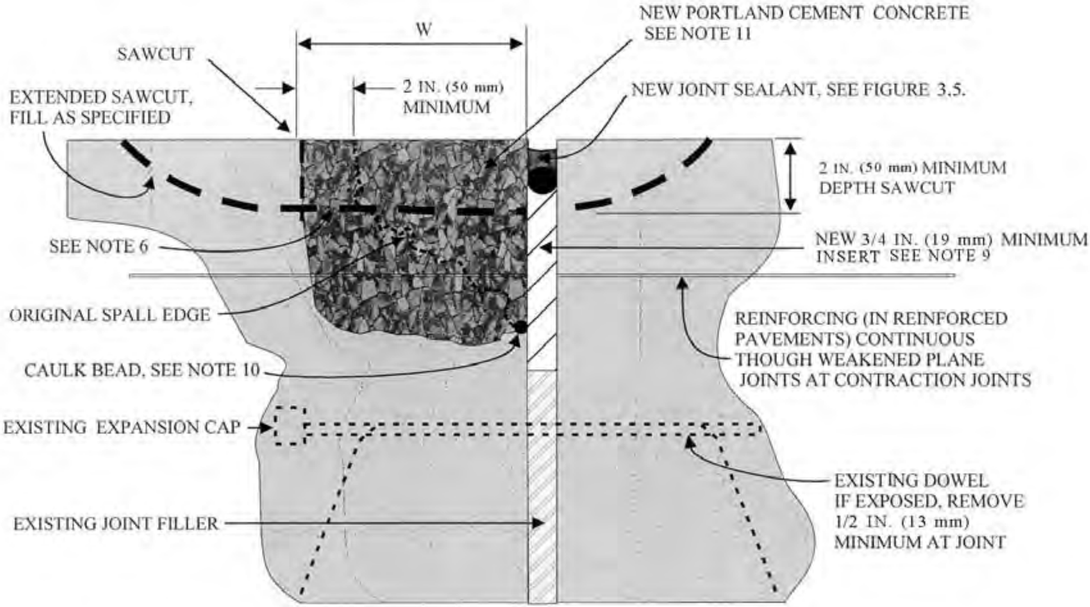


Figure 3.5. Groove for joint sealant at expansion joint

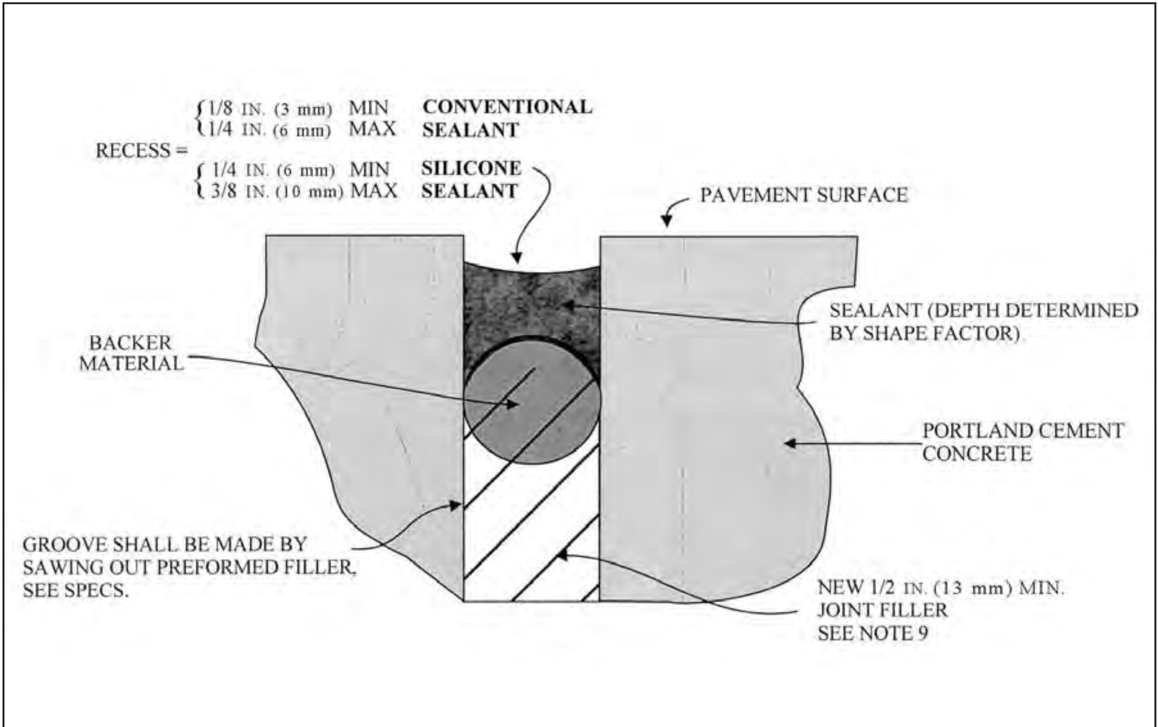


Figure 3.6. Typical section: popout repair

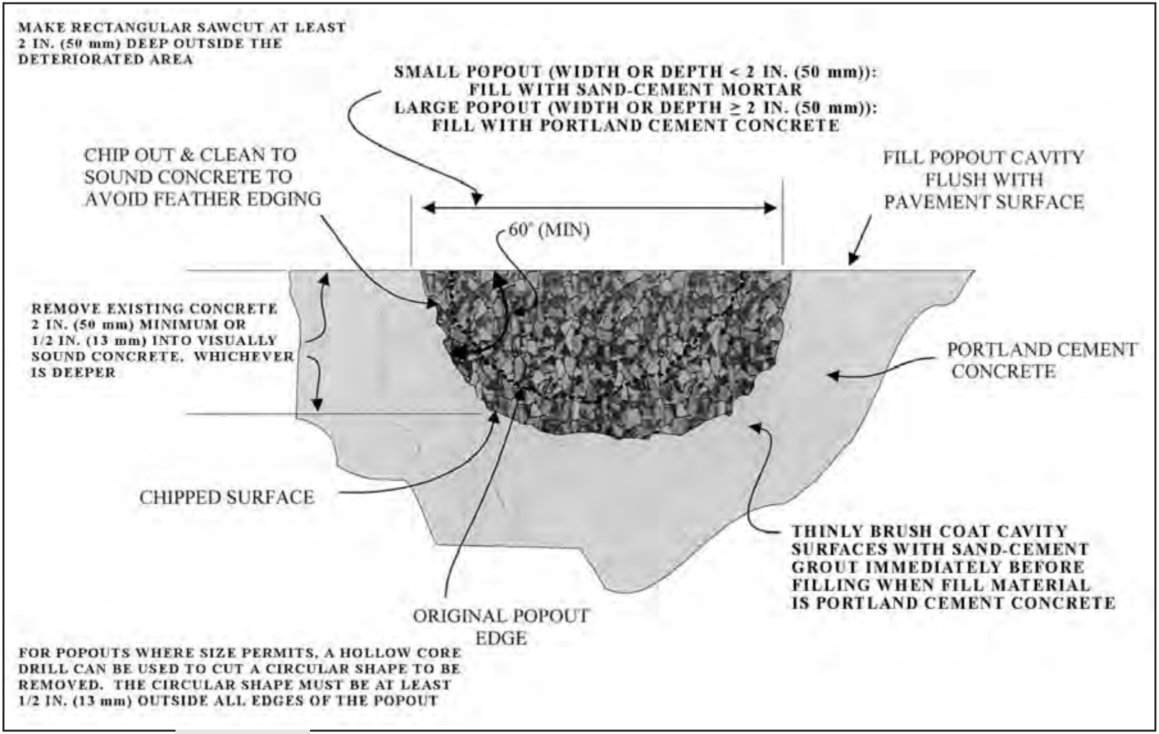


Table 3.1. Notes on Figures 3.1. to 3.6.

Note 1	Figures 3.1. to 3.6. are not drawn to scale. The minimum sides (both length (L) and width (W)) of a spall repair shall not be less than 6 in. (150 mm) for Army and Air Force pavements and 12 in. (300 mm) for Navy pavements, regardless of the spall size. The locations of the intended sawcuts should be clearly marked.
Note 2	Spalls occur in many sizes and shapes. Repair details shown are intended for removal and replacement of all deteriorated concrete and to maintain the size of the spall repair to the minimum practical to ensure a lasting repair while avoiding unecessary removal of sound concrete.
Note 3	For Navy pavement, joint spalls with actual cavity widths less than 2 in. (50 mm) shall be repaired by cleaning and filling with joint sealant in lieu of PCC.
Note 4	Where spall repairs are required on each side of a joint or crack, a nonflexible type filler or insert shall be secured in alignment with the joint or crack after breaking out the spalled concrete. Under no circumstances should a spall repair bridge a joint or crack.
Note 5	For corner spalls in Army and Air Force pavements, the repair shall be rectangularly shaped and the sawcut boundaries shall be no less than 6 in. (150 mm) from the joint corner. For triangular corner spalls in Navy pavements, the repair shall be made pentagonal to avoid feather-edged corners and to minimize the size of the repair area. The two sides of the repair area next to the joints should be a minimum of 12 in. (300 mm) in both length and width. Sawcuts shall be made at least 2 in. (50 mm) from each side of the spall and extending a minimum of 4 in. (100 mm) perpendicular to the

	joint. An additional sawcut is then made to intersect the two prevoius cuts at an approximately 60-deg angle with a minimum distance of 14 in. (360 mm). For corner spalls that are more rectangular in shape, a rectangular repair similar to that of a joint spall is conducted.
Note 6	Pavement and unsound concrete within sawcuts shall be broken out and removed to a depth not less than 2 in. (50 mm) or 1/2 in. (13 mm) into visually sound concrete, whichever is deeper. Exposed cavity surfaces shall be cleaned as specified.
Note 7	Dowels, tie-bars, or reinforcing bars, or WWF exposed for more than 90 deg of their circumference shall have the surrounding concrete completely removed to a depth of at least 1/2 in. (13 mm) below the bar or wire. See References a, f, and i.
Note 8	A groove may be sawed at existing joint lines to a point 1/2 in. (13 mm) below the prepared cavity surface to hold new bond-breaking medium in place during concrete placement.
Note 9	A bond-breaking medium is required to maintain existing joints and working cracks. Width of the medium shall be equal to the width of the existing gap at the joint or crack and should extend at least 1 in. (25 mm) on each side of the prepared cavity. Depth of the medium shall be not less than the depth of new patch materials. The medium should be neatly installed to prevent new grout or concrete from by-passing the medium and entering the joint space.

Note 10	For Navy pavements, a neat bead of caulk may be applied as indicated to prevent grout or concrete from by-passing filler and entering the joint space. For keyed joints, an additional bead of caulk may be necessary to prevent grout or concrete from entering keyed joint.
Note 11	Repair personnel should apply and scrub cement grout bonding course on all exposed cavity surfaces except faces of joints and working cracks. The cavity should be filled with concrete flush with the pavement surface. Sand-cement grout bonding is not to be used when a particular type of bonding agent is specified for a manufacturer’s material (for example, an epoxy bonding agent for an epoxy concrete).

CHAPTER 4

PURPOSE OF CRACK AND SPALL REPAIR

4.1. Description. The primary purpose of sealing cracks and repairing spalls in Portland Cement Concrete pavements on airfields is to reduce the costs associated with aircraft damage due to FOD and to prolong the service life of the pavement to reduce the life-cycle costs for the pavement structure. A considerable investment has been made in the construction of a concrete surface and the vehicles that use these surfaces; therefore, costs decrease dramatically for every additional year of pavement use that does not cause vehicle damage or require repeated patching or full slab replacement. Routine periodic inspections and rapid repair of pavement problems are essential for reducing life-cycle costs (References 1.3.1. and 1.3.2.). A properly constructed and maintained pavement can last for many years.

4.2. Spalls. Spalling is generally caused by incompressible materials present in the joints and cracks that prevent the necessary movement of the slab due to thermal fluctuations, thereby causing breaks in the concrete adjacent to the joint or crack. Spalls may also be caused by snowplows, over working, or popouts. Incompressible materials must be removed from the joint or crack, the spalled area patched, and the joint sealant replaced. Additional repairs of previous spall repairs due to failure of the material or poor repair practices are also common. If the spall depth is greater than the depth of half the slab, full-depth patching is needed. Full-depth patching will not be covered in this manual but is addressed in Reference 1.3.1. Cracking of slabs can be due to load-related failure or environmental stress on the slab.

4.3. Objective. The objective of crack sealing and spall repair is to reduce FOD and prevent moisture or incompressible material (rocks, sand, other pieces of concrete, etc.) from entering into the crack or joint. Unsealed cracks will allow moisture to penetrate under the slab causing an increase in the moisture content in the base and subbase. As thermal cycling occurs and the joint or crack expands and contracts, incompressible material such as rocks, chunks of concrete, sand, or ice in the crack may cause stress to build in the slab. Such stress can result in more spalling or cracking and further damage to the slab, thereby increasing the potential for FOD.

4.4. Airfield Inspections. For airfields, inspections of the pavement surfaces receiving traffic should be conducted at least monthly to locate spalls or cracks that may cause FOD. Otherwise, routine field evaluations must be conducted at least biannually, once during the summer and once during the winter. Seasonal checks allow for evaluation of the material during the two extremes of stress on the pavement. Cracks and spalls should be located and inspected. If concrete has begun to break away from the crack or spalled area, the damaged area must be repaired.

4.5. Cracks. Cracks less than 3/16 inch (5 millimeters) wide with no spalling do not require sealing. Cracks 3/16 inch (5 millimeters) and larger and less than 2 inches (50 millimeters) must be sealed. Cracks larger than 2 inches (50 millimeters) require full-depth patching. Use of a backer rod is recommended for all crack repair. If spalling is present adjacent to a crack, the damaged area must be repaired by treating the crack the same as an expansion joint. The sealed crack protects the spall repaired area from damage that might result from movement of the slab along the crack faces.

4.6. Moderate-Severity Spalling. An example of moderate-severity spalling is shown in Figure 4.1. Spalls are present from the corner of the slab and along the face of the expansion joint. Missing chunks of concrete are visible with the potential for more pieces to become dislodged and cause FOD. All spalled areas with loose concrete should be repaired to reduce FOD potential.

Figure 4.1. Moderate-severity spalling along an expansion joint

CHAPTER 5

CRACK REPAIR

5.1. Description. The recommended method for preparing cracks with no raveling along the edges is to saw the crack with a small-diameter blade or route it to the proper depth and width for the particular sealant and use backer rods. Each face of the sawcut or routed crack must be sandblasted. The crack faces are then cleaned with high-pressure water and air and the area swept with a vacuum-broom to prevent the material from reentering the sawed crack. Small sections of repair are made at a time to prevent the sawed crack faces from being exposed to the elements for more than 24 hours. If the cracks are wet, they must be dried with a hot-air lance or high-pressure air compressor equipped with an operating water and oil separator before placing the sealant and backer rod. The sealant must conform to the applicable ASTM specifications and must be approved for use at a particular facility by the base engineer. The sealant is placed in the crack from the bottom up and in one smooth run from the beginning to the end of the crack. The crack must be filled to a depth of 1/8 to 1/4 inch (3 to 6 millimeters) for conventional sealant (Reference 1.3.3.) and 1/4 to 3/8 inch (6 to 9 millimeters) for silicone sealant below the surface of the pavement (Reference 1.3.4.).

5.2. Test Section. A test section of approximately 200 linear feet (61 meters) of cracks must be sealed and approved by the Contracting Officer before beginning the full crack sealing project. The same procedures and materials to be used in the full project must be used in the test section. Crack sawing or routing should be shown not to cause spalling. The crack faces must be clean before placement of any sealant. For two-component sealants, the correct mixing ratio must be verified to be within a specified tolerance according to the manufacturer's specifications for that particular sealant. If using hot-applied sealants, calibrated thermometers must be used to verify correct application temperatures. All equipment must be shown to be in good working condition and operating properly. Additional details on joint and crack repair are given in References 1.3.5. through 1.3.9.

CHAPTER 6

CRACK SEALANTS

6.1. Description. Concrete crack repair sealants are essentially the same as joint sealants and are designed to mitigate two problem areas, moisture intrusion into the pavement base and debris retention in the crack opening. The influx of moisture through a crack into the pavement base layer can seriously reduce the strength of the base and the ability to sustain a load. It can also erode underlying material and cause pumping. Debris retention is a particular problem due to thermal movement of the slab at the joint. If incompressible material is present in the joint and the slab expands due to thermal changes, spalling may result due to the inability of the stress to be relieved through movement of the slab at the crack.

6.2. Fuel and Blast Resistance. Additional considerations for the crack repair material are jet fuel and jet blast resistance. The crack to be repaired may be located in an area in which fuel or lubricating or hydraulic fluid spillage may occur or in an area subjected to high temperature from jet blast or exhaust from auxiliary power units. The repair material must conform to ASTM specifications designated for joint and crack sealants for use in these areas, as listed in Table 1.1. under "Joint and Crack Repair."

6.3. Navy Regulations. Naval regulations require that all materials used on U.S. Navy facilities must conform to NFGS-02982 (Reference 1.3.3.). The Navy recommends use of silicone sealants on all Naval facilities and as an alternative to materials meeting ASTM D 5893, if approved by the local base engineer. Silicone sealants may be used in place of neoprene sealants for new joints if cost becomes a major factor in placement of neoprene sealant (Refernces 1.3.3. and 1.3.4.).

6.4. U.S. Army and Air Force Regulations. Sealants used on U.S. Army and Air Force pavements must conform to the ASTM specifications listed in Table 1.1. under "Joint and Crack Repair." Neoprene compression seals are common on Air Force pavements.

CHAPTER 7

BACKER AND SEPARATING MATERIALS

7.1. Description. Backer material is placed in the sawed crack to minimize excess stress on the sealant material from improper shape factors and to prevent three-sided adhesion that would inhibit the ability of the sealant to expand and compress under thermal stress. Typically, backer materials are rod-shaped and are often referred to as "backer rod" (Figure 7.1.). The backer material must be chemically inert to prevent reaction with the sealant, flexible to conform to the shape of the crack path, nonabsorptive to prevent water retention, nonshrinkable, and compressible to allow for easy installation. Typical backer materials are polychloroprene, polystyrene, polyurethane, and polyethylene closed-cell forms. Paper, rope, or cord should not be used. The melting temperature of the backer material must be at least 25 degrees Fahrenheit (14 degrees Celsius) higher than the sealant application temperature to prevent damage during sealant placement. The uncompressed backer rod must have a diameter at least 25 percent larger than the sealant reservoir to ensure that it remains in position during the sealing operation. Backer rod is the recommended material for repairing cracks.

7.2. Separating Materials. Separating tape may be employed when the sealant reservoir dimensions correspond to that for the proper shape factor and the use of backer material would lead to an incorrect shape factor for that sealant material. Separating materials are usually a thin adhesive tape or a flexible plastic strip employed to prevent three-sided adhesion of the sealant. These materials must be flexible enough to deform with the sealant as the concrete expands and contracts. However, this repair method should only be used when the crack has been sawed to provide a reservoir of the proper depth.

Figure 7.1. Examples of various sizes of backer rod

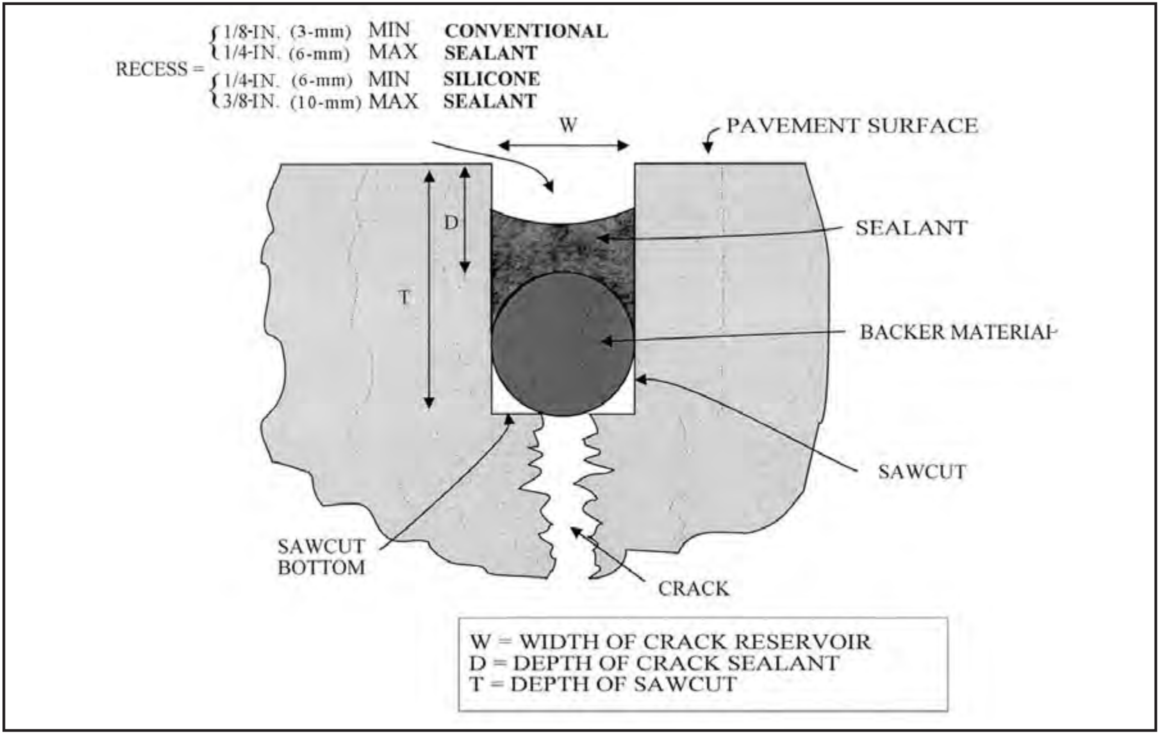
CHAPTER 8

SHAPE FACTORS

8.1. Description. For proper crack sealing, the crack must be routed or sawed to a designated width and depth for the particular type of sealant employed in the crack repair. The dimensions of a typical crack reservoir (Figure 8.1.) are defined by a shape factor (S = D/W) that is the ratio of the depth of the sealant (D) to its width (W). Shape factors generally range from 1.0 to 2.0; however, these dimensions may be particular for the type of sealant employed in the repair operation and a recommended value will be supplied by the sealant manufacturer.

8.2. Silicone Sealants. Silicone sealants require a shape of approximately 0.5 (Reference 1.3.3.). For example, if the width (W) of the sawed crack is 1/2 inch (13 millimeters), the depth of the sawed crack (T) must be 1-1/4 inches (30 millimeters) to accommodate a backer rod of 5/8 inch (16 millimeters). The top of the backer rod will be at 1/2 inch (13 millimeters) below the pavement surface. This allows for a depth (D) of 1/4 to 3/8 inch (6 to 9 millimeters) of silicone sealant on top of the crown of the backer rod to keep the sealant at 1/8 to 1/4 inch (3 to 6 millimeters) below the pavement surface.

Figure 8.1. Diagram of a properly repaired crack showing dimensions of a typical sealant reservoir



CHAPTER 9

CRACK REPAIR EQUIPMENT

9.1. Description. All equipment employed in the crack repair operation must be inspected before, during, and after the repair project to ensure proper operation of the equipment, safety of the personnel involved in the project, and potential damage to the pavement due to equipment problems. Proper safety procedures in accordance with OSHA guidelines and common sense practices must be followed for the protection of all project personnel. Hand tools should always be available for working in areas where machinery is not practical or allowed.

All sealant equipment must be equipped with nozzles designed to fill the cracks from the bottom up. The equipment must be inspected daily prior to application of the sealant and during the operation to ensure safe operation and that the sealant is being applied properly. If a two-component sealant is used, the metering ratio must be checked daily.

9.2. Random Crack Saw. Sawing is the preferred method for preparing cracks for sealing. This device is essentially a concrete saw but has a smaller rear-mounted blade approximately 5 inches (130 millimeters) in diameter (Figure 9.1.). These saws are generally self-propelled machines with caster wheels that allow more freedom of movement than an ordinary concrete saw for following the path of cracks. Diamond blades are typically employed and should be thick enough to saw the crack to the desired width and prevent warping of the blade during operation.

9.3. Vertical Spindle Router. Cracks may be routed out if a saw is not available. The vertical spindle router has a vertically mounted router bit and is constructed such that the device can caster and easily follow the contours of a crack (Figure 9.2.). The bit must be the proper size for the sealant reservoir and be belt-driven for safety considerations arising from jamming of the bit if the router is forced along the crack. The bits must yield the proper shape for the sealant reservoir and not cause spalling or ravelling along the crack path.

9.4. Sandblasting Equipment. The necessary sandblasting equipment includes an air compressor, air hose, and a 1/4-inch- (6-millimeter-) diameter venturi-type nozzle. The compressor must be capable of delivering 150-cubic feet/minute (4.25-cubic meters/minute) at 90 pounds/square inch (620 kPa) and be equipped with operating in-line traps to keep the air hoses and the sandblasted surface free of oil and water. This device must be capable of removing all sawed slurry, dirt, and old sealant that may be present in cracks that are being resealed. Ceramic and tungsten carbide nozzles are available for sandblasting, but the tungsten nozzles last longer. A guide that keeps the nozzle a constant height from the pavement surface promotes consistency to the sandblasting technique and reduces operator fatigue. The nozzle should have an adjustable guide that will hold the nozzle aligned with the joint approximately 1 inch (2.5 centimeters) above the pavement surface.

Safety must always be a primary concern. Sandblasting operators are required to follow OSHA guidelines. A helmet with a separate air source and air purification equipment reduces the possibility of inhalation of silica dust. Protective clothing may also be required.

9.5. Compressed Air Equipment. Compressed air can be employed for the final cleaning phase of the project. The air source must produce sufficient pressure and contain no oil that may foul the surface prior to sealing. Some compressors have in-line sources for the constant lubrication of air tools. These devices must be removed along with the oil-coated pressure hoses, and in-line oil and water traps must be installed to provide a clean air source for the airblasting operation.

9.6. Hot-Air Lance. A hot-air lance is sometimes employed to dry the surface of the pavement immediately prior to sealing (Figure 9.3.). Strict safety precautions that must be employed to reduce operator hazard may include protective clothing as well as eye and ear protection. The operator must take special precaution not to overheat the pavement which may cause cracks and chalking of the concrete surface. Direct flame devices must not be used.

9.7. Waterblasting Equipment. Waterblasting is an excellent technique for cleaning joint faces. This technique is sometimes employed as an alternative to sandblasting due to local air regulations or where the sand and debris might create additional problems. Waterblasting equipment should consist of a trailer-mounted water tank, pumps, high-pressure hoses, an auxiliary water supply, a wand with a safety cutoff if the operator should lose control, and a proper size nozzle for the crack width (Figure 9.4.). After waterblasting is completed, the entire joint must be dried.

9.8. Power Broom. A vacuum-type power broom should be present to remove debris from the pavement surface and reduce the potential for FOD (Figure 9.5.).

9.9. Backer Rod Installation Equipment. Backer rod may be placed by hand and many contractors have constructed their own hand-held equipment for this operation. However, there are manufacturers of installation equipment. These devices place the rod at a consistent depth without undue stretching or tearing of the backer materials (Figure 9.6.).

9.10. Hot-Applied Sealant Equipment. There are two basic types of hot-applied sealant equipment: one for heating sealants that are solids or liquids at room temperature and one for sealants that are liquids only. The former devices are much more prevalent. Both types must be capable of holding a sufficient amount of sealant and be able to heat the material to the proper controlled application temperature (usually between 325 degrees Fahrenheit (163 degrees Celsius) and 480 degrees Fahrenheit (249 degrees Celsius)) without overheating.

9.10.1. Solid. The equipment necessary for application of room-temperature solid sealants must consist of a double-wall-type kettle that is heated by a fluid between the walls of the chamber and a mechanical agitator to prevent localized overheating at the walls. Calibrated thermometers must be easily visible to allow constant monitoring of the sealant temperature to prevent the possibility of overheating. The sealant must be circulated through the delivery hose and back to the heating chamber when not being applied.

9.10.2. Liquid. The equipment employed to apply sealants that are liquids at room temperature does not maintain the sealant reservoir at the application temperature. The sealant is heated just prior to application by pumping through transfer lines immersed in an oil bath.

9.11. Cold-Applied Sealant Equipment. The necessary equipment for application of cold-applied sealants depends on whether the sealant is a single-component or a two-component mix and whether the material is hand-mixed or machine-mixed. Two-component machine mixers consist of an extrusion pump, air compressor, and the associated hoses to dispense the components through separate nozzles and mixed in a 50:50 ratio with less than ±5 percent error just prior to discharge from the nozzle. Hand-mixing equipment for two-component sealants is generally a slow-speed electric drill with a paddle mixer or an air-powered mixer. Single-component sealants should be mixed to overcome any segregation before they are applied to the pavement. Small hand-held caulking guns can also be employed for small jobs.

Figure 9.1. Random crack saw

Figure 9.2. Vertical spindle router

Figure 9.3. Hot-air lance

Figure 9.4. High-pressure water cleaning

Figure 9.5. Power broom

Figure 9.6. Installation of backer rod

CHAPTER 10

CRACK PREPARATION

10.1. Description. One essential element of the crack sealing operation is proper preparation of the crack and the crack face. If the prepared cracks are dirty or contain excess moisture, the sealant will not adhere to the surface and eventually will separate from the crack wall. The crack sealing operation must be scheduled such that the prepared cracks are sealed as soon as possible to prevent contamination before sealant application. If vegetation is growing in the cracks, they must be removed and a water-based herbicide must be used to kill the weeds. Oil-based herbicides can leave a residue that may prevent adhesion of the sealant to the crack face. The cracks must be routed or sawed out to the proper depth and width according to the shape factor previously listed or designated by the manufacturer’s recommendations for the particular sealant being employed (Figures 10.1. and 10.2.). After completion of the sawing operation, the crack face must be sandblasted to remove laitance, sawing debris, and other foreign material. Sandblasting must be conducted with a multiple-pass technique in which one side of the sawed crack face is abraded, followed by the other face (Figure 10.3.). The pavement surface directly adjacent to the sawed crack must also be blasted to remove any debris or material that may cause problems during crack sealing.

10.2. Cleaning. The importance of proper cleaning of the crack faces cannot be overemphasized. Surface dust, debris, and laitance remaining in the sawed crack can prevent adhesion of the crack sealant to the prepared face. The sandblasting operation must be followed by an initial cleaning with high-pressure air followed by high-pressure water to remove material remaining in the sawed cracks. This process must be repeated immediately prior to placing the sealant in the sawed reservoir if the sealant is not placed within a few hours of the cleaning. A power broom or hand broom must be used to remove sand and dust to prevent the sand and dust from reentering the crack (References 1.3.7. through 1.3.9.).

Figure 10.1. Hand sawing a crack

Figure 10.2. A freshly sawed crack

Figure 10.3. Sandblasting a joint face

CHAPTER 11

CRACK SEALING PROCEDURES

11.1. Description. The crack sealing operation should only be conducted when pavement temperatures are above 50 degrees Fahrenheit (10 degrees Celsius). Application temperatures for hot-applied crack sealants should constantly be monitored to ensure that they are in the correct range.

11.2. Preparation. Crack faces should be clean and free of moisture. If moisture is present, a hot-air lance or compressed air can be used to dry the crack face before sealing. The crack must be filled from the bottom up to prevent air from becoming trapped under the sealant and cause bubbling. The crack must also be filled from beginning to end in one smooth operation whenever practical (Figure 11.1.). For hot applied sealants, at the end of a day's work, the sealant remaining in the pot must be removed and discarded. Do not reheat and use.

Figure 11.1. Sealing a crack

CHAPTER 12

PARTIAL-DEPTH SPALL REPAIR

12.1. Description. The recommended method for partial depth spall repair is the saw and patch method. The joint or crack sealant adjacent to the spall area must be removed. A boundary surrounding the spalled area is sawed using a concrete saw. For Army and Air Force pavements, the minimum length and width of the rectangular sawcut boundary around a joint spall is 6 inches (150 millimeters), and for corner spalls, the rectangular sawcut boundaries should be no less than 6 inches (150 millimeters) from the joint corner. The minimum depth of the sawcut boundaries is 2 inches (50 millimeters). For Navy pavements, the minimum length and width of the rectangular sawcut boundary around a joint spall is 12 inches (300 millimeters). For corner spalls, the sawcuts should be no less than 12 inches (300 millimeters) from the joint corner and extend a minimum of 4 inches (100 millimeters) perpendicular to the joint. A third cut is then made between the two 4-inch (100-millimeter) cuts to form a pentagon with the joint corners and sawcuts comprising the five sides. The minimum depth the sawcut boundaries is 2 inches (50 millimeters). A light jackhammer (less than 30 pounds (14 kilograms)) equipped with a chipping hammer, scarifier, or high-pressure water blaster is then used to remove the concrete within the boundary to a depth of at least 2 inches (50 millimeters), or to 1/2 inch (12 millimeters) below the surface of visually sound concrete, whichever is deeper. If a dowel is exposed during the concrete removal, it must be replaced. Procedures for dowel replacement will not be covered here but may be found in References 1.3.1., 1.3.6., and 1.3.9. If more than 90 degrees of the perimeter of reinforcement is exposed, a space must be exposed completely around the bar or wire and at least 1/2 inch (12 millimeters) below it. A joint filler is used to maintain the existing joint or crack. Under no circumstances should the spall repair bridge the joint. If PCC is to be used in the spall repair, a bonding agent must be used to ensure a good bond between the old concrete and the patching material. Curing procedures for PCC must be strictly followed to prevent shrinkage cracking. Curing shall be by moist curing for at least 7 days followed by application of white-pigmented membrane-forming curing compound. The curing procedures for PCC shall be performed as follows:

12.1.1. Commence immediately after finishing is complete for each repair (patch).

12.1.2. Apply two layers of completely presaturated clean burlap conforming to AASHTO M182 (Reference 1.3.13.).

12.1.3. Resaturate (oversaturate) the burlap after placing and immediately cover with clear or white polyethylene sheeting at least 100 micrometers (4 mils) in thickness.

12.1.4. Cover with plywood at least 1/2 inch (12 millimeters) thick or wood form material and weight down sufficiently to prevent displacement by wind.

12.1.5. All covering materials, burlap, plastic, and wood shall extend at least 6 inches (150 millimeters) beyond every edge of the patch.

12.1.6. At least once every 24 hours, the plywood and plastic shall be removed, the burlap resaturated, and the plastic and plywood immediately replaced.

12.1.7. When moist curing operations are complete, remove the plastic sheet and the plywood between 20:00 and 24:00 hours in the evening. Between 3 and 7 hours later, remove the burlap and immediately apply a uniform coat of white-pigmented curing compound to the repair area. Curing compound shall conform to CRD-C300, and shall be applied at a coverage rate 200 square feet per gallon (4.9 square meters per liter).

12.1.8. Patches shall be protected from traffic for at least the following 7 days.

If proprietary concrete patching materials are to be used in the repair, be sure to follow the manufacturer's recommendations for bonding agents, mixing, placement, and curing. After the spall area has been filled, the joint or crack must be sealed.

12.2. Test Area. Before beginning a full-scale patching operation, a test area of spall repair must be conducted. This ensures familiarity with equipment and materials and any potential problems with techniques, etc., before beginning the full-scale repair operation. Additional information on spall repair is available in References 1.3.10. through 1.3.12. All applicable ASTM test methods are listed in Table 1.1. and information on concretes from the American Concrete Institute is listed in Table 1.2.

CHAPTER 13

SPALL REPAIR MATERIALS

13.1. Specifications. The particular repair materials chosen for the repair operation must conform to the appropriate specifications as discussed below. For Navy pavements, use of asphalt patching materials for temporary spall repair is allowed. The Army and Air Force do not allow the use of asphalt patching materials for spall repair. The concrete, curing compound (if used), sealant (see the section “Crack Sealants”), backer rod (see the section “Backer Materials”), and joint filler must meet ASTM specifications. For U.S. Army Corps of Engineers construction, the curing compound must conform to CRD-C300 (Reference 1.3.14.). Joint fillers can be asphalt- impregnated fiber-board, styrofoam sheeting, sponge rubber, or cork but must conform to ASTM D 1751 or D 1752. Recommended maximum aggregate size is 3/8 inch (10 millimeters). Type I concrete is the required patching material unless other materials are approved by the base engineer. Cementitious materials in the PCC shall be portland cement that conforms to ASTM C 150, Type I, unless other materials are approved by the base engineer. Type II cements are generally not necessary for repair projects. Type III cements can be employed when the repaired area must be opened to traffic within 1 to 3 days after placement of the PCC. The PCC should have a range of 0 to 1/2 inch (0 to 13 millimeters) of slump, and a throughly tamped in-place specimen must meet a minimum compressive strength of 5,000 pounds per square inch (35 megapascals) at 28 days of age. On U.S. Navy facilities, the materials chosen must meet all of the specifications outlined in NFGS-02983 (Reference 1.3.10.), and NFGS-02982 (Reference 1.3.3.). For U.S. Army and Air Force facilities, refer to CEGS-02980 (Reference 1.3.11.) and CEGS-02760 (Reference 1.3.5.). For U.S. Air Force pavements repair, see Reference 1.3.6. also. For filling popouts, operators should use a sand-cement mortar of one part cement to two parts sand. The water-to-cement ratio should not exceed 0.40 by weight.

13.2. Alternative Repair Materials. Spall repair materials can be classified into three broad categories: cementitious, polymeric, and bituminous. Only the cementitious or polymeric materials are approved for use on airfields. Bituminous materials must not be employed as a spall repair material on Army and Air Force airfields due to the potential for FOD. Typical concerns for selection of a spall repair material are cost, physical properties, curing time (how soon can the section be opened to traffic), material availability, familiarity with the product, etc. There are numerous products for concrete repair that address various aspects of the repair project such as high early-strengths, rapid set times, ease of workability, low shrinkage, and low permeability. However, since use of rapid-setting concretes and polymer concretes may require very different placement and curing procedures, personnel should be aware of what is required for the repair material before making a decision. Use of admixtures in PCC, rapid-setting, and polymer concretes must meet appropriate specifications (ASTM C 260 and C 494 (Table 1.1.). If using fast-setting polymer concretes or admixtures, the manufacturer's recommendations on the use and cleanup of these materials should be followed to avoid problems. Mixing procedures for the polymer concretes vary depending on the material. Concrete mixes may harden much faster when temperatures are above 90 degrees Fahrenheit (32 degrees Celsius). Retarding compounds can be added to the mixtures to slow the curing process at pavement temperatures above 90 degrees Fahrenheit (32 degrees Celsius), or special mixtures premixed with retarders that extend the setup time are also available. Due to the high heat released upon curing of many of the polymer materials, only 2-inches (50-millimeters) or smaller lifts are suggested. Cleanup of rapid-setting materials must begin soon after placement to prevent these materials from ruining equipment. Guidelines for use in placement of polymer concretes are provided in ACI 548.1R (Table 1.2.).

CHAPTER 14

SPALL REPAIR EQUIPMENT

14.1. Description. Much of the equipment necessary for spall repair has been previously described under "Crack Preparation." However, additional equipment such as concrete saws, jackhammers, mixers, small spud vibrators, tampers, and hand tools may also be necessary.

14.2. Concrete Saws. A conventional concrete saw is similiar to a random crack saw but generally is less maneuverable and has a larger blade (Figure 14.1.). Concrete saws are employed extensively for refacing joints for joint sealing projects but are often used for large patching operations or full-depth repair. Small blades of 6 to 10 inches (170 to 250 millimeters) should be used to minimize the size of the runout kerfs when sawing out the spall area. Larger blades may be necessary for refacing joints or cracks. Small patches can be sawed with a random crack or a hand-held saw.

14.3. Jackhammers. The jackhammer needed for large patching operations where full-depth repairs are needed may be a 30-pound (13.6-kilogram) model (Figure 14.2.); for smaller jobs, a 10- to 15-pound (4.6- to 6.8-kilogram) model is sufficient. The jackhammer must be equipped with a chipping hammer and worked at an angle of between 45 and 90 degrees relative to the pavement surface. Special care must be taken not to damage the layer of concrete under the spall repair area or cause microcracking around the crack.

14.4. Mixers. Drum or mortar mixers are usually employed for most patching operations. Buckets may be used with a hand-held, electric drill-powered (or pneumatic), paddle-wheel mixer for smaller operations.

14.5. Hand Tools. Hand tools such as shovels, trowels, tampers, and screeds must be available.

Figure 14.1. Sawing out the edges of a spalled area

Figure 14.2. Using a jackhammer to remove damaged concrete

CHAPTER 15

SPALL REPAIR PREPARATION

15.1. Description. As with most concrete repairs, an essential element of the spall repair operation is the proper preparation of the spalled area. If the prepared spalls are dirty or contain excess moisture, the repair material or bonding agent will not completely adhere to the surface. The spall repair operation must be scheduled such that the prepared areas are filled as soon as possible to prevent contamination of the surface. The importance of proper cleaning of the repair area cannot be overemphasized. After completion of the sawing and removal of the concrete, the recess must be cleaned by airblasting and waterblasting to remove concrete chips, laitance, sawing debris, and other foreign material from the recess. The area must then be thoroughly swept, using a vacuum broom if available, to prevent debris from reentering the spall repair area.

15.2. Detailed Schematics. Detailed schematics of spall repair for construction and keyed joints are presented in Figures 3.1. to 3.4. Figure 3.1. provides details for determining the boundary around the spall where the sawcuts should be located. Repair boundaries for corner spalls and joint spalls at both construction and keyed joints are shown. Closeup details for each of the types of spall repair located in various positions around a slab are given in Figures 3.2. to 3.4. Figure 3.5. shows details for joint sealant repair, and Figure 3.6. gives details for repair of popouts.

15.3. Boundaries. To begin the saw and patch procedures, mark the boundaries of the area to make the sawcuts easier and decide which repair material(s) are to be employed in the patching effort. Remove the joint or crack sealant a few inches on either side of the spall. The sawcuts must be at least 2 inches (50 millimeters) deep and 2 to 3 inches (50 to 80 millimeters) outside the boundary of the spall (Figure 3.2. and Figure 14.1.). For joint and crack spalls in Army, Air

Force, and Navy pavements and corner spalls in Army and Air Force pavements, the sawcuts should be straight and at right angles to each other with the cuts forming a rectangle with the joint or crack as one side. For corner spalls in Navy pavements, the initial cuts should be at least 4 inches (100 millimeters) long and perpendicular to the joint with the final cut joining the initial cuts to form a pentagon at the slab corner (Figure 3.2.). The jackhammer may then be used to remove the concrete to a depth of at least 2 inches (50 millimeters) from the surface or 1/2 inch (13 millimeters) into visually sound concrete, whichever is deeper, within the cut area by starting in the center of the spall and working toward the cuts (Figure 14.2.). If both sides of the joint or crack are spalled, the spall on each side of the joint must be repaired while maintaining the joint or crack. An example is shown in Figure 15.1. Joint filler is placed in the expansion joint, and the spalls on each side of the joint are repaired independently. See References 1.3.7. through 1.3.9. and 1.3.12. for additional details on joint sealant removal and repair.

15.4. Soundness. After the concrete in the area has been removed, it must be tested for soundness to ensure that there are no cracks in the underlying concrete or loose material present. This can be easily accomplished with a steel rod, a short length of chain, or a ball peen hammer. A dampened ring from the steel indicates a crack or loose material beneath the sounding device. If unsound concrete is located, it must be removed to a depth of at least 1/2 inch (13 millimeters) into sound concrete. A thorough cleaning of the repair area to remove debris must be conducted by compressed air and high-pressure water. A power broom, vacuum sweeper, or at least a thorough hand broom sweeping of the area must be conducted to prevent debris from reentering the repair zone.

Figure 15.1. A spalled area on both sides of an expansion joint ready for installation of joint filler

CHAPTER 16

SPALL REPAIR PROCEDURES

16.1. Description. The repair process begins after the final cleaning of the area. The area must be dry and free of dust, oil, dirt, etc. A good repair begins with a clean surface. Since the volume of most spall repairs is usually small, most mixing must be done in a small drum or mortar mixer. Some repair materials come premixed and others allow the mix to be extended by adding aggregate (maximum recommended size is 3/8 inch or 10 millimeters). The material must be consolidated through tamping, supplemented, when possible, by vibration, and the surface worked to match the surrounding finish as closely as possible.

16.2. Joint Filler. If the spalled area is adjacent to an expansion joint or a crack, a joint filler must be employed to prevent the repair material from fouling the joint (Figure 16.1.) and to retain the joint shape. If the spall is next to a crack, the crack must be treated as an expansion joint. Spall repairs must not bridge cracks or expansion joints. The crack must be formed up just as an expansion joint. The joint filler should be the same width as the existing joint or crack, long enough to cover the spall area, and deep enough to cover the full depth of the spall.

16.3. Bonding Agents. Bonding agents are utilized to improve the bond between the patch and the patch repair materials. A light coating of bonding agent must be used when using PCC as the repair material. If using a rapid-setting or polymer concrete, consult the manufacturer’s recommendations on the use of bonding agents. For PCC repairs, the bonding grout used is a mixture of one part portland cement to one part sand with a water-to-cement ratio less than 0.45. The bonding agent must be brushed into cracks and crevices to ensure good contact with the repair surface (Figure 16.1.). Many repair materials are proprietary and may also require a proprietary bonding agent. When employing these types of material in the repair, the manufacturer's recommendations must be followed closely. The entire surface of the repair area must be lightly coated or sprayed with the bonding agent, and the repair material must be placed when the bonding agent has reached a tacky consistency. If the bonding agent is dripping through small openings where the joint filler meets the bottom of the spall recess, a small bead of caulk may be placed to prevent the dripping.

16.4. Mixing and Placing. The mixing and placing of spall repair materials often varies considerably due to the widely different materials that can be used. It is good practice to place the repair material at pavement temperatures above 55 degrees Fahrenheit (13 degrees Celsius) and below 90 degrees Fahrenheit (32 degrees Celsius). If water is required, the correct amount of clean, fresh water must be added and thoroughly mixed. Hand mixing almost always requires more time than drum or mortar mixers. When hand mixing, there is also a tendency to add more water than required to ease the mixing effort. Manufacturer's recommendations for mixing and curing of materials must always be strictly followed to ensure a quality patching job. For more details on placing concrete in hot and cold weather, refer to ACI 305R and ACI 306R (Table 1.2.). Repair materials must not be placed at temperatures less than 40 degrees Fahrenheit (4 degrees Celsius) and only with special insulation and longer cure times for temperatures less than 55 degrees Fahrenheit (13 degrees Celsius). In summer, it is best to place repair materials in the morning when pavement temperatures are lower. In winter, afternoons are best.

16.5. Consolidation. After placement, the repair material must be throughly consolidated to remove trapped air. Cementitious and polymer concrete materials require some type of consolidation, by tamping or, if suitable, supplemented by vibration (Figure 16.2.). Vibrators with a small (less than 1 inch or 25 millimeters) head or vibratory screeds are recommended for small repairs. Grate tampers must not be used. After consolidation, the repair material must be finished to match that of the surrounding pavement (Figure 16.3.). A completed patch is shown in

Figure 16.4. where the spall repair was conducted on both sides of the expansion joint. Note the joint filler separating the spall repair.

16.6. Curing. Curing of the material is very important, especially for partial-depth repairs where the surface-area-to-volume ratio of the repair area is larger than a full-depth repair, and bond strength develops much slower than compressive strength. Rapid water loss from the surface due to high temperature, low humidity, and/or windy conditions can result in severe shrinkage cracking on the surface. Curing should consist of covering the patched area with two layers of presaturated burlap which is then covered with clean polythylene sheeting. The burlap and sheeting is then covered with wieghted plywood or form board. All cover layers should extend 12 inches (300 millimeters) beyond the outline of the patch. Covers should be removed, the burlap resaturated, and the covers replaced daily for at least 7 days. The fresh PCC should be covered as soon as possible after finishing the surface. Special curing procedures for rapid-setting concretes must be followed to prevent excessive shrinkage cracking. These materials harden rapidly and severe plastic shrinkage cracking may develop on the surface if the materials dry too fast. Manufacturer’s recommendations for curing of proprietary concretes must be followed.

16.7. Resealing. After the patch has cured, the final repair step is to replace the sealant to maintain the existing joint or crack. Joint or crack resealing should not begin until the concrete curing process is complete. The joint sealing operation is analogous to crack sealing. The joint or crack adjacent to the spall is sawed out to the same width as the existing joint or crack using a concrete saw, router, or hand saw. The joint filler must be removed by hand or by sawing. Joint preparation should conform to the specifications outlined in Figure 3.6. The sides of the sawcuts are then sandblasted, airblasted with compressed air, and washed with high-pressure water to prepare a good surface for sealant adhesion. The area surrounding the repair should be swept with a vacuum broom to remove debris, etc. After cleaning the area, backer rod is installed in the joint or crack recess. For U.S. Army and Air Force facilities, the joint sealant employed must conform to the ASTM specifications for the particular location in which the sealant is being replaced. For pavements on naval facilities, the joint sealant must conform to NFGS-02982; however, silicone sealants may be used in lieu of materials called for in ETL 94-9 (Reference 1.3.4.).

16.8. Placing Sealant. Placement of the sealant is similar to that of crack sealants in that the sealant should be placed from the bottom up and in a smooth stroke from the beginning to the end of the joint or crack, if practical. For details on sealing of joints, refer to the section on crack sealing as this is analogous to sealing joints. In addition, procedures for sealing joints are given in References 1.3.4. through 1.3.8.

16.9. Cleanup. After the repair is complete, all equipment should be cleaned, lubricated if necessary, and properly stored until needed for the next repair operation.

Figure 16.1. Application of bonding agent to the concrete surface. Note the joint filler bordering the repair area

Figure 16.2. Consolidation of the repair material by vibration

Figure 16.3. Finishing the patch surface

Figure 16.4. A completed spall repair that bridges an expansion joint