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**FACILITIES ENGINEERING
APPLICATIONS PROGRAM**

USER'S GUIDE

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USER'S GUIDE: PAVEMENT JOINT AND CRACK SEALING USING FIELD-MOLDED SEALANTS



by

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U.S. Army Engineering and Housing Support Center
Fort Belvoir, VA 22060-5516

Innovative Ideas for the Operation, Maintenance, & Repair of Army Facilities

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13. ABSTRACT (Maximum 200 words) This report details equipment, personnel, and types of materials as well as the procedures used to demonstrate the application and inspection of field molded joint sealants to joints and cracks in portland cement and bituminous pavements. The description, applicability, benefits, limitations, costs, recommended uses, and location of demonstrations for pavement joint and crack sealing technologies are discussed.				
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PART I: EXECUTIVE SUMMARY

Description

Pavement joint and crack sealants perform two vital functions: minimize water seepage into moisture susceptible base and subbase materials and prevent the retention of debris in the joint or crack opening of a pavement structure. Water seepage can lead to a decrease in the strength of the pavement structure, and debris retention negates the thermal movement allowed at the joint. If either of the designed functions of a sealant material are circumvented, premature pavement failure can occur. The pavement failure can lead to operational problems by causing traffic, whether vehicular or aircraft, to be detoured and to an increase in maintenance requirements. Pavement joint and crack sealant materials are designed to protect rigid and flexible pavement structures by minimizing water infiltration and preventing debris retention. By implementing the proper techniques for joint and crack preparation and sealant application, the satisfactory field performance of the sealant can be extended thereby reducing maintenance cost and extending the life cycle of rigid and flexible pavement structures.

Application

The use of joint and crack sealants is applicable to all rigid and flexible pavements that have joints and/or cracks. The sealant materials are used to protect the pavement structure by preventing debris retention in the joint or crack opening and minimizing water infiltration through the joint or crack opening.

Benefits

Joint and crack sealant materials are designed to protect the pavement structure. Therefore, by employing the proper techniques for joint and crack preparation and sealant application, the life-cycle and maintenance costs of the pavement structure can be decreased. The actual financial benefits realized by this technology will be dependent upon the individual installation. It is expected that by using the proper preparation and sealing techniques, the life of the sealant can be doubled as a minimum leading to significant savings in funds currently obligated for resealing projects.

Limitations

There are three federal specifications which can be used to specify joint sealant materials for pavement applications. The three specifications are Federal Specification SS-S-1401C, "Sealants, Joint, Non-Jet-Fuel-Resistant, Hot-Applied for Portland Cement and Asphalt Concrete Pavements;" Federal Specification SS-S-1614A, "Sealants, Joint, Jet-Fuel-Resistant, Hot-Applied for Portland Cement and Tar Concrete Pavements;" and Federal Specification SS-S-200E, "Sealants, Joint, Two-Component, Jet-Blast-Resistant, Cold-Applied for Portland Cement Concrete Pavements."

Sealants manufactured to meet Federal Specification SS-S-1401C are hot-applied, asphalt based materials. These sealants are not fuel resistant, and, therefore, they should not be used in areas where fuel spillage would be expected. Federal Specification SS-S-1401C sealants can be used in both rigid and flexible pavements. Specific areas where SS-S-1401C sealants should be used are parking lots, roadways, and some taxiway applications. These materials have a tendency to exhibit bubbling during and/or shortly after installation in the joints of rigid pavements. Because of the bubbling tendency, an additional test requirement is being required by HQUSACE. The test requirement is CRD-C 525-89, "Test Method for Evaluation of Hot-Applied Joint Sealants for Bubbling Due to Heating" (USACE, 1988).

Sealants manufactured to meet Federal Specification SS-S-1614A are hot-applied, coal tar based materials. These sealants are fuel resistant, and, therefore, should be used in areas where fuel spillage would be expected such

as maintenance areas and aircraft parking aprons. Since these materials are coal tar based, they should not be used in asphalt pavements. The test requirement CRD-C 525-89 is also being required for SS-S-1614A because some of these materials have shown a tendency to bubble.

Sealants manufactured to meet Federal Specification SS-S-200E are cold-applied, two-component materials and are designed to be both fuel resistant and resistant to the effects of aircraft engine exhaust. These sealants should be used in areas where both fuel spillage and excessive exhaust may be encountered. Areas where SS-S-200E sealants should be used are the run-up ends of runways, warm-up pads, etc. The SS-S-200E sealants should not be used in asphalt pavements.

A silicone sealant material was included in the Facilities Engineering Applications Program (FEAP), Pavements and Railroads, Pavement Crack and Joint Sealing. There is neither a federal specification nor an American Society for Testing and Materials (ASTM) specification which apply to silicone sealants. To specify these sealants, the designer must use Federal Aviation Administration Engineering Brief 36, CRD-C 527-88, "Joint Sealants, Cold-Applied, Non-Jet-Fuel-Resistant for Rigid and Flexible Pavements," or some type of manufacturer's specification. The silicone materials are not fuel resistant; therefore, they should not be used in areas where fuel spillage is expected. The silicone sealants can be used in the same areas as the Federal Specification SS-S-1401C sealants.

Costs

The cost of in-place sealant (1992) ranges from approximately \$1.25 to \$2.00 per linear foot. The actual cost will vary for different geographical areas depending upon the labor cost for that area. The material costs range from approximately \$.11 to \$.16 per foot for hot-applied sealants to approximately \$.80 per foot for cold-applied, single component materials.

Recommendations for Use

The use of this technology is recommended in construction, reconstruction, and/or rehabilitation of pavement structures.

Points of Contact

Points of contact regarding this technology are:

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PART II: PREACQUISITION

Description of Pavement Sealant Materials

It is important to understand the function of a pavement crack or joint sealant, the type of materials available, and generic areas of application of those sealants before discussing the methods that should be employed to install the sealant materials. Sealant materials are designed to protect the pavement structure by performing two basic functions. These two functions are to minimize the infiltration of moisture through joints and cracks, and to prevent the retention of debris in the joints or cracks. Failure of the sealant material to perform these two functions can lead to premature pavement failure thereby increasing the life-cycle cost of the pavement and increasing maintenance costs.

There are three types of joint sealant materials which can be specified using Federal Specifications. The three Federal Specifications are as follows:

- a. Federal Specification SS-S-1401C, "Sealant, Joint, Non-Jet-Fuel-Resistant, Hot-Applied for Portland Cement and Asphalt Concrete Pavements."
- b. Federal Specification SS-S-1614A, "Sealants, Joint, Jet-Fuel-Resistant, Hot-Applied for Portland Cement and Tar Concrete Pavements."
- c. Federal Specification SS-S-200E, "Sealants, Joint, Two-Component, Jet-Blast-Resistant, Cold-Applied for Portland Cement Concrete Pavement."

A silicone sealant material was also used in the FEAP demonstrations and is sometimes installed at Army installations. There is not a Federal Specification or an ASTM Specification that can be used to specify silicone sealants for sealing projects; however, two specifications do exist that will allow the designer to use silicones or other single component, cold-applied materials on sealing projects. The two specifications are as follows:

- a. US Army Corps of Engineers Handbook of Concrete and Cement CRD-C 527-88, "Standard Specification for Joint Sealants, Cold-Applied, Non-Jet-Fuel-Resistant for Rigid and Flexible Pavements."

- b. Federal Aviation Administration, Engineering Brief Number 36, dated May 21, 1986, "Silicone Joint Sealants."

The Federal Specification SS-S-1401C type sealants are hot-applied materials that can be used in either portland cement concrete (PCC) or asphalt cement pavements. The SS-S-1401C sealants are not resistant to aircraft or vehicle fuel spillage; therefore, they should not be used in pavements where fuel spillage would be expected. Typical areas where SS-S-1401C sealants should be used are primary and secondary roadways, parking lots, and some taxiway areas.

The Federal Specification SS-S-1614A type sealants are hot-applied materials that can be used in PCC or tar concrete pavements. The SS-S-1614A sealants are resistant to both aircraft and vehicle fuel spillage; therefore, they should be used in those areas where fuel spillage would be expected. Typical areas where SS-S-1614A sealants should be used are aircraft parking areas and vehicle maintenance areas. The SS-S-1614A sealants are not resistant to the effects of aircraft exhaust. Therefore, the SS-S-1614A sealants should not be used where they will be exposed to excessive aircraft exhaust. Also, SS-S-1614A sealants should not be used to seal cracks in asphalt pavements due to potential incompatibility problems between the sealant and the pavement.

Federal Specification SS-S-200E sealants are two-component, cold-applied materials that are resistant to both fuel spillage and aircraft exhaust. The SS-S-200E sealants are manufactured in one of two types. One type is Type M or machine-mixed and applied. Each component of the Type M material is placed into a separate reservoir of the application equipment. The individual components are then pumped through the application equipment to the mixing head. The mixing head is located on the nozzle of the applicator wand, and it mixes the sealant immediately prior to installation into the joint. The other type of SS-S-200E sealant is Type H or hand-mixed and applied. Normally the Type H sealant is mixed by pouring one of the components into a container which contains the second component and mixing them using a pneumatic or electric drill. The manufacturer's recommendations should be followed concerning the mixing time to use and the type of mixing paddle that is required to properly mix the sealant. The Type H sealant is poured from the

mixing container into smaller containers for application into the joint or is poured directly from the mixing container into the joint.

The SS-S-200E sealants should be used in areas where portland cement concrete pavement is exposed to fuel spillage and/or aircraft exhaust. Typical areas where SS-S-200E sealants should be used are the ends of runways, aircraft warm-up areas, hardstand areas, and parking aprons exposed to VSTOL aircraft. The SS-S-200E sealants should not be used to seal cracks in asphalt pavements.

Silicone sealant materials have become accepted by various state Departments of Transportation throughout the country for use in transverse joints in PCC interstate highways and roadways. Silicone sealants are not fuel resistant, and, therefore, they should not be used in areas where fuel spillage is expected. Typical areas where silicone sealants can be used would be the same as SS-S-1401C sealants.

Testing of joint sealant materials is required to assure that the sealing materials conform to the appropriate material specification, either Federal Specification, Corps of Engineers Handbook of Concrete and Cement, or Federal Aviation Administration Engineering Brief 36. Conformance of the sealant material to the appropriate specification will not guarantee satisfactory field performance of the sealant material, but it is the first step in obtaining satisfactory field performance.

The Corps of Engineers procedure for all construction is for the Contractor to perform quality control and for the Government to perform quality assurance. Quality assurance may involve a review of the Contractor's test results, observance of the Contractor's test procedures, or conducting check tests. For joint sealant materials, it is necessary that the actual batch or batches of joint sealant materials being used on a project be tested. Experience has shown that a non-trivial percentage of batches of several commercially available joint sealing materials have not fully met specifications when tested. Thus manufacturer's certificate of compliance should not be accepted unless the quantity of joint sealant to be used is less than 50 gal or 500 lb. In instances where the manufacturer's certificate of conformance is accepted, samples of the joint sealant materials should be retained for future testing if necessary.

Description of Joint and Crack Preparation

The sealing or resealing of joints and cracks in both PCC (rigid) and asphalt (flexible) pavements is a reoccurring maintenance problem at most military installations. By learning and employing the proper techniques for joint or crack preparation and sealant application, the satisfactory field service of the sealant can be extended thereby reducing maintenance cost and extending the life cycle of the pavement structure.

PCC pavement joint preparation

Joint preparation is the beginning phase of any sealing or resealing project. The procedures for joint preparation are the same regardless of the type sealant material used. If care is not used during this phase of the project, the overall quality of the project will suffer.

Joints in the pavement that have never been sealed must first be sawed or routed to the desired depth and width. The joint should be deep enough to accommodate a backing material and should be between 3/8 and 3/4 in. wide. To remove debris left by sawing or routing, the joint will need to be sand-blasted or cleaned with high pressure water equipment. It is easier to flush the joint with water immediately after sawing to remove all residue left by the sawing operation. Sandblasting is conducted after the water used during the sawing operation has dried. Sandblasting is used to ensure all residue has been removed from the joint and to roughen the joint face texture to improve the sealant's adhesion to the concrete. A multiple pass technique with the nozzle close to the joint wall yields the best cleaning results when sandblasting. The sandblasting must be completed on the same day that the joint will be sealed to ensure that the sealant will be placed against clean surfaces.

Resealing requires an additional step of removing the old sealant material. One of the easiest methods for removing old sealants from joints is with a concrete saw. This method removes the sealant and refaces the joint wall at the same time. Another easy method is to use a tractor-mounted plow. The plow should fit inside the joint without chipping the joint wall. Plows that are "V-shaped" should not be allowed on the jobsite because their use will cause chipping and spalling of the concrete. Instead, a rectangular plow should be employed.

Due to the nature of the plowing technique, there will be some of the existing joint sealant left in the joints. The residual joint sealant material must be removed from the joint walls to allow adequate bonding of the new sealant to the concrete. If the old sealant is not removed, the new sealant will experience adhesion failures, and the sealant will not perform its designed functions, i.e., minimize water infiltration and prevent debris retention. Wire brushing should not be allowed as a method to remove debris from the joints. The wire brushes will often smear the residual joint sealant material on the joint walls and/or polish the joint walls. Both of these effects will reduce the sealant's ability to adhere to the joint walls.

Once the sandblasting operation is completed, all sand and debris must be removed from the joint. This can be accomplished using compressed air and/or a vacuum sweeper. The cleaning operation should precede the sealing operation by approximately 100 to 300 ft. Keeping the sealing operation close to the cleaning operation minimizes the potential of debris blowing back into the joint.

PCC pavement crack preparation

The preparation of random cracks in PCC pavements is similar to the preparation of joints with respect to the procedures, but changes in techniques and equipment may be required. Variances in the depth, width, and direction of cracks make them more difficult to prepare and seal than joints. The procedures include sealant removal (from previously sealed cracks), routing or sawing, crack repair, and cleaning. The procedures used to prepare the crack will depend upon the individual cracks. Specific guidelines for crack repair in PCC pavements can be found in TM 5-624/AFR 85-8. General recommended procedures are as follows:

- a. Cracks that are hairline to 1/4 in. wide with no spalling or additional pavement damage do not require widening or sealing.
- b. Cracks that are hairline to 1/4 in. wide that have minor spalling should be widened with a router or concrete saw and sealed.
- c. Cracks 1/4 to 1/2 in. wide that have no spalling and rough edges or have minor spalling should be widened with a router or concrete saw and sealed.

- d. Cracks $3/8$ to $3/4$ in. wide that have major spalling should have the spalls repaired in the same manner as one would reconstruct a joint. The integrity of the crack should be maintained through the repaired area.
- e. Cracks $3/4$ to $1-1/2$ in. wide with no spalling should be routed and sealed. Backer rod material should be used if the crack is greater than $3/4$ in. deep or a separating tape if it is less than $3/4$ in. deep.
- f. Cracks $3/4$ to $1-1/2$ in. wide with major spalling should be rebuilt in the same manner as one would reconstruct a joint.
- g. Cracks greater than $1-1/2$ in. wide can be temporarily repaired using asphalt hot mix as a patch. Asphalt hot mix is considered an incompressible material and will give adequate performance for only a limited time. The patched crack must be observed carefully to ensure that the crack is functioning properly and the asphalt hot mix is not creating problems. For a permanent repair, the crack must be reconstructed in the same manner as one would reconstruct a joint.

Routing the crack is accomplished using a vertical spindle router. The router produces a reservoir for the sealant. A rotary impact router should not be used on PCC pavements because the impact action of the router will chip and spall the pavement surface around the crack. Sawing is an alternative to the vertical spindle router. Adjustments such as casters and a small diameter blade may be required for the saw to allow the saw to trace the crack. Once the crack is routed or sawed, the sealant reservoir dimensions of the crack should be similar to those of a normal joint, i.e., have a more uniform width and depth. The final width and depth of the crack should be specified in project specifications. Normally the crack should be widened approximately $1/8$ to $1/4$ in. to provide exposed sound concrete for the sealant to adhere.

After the crack has been routed or sawed and damaged areas have been repaired, it is cleaned in the same manner as the joints (i.e. sandblasted or waterblasted and air blown) to achieve the same level of cleanliness attained in joint cleaning.

Asphalt pavement crack preparation

Variances in depth, width, and direction make crack preparation techniques difficult, but cracks in asphalt pavements are not as difficult to prepare as cracks in PCC pavements. The preparation procedures used to prepare cracks in asphalt pavements will be dependent upon the size of the crack. The following information should be used as a guide for crack preparation.

- a. Hairline cracks that are 1/4 in. or less in width do not require widening or sealing. If these cracks cover 80 percent or more of the pavement surface, the pavement should be treated with some type of surface treatment. The exact type of surface treatment will be dependent upon the pavement use. If the pavement is a parking lot or roadway, a simple surface treatment may be satisfactory; however, if the pavement is a runway then an overlay may be required. CEGS 02555 and TM 5-822-8/AFM 88-6, Chap. 9 provide additional information concerning surface treatments.
- b. Small cracks that are 1/4 to 3/4 in. wide should be widened to a nominal width of 1/8 in. greater than the existing nominal or average width. Widening the cracks 1/8 in. will help eliminate the potential for raveling of the pavement along the edges of the crack and will provide a sealant reservoir that has vertical faces. The depth of the routed crack should be approximately 3/4 in.
- c. Cracks that are 3/4 to 2 in. do not require widening. Instead, the crack should be cleaned using a sandblaster, hot compressed air (HCA) heat lance, or wire brushes and then clean with compressed air.
- d. Cracks that are greater than 2 in. in width should be prepared in the same manner as one would prepare a pothole. A saw should be used to cut away damaged pavement and to provide vertical faces. The area should then be cleaned and filled instead of sealed.
- e. Cracks in pavements to be overlaid that are larger than 1/4 in. can be prepared using a sandblaster, HCA heat lance, or wire brushes and then cleaned with compressed air. If the cracks are less than 2 in. in width, the cracks may be left unsealed. Instead, the cracks are sealed when they reflect through the overlay. Cracks that are greater than 2 in. in width should be repaired as potholes.

Meandering cracks, if they are to be widened, can be widened using a router or a saw. A rotary-impact router may be used to widen cracks in asphalt pavement if a carbide tipped bit is used. After the crack has been widened, the debris can be cleaned out using high pressure water equipment, a sandblaster, HCA heat lance, or wire brushes and compressed air. When the sandblasting equipment is used, a technique that enables both faces of the crack to be sandblasted should be established. A multiple pass technique, which consists of positioning the sandblaster nozzle approximately 1 in. above the pavement surface and directing it at one of the crack faces and then the other, should be used. After the entire length of one crack face is sandblasted, the opposite face is sandblasted. The cracks should not be overblasted. Overblasting can damage the pavement causing raveling and premature bond failure of the sealant.

The HCA heat lance should only be used when the pavement is wet and cold (pavement temperature below 50° F). Extreme care should be used to ensure that crack faces do not become overheated or burned. Overheating the crack faces can greatly reduce the life expectancy of the sealant and adjacent pavement. The expected failures may be in the form of adhesion failure of the sealant or additional cracking of the pavement between the area that was overheated and the remainder of the pavement. The problem of overheating the pavement becomes more of a possibility if the pavement is already warm and dry.

Wire brushes are commonly used during sealing projects; however, wire brushes are not always capable of removing debris from the crack faces and this debris can cause adhesion failures. Careful inspections should be conducted to ensure that wire brushes are not worn and that all debris and dust have been removed.

Once the old sealant and bond breaking debris have been cleaned from the crack, the crack is cleaned with compressed air. The compressed air is blown into the crack to remove sand or any debris that was loosened during the initial cleaning. The compressed air also aids in the removal of moisture.

Equipment

The equipment used during a joint or crack sealing or resealing project must be inspected before work is started. It is important that the equipment be kept in good working order and that the equipment operators are familiar with the operation of the equipment as well as the work they are expected to perform. Test sections are useful in ensuring that the operators and equipment are capable of performing the designated work without damaging the pavement. The equipment required for a PCC pavement sealing project includes the following:

- a. Concrete saw. The concrete saw can be used to remove existing joint sealant material, to enlarge the joint sealant reservoir, and/or to reface the joint walls. The concrete saw should be a water-cooled power saw using diamond or abrasive saw blades to cut the pavement without damaging it. A typical saw is shown in Photo 1. The saw is used primarily for forming new joints and refacing existing joints. Using the saw to reface existing joints helps to provide a clean surface.

- b. Joint plow. The joint plow is a tractor-mounted cutting tool similar to the equipment shown in Photo 2 and is used to remove old joint sealant from joints. The plow is pulled through the joint, removing the sealant from the joint walls. The plow should be rectangular in shape and it should be approximately 1/8 in. narrower than the width of the joint being cleaned. The use of V-shaped plows should never be allowed because they will chip the pavement damaging the joint face.
- c. Sandblasting equipment. Sandblasting is used to remove sealant residue and other debris from the joint. The sandblasting equipment will include an air compressor, hose, and nozzle of the proper shape and size for the joints being cleaned. Occupational and health standards must be reviewed and followed when operating sandblasting equipment. Typical sandblasting equipment is shown in Photo 3. A small section of angle iron may be attached to the nozzle to aid in directing the blast at the joint faces.
- d. Air compressor. The air compressor used on the sealing project serves two purposes. The compressor is used with the sandblasting equipment and to air blow loose debris from the joints or cracks. The compressor should be equipped with in-line traps that will maintain the air free of water and oil. Moisture and oil both interfere with the sealant bonding to the joint face.
- e. Waterblasting or high pressure water cleaning equipment. Water-blasting or high pressure water cleaning equipment can be used to remove saw residue and other debris from the joint. The equipment consists of a trailer-mounted water tank, pumps, high-pressure hoses, auxiliary water resupply equipment, a wand with a safety release cutoff control, and nozzle of the proper size for the joints in the pavement. Occupational and health standards must be reviewed and followed at all times during the operation of the waterblasting equipment. Typical water-blasting equipment is illustrated in Photo 4.
- f. Vertical spindle router. The vertical spindle router shown in Photo 5 is equipped with a bit that rotates around a vertical axis. The spindle is mounted on the chassis in such a manner that it can maneuver along the irregular dimensions of a crack to clean the crack and form a sealant reservoir. It is recommended that the spindle be belt driven to prevent damage to the pavement and more importantly to prevent injury to the operator. This recommendation is based upon the fact that the spindle can become jammed in the pavement if the operator tries to force the router along the crack. The use of rotary-impact routers should not be allowed on PCC pavements.

Much of the equipment required to prepare joints and cracks in PCC pavements can also be used to prepare the cracks in asphalt pavements. However, there are some pieces of equipment that may be used to prepare cracks in asphalt pavements that should not be allowed on PCC pavement sealing

projects. The equipment required for preparing cracks in asphalt pavements include:

- a. Routing equipment. Routing equipment is used to widen meandering cracks to the desired depth and width creating a sealant reservoir. Two types of routers may be used to prepare the cracks in an asphalt pavement, the vertical spindle router as described above and a rotary-impact router. Rotary-impact routers are equipped with bits that are mounted to a vertical wheel that rotates forcing the bits to impact the pavement. Only rotary-impact routers which are equipped with carbide tipped bits may be used to rout cracks in asphalt pavement. Other types of bits will damage the pavement instead of preparing the crack. The rotary-impact router equipped with carbide tipped bits provides a relatively quick method to form an adequate sealant reservoir. A typical rotary-impact router is shown in Photo 6.
- b. Concrete saw. A concrete saw can be used to widen the cracks in an asphalt pavement. The concrete saw used for asphalt crack repair is similar to the one described for the preparation of joints and cracks in PCC pavements.
- c. HCA heat lance. The HCA heat lance shown in Photo 7 is used to warm, dry, and clean the crack when the sealing operation must be conducted in less than desirable conditions. Such conditions would be following rain or when the pavement temperature is below 50° F. The heat lance can also be used to remove small amounts of vegetation from the crack. Heat lances are capable of producing heated air at 3,000° F at velocities of up to 3,000 ft/sec; therefore, extreme care must be used by the operator to ensure that the asphalt pavement is not overheated. Overheating will cause the pavement to become charred and brittle resulting in premature sealant bond failure. Heating the cracks using direct flame methods should not be permitted. Direct flames harden the asphalt and leave a sooty residue that prevents adequate bonding of the sealant to the asphalt pavement.
- d. Sandblasting equipment. Sandblasting equipment as describe above is used to remove residue left by the saw, loose aggregate left by the router, vegetation, and other foreign debris from the crack. If the debris is left in the crack, the sealant will not bond adequately to the asphalt pavement causing premature failure of the sealant. Caution should be exercised to prevent overblasting of the crack. It is important to remove all debris from the crack, but overblasting could cause the pavement to ravel or create voids in the crack face.
- e. Wire brushes. Wire brushes may be helpful in removing debris and vegetation from shallow cracks, but they do not easily remove bond breaking debris, such as saw residue, from the walls of the cracks. Also, brushes tend to wear easily thus decreasing their cleaning effectiveness. Care should also be taken when wire brushes are used to clean cracks that have been sealed before. The brushes will have a tendency to smear the old sealant residue on the crack wall instead of removing it.

Other equipment such as handtools and sweepers will be required regardless of the pavement type to keep the work area clean. Additional information concerning the preparation procedures and equipment can be found in CEGS 02594, CEGS 02583, and TM 5-822-11/AFM 88-6, Chapter 7.

Description of Pavement Joint and Crack Sealing

Once the joint or crack sealant material has been tested to the appropriate specification for conformance and the joints and/or cracks have been properly prepared, the backer material or bond breaker tape is then installed and sealant applied.

Backer materials and bond breaker tapes

Backer materials can be either round or rectangular and are compressible, nonabsorptive materials that are placed in joints and some cracks to maintain the proper depth to width ratio (shape factor) of the sealant and to prevent three-sided adhesion between the sealant and the bottom of the joint. One of the most common types of backer material is the rod shaped material which is often referred to as "backer rod." Bond breaker tapes are materials used to prevent three-sided adhesion in joints where the shape factor is satisfactory without the use of backer rod materials. The backer rod and bond breaker tapes are an essential part of PCC pavement joint sealing. Their use in asphalt pavements is not as critical, and normally they will not be used unless the crack in the asphalt pavement is greater than 3/4 in. deep.

It is important to maintain the proper shape factor and to prevent three-sided adhesion to minimize the internal stresses of the sealant, to prevent cohesion failure, to maximize the bonding strength of the sealant to the joint or crack face, and to prevent adhesion failure. The proper shape factor for most pavement joint and crack sealant materials is 1.0 to 1.5. However, some sealants such as silicones and some two-component sealants require a shape factor of approximately 0.5. The manufacturer's recommendations for the proper shape factor should be taken into consideration during the planning and construction stages of any project.

Three-sided adhesion of a joint sealant material is when the material adheres to both walls of the joint and to the bottom of the joint. As the

joint or crack moves, the three-sided adhesion causes stresses to become so great in the material that it exhibits cohesion failure.

Along with being compressible and nonabsorptive, backer rod materials and bond breaker tapes should be nonshrinking, nonstaining, and nonreactive with the sealant material. The materials should have a melting point of at least 5° F higher than the pouring temperature of the sealant. The diameter of the backer rod materials should be approximately 25 percent larger than the nominal width of the joint or crack. The bond breaker tape should be 1/8 in. wider than the nominal width of the joint. The larger sizes ensure that the backer rod or bond breaker tape will not move during the application of the sealant.

The backer rod or bond breaker tape should be placed in the joint immediately behind the air cleaning operation and immediately prior to the sealing operation. The placement of the material in this manner helps prevent debris from collecting in the joint before the sealant is installed. The materials should be inserted in such a manner that they are not twisted, torn or stretched.

The equipment shown in Photo 8 is used to insert the backer rod material to the predetermined depth without tearing the material. Most equipment that is used to insert the backer rod material is made by the individual contractors, but usually consist of a wheel to push the backer rod into the joint and rollers to adjust the depth of the wheel in the joint.

Sealant installation

Hot-applied sealants, those manufactured to conform to both Federal Specifications SS-S-1401 and SS-S-1614, are heated in a double-boiler, agitator-type kettle with an oil medium for heat transfer. The double-boiler allows uniform heating of the sealant material. Direct heating of the sealant creates hot spots in the material which can damage the sealant material. The sealant material is transferred from the kettle to the joint by an extruding device fitted with a nozzle that can be inserted into the joint. It is important that the nozzle fits into the joint so that the joint can be filled from the bottom to the top. Excessive bubbling is caused when the sealant is gravity fed into the joints; therefore, gravity installation of sealants should never be allowed. The bubbling creates an unsightly finish and also may cause premature sealant failure. No material should be subjected to

heating for over 3 hr. Any material that has been heated above the manufacturer's recommended safe heating temperature, heated for over 3 hr, or remains in the applicator equipment at the end of a day's production should be wasted to prevent defective material from being placed the next working day. If any bubbling or other irregularities are noticed, work should be stopped until the problem is corrected.

Cold-applied, two-component sealants that are manufactured to conform to Federal Specification SS-S-200, Type M are more difficult to apply due to the nature of two-component materials. Each component is placed in a mechanically agitated reservoir. The components are delivered from the reservoir to a portable mixer located at the nozzle. The two components are delivered to the mixer in a one-to-one ratio (by volume) for uniform mixing. The delivery lines from the reservoir should be operated independently of one another so that the machine can be calibrated. The machine is calibrated by collecting a known volume of one component and measuring the time required to collect the material. The second component is collected in the same manner and the results compared. Differences between the measurements are corrected by adjusting the delivery pressure of the components. It is important that a one-to-one ratio be maintained. Failure to do so will result in a sealant that is brittle or one that does not properly cure. After curing, the sealant can be examined for any defects.

The nozzle of the two-component machine must fit inside the joint to allow the joint to be sealed from the bottom to the top in the same manner as the hot-applied sealants. The speed of the operator must be slow and consistent to prevent air entrapment in the joint. Air entrapment will reduce the effectiveness of the sealant by creating voids in the sealant and reducing the effectiveness of the sealant bond to the joint wall.

Silicone sealants are transferred from their storage container to the joint by an extrusion pump. The joints should be filled from the bottom to the top as with the other sealants using the same precautions to prevent air entrapment.

The hot- and cold-applied, two-component sealant materials, in general, are self-leveling, and, therefore, tooling is not required after placement. Silicone sealants are manufactured in both self-leveling and non-sag types. The non-sag sealants must be tooled to smooth the sealant surface and to

ensure bonding between the sealant and the pavement. Tooling of a sealant is pulling a small object, such as a piece of backer rod material, along the surface of the sealant. The tooling forces the sealant against the sides of the joint increasing the bonding properties.

All sealant materials should be placed in the joints so that the top of the sealant is approximately 1/4 in. below the surface of the pavement. The placement of the joint sealant in such a manner allows the pavement to expand without forcing the sealant out of the joint. The depth below the pavement surface that a sealant should be placed is dependent upon the atmospheric temperature where the sealant is being placed and the type of sealant being used. In general, 1/8 to 1/4 in. below the pavement surface is acceptable.

Work should be discontinued during inclement weather (i.e. rain) and should not be allowed to resume until the joints have been recleaned and are dry. Air blowing of the joints is usually sufficient for recleaning; however, the joints should be inspected to determine if further cleaning or sand-blasting is required since rainfall runoff can be muddy and carry organic materials. Also, the pavement temperature should be at least 50° F and rising before the sealant material is placed into the joint or crack.

All joint sealing equipment should be cleaned at the end of each day's work. Cleaning the equipment prevents sealant material from curing in the lines causing down time and contaminated sealant the following day.

Equipment

The equipment used to install the sealant material will be dependent upon the type of sealant being used. It is not dependent on the type of pavement being sealed. The equipment used to install pavement sealant materials is as follows:

- a. Hot-applied sealing equipment (melter). There are basically two types of hot-applied sealing equipment. One is for the application of hot-applied sealants that are solid at room temperature, and the other is for the application of hot-applied sealants that are liquid at room temperature. All applicators should be equipped with nozzles that are shaped to allow the sealant to seal the joint from the bottom to the top of the reservoir.
- (1) Solid hot-applied sealing equipment. The equipment used for heating and installing solid hot-applied joint sealant materials (Photo 9) consists of a double-boiler, agitator-type kettle to prevent localized overheating of the material. Thermometers for indicating the temperature of the sealant and the oil bath should

be calibrated and located where they can be easily read. The melter should be designed to circulate the sealant through the delivery hose and return to the inner kettle when not in use.

- (2) Liquid hot-applied sealing equipment. The equipment used for heating and installing the liquid hot-applied joint sealant materials is equipped with a reservoir tank that is not maintained at the application temperature. The sealant is drawn from this tank and is pumped through tubes in a heated oil bath which brings the sealant to the application temperature. Once at the application temperature, the sealant is inserted into the joint. This type of equipment is not designed to recirculate the sealant.

b. Cold-applied sealing equipment. The type of equipment used to install cold-applied sealants will depend upon the type of sealant, two-component or single component, hand mix or machine mix. All applicators should be equipped with nozzles that are shaped to allow the sealant to seal the joint reservoir from the bottom to the top.

- (1) Cold-applied, two-component, Type M sealing equipment. The equipment used for proportioning, mixing, and installing cold-applied, two-component machine mix joint sealants (Photo 10) is designed to deliver two liquid components through separate hoses to a portable mixer. The components are pumped at a preset ratio of 1 to 1 by volume. The reservoir for each component is mechanically agitated to maintain the materials in a uniform condition without entrapping air. Screens should be located near the top of each reservoir to remove debris from the components as they are being poured into the reservoir.
- (2) Cold-applied, Two-component, Type H sealing equipment. Mixing equipment for cold-applied, two-component hand mix sealants normally consists of a slow-speed electric drill or air-driven mixer with a stirrer meeting the manufacturer's recommendations.
- (3) Cold-applied, single-component sealing equipment. The equipment for installing cold-applied, single component joint sealants (Photo 11) consists of an extrusion pump and air compressor followed by plate, hoses, and nozzle. Small hand-held air-powered equipment (i.e., caulking guns) may be used for small applications.

All equipment should be inspected prior to beginning work in order to ensure that it meets the specifications and is in proper working condition. Equipment specifications are usually spelled out in the contract specifications.

Application

The use of joint and crack sealants is applicable to all rigid and flexible pavements that have joints and/or cracks. The sealant materials are used to protect the pavement structure by preventing debris retention in the joint or crack opening and minimizing water infiltration through the joint or crack opening.

Limitations/Disadvantages

There are three Federal specifications which can be used to specify joint sealant materials for pavement applications. The three specifications are Federal Specification SS-S-1401C, "Sealants, Joint, Non-Jet-Fuel-Resistant, Hot-Applied for Portland Cement and Asphalt Concrete Pavements," Federal Specification SS-S-1614A, "Sealants, Joint, Jet-Fuel-Resistant, Hot-Applied for Portland Cement and Tar Concrete Pavements," and Federal Specification SS-S-200E, "Sealants, Joint, Two-Component, Jet-Blast-Resistant, Cold-Applied for Portland Cement Concrete Pavements."

Sealants manufactured to meet Federal Specification SS-S-1401C are hot-applied, asphalt based materials. These sealants are not fuel resistant, and, therefore, they should not be used in areas where fuel spillage would be expected. Federal Specification SS-S-1401C sealants can be used in both rigid and flexible pavements. Specific areas where SS-S-1401C sealants should be used are parking lots, roadways, and some taxiway applications. These materials have a tendency to exhibit bubbling during and/or shortly after installation in the joints of rigid pavements. Because of the bubbling tendency, an additional test requirement is being required. The test requirement is CRD-C 525-89, "Evaluation of Hot-Applied Joint Sealants for Bubbling Due to Heating."

Sealants manufactured to meet Federal Specification SS-S-1614A are hot-applied, coal tar based materials. These sealants are fuel resistant, and, therefore, should be used in areas where fuel spillage would be expected such as maintenance areas and aircraft parking aprons. Since these materials are coal tar based, they should not be used in asphalt pavements. The test

requirement CRD-C 525-89 is also being required for SS-S-1614A because some of these materials have shown a tendency to bubble.

Sealants manufactured to meet Federal Specification SS-S-200E are cold-applied, two-component materials and are designed to be both fuel resistant and resistant to the effects caused by aircraft engine exhaust. These sealants should be used in areas where both fuel spillage and excessive exhaust may be encountered. Areas where SS-S-200E sealants should be used are the run-up ends of runways, warm-up pads, etc. The SS-S-200E sealants should not be used in asphalt pavements.

A silicone sealant material was included in the FEAP Pavements and Railroads and Pavement Crack and Joint Sealing demonstrations. There is neither a federal specification nor an ASTM specification which apply to silicone sealants. To specify these sealants, the designer must use Federal Aviation Administration Engineering Brief 36, CRD-C 527-88, "Joint Sealants, Cold-Applied, Non-Jet-Fuel-Resistant for Rigid and Flexible Pavements," or some type of manufacturer's specification. The silicone materials are not fuel resistant; therefore, they should not be used in areas where fuel spillage is expected. The silicone sealants can be used in the same areas as the Federal Specification SS-S-1401C sealants.

Joint and crack sealant projects should generally be scheduled in the spring or fall of the year. If the sealant is placed during this time, it will be exposed to tensile and compressive stresses which are within the sealant's working range. Another important consideration for sealing projects is weather conditions. The temperature should be at least 50° F and rising during sealant application and the joints or cracks should be free from all moisture. The manufacturer's product literature should be examined to verify the environmental conditions under which the material can be applied.

The sealant material's performance may be diminished if the joint or crack configuration is not carefully designed. Many sealants will not perform satisfactorily in joints or cracks that are greater than 2 in. in width. The manufacturer's literature should be examined to gain an indication of the sealant's working range.

FEAP Demonstration/Implementation Sites

There were three demonstration projects conducted between 1985 and 1987. The 1985 project site was Fort Eustis, VA. Two areas were to be sealed at this site. The first area was an asphalt pavement roadway in which the cracks were sealed using a sealant which conformed to Federal Specification SS-S-1401C. The cracks were routed out and cleaned using the procedures described in "Asphalt Pavement Crack Preparation." As of 1989 approximately 95 percent of the sealant installed during this phase was still performing satisfactorily. The second area was an equipment storage area constructed of PCC. The contractor was suppose to reconstruct and seal approximately 250 lin ft joints, but the contractor defaulted on the contract because of lack of experience using epoxy concrete. The knowledge gained or verified from this first site was twofold. First, preparing and sealing cracks in accordance with the recommended procedures can provide satisfactory field performance of the sealant material for at least 4 years, and secondly, experienced contractors must be used to obtain the desired results.

The 1986 project site was Fort Sam Houston, TX. Only one area, the Kelly Heliport, was sealed. Approximately 11,000 lin ft of concrete joints were cleaned using a joint plow, sandblasting, and compressed air, and then sealed using a sealant which conformed to Federal Specification SS-S-1614A. Field monitoring of this project indicates that as of August 1990, the joint sealant material is performing excellently. Again indicating that when the recommended procedures are followed, satisfactory field performance can be obtained from the sealant material.

The 1987 project site was Fort Riley, KS. This project included two asphalt pavement roadways and one tank hardstand/maintenance area constructed of PCC pavement. The cracks in the asphalt pavement were sawed and cleaned with high pressure water equipment. The cracks were allowed to dry and were then sealed with a sealant material which conformed to Federal Specification SS-S-1401C. As of August 1990, the sealant material on the roadways was performing excellently, and no additional maintenance work has been required in the area. On the other hand, much of the sealant material used in the maintenance area was missing from the joints. This failure was attributed to two facts. First, the sealant had been installed flush with the pavement

surface allowing the tracked traffic to pull it from the joint. Secondly, the joint faces had not been refaced before the sealant was installed. The joint faces in this area were V-shaped, and it is believed that as the pavement expanded, it forced the sealant out of the joint.

Life-Cycle Costs and Benefits

The monetary benefits realized by taking the care to properly seal or reseal joints and cracks will vary for every installation; however, if one uses the asphalt pavement at Fort Riley as an example, some generalized savings can be estimated. Personnel from Fort Riley stated that they had resealed the same cracks in their asphalt pavements every year. If one assumes the cost per linear foot of in-place sealant is \$1.25 and a total of 50,000 lin ft of cracks were sealed, the cost of sealing totaled \$62,500. No additional sealing or maintenance work was required for the two roadways which were included in the project; therefore, Fort Riley saved approximately \$187,500 from 1988 to 1990. The savings seem small for the 3-year time frame when compared to total expenditures for maintenance operations, but one must consider that Red Book data from FY 87 indicate that the Army has approximately 60,000 lane miles of pavement, which equates to approximately 6.5 million lin ft of joints and cracks. Conservatively assuming that 10 percent of these joints and cracks are being sealed annually because procedures or materials used are not up to specification and using \$1.25/lin ft of in-place sealant, the Army could save over \$800,000 annually by adopting the technology described here and taking the care needed to implement it correctly.

Costs

The cost of in-place sealant ranges from approximately \$1.25 to \$2.00/lin ft. The actual cost will vary for different geographical areas depending upon the labor cost for that area. The project specifications currently used by the Department of the Army require the type of preparation that is described in "Description of Joint and Crack Preparation" and Description of Joint and Crack Sealing". So an increase in contract price is not expected.

Advantages/Benefits

Joint and crack sealant materials are designed to protect the pavement structure. Therefore, by employing the proper techniques for joint and crack preparation and sealant application, the life-cycle and maintenance costs of the pavement structure can be decreased. The actual financial benefits realized by this technology will be dependent upon the individual installation; however, it has been estimated that approximately \$12 million is spent annually resealing pavement joints and cracks. It is expected that by using the proper preparation and sealing techniques, the life of the sealant can be doubled as a minimum leading to significant savings in funds currently obligated for resealing projects.

PART III: ACQUISITION/PROCUREMENT

Potential Funding Sources

Typically, installations fund the implementation of pavements and railroads technologies out of their annual budgets. However, the annual budget is always underfunded and normally the pavements and railroads projects just do not compete well with other high visibility/high interest type projects. As a result, it is in your best interest to seek all of the funds possible from other sources when the project merits the action. Listed below are some sources commonly pursued to fund projects.

- a. Productivity program. See AR 5-4, Department of the Army Productivity Improvement Program for guidance to determine if the project qualifies for this type of funding.
- b. Facilities Engineering Applications Program (FEAP). In the past, a number of pavement and railroad maintenance projects located at various installations were funded with FEAP demonstration funds. At that time, emphasis was placed on demonstrating new technologies to the Directorate of Engineering and Housing (DEH) community. Now that these technologies have been demonstrated, the installations will be responsible for funding their projects through other sources. However, emphasis concerning the direction of FEAP may change in the future; therefore, don't rule out FEAP as a source of funding.
- c. Special programs. Examples of these are as follows:
 - (1) FORSCOM mobilization plan which may include rehabilitation or enlargement of parking areas and the reinforcement of bridges.
 - (2) Safety program which may include the repair of unsafe/deteriorated railroads at crossings and in ammunition storage areas.
 - (3) Security upgrade which may include the repair or enlargement of fencing.
- d. Reimbursable customer. Examples of this source are roads to special function areas such as family housing or schools and airfield pavements required to support logistical operations.
- e. Special requests from MACOMS.
- f. Year end funds. This type funding should be coordinated with the MACOMS to ensure that the funds will not be lost after a contract is advertised.

- g. Operations and Maintenance Army (OMA). These are the normal funds used for funding pavement and railroad projects.

Technology Components and Sources

Components of this technology which must be procured for pavement crack and joint sealing are project design (may be accomplished in-house or contracted out), contractor or in-house crew to perform sealant removal, joint or crack preparation, and sealant installation.

All of the items used in pavement crack and joint sealing are conventional materials and procedures; therefore, no special materials or procedures are required.

Procurement Documents

Corps of Engineers Guide Specifications (CEGS) and a Departments of the Army and Air Force manual are available to provide assistance in completing project specifications. The available guidance includes:

- a. CEGS-02583, "Field-Molded Sealants for Sealing and Resealing Joints in Rigid Pavements".
- b. CEGS-02594, "Sealing Cracks in Bituminous Pavements".
- c. Departments of the Army and Air Force Technical Manual TM 5-822-11/AFM 88-6, Chap. 7, (Draft), "Standard Practice for Sealing Joints and Cracks in Rigid and Flexible Pavements".

Procurement Scheduling

Pavement crack and joint sealing work should be schedule during the spring or fall of the year. Time for specification conformance testing of the sealant materials should be allowed prior to the estimated initiation of work. The time required for conformance testing is 14 to 21 days for Federal specification type sealants and 30 to 40 days for silicone type sealants.

PART IV: POST ACQUISITION

Initial Implementation

Equipment

The equipment required for pavement crack and joint sealing is described in PART II. This equipment is standard construction equipment for pavement sealing; therefore, no special equipment is required.

Material

The pavement sealant material required for a sealing project will be dependent upon the pavement type and the type of traffic to which the pavement is exposed. The specific type of material that should be used for a general area is provided in "Description of Pavement Sealant Materials". The manufacturer's literature should be consulted when selecting a backer material or bond breaking tape.

Personnel

Personnel familiar with the procedures of joint and crack preparation and sealing should be employed for sealing projects. At each of the demonstration sites, the work was contracted out to local contractors.

Procedure

The procedures used to prepare and seal the cracks or joints will be dependent upon the type of pavement being sealed. The specific procedures are outlined in PART II.

Operation and Maintenance

Pavement crack and joint sealing is in itself basically considered a maintenance activity. By incorporating the correct techniques for pavement crack and joint sealing, it is estimated that maintenance costs can be reduced.

Service and Support Requirements

No special services or support is required to implement or maintain this technology.

Performance Monitoring

Installation personnel can monitor and measure the performance of pavement sealant materials by conducting visual inspections of the area that has been sealed. The best method of inspection is to get out and touch the sealant. The sealant should be pliable and resilient, and adhering to the joint or crack face. Another method of determining if the sealant is adhering to the pavement would be to examine the area after a rain. If the pavement surface has a slick appearance on one side of the joint or crack and a dull appearance on the opposite side, then water is probably penetrating the opening around the sealant.



Photo 1. Concrete saw being used to reface joint

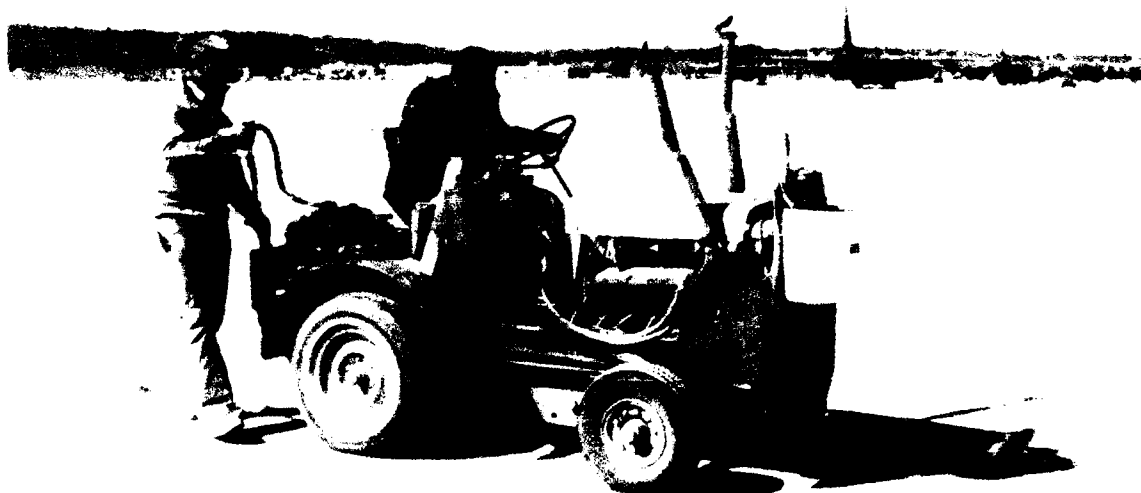


Photo 2. Joint plow being used to remove existing sealant

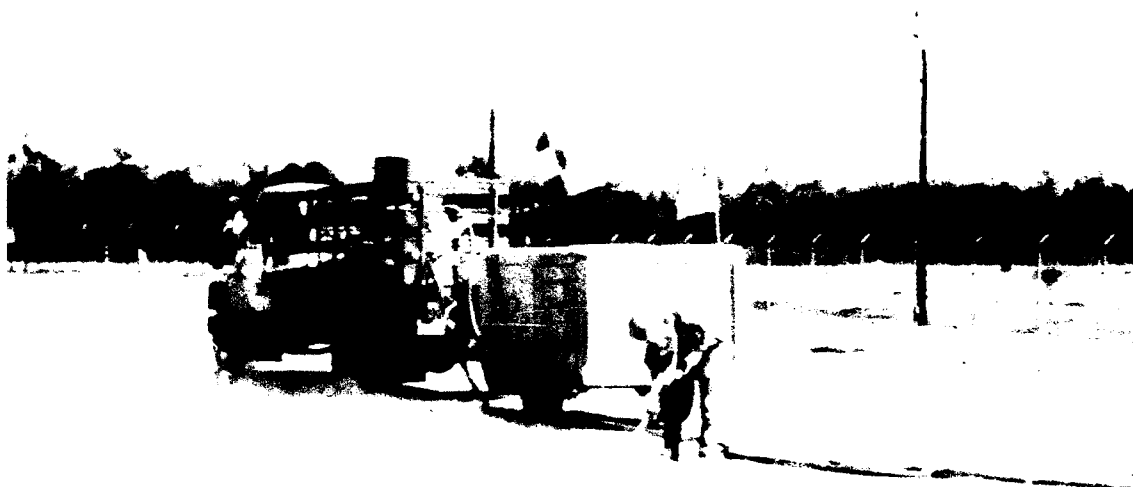


Photo 3. Typical sandblasting equipment



Photo 4. Typical waterblasting equipment

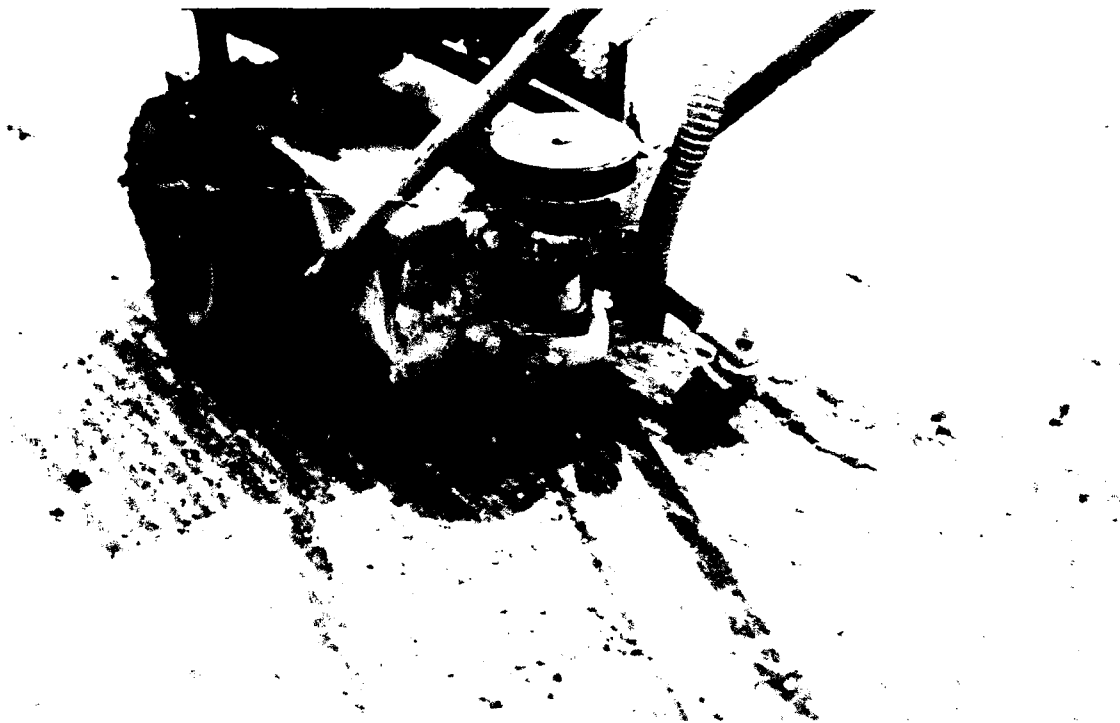


Photo 5. Vertical spindle router used to widen random cracks



Photo 6. Rotary impact router for widening random cracks in asphalt pavements



Photo 7. Hot compressed air heat lance being used
to warm random cracks in an asphalt pavement



Photo 8. Equipment used to install backer rod material



Photo 9. Equipment used to apply hot-applied sealants



Photo 10. Equipment used to apply Federal Specification SS-S-200, Type II sealants



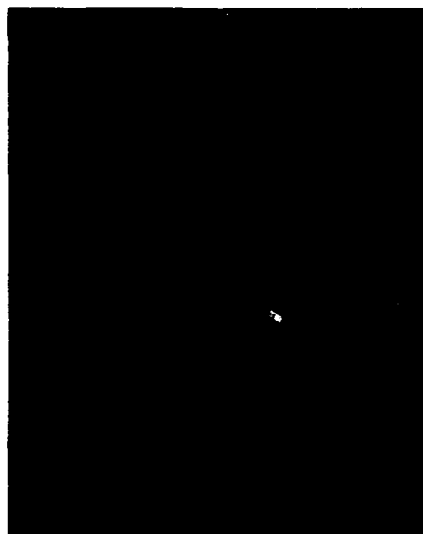
Photo 11. Equipment used to install single component, cold-applied sealants



**FACILITIES ENGINEERING
APPLICATIONS PROGRAM**

***Innovative
Ideas for the
Operation,
Maintenance,
& Repair of
Army Facilities***

Installing Pavement Crack and Joint Sealants



**Sandblasting joints to remove
residue.**



**Hot-applied sealant being
inserted into cracks in an
asphalt roadway.**



**Installing a backer rod to maintain the
proper shape factor in the joint.**

Lessons Learned Extend Sealant Service Life

PROBLEM: Improper installation of pavement joint sealant materials accelerates deterioration, leading to more frequent joint maintenance or even costly pavement structural failures.

TECHNOLOGY: Proper preparation of joints and installation of sealant material provides a lasting seal that ensures pavement integrity.

DEMO SITES: Fort Eustis, VA - FY85 Fort Sam Houston, TX - FY86
Fort Riley, KS - FY87.

BENEFITS: With proper preparation and sealing techniques, sealant life can be extended, leading to at least a 50% savings in the annual cost of resealing.

Proper Procedures: A Must for Crack and Joint Sealing

The proper preparation of cracks and joints is vital to maintain the serviceability and life of a pavement, whether the pavement is portland cement concrete (PCC) or asphalt cement concrete. Joints and cracks must be sealed to minimize water infiltration and to prevent debris retention. Both conditions accelerate pavement deterioration and ultimately, increase maintenance costs.

The proper repair procedure starts with removal of the old joint sealant material. The joints and cracks are sandblasted or waterblasted to remove all residue. Compressed air is used to clean the joint and to remove any sand or moisture left from the residue blasting. A separating material is placed in the joint to maintain the proper shape factor (i.e., depth-to-width ratio) and prevent three-sided adhesion. The joints must be closely inspected for cleanliness. The sealant is inserted and recessed below the pavement surface 1/8 to 1/4 inch to prevent tracking on the pavement. This also prevents the sealant from being pushed out of the joint during thermal cycling of the pavement.

Lessons Learned From Demonstrations

The three FEAP demonstration projects used four different kinds of sealants but followed the same application procedure. The demos showed that proper surface preparation and installation can help prevent joint sealant failures, which are largely due to workmanship and materials. It is critical that construction inspectors know the proper joint preparation and sealant installation techniques. The inspectors must then ensure that contractors follow the correct procedures to maximize joint sealant life. Contractors who specialize in pavement joint and crack repair should be used whenever possible.

Costs and Benefits

An installation can expect to spend \$1.25 to \$3 per linear foot treated. This price range includes the cost of proper surface preparation and depends on the local market.

The Army has over 60,000 miles of pavement, or about 6.5 million linear feet of cracks and joints. An estimated \$12 million per year is spent to reseal cracks and joints. Today most crack and joint sealant materials are failing within 3 years and, in some areas, re-sealing is required annually. Installed properly, joint or crack sealants should last 5 years, nearly doubling the average service life. This could save up to \$6 million per year, allowing maintenance dollars to be diverted to other projects while maintaining pavement integrity.

Procurement

Proper application procedures for pavement crack and joint sealants are presented in detail in Miscellaneous Report GL-88/29, *Pavement Crack and Joint Sealant*, by Larry Lynch, August 1988. Additional information is available in Navy publication NAVFAC MC 102.6, *Asphalt Crack Repair Field Manual*. A videotape showing the procedures, "Pavement Crack and Joint Sealing," will be available from the FEAP Information Center.

Points of Contact

For more information, contact Larry Lynch, U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180, COMM 601-634-4274, FTS 542-4274, or toll-free 800-522-6937, ext 4274. Ken Gregg, U.S. Army Engineering and Housing Support Center (USAEHSC), COMM 703-355-3582.



APPENDIX B

REFERENCES

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