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Innovative Materials and Equipments for Pavement Surface Repairs

**Volume II: Synthesis of Operational
Deficiencies of Equipment Used
for Pavement Surface Repairs**

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Executive Summary

The need for improved materials and procedures for pavement maintenance activities is evident to most people. Methods and materials that last longer and perform better would be a tremendous boon, not only to the traveling public's image of our roads, but also to the already stretched budgets of the maintenance departments. One of the major goals of the Strategic Highway Research Program (SHRP) is to further the state of knowledge in the pavement maintenance area. This goal is being accomplished by research activities that are being sponsored in several key areas. These areas include a study of pavement maintenance effectiveness (SHRP H-101), maintenance measuring equipment (SHRP H-103 and H-104), work zone safety improvement (SHRP H-108 and H-109), and the development of improved maintenance equipment (SHRP H-105 and H-107). Consideration is also being given to the implementation of the findings from SHRP research (SHRP H-110).

The research reported herein was performed under SHRP Project H-105, *Innovative Materials and Equipment for Pavement Surface Repairs*. This study was begun in late 1988, and the research effort was completed in April 1990. The results of this study were used in the development of *Experimental Design and Research Plans (EDRP)*, which formed the basis of a Request for Proposals to conduct a field evaluation of these materials in SHRP Project H-106. The overall goals of this project can be summarized as follows:

- To identify material, procedures, and equipment for patching potholes in asphalt concrete (AC) and repairing spalls in portland cement concrete (PCC) that are more effective and more efficient in preventing pavement deterioration than existing methods.
- To identify materials, procedures, and equipment to use in filling and sealing cracks in both AC and PCC pavements, and resealing joints in PCC pavements, that are more effective in preventing the intrusion of water

into the pavement structure, and that are more efficient than existing methods.

- To develop a set of experimental plans to test new or improved maintenance materials and to develop a set of plans to guide the development of improved maintenance equipment.

The study also sought to identify laboratory tests whose results might be good indicators of field performance. The existence of such "performance-related specifications" would greatly enhance maintenance departments' ability to identify which new or untried materials show the greatest promise and therefore warrant field testing.

The research effort for H-105 was divided into five major pavement maintenance activities:

- AC pothole repair
- AC crack repair
- PCC spall repair
- PCC joint resealing
- PCC crack sealing

For each maintenance activity, information was collected to assist in the evaluation of the performance of materials used for these repairs and the procedure used to prepare the pavement and place the materials.

In this report, the findings from the H-105 research effort pertaining to the evaluation of pavement maintenance materials are presented. Three volumes were prepared under the general heading *Innovative Materials and Equipment for Pavement Surface Repairs*. Volume I, *Summary of Material Performance and Experimental Plans*, includes a discussion of the general methodology used in the conduct of this research study and an analysis of the results from the survey of maintenance materials users. Literature related to the above-noted maintenance activities was also evaluated and incorporated in the study. The result was a list of pavement maintenance materials recommended for further study in field trials and a list of laboratory tests that could be evaluated for their ability to relate to field performance.

The second volume of the report, *Synthesis of Operational Deficiencies of Equipment Used for Pavement Surface Repairs*, describes the deficiencies of the equipment currently used to perform these maintenance activities. The information presented in this volume was collected from questionnaires sent to states, contractors, and other agencies. The data gathered in this part of the study was used to develop the experimental plans for SHRP

Project H-107, which addresses the development or modification of improved pavement maintenance equipment for performing crack sealing and pothole repair.

The third volume of the report, *Data Base Users Guide*, is a user's manual that describes the use and manipulation of the data base used in this project. The data base contains information and performance histories of many patching and sealing materials, as well as performance information on various types of equipment used for pavement maintenance.

Abstract

Pavement maintenance activities generally account for a significant portion of an agency's operating budget. This can be attributed to the high initial costs associated with maintenance activities, the historically poor performance of maintenance repair which often necessitates additional maintenance work, and the exorbitant safety and legal costs associated with the need for traffic control of these activities. As such, any improvements or advancements in this area could result in substantial cost savings.

In an effort to address these areas of concern, SHRP has initiated a major research project on the materials and equipment used for five of the more common pavement maintenance activities: portland cement concrete (PCC) crack sealing; PCC joint resealing; PCC spall repair (partial-depth); asphalt concrete (AC) crack sealing and filling; and AC pothole repair. The objectives of this study are to identify materials, procedures, and equipment for these maintenance activities that are more effective and more efficient than past methods.

In this report, deficiencies of current maintenance equipment are investigated. Each type of equipment used for each maintenance activity is thoroughly examined, and its associated advantages and disadvantages are noted. Much of this information was obtained through questionnaires sent to state agencies and contractors in an effort to obtain user responses to the deficiencies of existing maintenance equipment. The purpose of this report is to present those deficiencies and limitations. This information will then be used in subsequent work to define desirable equipment characteristics for pavement maintenance.

1

Introduction

Overview

Pavement maintenance activities constitute a large percentage of the work effort of many highway departments and it is an area in which many improvements are needed. One of the major goals of the Strategic Highway Research Program (SHRP) is to further the state of knowledge in the maintenance area by sponsoring research activities in several key areas.

The research reported herein was performed as part of the SHRP project H-105, *Innovative Materials and Equipment for Pavement Surface Repairs*. The overall goals of the research are summarized as follows:

1. Identify materials, procedures and equipment for patching potholes that are more effective in preventing deterioration and more efficient than existing methods.
2. Identify materials, procedures and equipment to use in filling and sealing cracks that are more effective in preventing the intrusion of water into the pavement structure, and that are more efficient than existing methods.

The major objective of this part of the SHRP research is to identify pavement maintenance equipment specifications that would be more cost-effective and efficient in operation while providing an improvement in work-site safety to both highway users and maintenance personnel. This report specifically addresses the deficiencies of equipment currently used for joint sealing, crack sealing and pothole repairs for both asphalt and concrete pavements along with the developed functional specifications for equipment used for pothole repair and joint and crack sealing in asphalt pavements. The functional specifications developed as part of this project formed the basis of the equipment development plans for SHRP project H-107, "Fabrication and Testing of Maintenance Equipment Used for Pavement Surface Repairs."

Research Approach

This report provides an evaluation of equipment used for cavity seals and repairs. The initial phases of the study involved a world wide search for improved materials, procedures and equipment for sealing and filling cracks and joints and patching spalls and potholes. This was accomplished through a review of published literature, analysis of the results from questionnaires received from many highway agencies in the United States, Canada and abroad, and information received from materials suppliers and equipment manufactures. Personal intervals were held with experienced agency maintenance and materials personnel and equipment manufacturers. Extensive detailed information has been received from personal interviews with additional knowledgeable highway agency personnel.

Equipment, materials and procedures commonly used by maintenance forces to repair pavement cavities have significant limitations. These limitations result in premature failures and accelerated pavement deterioration, which causes increased highway and highway user costs, and increased accident rates. A number of factors have combined to create the existing condition. They include:

1. a lack of understanding of cavity and cavity repair failure modes;
2. use of inadequate or inappropriate repair materials;
3. deficient equipment;
4. inadequate repair procedures;
5. disincentives for the use of unproven but innovative equipment, materials and procedures;
6. lack of a substantive, effective, ongoing program for evaluating innovative (or existing) equipment, materials or procedures.

The current state-of-the-practice and equipment utilization was evaluated throughout the distribution of a questionnaire prepared for the following maintenance activities:

1. Concrete pavement joint resealing.
2. Concrete pavement crack sealing.
3. Asphalt pavement pothole repair (permanent).
4. Asphalt pavement crack sealing/filling.
5. Concrete pavement spall repair (partial depth).

Copies of these questionnaires are included in Appendix A. A Total of 94 questionnaires have been returned. Nine responses came from Canadian Provinces, nine from the United Kingdom and 76 from State transportation departments in 36 States. Table 1 provides a

Table 1
Equipment Questionnaire Summary
Agencies Responding

United States		Canadian Provinces	United Kingdom Counties
Alaska	Nebraska	Alberta	Berkshire
Arkansas	Nevada	Br Columbia	Cambridge
California	New Jersey	Manitoba	Cornwall
Connecticut	New York	New Brunswick	Devon
Delaware	North Carolina	Northwest Terr.	Essex
Georgia	North Dakota	Nova Scotia	Humberside
Hawaii	Ohio	Prince Ed Isle	Huntingdon
Illinois	Oklahoma	Saskatchewan	Kent
Indiana	Oregon	Yukon	Somerset
Iowa	South Carolina		
Kansas	Tennessee		
Kentucky	Texas		
Maine	Utah		
Maryland	Vermont		
Michigan	Virginia		
Minnesota	Washington		
Missouri	West Virginia		
Montana	Wisconsin		

summary of the agencies responding. The data obtained from these questionnaires are presented in tabular form within each appropriate section of this report. Within each table, the percent usage of each equipment type is presented. It should be stressed that this number reflects only the percentages obtained through the questionnaires and is not meant to imply representative usage throughout the country. It must also be stated that while information was received on particular brands and models of equipment in most cases, it is not the intent of this research to highlight the advantages or disadvantages of a specific manufacturer's equipment. The information is presented generically in order to indicate general deficiencies with the different classes of equipment.

The satisfactory completion of the maintenance activities presented above requires a wide variety of equipment. There are also many different makes and models of equipment for each of the above maintenance activities. Information was solicited from users on the advantages and deficiencies for the equipment used to perform these maintenance activities. These deficiencies are described in appropriate chapters of this report devoted to each maintenance activity. This information was utilized, along with additional information collected, to recommend performance specifications for modified or new equipment to be developed under SHRP contract H107.

Each chapter of this report covers one of the above listed maintenance activities. Each of these major sections includes a brief description of the maintenance activity, a detailed list of the procedures and equipment used, and a summary of the deficiencies of the equipment used for each maintenance activity. Appendix B contains descriptive summaries of specific equipment used for joint and crack sealing. Appendix C contains descriptive summaries of specific equipment used for pothole and spall repairs. Information contained in these appendices was extracted from product brochures and technical specifications provided by the manufacturers.

2

PCC Spall Repair

Introduction

Partial-depth repairs extend the life of portland cement concrete (PCC) pavements by restoring surface continuity to pavements that have spalled or distressed joints and cracks. Partial-depth repairs of spalled areas also restore a well-defined, uniform joint sealant reservoir prior to joint resealing. When properly placed with durable materials, these repairs can perform well for many years. Partial-depth repair is appropriate in areas where slab deterioration is located primarily in the upper third of the slab and the existing load transfer devices, if any, are still functional.

The procedures for partial-depth spall repair are as follows:

1. Identification of the extent of deteriorated concrete.
2. Formation of the spall repair boundaries.
3. Material removal and surface cleaning.
4. Placement of the patch material.
5. Compaction or consolidation of the patch material.
6. Final finishing and sealing of the repair.

The equipment used in each of these phases is discussed in the following section.

Procedures and Equipment Deficiencies

Identification of the Deteriorated Concrete

A concrete spall is easily identified by its appearance, characterized by cracks extending from the joint or edge face diagonally up through the concrete to the surface. In the early stages of spall development, the extent of deteriorated concrete may be difficult to determine by a visual inspection. The cracks may be either hairline or not even completely through to the surface.

Spalls that are less than 6 in (153 mm) in length and less than 1.5 in (38 mm) wide are normally not repaired, but are filled with a poured sealant. If several spalls exist along a joint, the entire joint is repaired instead of several individual repairs. These repairs only need to be as deep as the deteriorated concrete.

If the spall is not easily identifiable, but areas of deteriorated concrete are suspected, then a sounding technique may be used to identify those areas in need of repair. This sounding method is simple and consists of striking a steel rod or a ball peen hammer against the concrete. Areas yielding a clear ringing sound are judged to be in good condition, while those emitting a dull thud are considered weak. The process can be slow if there are several areas of questionable deterioration.

A drawback of this approach is that the different pitches of intact and deteriorated concrete are not discernible if there is appreciable background noise due to traffic. High traffic volumes will also make it difficult for inspectors to get lane closures, and present a safety hazard while on the road. This method, while effective, is not always applicable nor safe. As an alternative, sophisticated sounding equipment is commercially available.

Shaping the Spall Edges

After identification of the deteriorated areas, the spalled concrete needs to be removed. The first step requires cutting of the edge. The edge is cut because the bottom of the spall is sloping and the replacement material will not have a uniform thickness and may be too thin or feathered at the edges. The thinned sections may result in early failures of conventional materials. Furthermore, the edges of the spall are jagged, both across the surface and vertically, making it difficult for the patch material to be intimately in contact with the slab for a good bond. The desirable edge in repairing spalls is vertical, smooth (not polished), and possesses squared corners at the top and bottom. It must be noted, however, that the

procedure of milling out a spalled area, which produces nonvertical, irregular edges, has resulted in good performance in one state.

Saws

Table 2 lists the types of equipment currently used for cutting the spall edges. Concrete saws are the most popular, used by 83 percent of the respondents. Concrete saws are available in many sizes from hand-held to 65 hp self-propelled units. Saws are available to cut up to 15 in (381 mm) in depth. Some saws are equipped with self-contained watering systems which serve primarily to cool diamond blades to prevent breakage and control dusting. Saws with abrasive blades are used dry, as wetting the blades results in rapid blade deterioration which can result in large fragments of the blade coming loose, creating a safety hazard.

A drawback for all saws equipped with large diameter blades is that the cut has to overrun the damaged area in order to cut to the required depth. This can be corrected by stopping the cut to meet the intersecting cut, but the remaining corner material will have to be removed by a breaker or some other means.

Hand-held saws are lightweight, require one operator, and can be easily maneuvered to outline irregular areas. However, if several repairs are to be made, operator fatigue may diminish productivity. It is also difficult to maintain a constant depth of cut and to provide consistently square edges using hand-held saws. Chassis are available for certain models of saws which provide positive depth control and less operator strain. Although watering systems are not available on the majority of these saws, dry-cut diamond blades are available for use.

The next size of saws are the 14 to 30 hp models. These saws are mounted on a chassis to allow straighter cuts with square edges. The units are self-propelled to reduce operator fatigue and are equipped with watering systems. The cutting depth can be positively controlled. The saw can be maneuvered by one worker, but two workers are generally needed for loading and unloading onto a vehicle for transportation. These saws are not well suited to outline irregular areas because they are designed for straight cutting. If used with abrasive blades, the depth of cut needs to be checked often to adjust for blade wear.

The largest saws are the 65 hp, high-production models. These saws are designed for cutting pavement full-depth, but can be used for partial depth. Although their high power output will increase productivity, their size limits maneuverability which may offset productivity. These saws also require an external supply for water, usually from a towed water tank. Diamond blades are used exclusively for these saws, and the blade cost alone is in the range of two to three thousand dollars each.

Table 2
Equipment Questionnaire Summary
Concrete Pavement Spall Repairs
Forming Repair Boundaries

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Concrete Saws	83	<ol style="list-style-type: none"> 1. Easy to Operate 2. Light Weight 3. Provides Vertical Edge 4. Easy to Maneuver 	<ol style="list-style-type: none"> 1. Slow for Large Volumes 2. High First Cost 3. Dusty When Used Dry
Pavement Breakers	21	<ol style="list-style-type: none"> 1. Dependable 2. Quick and Accurate 3. Easy to Maneuver 4. Contour Capable 	<ol style="list-style-type: none"> 1. Fractures and Spalls Edges 2. Slow, Labor Intensive 3. Operator Dependent
Miller/Planer	7	<ol style="list-style-type: none"> 1. Fast, Clean Cuts 2. No Breakout Needed 3. Good Production 	<ol style="list-style-type: none"> 1. Needs Room to Maneuver
Routers	2	<ol style="list-style-type: none"> 1. Easy to Maneuver 	

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

Pavement Breakers

Pavement breakers (jackhammers) are the next most popular tool, used by one-fifth of the respondents. Breakers are available in a variety of sizes, and the appropriate size should be chosen for the intended use. Breakers in the 15 to 80 lb (6.8 to 36.3 kg) class are usually recommended, fitted with a spade bit to provide the best edge. The breakers are dependable, accurate, and easy to maneuver around contours. Their versatility makes them common enough not to require a special purchase for spall repairs. However, the breaker does not make a straight, clean edge. Instead, a "scalloped" edge results, making removal of voids at the patch/slab interface during consolidation or compaction difficult. The breaker may also spall and fracture sound concrete and cause hairline cracks in surrounding pavement. The process is slow and tedious, with the accuracy dependent upon the skill of the operator. It is also fatiguing if used for many consecutive repairs. Its use for shaping spall edges should be considered cautiously.

Routers

Routers are relatively new for the purpose of shaping concrete spall edges. Routers are mounted on a wheeled chassis and typically have a carbide bit which forms a vertical groove. Only 2 percent of the respondents use routers and noted their ease of maneuverability as an advantage. Routers are designed to widen existing cracks; therefore when used for spall edge shaping they may have difficulty cutting through concrete the full width of the bit.

Millers/Planers

Millers/Planers were noted for use by 7 percent of the respondents. Millers use a rotating, carbide-toothed, cutting drum with widths available from 1 to 12 ft (0.3 to 3.7 m). Milling machines provide fast, uniform cuts with straight edges. Three sizes of millers are available: small, tow-behind units; middle-sized millers mounted on a refitted motor-grader chassis; and large, crawler units with half- and full-lane milling widths. Due to operating costs and maneuverability, the small and motor-grader sized mills are best suited for spall repair.

The advantage of the millers is they will shape the edge and break up the spoil material in one operation. Some of the smaller mills can rotate the cutting drum up to 90 degrees to allow for transverse cutting while positioned longitudinally in the driving lane. The disadvantage of the mills is they only make a square edge on the end of the drum; the cutting side leaves a rounded edge. This rounded edge does deepen quickly, but may not be desirable, although one state reports very good performance of the concrete patch. All millers will leave some debris piles to be removed. After the millings have been removed, there is

still a layer of fine particles and dust which must be removed. The mills will also enlarge the spall repair area to the width of the drums. Ample maneuvering room is also needed for the medium and large mills, and the mill operators can only get within 2 to 3 inches (51 to 76 mm) of obstructions such as manhole castings to avoid damage to the drum.

A principle concern in preparing the patch area is refraining from damaging the underlying concrete. Some of the devices used in shaping the spall edges can rupture adjacent sound concrete. Such devices include the mill/planers and jackhammers in excess of 30 lb (13.6 kg). One state has had excellent results using millers to remove deteriorated PCC during spall repairs.

Material Removal and Surface Cleaning

After shaping of the spall repair area, removal of the deteriorated concrete and cleaning follow. Hand tools such as picks and shovels are often used for removal of the large pieces of concrete. The difficult part of cleaning is removing material that has not yet fully spalled and preparing the surface for the patch material. Several methods which have been employed for the partial-depth removal are listed in Table 3.

Pavement Breakers

The majority of respondents use small pavement breakers up to the 30-lb (13.6 kg) class for breaking loose the spalls and for shaping the patch area. These sizes are sometimes referred to as chipping hammers since they do not have the force to break the pavement. The chipping hammers are easily handled by one person to provide dependable, accurate removal of small areas. The head of the hammers is usually square with a serrated face. This serration provides a textured surface on the pavement to promote bonding of the patch material. The hammers are slow to use since they chip instead of break the concrete. Their accuracy is dependent upon the operator, but with an outlined area, good accuracy can be achieved. Many breakers require a compressor and all require safety equipment for noise and debris.

Millers/Planers are also used for removal of the spalled material, with the advantages and disadvantages presented in the previous section. Milling machines were noted as used by 5 percent of the respondents.

The purpose of cleaning the surface for the spall repair is to provide intimate contact between the slab and the patch material. The patch surface must be clean of all oil, water, residue,

Table 3
Equipment Questionnaire Summary
Concrete Pavement Spall Repairs
Cleaning Deteriorated Areas

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Jack Hammers & Hand Tools	54	<ol style="list-style-type: none"> 1. Dependable 2. Accurate Removal 3. Promotes Bond 4. Good for Small Areas 5. Produces Textured Surface 	<ol style="list-style-type: none"> 1. Slow, Difficult to Use 2. Operator Dependent 3. Cumbersome 4. Noisy 5. Flying Debris
High Pressure Air Blast	26	<ol style="list-style-type: none"> 1. Good Production 2. Removes Sand 3. Promotes Bond 4. Cleans & Dries 	<ol style="list-style-type: none"> 1. Inadequate Cleaning 2. Can Add Moisture 3. Requires Cleanliness
Sand Blasting & Hand Tools	19	<ol style="list-style-type: none"> 1. Promotes Bond 2. Removes Loose Material & Dust 3. Removes Micro-Fractures 	<ol style="list-style-type: none"> 1. Silica Hazard 2. Sand Disposal 3. Slow & Dangerous 4. Slow Production
Water Blasting	9	<ol style="list-style-type: none"> 1. Removes Unsound Concrete 2. Promotes Bond 3. Clean Edge 	<ol style="list-style-type: none"> 1. Waste Water Problem 2. Needs Drying Time 3. Messy Residue 4. Requires Cleanliness
Planers/Millers	5	<ol style="list-style-type: none"> 1. Good Production 2. Produces Roughened Surface 3. Fast Removal of Debris 	<ol style="list-style-type: none"> 1. Edges Must be Sawed 2. Needs Maneuvering Room 3. Inadequate Cleaning of Deep Areas

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

debris or other deleterious materials to facilitate chemical bonding, and should be slightly roughened to augment mechanical bonding. As a check, if the fingers pick up loose material when rubbed against the prepared surface, the surface should be cleaned again. Three types of equipment, sand-blast, water-blast, and air-blast are generally used for cleaning the bond surface.

Sand Blasting

Sand blasting removes loose material, dust, and micro-fractures and cleans thoroughly to promote bonding. However, the silica hazard and sand disposal are problems. The process is time consuming and care must be taken to avoid bodily contact with the sand jet and to prevent the sand blowing into traffic. Sand blasting is used by one-fifth of the respondents for final cleaning.

Water Blasting

Water blasting, used by one-tenth of the respondents, uses a high pressure water blast to clean the spall surface. This method will remove the unsound concrete and clean the spall edges and surfaces to promote bonding. However, the waste water causes problems of disposal, leaves a messy residue, and requires drying time. Because of the introduction of moisture, water blasting is not as desirable as sand blasting. Water has to be supplied to the site, typically by a towed water tank, and more than one tank may be needed for continuous blasting operations.

Air Blasting

The simplest method for cleaning is the use of high pressure air from a compressor. Air blasting is a quick method which removes loose sand, debris, and small amounts of water to promote drying. However, the air compressor can add oil droplets and moisture to the surface, which will impair bonding. Furthermore, the air will not abrade and clean the surface as well as sand or water blasting. Air blasting was reported used by one-fourth of the respondents.

Placement of Patch Material

Two basic patch materials are used in spall repair: cementitious products and bituminous products. Equipment used for each is listed in Table 4. Before placing the patch material, the prepared surface typically is coated with a bonding agent, the type dependent upon the patch material. Usually cement grouts or bituminous tack coats are used. Epoxy kits were

Table 4
Equipment Questionnaire Summary
Concrete Pavement Spall Repairs
Placement of Patch Material

<i>EQUIPMENT TYPE</i>	<i>% USAGE</i>	<i>ADVANTAGES</i>	<i>DISADVANTAGES</i>
Cementitious Materials			
Small Mixers	83	1. Good Quality Control 2. Very Portable 3. Quick & Easy to Use 4. Less Waste 5. Less Downtime	1. Small Quantities 2. Time Consuming 3. Needs Additional Clean-up Time
Transit Mixers Air Blast	13	1. Large Quantities 2. Quick Operation	1. Costly for Small Quantities 2. Delivery Delays
Hand Tools	13	1. Portable 2. Less Waste 3. Smooth Finish	
Asphaltic Materials			
Small Mixers/ Recyclers	44	1. Hot Material in All Conditions 2. Portable 3. Compatible With Old & Virgin AC 4. Heats Cold Mix	1. Slow & Costly 2. Small Quantities 3. Cannot Recycle All Material
Hand Tools (Cold Mix)	44	1. Quick 2. No Traffic Disruption	1. Temporary Repair 2. Limited Coverage
Heated Storage Box	12	1. Maintains Mix Temperature	1. Limited Size
Unheated Storage Box	6	1. Retains Heat	

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

used by 2 percent of the respondents for reducing lane closure time. The preparation and application of these materials varies, therefore the manufacturers directions must be followed exactly for the desired performance.

Cementitious Patch Placement

PCC is the primary cementitious product used for patching concrete pavements, formulated either with or without special additives.

Mixers

For material preparation, small mixers were noted used by 83 percent of the respondents. Mixers with 1 to 2 ft³ (28 to 57 l) batch quantity offer good quality control due to their small size and ease of operation. For small repairs, this size will allow mixing of the appropriate amount of material with less waste than larger mixers or ready-mix trucks. These mixers are usually towed and have a gasoline engine for driving the drum. The mixers can be positioned to discharge the material directly into the patch. If several areas are to be repaired, use of small mixers can become time consuming because of their limited capacities. Cleaning of the mixer is important at the end of each day's use, otherwise concrete build-up will inhibit performance.

Ready-mix Trucks

For large areas of spall repair, or when there are several repairs within close proximity to each other, a ready-mix truck (transit mixer) may be warranted. Ready-mix trucks are used by 13 percent of the respondents. The ready-mix truck has the capacity to bring larger amounts of material to the site than can be efficiently prepared in a small mixer on site. Most ready-mix suppliers require a minimum order before dispatching a truck, but a close working relationship between the agency and the supplier may override this rule to deliver smaller batches. Care has to be taken when ordering the amount of concrete needed so that it may all be placed and consolidated before initial setting begins.

Hand Tools

Hand tools, such as shovels and rakes, are used to place the concrete into the patches. The shovels used have a square bottomed blade with low shoulders. The square bottom allows the shovel to be used for rough strike off of the concrete, and the low shoulder prevents too much material from being picked up which might break the shovel. Concrete rakes are similar to stiff pronged garden rakes, except they are built more ruggedly. Hand floats and trowels are

used to smooth and finish the concrete surface. Thirteen percent of the respondents noted the use of hand tools for placing patch material.

Bituminous Patch Placement

Hot mix asphalt concrete (AC) is the most common bituminous material used for patching spall repairs. Cold mix asphalt materials are not considered durable spall repair materials but are used as a stop-gap measure until a permanent patch can be placed. The key factor affecting long term performance of hot mix AC is maintaining the mix temperature until adequate compaction density is achieved. Asphalt concrete is widely produced at local plants and has to be transported to the patch site, placed, and compacted before cooling. Several equipment types, including small mixers/recyclers, heated boxes for trailers or inside of dump trucks, and insulated patch boxes are available to maintain mix temperatures.

Small Mixers/Recyclers

The small mixers/recyclers typically consist of a trailer-mounted kiln which can heat cooled AC and recycle old AC. These units are used by nearly half of the respondents. The recyclers typically have a heated horizontal drum with mixing augers. Old or virgin material is loaded through the top, mixed, and discharged at the rear into a shovelling box. The main advantage of the mixers/recyclers is that they provide hot material in all conditions. The recyclers are however slow for reheating, and can typically only handle 1 or 2 yd³ (0.8 to 1.5 m³).

Heated Storage Boxes

Another item for transporting AC is heated storage boxes. These typically have a 1 to 2 yd³ (0.8 to 1.5 m³) capacity and are mounted either on a trailer or inside the bed of a dump truck. The boxes have the advantage of maintaining material temperature from the plant to the site, but do have a limited size. Precautions have to be made not to overheat or burn the AC in the box, especially when the amount of material is small. Heated storage boxes are used by one-eighth of the respondents.

Unheated Storage Boxes

Unheated, insulated storage boxes are also be used for material transport. These boxes are similar in size and type to the heated boxes, but have no external heating source. The insulation serves only to reduce the rate of heat loss while the material is being transported to

the site. Only 6 percent of the respondents use unheated storage boxes. These boxes rely on the mass of the material to retain the mix temperature.

Hand Tools

Placement of the material is usually by hand shovelling from the transport unit. Some of the larger transport units have augers that discharge the material to the rear into a shoveling box. For large repairs, material may be transported in full-size dump trucks and dumped from the tailgate. Hand shoveling and raking is required to level the AC before compaction. The shovels for AC can be the same style used for concrete. Asphalt rakes are known as lutes, and differ from concrete rakes in that the prongs are replaced by a serrated steel strip, approximately 3 ft (0.9 m) long. Hand tools were reported used by 44 percent of the respondents, although all AC patching crews would require these or similar tools.

Compaction and Consolidation of the Patch Material

Most repair materials need to be consolidated or compacted for durability. Lack of proper consolidation or compaction can result in voids at the patch/slab interface and/or in the patch material, decreasing performance of the patch. Table 5 lists the equipment used for consolidation and compaction.

PCC Consolidation

For concrete, consolidation to release trapped air from the mix can be accomplished by one of three methods; internal vibrators, vibrating screeds, and manual rodding or tamping.

Internal Vibrators

Internal vibrators consist of an eccentrically mounted weight rotating inside a steel head. The weight is mounted to a flexible shaft, typically 6 ft (1.8 m) long, driven by an electric motor. The steel head, usually 12 in (305 mm) long and approximately 1.5 in (38 mm) in diameter,

is inserted into the fresh concrete. The vibration from the eccentric weight will allow the air to bubble to the surface and consolidate the concrete. Consolidation is complete when bubbles no longer emerge and the mix stops settling. Care has to be taken not to over-vibrate and segregate. The vibrators can be slow when used on large patches because of the many positionings required to achieve uniform consolidation. These vibrators are sometimes referred to as spud vibrators, and are used by 68 percent of the respondents.

Table 5
Equipment Questionnaire Summary
Concrete Pavement Spall Repairs
Consolidation or Compaction

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Cementitious Materials			
Small Vibrators	68	<ol style="list-style-type: none"> 1. Portable 2. Consolidates Concrete 3. Removes Voids 	<ol style="list-style-type: none"> 1. Slow Production
Hand Tools	26	<ol style="list-style-type: none"> 1. Provides Finish 	
Screed Vibrators	16	<ol style="list-style-type: none"> 1. Removes Voids 2. Consolidates & Screeds 3. Easy to Finish 4. Can Work With Dry Materials 	<ol style="list-style-type: none"> 1. Loading & Unloading 2. Shallow Patches Only
Asphaltic Materials			
Plate Compactors	60	<ol style="list-style-type: none"> 1. Good For Small Patches 2. Very Portable 3. Good Compaction 	<ol style="list-style-type: none"> 1. Loading & Unloading
Hand Tamper	40	<ol style="list-style-type: none"> 1. Easy to Use 2. Good Compaction 	<ol style="list-style-type: none"> 1. Operator Fatigue 2. Temporary Repair
Vibratory Rollers	26	<ol style="list-style-type: none"> 1. Better Compaction 	<ol style="list-style-type: none"> 1. Transportation to Site 2. Difficult to Handle
Steel Rollers	26	<ol style="list-style-type: none"> 1. Transport Ease 2. Good Compaction 	<ol style="list-style-type: none"> 1. Rides on Adjoining Concrete
Truck Tires	6	<ol style="list-style-type: none"> 1. Available 	<ol style="list-style-type: none"> 1. Poor Compaction

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

Screed Vibrators

Screed vibrators provide a surface vibration. The source of vibration may be a spud vibrator attached to a screed for small uses, or a larger gasoline-driven vibrating unit mounted on a screed frame. The screeds are heavy, and the gasoline-driven units may need to be loaded with the aid of lifting equipment. The screeds are also only effective for partial depth patches, as the vibration may not penetrate to the bottom interface on full depth patches. Vibrating screeds are used by 16 percent of the respondents.

Hand Tools

For very small patches, the finishing trowels and floats may be adequate for consolidation. By patting the concrete surface with the float face, or rodding the mix with the float edge, sufficient consolidation can be achieved. This method is used by one-fourth of the respondents.

AC Compaction

For AC patching, hand tampers, plate compactors, truck tires, static and vibratory rollers are used to achieve the required density. The required density varies by mixes, but if it is not achieved, the patch will deteriorate rapidly.

Hand Tampers

For small patches, hand tampers are used for compaction. The hand tamper is simply a 9 in (203 mm) square steel plate attached to a wooden handle. The tamper is raised and dropped on the AC. The tamper is quick and easy to use but is not effective when patch thickness exceeds 1 in (25 mm). Tampers were noted as used by 40 percent of the respondents. Due to the manual operation of the hand tamper, it is not a popular tool and its use is usually discontinued before proper density is achieved.

Plate Compactors

Plate compactors consist of a gasoline engine with an eccentric weight vibrator, mounted on a steel plate approximately 2 ft (0.6 m) square. Its vibrating motion propels the compactor forward, reducing operator fatigue. Most compactors have a self-contained watering system to lubricate the plate, preventing the asphalt from sticking to it. Plate compactors are faster and more effective than hand tampers, but are slower than rollers. It is important to maintain contact at all times with concrete or compacted asphalt to prevent the compactor from settling

into the hot AC. Although one person may maneuver the compactor, two are typically needed to load it onto a vehicle for transport. Transport and loading requirements may be eased through the use of a skid plate mounted on a hydraulic lift mechanism attached to the supply truck. Plate compactors are used by 60 percent of the respondents.

Truck Tires

Truck tires were noted as used to compact AC by 6 percent of the respondents. The truck driver will pass the rear wheels over the patch several times. The truck used is typically the one transporting the mix. This method gives an uneven surface and inadequate compaction, but is used because it is readily available.

Static and Vibratory Rollers

Static and vibratory asphalt rollers are used for compaction of larger patches. These rollers are a smaller version of those used for mainline paving operations, but still provide adequate compaction and smooth riding surface. The static rollers rely upon their weight to provide the compactive force, whereas the vibratory rollers may have one or both drums vibrating for compaction. The rollers need to be transported to the site. Rollers can not get within the edges of a patch that is narrower than the drum width. For this situation, plate compactors or hand tampers are needed. Rollers also require ample maneuvering room outside of the patch area to make direct passes on the patch without turning. The area outside of the patch needs to be clean, otherwise dust and dirt will pick up on the drums and be deposited on the fresh patch. The static and vibratory rollers are used by one-fourth of the respondents.

Finishing the Spall Repair

Finishing of spall repairs is only done with concrete patching, as the AC patching is finished by the compaction operation. In either case, the finished surface should be the same level as the surrounding slab. The equipment used for concrete finishing of spall repairs are listed in Table 6.

Partial-depth repairs are usually small enough so that a stiff board resting on the adjacent pavement can be used as a screed. The materials should be worked against the grade to prevent downflow. This also pulls the material against the face of the original pavement, which enhances bonding. Screeding generally requires at least two passes to ensure a smooth repair surface. The repair surface must be hand-trowelled to remove any remaining minor irregularities. The edge of a repair located adjacent to a transverse joint should be tooled to provide a good reservoir for joint sealant.

Table 6
Equipment Questionnaire Summary
Concrete Pavement Spall Repairs
Final Finishing/Sealing

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Hand Screed/ Trowel	93	1. Simple to Use 2. Provides Good Finish 3. Inexpensive	1. Operator Dependent
Power Screed	7	1. Better Consolidation 2. Good Production 2. Good Compaction	
Broom Finish	4	1. Good Skid Resistance	1. Noisy Under Traffic

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

Hand Tools

Tools used for finishing are hand trowels, floats, brooms, and power screeds. The hand trowels and floats are common finishing tools and are inexpensive. As with all hand tools, these are dependent upon the finishers skill in attaining the proper surface finish. These tools were reported used by 93 percent of the respondents.

A bristle broom may be used to apply a rough surface texture for skid resistance. Broom finishes are used by 4 percent of the respondents, but this finish causes a different sound under traffic, which is not desirable.

Power Screeds

Power screeds (vibrating screeds) are used by 7 percent of the respondents. The use of these screeds was described in the previous section. The vibrating screeds are an intermediate finishing process, following strike-off and preceding hand finishing. The power screed will often leave small ripples in the concrete surface which need to be removed by hand finishing on small patches, or bull floating for larger ones.

Emergency Repairs

An emergency concrete spall repair is not expected to last as a permanent patch, but only until such time as a permanent patch may be installed. Emergency repairs are commonly installed during the winter months when weather conditions are not favorable for the preparation and curing of the patch material. Emergency repairs may also be placed when the weather is favorable, but crews and equipment are not available to install a proper patch, or when extended lane closure may cause traffic hazards and delays. In either case, an immediate repair is required to maintain pavement rideability and public safety. Emergency repairs may have to be performed with temporary materials or procedures until a permanent patch can be made.

The performance of an emergency repair is typically more dependent upon the material than the equipment. The common material used is cold mix asphalt concrete (cold mix), as it will stay workable under most conditions. However, the material stockpile should be kept dry to prevent freezing. Ideally the same preparation of the spall area should be performed for the emergency repair as for the permanent repair. The areas repaired are typically only those that are obviously spalled and the spalled concrete may already be dislodged from the slab by traffic. The debris in the spall cavity is removed by hand tools, and if needed a breaker is

used to loosen tight or wedged pieces. The area should be dried and a tack coat or bonding agent applied, suitable for the patch material, if conditions permit. The patch material is placed and compacted using the same equipment as with the permanent patches. In the case of a cold mix material, it is more common to wheel roll the mix with the truck tires in lieu of the mechanical compactors or rollers. Although the wheel rolling is quicker than mechanical compaction, the few extra minutes for the compactor may improve the performance of the repair.

3

AC Pothole Repair

Introduction

Emergency pothole maintenance during cold and wet weather is a recurring area of repair deficiency. Emergency repairs frequently fail rapidly, in some cases surviving less than a day. Pothole repairs during wet and/or cold weather have the poorest performance of any emergency repair. This is particularly troublesome, since emergency pothole repairs, installed during inclement weather, have one of the highest danger exposure rates of any maintenance activity.

A more rigorous patching procedure, which involves additional work tasks to more adequately prepare the pavement for patching, is usually completed during more favorable environmental conditions. This type of repair is referred to as "permanent" repair procedures for the purposes of this report.

The principal needs for pothole patching in asphalt surfaced pavements is to repair areas with severe fatigue cracking or deteriorated transverse and longitudinal cracks. The visibly distressed area is not usually indicative of the true extent of the deterioration. Existing cavities and visibly fatigue-cracked areas are obvious candidates for patching. However, because fatigue cracking begins at the bottom of the asphalt concrete, there may be adjacent areas of deterioration that do not yet show surface fatigue cracking but are greatly weakened. These areas should also be considered as candidates for patching. Likewise, crack deterioration may exist on both the top (visible) and/or the bottom (hidden) sides of the AC pavement layer. Identification of the appropriate limits of patching is thus an involved procedure requiring sound judgement in the field.

Pothole patching, in general, requires consideration of the pavement structure, the cause of failure, the extent of existing deterioration, the patch material and the procedures to be used

during the construction of the patch. Asphalt patching materials are usually mixtures of aggregates and asphalt binders which may have special properties and/or additives. There are three main types of asphalt patching materials commonly used for both routine and emergency pothole repair:

1. Mixtures which are mixed and stockpiled for a period of time before use, known as cold mixes (these can be heated at the time of application). Cold mixes are a combination of aggregate and either of two asphalt-based binders: cutbacks or emulsions. Cold mixes have traditionally been used as a temporary patch material. There also exist numerous proprietary cold mixes which are gaining increased usage for both routine and emergency repairs.
2. Mixtures which are mixed hot and compacted in the hole while still hot, known as hot mix or asphaltic concrete (AC).
3. Mixtures which are combinations of aggregates and emulsions blended at the time of application and applied into the pothole cavity using air pressure.

Procedures and Equipment Deficiencies

Pothole maintenance consists of six procedures:

1. Establish the pothole boundaries by shaping the edges.
2. Clean and dry the pothole cavity.
3. Prime the edges and bottom of the pothole cavity.
4. Place the patching material in the pothole cavity.
5. Compact or consolidate the patch material.
6. Finish the surface or seal the edges of the patch.

Emergency pothole repair usually does not include procedures 1 and 6. Under high traffic and/or particularly adverse conditions, procedures 2, 3 and 5 may be less than adequately performed.

Individual equipment used during each phase of this repair are discussed by activity. Combination equipment, capable of performing all or most of these activities will be discussed in a separate section. Tables 7 through 12 summarize the types of equipment used during the pothole repair procedures by the various responding agencies.

SHRP project H-107 will support the development and fabrication of specialized equipment for the repair of potholes in asphalt pavements. Appendix D provides a listing of the functional specifications required of this equipment. This listing of functional specifications was developed based on the information gathered during the conduct of the H-105 project.

Shaping the Pothole Edges

The choice of equipment used to shape the edges of the repair is influenced to a large extent by the size of the cavity to be filled. During emergency situations, equipment selection or lack of it may be based solely on the speed of the repair rather than the quality. In any event, vertical sidewalls, abutting sound pavement material around the patch, should be constructed whenever possible. These vertical sides will confine the patch mix during compaction, increasing the compactive effectiveness. The use of the cutting tool facilitates the removal of deteriorated material and helps to ensure a sound, unbroken vertical edge. Table 7 contains a summary of the questionnaire responses obtained on equipment used for pothole edge shaping.

Pavement Breakers

Of all questionnaires returned, 83 percent included discussions of equipment used for shaping the pothole edges. The majority of responses (62 percent) noted the use of common pavement breakers or jackhammers for pothole edge shaping. These were either air powered or used on-board gas engines.

Use of air compressors is fairly common, as they provide power to tools used for shaping boundaries, cleaning, and compacting. Air hoses may limit the mobility of the breaker crew. However, multiple hose connections to the air compressor serve to increase the productivity of the break-out crew by allowing additional hammers to be used. This advantage is restricted to areas with a high density of repairs within the typical 50 ft (15.2 m) reach of the hoses. It is also important to fit the air hoses with safety connections to diminish the possibility of the hose whipping across the pavement should a connection be broken.

Gas-powered breakers can increase the mobility of the break-out crew and eliminate the need for an air compressor on site. This serves to increase the productivity of the crews as their equipment start up time is reduced. The increase in productivity is somewhat offset by the fact that break-out takes approximately 50 percent longer with these smaller units.⁽⁶⁾

Table 7
Equipment Questionnaire Summary
Asphalt Pavement Pothole Repair
Shaping the Pothole Edges

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Pavement Breakers/ Jack Hammers	62	<ol style="list-style-type: none"> 1. Easy to Operate 2. Dependable 3. Easy to Maneuver 4. Contour Capable 5. Available Air for Cleaning 	<ol style="list-style-type: none"> 1. Noisy 2. Slow, Labor Intensive 3. Non-Uniform Cut 4. Can Produce Ragged Edge
Concrete Saws	40	<ol style="list-style-type: none"> 1. Easy to Operate 2. Clean, Vertical Edge 3. Easy to Maneuver 4. Cutting Depth Control 	<ol style="list-style-type: none"> 1. Dusty When Used Dry 2. High First Cost 3. Slow Production
Miller/Planer	10	<ol style="list-style-type: none"> 1. Efficient Material Removal 	<ol style="list-style-type: none"> 1. Portability
Backhoes	9	<ol style="list-style-type: none"> 1. Good Production on Large Holes 	<ol style="list-style-type: none"> 1. Base Layer Damage
Infrared Heater	2	<ol style="list-style-type: none"> 1. Improves Bond 	<ol style="list-style-type: none"> 1. Transport to Site

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

The major deficiencies of the pavement breakers include high noise levels, slow, labor intensive operations, non-uniform cuts, and ragged edges.

Concrete Saws

Concrete saws are also commonly used to establish pothole boundaries. Forty percent of the respondents indicated the use of this equipment. Some respondents noted that the saw cut tends to produce a polishing effect on the aggregates along the face of the cut. On full-depth saw cuts, this polishing diminishes the bond. Partial-depth saw cuts and break out with jackhammers leaves a roughened face that permits interlock between the patch and the surrounding AC. The smooth cut at the surface provides a good riding surface and an edge which can be easily sealed, increasing the aesthetic, riding, and durability properties of the repair.

Deficiencies of concrete saws include slow production rates, high first cost, and dusty conditions when used dry. The large, walk-behind saws are difficult and time-consuming to load and unload. This can hinder the production when the potholes are widely spaced. The smaller, lightweight gas-powered saws are much easier to handle. However, a lower production rate is typical of these machines.

Millers/Planers

Millers and planers were also noted as used by one-tenth of the respondents for shaping the pothole edges. This equipment is generally used for large repairs, but has been used on smaller, localized repairs. Advantages of this equipment include high production rates on large repair areas and the availability of a conveyor to remove the millings, eliminating a large portion of the clean-up requirements. Additionally, millers can remove underlying deteriorated PCC material, thus eliminating a potential base failure of the pothole repair. Portability and high first cost were noted as deficiencies of milling equipment. In addition, the millers/planers have the tendency to remove additional, sound material from around the deteriorated repair areas, thereby enlarging the cavity and increasing the quantity of filler material required.

Backhoes

One-tenth of the respondents noted the use of backhoes for shaping the pothole edges. While providing for efficient material removal from the pothole, the mobility of the equipment both during repairs and during transport is a drawback. Base material damage and extremely

rough edges are the potential drawbacks of using this equipment if the operator is not highly trained.

Cleaning and Drying the Cavity

Cleaning must be adequate to provide a surface to which the tack and/or patch material can readily bond. All deteriorated material must be removed to a depth that exposes sound, relatively dry, and compact foundation material. Water, rocks, and dust all interfere with bonding of conventional materials and must be removed. Certain proprietary materials have been reported effective for use patching cavities that are partially or completely full of water. Table 8 summarizes equipment questionnaire responses for cleaning/drying of pothole cavities.

Air Compressors

Roughly one-half of the respondents use air compressors for cleaning of the pothole cavity. This figure includes combination equipment. High noise levels, high first costs, debris hazards, transportation requirements, inadequate cleaning, and slow production during wet periods were noted as deficiencies of this equipment.

Hot Air Lances

Nearly half of the respondents use of hot air/propane torch heat lances for pothole cleaning and drying. Operating temperatures and air velocities for this group of equipment vary widely. Propane torches have operating temperatures around 600 °F (316 °C) with very little air velocity. Some types of heat lances have operating temperatures of 3000 °F (1650 °C) and air velocities of 3000 fps (914 m/s). These units provide improved performance under cold and/or moist conditions. Safety hazards, potential pavement burning and, with some units, slow production are the major deficiencies noted of this equipment.

Hand Tools

Simple hand tools, such as picks, shovels, and brooms, were noted used by one-fourth of the respondents for pothole cavity cleanout. While providing simplified material removal, the ability to adequately dry the cavity during rainy weather or wet pavement conditions is severely hindered. Simple hand tools are generally used under adverse conditions and typically result in early patch failure.

Table 8
Equipment Questionnaire Summary
Asphalt Pavement Pothole Repair
Cleaning / Drying Pothole

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Air Compressor/ Hand Tools	52	<ol style="list-style-type: none"> 1. Availability 2. Removes Fine Material 3. Good Capacity 4. Easy to Use 5. Cleans & Dries Pavement 	<ol style="list-style-type: none"> 1. Noisy 2. Slow if Pavement is Wet 3. High Cost 4. Transport to Jobsite 5. Debris Hazard 6. Inadequate Cleaning
Hot Air/ Propane Torch	43	<ol style="list-style-type: none"> 1. Dries & Heats Pavement 2. Heat Can be Directed 3. Easily Handled 4. Portable 	<ol style="list-style-type: none"> 1. Dangerous 2. Can Burn Pavement 3. Inadequate for Large Areas
Hand Tools	25	<ol style="list-style-type: none"> 1. Practical 2. Easy to Use 	<ol style="list-style-type: none"> 1. No Shaping 2. Does Not Dry Pothole
Jackhammers	9	<ol style="list-style-type: none"> 1. Availability 2. Familiar Equipment 3. Compact & Maneuverable 	<ol style="list-style-type: none"> 1. Operator Dependent
Backhoe / Front End Loader	8	<ol style="list-style-type: none"> 1. Quick & Easy 2. Material Dumping in Truck 	<ol style="list-style-type: none"> 1. Expensive 2. Usually Too Big
Infrared Heater	4	<ol style="list-style-type: none"> 1. Improves Bond 2. Dries Pavement 	<ol style="list-style-type: none"> 1. Can Burn Pavement 2. Cumbersome
Conveyor for Millings	2	<ol style="list-style-type: none"> 1. Removes 95% of Debris 	

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

Infrared Heaters

Infrared heaters are also used for preparation of the pavement prior to the actual pothole repair. Oxidation potential and slow production rates were the major deficiencies noted. These units are basically self-contained and can be towed behind the supply truck or mounted to the rear of the truck. Areas up to 36 ft² (1.8 m²) and 1.5 in (38 mm) deep can be heated in approximately 4 minutes.

Priming

Application of a prime or tack coat is important to the long-term performance of a hot mix AC patch. The tack coat "wets" the existing material and promotes bonding with the patch mix. Asphalt cements, emulsions, cutbacks, and synthetic resins can all provide suitable results.

When using cold mix patch materials, the tack should be omitted unless the bottom of the patch is portland cement concrete. The solvents in the tack can soften the cold mix, increase shoving, and promote stripping. Hot mix AC patching materials should always be tacked. Table 9 provides a summary of the responses obtained.

Hand Tools

One-half of the respondents use hand brushes, brooms and/or pouring buckets for pothole priming. These methods are usually restricted to small potholes. Coverage rates are difficult to maintain and the potential for material waste and messy surfaces is high.

Spray Applicators

The use of spray applicators, with portable tanks, was reported by one-third of the respondents. The equipment is simple to use and provides for good, inexpensive coverage. As with the brush methods, these small, portable tanks are best suited for small repair areas where the material requirements are low. Cleaning of the spray lines must be done often to ensure good flow characteristics throughout the day, as the need for priming is intermittent. Typically, the hose is flushed with kerosene or diesel fuel after each tack application.

Asphalt Distributors

Asphalt distributors, typically with wand spray applicators, were reported used by roughly one-fifth of the respondents. Good coverage is readily obtained with this equipment. While

Table 9
Equipment Questionnaire Summary
Asphalt Pavement Pothole Repair
Priming

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Brushes & Brooms	51	1. Simple to Use 2. Inexpensive 3. Covers Area 4. Works in Cold Weather	1. Cold Applied 2. Poor Coverage 3. Rate Uncontrolled 4. Poor Production 5. Messy
Portable Sprayers	35	1. Good on Joints 2. Simple to Use 3. Good Coverage	1. Hard to Prime Straight Lines 2. Clogged Hoses
Wand Applicators & Sprayers	18	1. Good Coverage 2. Portable 3. Provides Hot Asphalt 4. Uniform Application 5. Fast Application to Large Areas	1. Extra Equipment on Jobsite 2. Transport 3. Clogged Hoses 4. Frequent Cleaning

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

the capacity of the distributor often exceeds the requirements of routine pothole repairs, the increased capacity provides a sufficient material source for use in bottom tacking of larger repair areas. Care must be exercised during these operations to prevent damage to the sides of the repair areas when driving the distributor onto the exposed base. This is commonly done by building a ramped entrance/exit to the repair area using base material. Cleanout requirements of the hoses and spray nozzles are similar to those mentioned for the portable equipment.

Tar Kettles

Hot applied asphalt cements were reported used by one-fifth of the respondents. Small tar kettles, typically with wand applicators, were the common equipment used to maintain proper application temperatures. The ability to recirculate the material in the hoses when not in use is a major advantage in keeping the hoses free of clogs.

Material Placement

The equipment used during material placement is highly dependent on the choice of material used for repairs. Table 10 provides a summary of the type of equipment used by the respondents. Cold mix is used by some agencies exclusively and by others only when hot mix is not available.

Hand Application

In many applications, the patch material is hand-shoveled from the back of a supply truck into the pothole cavity. This method is very labor intensive and can lead to extreme operator fatigue when applying large quantities and/or using dump trucks with high tailgate heights. With hot mix AC material, the dump truck is often tarped or insulated to help maintain the temperature of the mix prior to placement. Tailgate spreaders have also been used to distribute the material; however, the capacity of these units is limited.

Portable Heaters/Recyclers

Small, portable heaters/recyclers are also commonly used for material storage. Slow production rates, limited capacity, and hand loading/placement requirements were the major deficiencies noted of this type of equipment. Manual loading requirements have been alleviated by some agencies through the use of a small conveyor fitted to the rear of the supply truck.

Table 10
Equipment Questionnaire Summary
Asphalt Pavement Pothole Repair
Material Storage / Placement

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Portable Heater / Recycler	58	1. Keeps Material Hot in All Conditions 2. Reheats Old Mix	1. Requires Hand Placement 2. Limited Capacity 3. Slow Production
Truck Boxes	24	1. Availability 2. Good Capacity	1. Requires Hand Placement 2. Tailgate Height
Insulated Truck Boxes	10	1. Keeps Mix Hot	1. Requires Hand Placement 2. Waste Potential
Injection Method	10	1. Produces Blended Mix 2. Compacts During Placement 3. No Hand Placement	1. Slow Production

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100 %.

Transport Boxes

Heated transport boxes are used by one-tenth of the respondents for material storage. These units are towed or truck-mounted, either as permanent or slip-in/slip-out units. In most cases, the capabilities of this equipment to maintain material temperatures is adequate. The storage capacities, typically in the 4-6 ton range, have been reported as deficient for some applications.

Combination Equipment

Injection methods are also used to place the patch material within the cavity. A mixture of aggregate and emulsion, blended together during the injection process, is sprayed directly into the cavity. This forced injection provides some compactive effort during placement. The labor requirements of this equipment and slow production rates were the major deficiencies noted.

Compaction or Consolidation

Depending on the material, adequate compaction is critical in obtaining a patch which will perform well. An undercompacted mix will ravel, shove out of the patch, or compact excessively and leave a depression. Depending on the size of the patch, there are procedures which can make it easier to achieve density. The mixture should first be pinched into the hole by compacting the edges of the mixture. Next, the center of the patch should be compacted, moving outward toward the edges with each succeeding pass. This helps force the patch mix tightly against the edge of the existing pavement. During compaction, the equipment should rest completely on the patch mix and not on the old pavement. This will require moving transversely across the pavement if rutting is present. Slight overfilling of the cavity may also be required where the cavity size is smaller than the compactive "footprint" of the equipment used.

Nearly all of the respondents noted the use of compaction equipment during pothole repairs. Table 11 provides a summary of the types of equipment used.

Compactors

One-third of the respondents noted the use of vibrating plate compactors for material compaction. These plates have footprints of approximately 4 ft² (0.6 m²) and are generally adequate in compacting 2 to 3 in (51 to 76 mm) layer thicknesses. Slow production rates, handling difficulties, inadequacy to cover large areas and loading/unloading requirements were

Table 11
Equipment Questionnaire Summary
Asphalt Pavement Pothole Repair
Compaction / Consolidation

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Steel Wheel Rollers	62	1. Good Compaction	1. Rides on Adjoining Pavement 2. Transport 3. Time Consuming
Hand Tampers	48	1. Inexpensive 2. Easy to Use & Store 3. Provides Some Compaction	1. Inconsistent 2. Slow Production 3. Insufficient Compaction
Vibrating Plate Compactors	33	1. Good Compaction 2. Easy to Operate 3. Good for Small Patches 4. Compact & Maneuverable	1. Loading & Unloading 2. Slow Production 3. Inefficient for Large Areas
Truck Wheels	27	1. Availability 2. Inexpensive	1. Poor Compaction 2. Inefficient 3. Maneuverability 4. Uneven Compaction
Rubber Tired Rollers	3	1. Good Compaction	1. Loading & Unloading 2. Poor Finish

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

the major deficiencies noted. Transport and loading requirements may be eased through the use of a skid plate mounted on a hydraulic lift mechanism attached to the supply truck.

Steel Wheel Rollers

Roughly two-thirds of the respondents noted the use of steel wheel rollers for material compaction. Slow production rates, transport requirements, and roller size, which causes it to ride on the adjoining pavement, were the major deficiencies noted.

Small Tampers

Nearly one-half of the respondents noted the use of small plate tampers, either mechanical or hand driven, for compaction. Slow production, insufficient compactive force, and operator dependency were noted as the major deficiencies of this equipment. The relatively small footprint of these devices increases the likelihood of a poor surface finish on larger patches.

Traffic

One-fourth of the respondents noted the use of truck tires and/or traffic for compaction. Poor compaction, maneuverability problems and inefficient operations were the major deficiencies noted.

Finishing or Sealing Edges

Sealing the edge of the patch with a standard asphalt material improves performance. Synthetic resins should not be used because they remain tacky and will be picked up by vehicle wheels. The asphalt cement, emulsion, or cutback can be poured on the edge and brushed lightly. Clean sand or screenings may be placed over the asphalt product to prevent tracking. A thick layer of sealant may interfere with any subsequent overlay and should be avoided. Table 12 provides a summary of the responses obtained for finishing/sealing equipment.

Nearly one-half of the respondents noted the use of equipment for final finishing of pothole repairs. Half of these noted the use of distributors with sprayers for finishing pothole patches. One-third noted the use of hand rakes or lutes for surface finishing and one-fifth noted the use of pour pots for sealant application. The deficiencies of these equipments are similar to those noted for primer application.

Table 12
Equipment Questionnaire Summary
Asphalt Pavement Pothole Repair
Finishing / Sealing

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Distributor With Sprayer	50	<ol style="list-style-type: none"> 1. Good Production 2. Reduces Ravel 3. Seals Edges 	<ol style="list-style-type: none"> 1. Possible Tracking 2. Can Cause Bleeding
Rake / Lute	32	<ol style="list-style-type: none"> 1. Smooths Patch 2. Improves Ride Quality 3. Availability 	
Pour Pots	18	<ol style="list-style-type: none"> 1. Seals Edges 2. Quick & Inexpensive 3. Good For Small Quantities 	<ol style="list-style-type: none"> 1. Possible Tracking

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

Combination Equipment

Combination equipment are those that can perform several or all of the above-described subtasks. There currently are at least two basic types of combination equipment to perform pothole patching: one which performs each activity mentioned separately and one which utilizes specialized equipment to complete tasks simultaneously.

The first type employs a boom-mounted work arm which provides compressed air for cleaning, liquid asphalt for tacking and sealing, hot air jets for drying and setting of the asphalt, and a hydraulic tamper for material compaction. A heated storage compartment provides hot mix to the patch cavity by auguring. The operation of all components is performed through control levers mounted in the driver's cab. The quality of work performed by these machines is reported to be satisfactory by users, although the time required to complete a typical patch may be excessive for some applications.

The second type of combination equipment utilizes a boom-mounted, high-volume blower which provides compressed air for cleaning, liquid asphalt for tacking, and an asphalt-aggregate blend for cavity filling. The operation of all components is achieved through control valves mounted near the exit port of the blower. Aggregate is supplied to the blower from a towed hopper through an auguring system. Acceptable levels of compaction are reported by users.

4

PCC Joint Resealing

Introduction

Effective joint maintenance is critical to the performance of jointed concrete pavements. The joints are a point of weakness in the slab and therefore the location of many of the distresses which occur in concrete pavements. Through the effective sealing and resealing of the joints, the life of a concrete pavement may be extended by addressing the source of many concrete pavement problems.⁽²⁾

Various research studies have indicated that only a small portion of joints in existing concrete pavements are adequately sealed.^(3,4,5,6) In one recent survey, the frequency for sealing joints and cracks in concrete pavements was once every 5 years.⁽⁴⁾ However, good performance has not always been achieved over that time period, with sealant failures after only 1 or 2 years of service being quite common.

Types of Joint Damage

The primary reasons for resealing joints are to reduce the infiltration of water into the pavement sub-structure and to prevent the intrusion of incompressibles into the joint. The consequence of nonsealed or poorly sealed joints is the occurrence of various joint-related distresses. For example, surface water that easily infiltrates a joint can accelerate erosion of the underlying base material, thereby resulting in loss of support, corner breaks, pumping, and joint faulting. Additionally, incompressibles which lodge themselves in a joint resist the expansive pressures of the slab as it expands under elevated temperatures, thereby causing joint spalling, blowups, and bridge pushing.

Joint damage may also result from sawing inadequacies. These concrete failures adjacent to the joint face may take several years before they appear. Failures of this type permit water and incompressibles to infiltrate the joint system from a source other than the joints.

Other types of joint damage are related to deficiencies of the aggregate used in the concrete mix design. D-cracking is a series of fine, interrelated cracks that are initiated through freeze-thaw failure of susceptible coarse aggregates in a moist environment. Reactive aggregate is fine cracking of the cement matrix due to a reaction between alkalis in the cement paste and the siliceous components of certain aggregates. Although joint sealing will not prevent the occurrence of these distresses, a good joint resealing program is still expected to provide some benefit.

Types of Joint Sealants

There exist a large variety of joint sealants on the market today that have varying equipment needs. The different sealant types exhibit widely different properties and performance characteristics. Many factors influence their performance, including the expected movement (opening/closing) of the joint, the sealant reservoir shape, the bonding between the sealant and sidewall, the properties of the sealant itself, the climatic conditions encountered, and the procedures and equipment used to install the sealant. In the following section, the general categories of joint sealants and some of their associated characteristics are presented because of their importance in determining equipment deficiencies.

Field-Cured Liquid Sealants

This category consists of all petroleum-based sealants (asphalt, cutbacks, emulsions), modified petroleum-based sealants (rubberized asphalt, polymerized asphalt), polyurethanes, PVC coal tars, and silicones, among others. Depending on materials and formulations, the sealants can be either hot- or cold-poured.

Figure 1 shows a schematic of a concrete joint sealed with a field-cured sealant. The shape factor is defined as the ratio of the joint reservoir width to the joint reservoir depth. Ideally, the shape factor should be between 0.5 and 1.0 for petroleum-based sealants and between 1.0 and 2.0 for silicone sealants. When these criteria are met, the stress on the sealant will be relatively low.

The use of a backer rod, also illustrated in figure 1, determines the maximum depth of the sealant and prevents the sealant from entering the lower portion of the joint. In addition, the

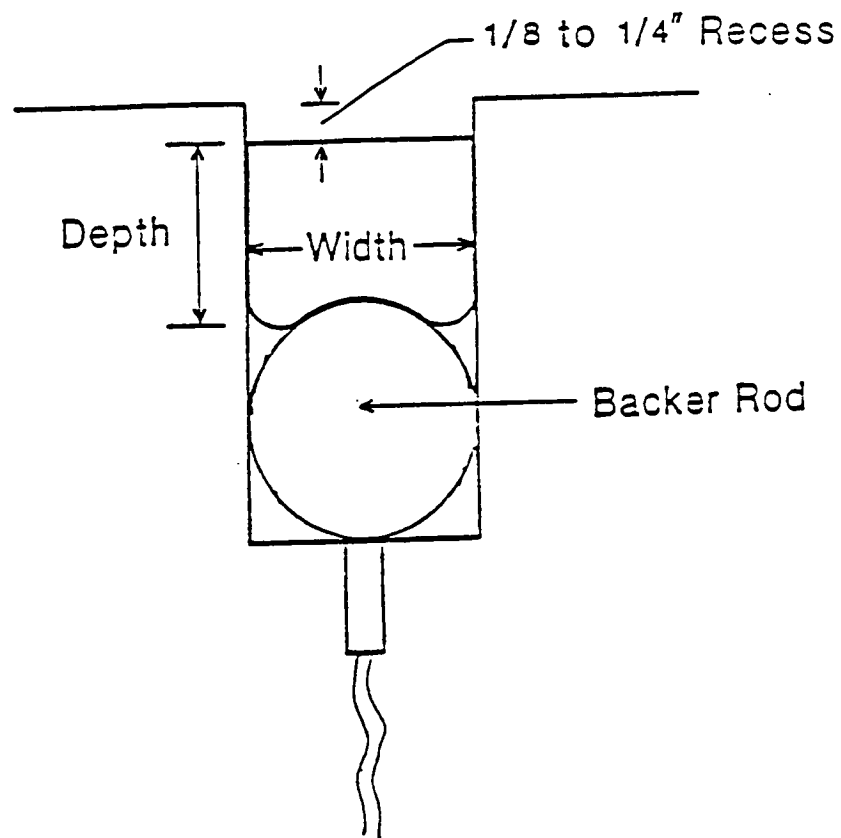


Figure 1. Cross section of a concrete joint sealed with a field-cured sealant.

backer rod is expected to function as a bondbreaker by preventing the sealant from bonding to the bottom of the joint reservoir.

Preformed Compression Seals

While the liquid sealants are designed to experience both tension and compression, preformed compression seals are designed to be in compression for their entire life. A compression seal is designed with webbing, as depicted in figure 2. The webbing provides a constant force against the sidewalls of the joint which holds the seal in place. Depending on the system, the compression seal may or may not use an adhesive on the sidewalls of the joint. When used, the function of the adhesive is to help prevent the sealant from failing in shear and "walking" out of the joint.

Similar to the liquid sealants, the joint width must be designed to handle the expected openings and closings. The depth of the reservoir must exceed the depth of the seal and the recess, but it is not related to the width of the joint.

Procedures and Equipment Deficiencies

Resealing joints in concrete pavements is necessary when the sealant has deteriorated to the extent that incompressibles and/or water can infiltrate into the pavement. The resealing operation consists of the following five stages:

1. Sealant Removal and Joint Refacing.
2. Cleaning.
3. Backer rod installation.
4. Sealant Preparation and Application.
5. Final shaping/tooling.

Each of these steps is discussed in more detail in the following sections. Equipment used in each operation is emphasized, with deficiencies and limitations discussed.

Sealant Removal and Joint Refacing

The first steps in the resealing operation are the removal of the old sealant material and the refacing of the joint. The sealant removal operation is generally preparatory to the joint refacing but, depending on the condition of the sealant and the equipment used, may occur simultaneously with the refacing operation.

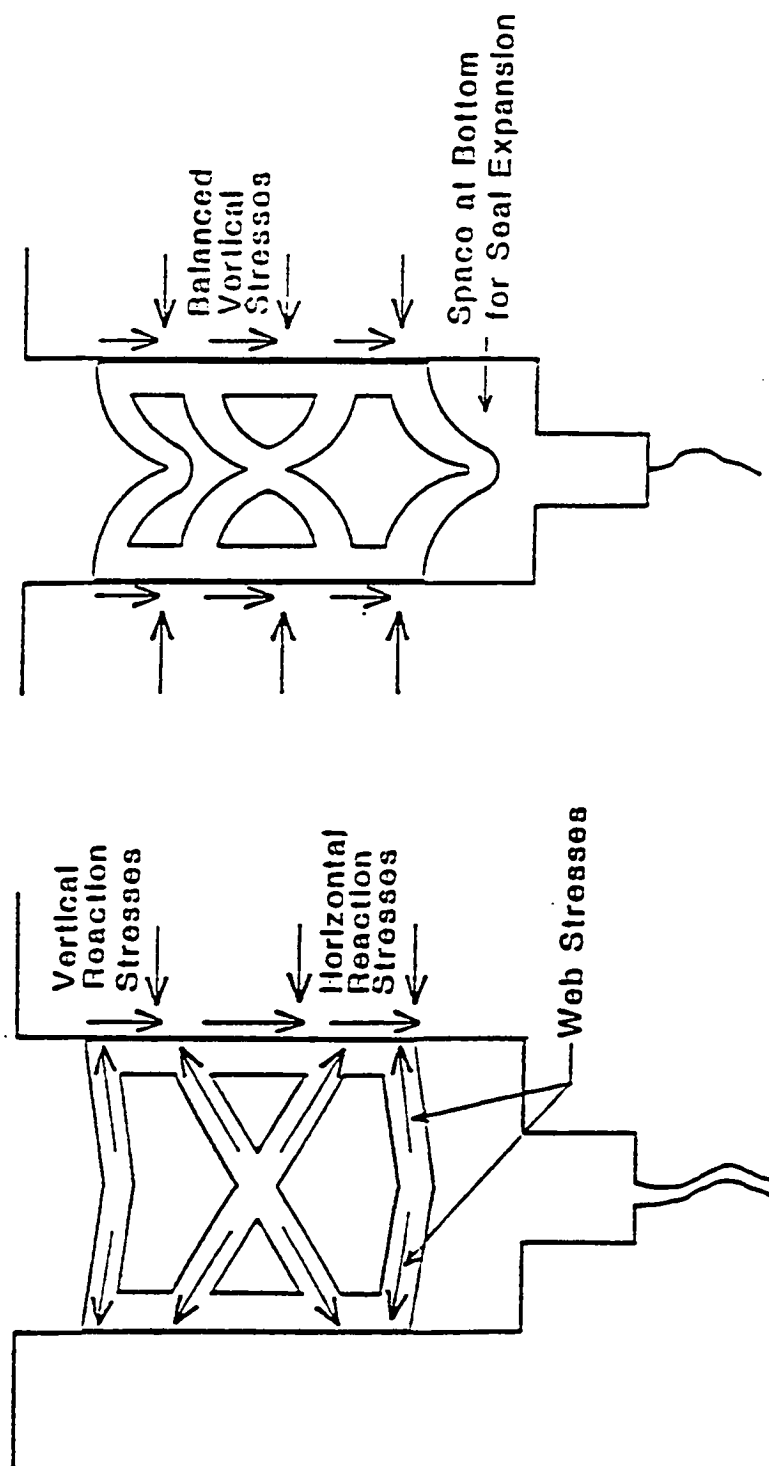


Figure 2. Cross section of concrete joint sealed with a preformed compression seal.

Sealant removal is intended to remove old deteriorated sealant material which could contaminate the refaced joint reservoir and prevent the uniform flow of new sealant materials. Joint refacing is intended to provide an uncontaminated fresh surface for which the new sealant to adhere. Usually joint refacing operations widen the joint reservoir less than 0.24 in (6.4 mm). The reservoir is generally not deepened, unless considerable widening was required which would necessitate the deepening of the reservoir to accommodate the required minimum sealant thickness.

Sealant removal and joint refacing operations may be done with any suitable procedure that does not damage the joint reservoir. Equipment commonly used for this operation includes concrete saws, routers, and joint plows.

Concrete Saws

Concrete sawing, using either a diamond or carbide saw blade, is an effective means of sealant removal when the existing sealant has hardened sufficiently and will not melt and "gum-up" the saw blade. This equipment can also be used to reface the joint, accomplished through the use of wider saw blades or through two blades ganged together with an internal spacer. However, the latter has often resulted in joints that vary in width along the length of the joint. Manufacturers are producing single blades of wider dimensions for the specific purposes of the establishment of the joint reservoirs.

Table 13 lists advantages and disadvantages for the various sawing/routing equipment. Nearly all respondents indicated the use of concrete saws for the removal of the old sealant material and joint refacing procedures. Advantages cited for concrete saws included their ease of operation and maneuvering; while disadvantages included inadequate sealant removal, high first cost, potential spalling, and additional joint face removal required.

Routers

Routers are also available for the removal of the old sealant material and for the formation of a joint reservoir. Similar to wood routers, these devices contain a vertical bit that rotates at a high rate of speed, removes all existing sealant material in the joint and refaces the joint sidewalls.

Roughly one-third of the respondents use routers for sealant removal and joint refacing. There apparently are some differences of opinion pertaining to its use and operation, as several respondents reported that it was easy to use and follows the joint well, whereas others

Table 13
Equipment Questionnaire Summary
Concrete Pavement Joint Resealing
Sawing / Routing

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Concrete Saws	91	<ol style="list-style-type: none"> 1. Easy to Operate 2. Dry Cutting Possible 3. Provides Straight Edge 4. Easy to Maneuver 	<ol style="list-style-type: none"> 1. Inadequate Sealant Removal 2. High First Cost 3. Potential Spalling 4. Additional Joint Face Removal
Routers	30	<ol style="list-style-type: none"> 1. Easy to Use 2. Follows Joint Well 	<ol style="list-style-type: none"> 1. Slow Production 2. Leaves Spalled Edges 3. Difficult to Maneuver
Joint Plows	13	<ol style="list-style-type: none"> 1. Simple to Use 2. Faster Cleaning 	<ol style="list-style-type: none"> 1. Inadequate Cleaning

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

noted that it was difficult to maneuver. Other disadvantages cited include slow production rates and the inducement of joint edge spalling.

Joint Plows

The joint plow is a rectangular tool installed on the hydraulic mount of a tractor that is inserted into the joint and pulled along the length of the joint, cutting the sealant away from the sidewalls. However, it should be noted that the joint plow is for sealant removal purposes only; it cannot reface the joint sidewalls. Saws or routers would have to be used for that purpose, thus requiring an additional piece of equipment and additional work time.

The joint plow must be rectangular and fit into the joint without scraping the sides excessively. In addition, it should be mounted in such a way that it is free to move vertically and horizontally in the joint without binding. Several widths of the cutting plow should be available as joint widths are seldom uniform over the length of the entire project. The use of a v-shaped plow can cause excessive spalling of the joints, resulting in a joint that is difficult to seal.

While joint plows are not extensively used, 13 percent of the respondents indicated their use for the removal of old sealant material. While the equipment was noted to be fast and simple to operate, the method did not always produce adequate cleaning of the joint faces. In addition, the use of this equipment does not allow for the refacing of the joint faces, thus requiring another piece of equipment to perform that operation, if needed.

Summary

In sum, the biggest deficiency of the equipment in this category appears to be that the adequate removal of the old sealant material is difficult to achieve at a high level of productivity. Equipment capable of performing the sealant removal and joint refacing in a one-pass operation is required to increase the efficiency of the operations to acceptable levels. This must be accomplished without spalling the PCC surround.

Cleaning

Perhaps the most critical phase of the joint resealing operation is the cleaning of the joint prior to the application of the sealant material. The joint walls must be cleaned of all foreign matter which might interfere with the bonding of the sealant to the joint sidewalls. However, a major impediment to the successful completion of this task is the lack of standard, repeatable means for measuring the cleanliness of a joint face.

Various types of equipment are available for the cleaning of the joint. Table 14 provides a summary of the responses to the questionnaire pertaining to the cleaning operation. Air blasting, sand blasting, and water blasting are the common equipment types for this operation. Air blowers, wire brush, and hot air lances have also been used.

Air Blasting

High pressure air blasting equipment consists of a standard air compressor and hoses. All loose debris is effectively removed by this procedure, but old sealant, laitance, and other materials are not adequately removed. Because of this inefficiency, air blasting may be most useful in combination with other cleaning methods to provide only the final cleaning of the joint immediately prior to the sealant installation. Air compressors used to clean new or refaced concrete joints must be equipped with functional water and oil traps to prevent contamination of the joint bonding faces. Air hoses must be dedicated exclusively to cleaning and must be free of all contaminants.

Pressure air blast systems are being used by a majority of the responding agencies. This method was noted to be quick, easy to use, readily available, nondamaging to the concrete, and good for cleaning and drying. However, high noise levels, hazard of flying debris, inadequate cleaning, and the possibility of introducing moisture into the joint are deficiencies of this cleaning method.

Sand Blasting

Sand blasting can be an effective means of removing laitance from the joint sidewall. This procedure requires that the nozzles of the sand blasting equipment be modified with deflectors to direct the sand against the sidewalls. Sand blasting is not designed to remove old sealant, and should not be performed in lieu of sealant removal.

Sand blasting is used by approximately one-fourth of the respondents as part of the cleaning procedures. While this method may provide good results in terms of cleaning and providing a good bonding surface, slow production rates, potential damage to joint faces, and safety concerns have been noted as deficiencies of this method.

Water Blasting

High pressure water blasting can be an effective method of cleaning the joint reservoir. Pressures of 2000 to 4000 psi (13.8 to 27.6 MPa) are commonly specified for joint cleaning. Water blasting is very effective in removing all foreign matter from the joint, and has the

Table 14
Equipment Questionnaire Summary
Concrete Pavement Joint Resealing
Cleaning

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
High Pressure Air Blast	57	<ol style="list-style-type: none"> 1. Easy to Use 2. Cleans & Dries 3. Availability 4. Does Not Damage Concrete 5. Quick Method 6. Good for Final Cleaning 	<ol style="list-style-type: none"> 1. Noisy 2. Old Sealant Not Removed 3. Flying Debris Hazard 4. Inadequate Cleaning 5. Can Add Moisture
Sand Blasting	23	<ol style="list-style-type: none"> 1. Cleans Well 2. Good Bond Surface 	<ol style="list-style-type: none"> 1. Slow Production 2. Safety Hazard 3. Potential Joint Face Damage
Water Blast	11	<ol style="list-style-type: none"> 1. Cleans Joint Well 2. Faster Cleaning 	<ol style="list-style-type: none"> 1. Leaves Wet Surface 2. Needs Drying Time or Heat
Back Pack Blowers	9	<ol style="list-style-type: none"> 1. Portability 2. Cleans & Dries 	<ol style="list-style-type: none"> 1. Inadequate Cleaning 2. Heavy, Operator Fatigue
Wire Brush	6	<ol style="list-style-type: none"> 1. Removes Dust 	<ol style="list-style-type: none"> 1. Metal Deposits on Joint Walls 2. Slow Production
Hot Air Lance	6	<ol style="list-style-type: none"> 1. Easy to Use 	

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

additional advantage of being able to deep-clean the entire joint, not just the joint reservoir. In this way, incompressibles lodged in the lower half of the slab which may have been pumped up from the underlying base course may be removed without additional operations. This will serve to reduce pressure-related joint damage that may occur because of incompressibles deep in the joint. However, this deep joint cleaning may damage the underlying base course and require extensive drying times. In addition, due to the high pressures involved, water blasting presents a severe safety hazard as it can easily cut or damage human extremities.

Roughly one-tenth of the respondents noted the use of water blasting for cleaning. While providing good cleaning, the method is time consuming and it inherently requires the need for substantial drying times before sealant installation. This time differential often allows for recontamination of the joint faces, increasing the potential for adhesion failures.

Back-Pack Blowers

Back-pack blowers are portable devices which produce blown air that can be used to clean out joints. Since they are carried by the user, they provide a great deal of mobility. However, their major disadvantage is that they lack power to produce sufficient air pressures.

Back-pack blowers are used for cleaning by one-tenth of the respondents. Although these devices were noted to increase the mobility of the operator, most respondents felt that this method provided too little power to provide an effective cleaning of the joint.

Power Brushes

Power-driven wire brushes have been used to clean out the joint prior to the sealant installation. While this procedure has been popular in the past, it's current usage has diminished due to the fact that joint sealant may be smeared onto the joint sidewalls, requiring additional cleaning efforts to achieve a satisfactory bond.

Wire brush usage was reported by only 6 percent of the respondents for joint cleaning. While being practical for removing dust and other loose debris in the joint, productivity levels are generally poor and contamination potentials from both metal deposits and sealant smearing are evident.

Hot Air Lances

Hot air lances combine heat with high air pressures to produce air blasts that can not only clean out a joint, but also dry it in the same process. Only four percent of the respondents noted the use of hot air lances for joint cleaning. While being easy to use and effective in performing cleaning and drying, safety concerns and high noise levels have been identified as problem areas.

Summary

The major shortcomings of current cleaning equipment may be summarized as an inability to adequately remove any joint sealant that remains from the sawing/routing operation and poor productivity levels.

Backer Rod Installation

A backer rod may be installed in the joint reservoir prior to the actual application of the joint sealant. A final cleaning of the joints, typically with compressed air, is generally performed to remove any dust or debris that may have collected in the joint after it was cleaned. Immediately following this final cleaning process, the backer rod is installed to the specified depth to provide for the proper shape factor. The backer rod is a nonrigid, nonabsorptive material, intended to provide the desired shape factor, to prevent the sealant from bonding to the bottom of the reservoir, and to prevent the liquid sealant from running down into the crack below the joint reservoir. The backer rod is coated with a non-reactive polyethylene coating to prevent sealant damage. The summary of responses for the equipment used for the installation of the backer rod material is provided in Table 15.

Custom-made Rollers

Backer rods are installed using custom-made rollers which place the backer rod to the specified depth. The advantages of this equipment include low cost and ease of use; however, uniform placement depths throughout the length of the joint are not being consistently achieved.

Hand Installation

Backer rods have also been installed by hand using screwdrivers or other prying-type equipment, but this method is not recommended due to poor depth control and potential

Table 15
Equipment Questionnaire Summary
Concrete Pavement Joint Resealing
Backer Rod Installation

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Shop Made Depth Rollers	93	1. Inexpensive 2. Works Well 3. Fast & Simple to Use 4. Prevents Ratholing	1. Uneven Depth
Hand Installation	7	1. Simple	1. Labor Intensive

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

damage to the backer rod. A chemical reaction between the damaged backer rod and some sealants may cause premature sealant failure.

Summary

The custom-made depth rollers appear to provide reasonable results, but problems in achieving and maintaining the proper depth of the backer rod remain. This may be due to several factors, including inadequate depth of the reservoir, the backer rod not being pulled taught, debris in the joint reservoir, a poorly-maintained roller, and operator inattention.

Sealant Preparation and Application

Once the backer rod has been installed and the final joint cleaning has been performed, the joint is ready for the application of the sealant. Depending on the type of sealant in use and the size of the joint resealing project, various types of equipment are available. The responses to the questionnaire on sealant preparation and application are given in Table 16.

Asphalt Kettles, Applicator Hoses, and Wands

Applicator hoses and applicator wands attached to oil heat transfer asphalt kettles are generally used for the application of asphaltic sealant materials into the joint. This method assures that sufficient materials are available to perform large resealing jobs. However, for small scale resealing operations, pour pots have been used to apply the sealant in the joint.

Over three-fourths of respondents noted the use of asphalt kettle/distributors for sealant heating prior to application, typically in the 200 to 400 gallon (757 to 1514 l) range. These devices showed adequate capacity, good workability, and ease of handling. However, those with open flames are reported as dangerous and direct heat (no heat transfer fluid) causes uneven heating and local hot spots which will burn the sealant. Their use is usually not recommended with concrete joint sealants. In addition, the majority of respondents reported that the kettles with oil heat transfer had slow start up times to attain proper sealant temperature. The larger, 400 gallon (1514 l) units are particularly prone to this problem.

Pour Pots

Pour pots are hand-carried containers that hold a small amount of sealant material that is subsequently applied in the joint through a spout. Pour pots were used by 13 percent of the respondents, who reported good results for small jobs. There were no deficiencies listed, although it is believed that these would be inefficient for large-scale resealing operations.

Table 16
Equipment Questionnaire Summary
Concrete Pavement Joint Resealing
Sealant Preparation & Application

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Asphaltic Materials			
Asphalt Kettles With Applicator Hoses	78	1. Keeps Material Workable 2. Good Capacity 3. Compatible With Rubber Sealants 4. Maintains Uniform Temperature 5. Easy to Handle	1. Dangerous, Open Propane Flames 2. Uneven Heating Without Double Jacketing 3. Requires Cleaning Often 4. Slow Heat-up 5. Clogging Hoses 6. High Fuel Consumption 7. Expensive
Pour Pots	23	1. Good for Small Areas	1. Labor Intensive 2. Messy
Silicone Materials			
Silicone Pumps	100	1. Works Well 2. Uniform Flow	1. Can Produce Bubbles in Sealant

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

Silicone Pumps

For silicone sealing operations, silicone pumps are used to transfer the silicone from 5 or 55 gallon (19 or 208 l) drums to applicator wands. The lack of a need to heat the material is a distinct advantage for this application, thereby reducing equipment and energy requirements prior to sealant placement.

All respondents who reported using silicone sealants indicated that they use silicone pumps. These devices work well and provide for a uniform flow, but they reportedly often produce bubbles in the sealant if careful installation practices were not observed. It is possible that this is due to a reaction between the backer rod core and the silicone sealant as a result of damage to the polyethylene coating of the backer rod.

Summary

While the applicators themselves appear to be sufficient, there appears to be a definite need for improvement in the heating/pumping equipment. Uneven heating, temperature control, high fuel consumption, and safety hazards of the asphalt kettles are areas where improvement can be made. The fact that the silicone sealants do not require elevated temperatures for placement is a distinct advantage, although they have a slower rate of installation.

Final Shaping/Tooling

After sealant installation, final shaping or tooling of the sealant is sometimes required to ensure the proper position of the sealant. For hot-poured sealants, hand-held squeegees are sometimes used to provide a banded surface application. For conventional silicone sealants, a separate tooling operation is needed to produce a uniform surface and to ensure bonding of the sealant with the sidewall. This operation requires that a shaped tool be drawn over the surface of the silicone sealant, forcing the sealant into contact with the sidewall at the top of the sealant and producing the correct amount of recess of the sealant. However, it should be noted that new, self-leveling silicone sealants have recently been developed which do not require this final tooling operation. Table 17 provides a summary of the equipment used for final shaping and tooling of the newly-place joint sealant material.

Squeegees

Hand-held squeegees are the predominant tool used for hot-pour sealant finishing. They are simple to use, inexpensive items which provide good uniform coverage. Disadvantages

Table 17
Equipment Questionnaire Summary
Concrete Pavement Joint Resealing
Final Shaping / Tooling

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Asphaltic Materials			
Hand Held Squeegees	53	<ol style="list-style-type: none"> 1. Inexpensive 2. Easy to Use 3. Smooth Finish 	<ol style="list-style-type: none"> 1. Spreads Material on Adjacent Slab
Hand Held V-Squeegees	45	<ol style="list-style-type: none"> 1. Simple to Use 2. Good Coverage 3. Good Material Control 4. Uniformity 	<ol style="list-style-type: none"> 1. Slow Production 2. Messy
Wand Applicator With Flanges	4	<ol style="list-style-type: none"> 1. Slides Well on Pavement 	<ol style="list-style-type: none"> 1. Too Wide for Joint
Silicone Materials			
Backer Rod	50	<ol style="list-style-type: none"> 1. Inexpensive 2. Works Well 3. Provides Proper Shape Factor 4. Easily Replaced 	<ol style="list-style-type: none"> 1. Operator Dependent 2. Sealant Build-Up 3. Shape Factor not Always Achieved
Shop Made Finishing Tools	50	<ol style="list-style-type: none"> 1. Inexpensive 2. Controls Shape Factor 	<ol style="list-style-type: none"> 1. Slow Production

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

reported by the respondents included the time-consuming nature of the work and that the squeegees are quite messy, often leaving sealant material spread on adjacent slabs. Four percent of the respondents had applicator wands containing flanges to perform the final shaping immediately after the sealant was placed. This type of equipment eliminates a step in the joint resealing process.

Silicone Tooling Devices

Silicone sealant tooling is typically accomplished using hand-held devices, most notably backer rods or shop-made finishing tools. Backer rods, either hand-held or attached to a stick, and shop-made finishing tools are used equally often as tooling devices. Both methods are reported as simple to use, inexpensive and effective. Operator dependency and low productivity rates are associated with these methods.

Summary

When used, the major problem with the use of separate equipment for the final tooling/shaping operation is low productivity. This is particularly true for the conventional silicone sealants that require special tooling techniques. Combining the final shaping/tooling operation with the actual sealant application provides for a more efficient methodology. This has in fact been adopted on some equipment and has been successful at increasing productivity rates.

5

PCC Crack Sealing

Introduction

The identification of cracks to be sealed in concrete pavements requires special considerations, as not all cracks benefit from sealing. For example, jointed reinforced and continuously reinforced pavements are designed such that the slab will develop transverse cracks. The reinforcement is provided to hold the cracks tightly together so that aggregate interlock and thus good load transfer will be maintained. In this case, the appearance of tight cracks is taken into account in the design of the slab and they permit only minimal entry of water or incompressibles. The routing and sealing of these cracks provides no benefit and could cause damage to the slab.^(4,5) These cracks can, however, deteriorate into "working" cracks for a variety of reasons, and at that time would benefit from sealing to inhibit the intrusion of moisture and incompressibles.^(4,5)

The opening and closing of working cracks varies widely, as a function of such factors as the distance between working cracks, joint spacing, the extent to which existing joints can open and close (which may be restricted by dowel bar corrosion or dowel misalignment), the friction between the base and the slab and, the seasonal temperature variations. In some cases, the situation may result in very large movements at the crack which should be accounted for in designing the crack sealant reservoir.

Procedures and Equipment Deficiencies

Sealing cracks in concrete pavements is necessary only when the crack has deteriorated to the extent that it is working, allowing incompressibles and water to infiltrate into the pavement.

The crack sealing operation consists of the following stages:

The crack sealing operation consists of the following stages:

1. Routing or sawing the crack reservoir
2. Cleaning the crack reservoir
3. Backer rod installation
4. Sealant application
5. Final shaping/tooling of the sealant

Routing or Sawing the Crack Reservoir

Cracks in a concrete pavement are normally non-uniform in size and not clean, and thus not appropriate for application of a sealant. The size of the reservoir in the crack should be similar to the size required for a joint undergoing the same movement to provide the sealant with an acceptable stress/strain condition.

The variability of cracks often necessitates different repair procedures for the different classifications of cracks. The newer, low modulus soft sealants do not perform as well if the crack is spalled. Low modulus sealants have a tendency to pull away from the irregular surfaces of the spall producing failure along the entire joint or crack. For optimum performance, spalls should be repaired prior to the crack sealing operations. The following criteria are utilized by some agencies to determine the type of repair to be performed:

1. Low-severity crack, hairline to 0.13-in (3.2 mm) wide with no spalling: do not widen or seal (do nothing).
2. Cracks 0.13 to 0.75 in (3.2 to 19 mm) wide with little or no spalling: the crack should be routed or sawed before sealing.
3. Cracks 0.375 to 0.75 in (9.5 to 19 mm) wide with significant spalling: perform partial-depth spall repair in the same manner as for a joint, maintaining the crack with an adequate reservoir shape through the repair and then sealing the crack.
4. Cracks greater than 0.75 in (19 mm) wide with no spalling: rout the crack and seal. Consider using a backer rod if the crack is too deep.
5. Cracks greater than 0.75 in (19 mm) wide with major spalling: rebuild the crack as if it were a joint. This may require large amounts of concrete pavement removal to obtain a true joint. These cracks are

generally working and are functioning as a joint. They may require load transfer restoration depending on traffic level to prevent excessive faulting. It may be more effective to place a doweled full depth repair.

A summary of the questionnaire results pertaining to reservoir creation equipment is shown in Table 18.

Routers

The formation of a sealant reservoir in a crack can be done with a routing tool which is similar to a wood router, using a vertical bit to remove concrete to the desired depth and width. These devices follow the irregular directions of the crack and they can be used in some instances to remove old sealant adhering to the crack sides. These devices are slow and are being replaced by the newer concrete saws. Rotary impact routers are not recommended as they spall the surface.

Forty-one percent of the respondents noted the use of routers for the formation of the sealant reservoir in concrete pavements. The major deficiencies were spalling of the crack, cost of the routers and excessive cutter wear on concrete.

Small Diameter Saws

Small diameter diamond saw blades and equipment are being produced that can follow a crack reasonable well. The blades have a small diameter and greater flexibility than joint saw blades, to allow the machine to follow the crack. These machines are smaller, and have three wheels, which allow the saw to pivot and follow irregular crack shapes.

Roughly one-half of the respondents noted the use of concrete saws for reservoir creation. Slow production rates, high first cost, and high blade replacement costs were noted as the major deficiencies.

Summary

In sum, the biggest deficiency of the equipment in this category appears to be low productivity. Equipment capable of performing crack refacing and old sealant removal in a one-pass operation is required to increase the efficiency of the operations to acceptable levels. This must be accomplished without spalling the PCC surround.

Table 18
Equipment Questionnaire Summary
Concrete Pavement Crack Sealing
Sawing / Routing

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Concrete Saws	55	<ol style="list-style-type: none"> 1. Works Well 2. Uniform Groove 3. Minimum Spalling 4. Light & Maneuverable 	<ol style="list-style-type: none"> 1. Slow Production 2. High Blade Cost 3. Expensive
Routers	44	<ol style="list-style-type: none"> 1. Follows Crack Well 2. Small, Easy to Handle 3. Good Production 	<ol style="list-style-type: none"> 1. Moderate Spalling 2. Expensive 3. Excessive Cutter Wear
Joint Plows	3	<ol style="list-style-type: none"> 1. Availability 	<ol style="list-style-type: none"> 1. Inadequate Cleaning

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

Cleaning of the Crack Reservoir

The most critical phase of the sealant installation is the cleaning of the crack. The walls must be cleaned of all foreign matter which would interfere with the sealant bonding. A major impediment to the satisfactory completion of this task is the lack of a standard, repeatable means for measuring the cleanliness of a crack face. A summary of the questionnaire results pertaining to cleaning equipment is shown in Table 19.

Sand Blasting

Sand blasting is used by 13 percent of the respondents as a method for crack cleaning. It can be an effective way of removing the fine material from the crack sidewall. The nozzles of some sand blasting equipment have been modified with deflectors to direct the sand against the sidewalls to provide a clean surface. Sand blasting is not designed to remove old sealant, and should never be performed in lieu of sealant removal. Slow production rates, safety hazards, and potential damage to crack faces were noted as deficiencies of this method.

Air Blasting

A pressure air blast system was noted as used by 83 percent of the respondents. The equipment, consisting of a standard air compressor and hoses, is generally available and quick and easy to use. Deficiencies noted include high noise levels, debris hazard, inadequate cleaning, and the possibility of introducing moisture into the joint.

Back-Pack Blowers

Thirteen percent of the respondents noted using back-pack blowers for this type of cleaning. While increasing the mobility of the operator, most respondents felt that this method provided too little power to provide an effective cleaning.

Water Blasting

Ten percent of the respondents noted the use of water blasting for crack face cleaning. Inadequate cleaning and the need for drying times were the main deficiencies noted.

Hot Air Lances

Hot air lances combine heat with high air pressures to produce air blasts that can not only clean out a crack, but also dry it in the same process. Thirteen percent of the respondents

Table 19
Equipment Questionnaire Summary
Concrete Pavement Crack Sealing
Cleaning

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
High Pressure Air Blast	83	<ol style="list-style-type: none"> 1. Easy to Use 2. Cleans & Dries 3. Availability 4. Removes Debris 5. Fast & Mobile 	<ol style="list-style-type: none"> 1. Noisy 2. Old Sealant Not Removed 3. Flying Debris Hazard 4. Inadequate Cleaning 5. Can Add Moisture
Sand Blasting	13	<ol style="list-style-type: none"> 1. Cleans Well 2. Roughens Vertical Surface 	<ol style="list-style-type: none"> 1. Slow Production 2. Safety Hazard 3. Inadequate Cleaning
Water Blast	10	<ol style="list-style-type: none"> 1. Cleans Joint Well 2. Fast & Mobile 	<ol style="list-style-type: none"> 1. Leaves Wet Surface 2. Needs Drying Time or Heat 3. Inadequate Cleaning
Back Pack Blowers	13	<ol style="list-style-type: none"> 1. Portability 2. Cleans & Dries 	<ol style="list-style-type: none"> 1. Inadequate Cleaning 2. Inadequate Pressure
Hot Air Lance	13	<ol style="list-style-type: none"> 1. Easy to Use 2. Quick & Efficient 3. Dries Pavement 	<ol style="list-style-type: none"> 1. Can be Noisy

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

noted the use of hot air lances for crack cleaning. While being easy to use and effective in performing cleaning and drying, safety concerns and high noise levels have been identified as problem areas.

Summary

The major shortcomings of current cleaning equipment may be summarized as an inability to adequately clean the crack reservoir after the sawing/routing operation and poor productivity levels.

Backer Rod Installation

A backer rod may be installed in the crack reservoir prior to the actual application of the sealant. A final cleaning of the cracks, typically with compressed air, is generally performed to remove any dust or debris that may have collected in the crack after it was cleaned. Immediately following this final cleaning process, the backer rod is installed to the specified depth to provide for the proper shape factor. The backer rod is a nonrigid, nonabsorptive material, intended to provide the desired shape factor, to prevent the sealant from bonding to the bottom of the reservoir, and to prevent the liquid sealant from running down into the crack below the formed reservoir. The backer rod is coated with a non-reactive polyethylene coating to prevent sealant damage. The summary of responses for the equipment used for the installation of the backer rod material is provided in Table 20.

Custom-made Rollers

Backer rods are installed using custom-made rollers which place the backer rod to the specified depth. 85% percent of the respondents noted the use of these devices for backer rod placement. The advantages of this equipment include low cost and ease of use; however, uniform placement depths throughout the length of the joint are not being consistently achieved.

Hand Installation

Backer rods have also been installed by hand using screwdrivers or other prying-type equipment, but this method is not recommended due to poor depth control and potential damage to the backer rod. A chemical reaction between the damaged backer rod and some sealants may cause premature sealant failure.

Table 20
Equipment Questionnaire Summary
Concrete Pavement Crack Sealing
Backer Rod Installation

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Shop Made Depth Rollers	85	1. Inexpensive 2. Works Well 3. Fast & Simple to Use 4. Prevents Ratholing	1. Uneven Depth 2. Labor Intensive
Hand Installation	15	1. Simple	1. Labor Intensive

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100 %.

Summary

The custom-made depth rollers appear to provide reasonable results, but problems in achieving and maintaining the proper depth of the backer rod remain. This may be due to several factors, including inadequate depth of the crack reservoir, the backer rod not being pulled taught, debris in the crack reservoir, a poorly-maintained roller, and operator inattention.

Sealant Application

The sealant must be installed in a uniform manner, filling the reservoir from the bottom upward to avoid trapping any air bubbles. Depending on the material, the crack reservoir is usually not to be over-filled during the filling operation. Typical specifications require that the surface of the sealant be recessed at least 0.13 to 0.25 in (3.2 to 6.4 mm) below the surface of the pavement.

The low-modulus silicone sealants have properties that allow them to be placed with shape factors of 2.0 or slightly higher. These sealants have good bonding strength in combination with their low modulus which allow them to be placed thinner than the normal sealants.⁽⁷⁾ These silicone sealants are not self-levelling like the standard field poured sealants. Silicone pumps are used to transfer the silicone from 5 or 55 gallon (19 or 208 l) drums to applicator wands.

The questionnaire results pertaining to the use of sealant application equipment are shown in Table 21.

Asphalt Kettle/Distributor

Ninety-four percent of the respondents noted the use of asphalt kettle/distributors for sealant heating prior to application with hoses, typically in the 200 to 400 gallon (757 to 1514 l) range. Those with open flames are reported as dangerous, with uneven heating. Direct heating kettles cause local hot spots which can burn the asphalt. The majority of respondents reported the kettles to have deficiencies of high fuel consumption and slow start up times to attain proper sealant temperature. The larger, 400 gallon (1514 l) units are particularly prone to these problems. Clogging applicator hoses was also noted as a deficiency of this equipment.

Table 21
Equipment Questionnaire Summary
Concrete Pavement Crack Sealing
Sealant Preparation & Application

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Asphaltic Materials			
Asphalt Kettles With Applicator Hoses	94	1. Keeps Material Workable 2. Good Capacity 3. Compatible With Rubber Sealants 4. Maintains Uniform Temperature 5. Easy to Handle	1. Dangerous, Open Propane Flames 2. Uneven Heating Without Double Jacketing 3. Requires Cleaning Often 4. Slow Heat-up 5. Clogging Hoses 6. High Fuel Consumption 7. Expensive
Pour Pots	9	1. Good for Small Areas 2. Can Trace Crack Well	1. Labor Intensive 2. Messy
Silicone Materials			
Silicone Pumps	75	1. Works Well 2. Uniform Flow	1. Can Produce Bubbles in Sealant
Hand Held Caulking Gun	25	1. Practical for Small Jobs	1. Slow Production

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

Pour Pots

Pour pots are hand-carried containers that hold a small amount of sealant material that is subsequently applied in the joint through a spout. Pour pots were used by one-tenth of the respondents, who reported good results for small jobs. There were no deficiencies listed, although it is believed that these would be inefficient for large-scale resealing operations.

Silicone Pumps

For silicone sealing operations, silicone pumps are typically used to transfer the silicone from 5 or 55 gallon (19 or 208 l) drums to applicator wands. The lack of a need to heat the material is a distinct advantage for this application, thereby reducing equipment and energy requirements prior to sealant placement.

Seventy-five percent of the respondents who reported using silicone sealants indicated that they use silicone pumps. These devices work well and provide for a uniform flow, but they reportedly often produce bubbles in the sealant if careful installation practices were not observed. It is possible that this is due to a reaction between the backer rod core and the silicone sealant as a result of damage to the polyethylene coating of the backer rod.

Summary

While the applicators themselves appear to be sufficient, there appears to be a definite need for improvement in the heating/pumping equipment. Uneven heating, temperature control, high fuel consumption, and safety hazards of the asphalt kettles are areas where improvement can be made. The fact that the silicone sealants do not require elevated temperatures for placement is a distinct advantage, although they have a slower rate of installation.

Final Shaping/Tooling of the Sealant

Most liquid sealants are self leveling and, if recessed properly (0.13 to 0.25 in [3.2 to 6.4 mm] below the surface), do not require any further shaping or tooling. However, if the sealant overfills the crack, a hand-held squeegee is typically used to remove or shape the excess material.

Silicone sealants require a separate operation to produce a uniform surface and ensure bonding with the sidewall. They must be tooled by drawing a shaped tool over the surface of the silicone sealant. This tool forces the sealant into contact with the sidewall at the top of

the sealant and produces the correct shape to the sealant. There now exists some silicone products that are self-leveling which do not require any tooling.

Results of the questionnaires are shown in Table 22. Twenty-six percent of the respondents noted the use of this method for final finishing of the liquid sealing operation. The majority of the respondents using squeegees employ a V-shaped squeegee which is reported as simple to use and provides good coverage. The squeegees are however slow to use and often times messy, leaving sealant material spread on the slab surfaces adjacent to the crack.

Seventy-five percent of the respondents using silicone sealants noted the use of backer rods, either hand held or attached to a stick, to perform the tooling function. The remaining respondents noted the use of shop made finishing tools. Both methods are reported as simple to use, inexpensive and effective. Operator dependency, slow production and sealant build-up were noted as a deficiency of this method.

Summary

When used, the major problem with the use of separate equipment for the final tooling/shaping operation is low productivity. This is particularly true for the conventional silicone sealants that require special tooling techniques. Combining the final shaping/tooling operation with the actual sealant application provides for a more efficient methodology. This has in fact been adopted on some equipment and has been successful at increasing productivity rates.

Table 22
Equipment Questionnaire Summary
Concrete Pavement Crack Sealing
Final Shaping / Tooling

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Asphaltic Materials			
Hand Held Squeegees	44	<ol style="list-style-type: none"> 1. Inexpensive 2. Easy to Use 3. Smooth Finish 	<ol style="list-style-type: none"> 1. Spreads Material on Adjacent Slab
Hand Held V-Squeegees	50	<ol style="list-style-type: none"> 1. Simple to Use 2. Good Coverage 3. Good Material Control 4. Uniformity 	<ol style="list-style-type: none"> 1. Slow Production 2. Messy
Wand Applicator With Flanges	24	<ol style="list-style-type: none"> 1. Variable Widths 	
Silicone Materials			
Backer Rod	75	<ol style="list-style-type: none"> 1. Inexpensive 2. Works Well 3. Provides Proper Shape Factor 4. Easily Replaced 	<ol style="list-style-type: none"> 1. Operator Dependent 2. Sealant Build-Up 3. Shape Factor not Always Achieved
Shop Made Finishing Tools	25	<ol style="list-style-type: none"> 1. Inexpensive 2. Controls Shape Factor 	<ol style="list-style-type: none"> 1. Slow Production

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

6

AC Crack Sealing/Filling

Introduction

The terms "crack sealing" and "crack filling" have similar connotations and are frequently used interchangeably. This has created confusion and, in many cases, inappropriate use of materials and equipment. Each will be addressed separately in this chapter.

Crack sealing is defined herein as the placement of specialized materials in carefully designed configurations. Crack sealing materials are typically of higher quality than filling materials, since they are primarily used where crack movement is being accommodated. Therefore, in order to perform their intended function of providing a water-tight seal, crack sealants must be able to expand and contract without tearing or loss of adhesion to the crack sidewalls.

Crack filling may be defined as the placement of appropriate asphalt materials, with or without fiber, polymer or rubber additives, in and/or over, open or partially-opened cracks. The intent of crack filling is to coat crack surfaces and to fill the pavement cavities in order to protect and reinforce the adjacent pavement.⁽⁸⁾ Crack filling is most suitable for use in cracks which experience less than 0.1 in (2.5 mm) of annual horizontal movement. When filling is performed on cracks which experience greater movements, the filler material will fail when the crack opens.

Impeding the flow of water into a crack is very important in minimizing raveling and deterioration of the crack faces due to stripping and freeze-thaw deterioration. Entry of water also results in settling due to deterioration of the pavement base and subbase. Sealing cracks in asphalt pavements should be performed as soon as possible after crack development to inhibit water from entering the crack and to slow the progressive decay of the cavity. Cracks having deteriorated edges or secondary surrounding cracks should be filled, not sealed, as sealing will not be effective on deteriorated cracks.

The crack sealing operation normally consists of the following five activities:

1. Reservoir Creation. (Optional)
2. Cleaning and drying the crack reservoir. (Required)
3. Backer rod installation. (Optional)
4. Sealant heating, mixing and application. (Required)
5. Final shaping or tooling of the sealant. (May or may not be required)

The filling operation, performed on cracks that have deteriorated past the point at which sealing would be effective, is much simpler than sealing and consists of the following steps:

1. Cleaning (May or may not be required)
2. Application (Required)
3. Sanding (May or may not be required)

Each of these steps is discussed in more detail in the following sections.

SHRP project H-107, "Fabrication and Testing of Maintenance Equipment Used for Pavement Surface Repairs" will support the development and fabrication of specialized equipment for use in the sealing and filling of transverse and longitudinal cracks in asphalt pavements. Appendices E and F provide a complete listing of functional specifications for the equipment to be developed. The functional specifications were developed based on the information gathered during the conduct of the H-105 project.

Procedures and Equipment Deficiencies

Reservoir Creation

A reservoir may be created along the path of a crack to provide sufficient space for opening and closing of the crack without overstressing the sealant and to protect the sealant from traffic. The width and type of cracks that warrant the creation of sealant reservoirs varies among agencies. Also, because of the expense and time needed to create this reservoir, the merits of reservoir creation are highly debated. A further complication involves the irregular crack patterns which are typical of transverse cracks in asphalt pavements. The paths of these cracks are difficult to follow and when missed, the portion of the crack which has not been treated must be filled to prevent adjacent deterioration.⁽⁹⁾

Cracks that are expected to undergo horizontal movements due to temperature cycling should have reservoirs designed to accommodate the sealant strain resulting from these movements. The reservoir should be deeper than it is wide by at least 0.25 in (6.4 mm) to allow the sealant to be placed beneath the pavement surface while still providing a shape factor approximately equal to 1.0. Crack reservoirs are generally created with either a router or a small saw. Table 23 shows the results of the questionnaire responses relating to equipment used for reservoir creation.

Routers

Routing in a flexible pavement is a dry process and is accomplished by using one of two types of routing equipment, either rotary impact routers or vertical spindle routers. Deep reservoir creation will typically require a considerable vertical force on the routing machine to ensure that an appropriately-sized reservoir is obtained. Routers utilize multiple percussion blades which produce rough edges and may cause varying levels of damage to the adjacent pavement. The damage caused by a router, however, is not critical to the performance of the repair in an asphalt pavement, as it assists in removing unsound or loose material from the edge of the crack.

The use of routers during crack preparation was noted by 63 percent of the respondents. Deficiencies listed included excessive cutter wear, handling problems, and expensive bit replacement.

Concrete Saws

Nearly half of the respondents noted the use of concrete saws. The concrete saws are typically equipped with a single blade 4 to 6 in. (102 to 152 mm) in diameter with a sufficient width to cut a smooth-walled reservoir in one pass. Sawing can be either a wet or dry operation.⁽⁶⁾ Dry sawing is generally preferred since wet sawing leaves a sticky latency which must be removed before applying the sealant. Slow production rates and moderate spalling were the major deficiencies noted. Important factors concerning the production rate of saws are horsepower, maneuverability, and blade size.⁽⁹⁾

Other Equipment

Other pieces of equipment which have been used to create reservoirs include wire brushes and hand tools. Two percent of the respondents noted the use of wire brushes. The only deficiency noted was inadequate crack widening. These devices create a jagged reservoir and are better classified as cleaners.

Table 23
Equipment Questionnaire Summary
Asphalt Pavement Crack Sealing
Sawing / Routing

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Routers	63	<ol style="list-style-type: none"> 1. Follows Crack Well 2. Small, Easy to Handle 3. Good Production 	<ol style="list-style-type: none"> 1. Expensive Bit Replacement 2. Handling Problems 3. Excessive Cutter Wear
Concrete Saws	47	<ol style="list-style-type: none"> 1. Smooth Sides on Cut 2. Well Defined reservoir 3. Easy to Maneuver 	<ol style="list-style-type: none"> 1. Slow Production 2. Moderate Spalling
Wire Brush	2	<ol style="list-style-type: none"> 1. Follows Crack Well 	<ol style="list-style-type: none"> 1. Doesn't Widen Crack

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

Summary

In sum, the major deficiency of equipment used for reservoir creation is slow production rates. Additionally, excessive wear of the cutting medium, resulting in high replacement costs, is also a noted deficiency.

Cleaning and Drying

The most critical phase of the sealant installation is the cleaning and drying of the crack. In order for sealant material to adhere properly to the pavement and ensure maximum sealant life, the crack must be prepared such that the bonding surfaces are free of moisture, dust, and loose particles.⁽¹⁰⁾ Improper cleaning and drying leads to inadequate bonding, resulting in failure at the outset.⁽⁸⁾ This operation can be accomplished through the use of sandblasters, air compressors, hot air lances, or wire brushes. Adequacy of the cleaning operation can be checked by pulling the cooled, freshly applied sealant from the crack face and checking for adhesion and contamination. This method can also be used to check impairment of bond caused by a cold or moist pavement surface. A summary of the questionnaire responses for the cleaning and drying operation is listed in Table 24.

Air Blasting

A pressure air blast system was noted as used by 62 percent of the respondents. This equipment, consisting of a standard air compressor and hoses, is generally readily available and easy to use. However, the high pressure and/or high velocity air blast is ineffective in removing moist soils, organic material, and clays or other adhesive soils. It neither removes moisture nor does it warm a cold pavement. Deficiencies noted by the respondents included high noise levels, debris hazard, inadequate cleaning and the possibility of introducing moisture into the crack.

Hot Air Lances

Forty-Two percent of the respondents noted the use of hot air lances for crack cleaning. This method is particularly effective when preceded by a broom or blower and is recommended for night or early morning work when conditions are damp. Major deficiencies noted were noise levels, safety hazards, potential asphalt burning and fuel source requirements.

Table 24
Equipment Questionnaire Summary
Asphalt Pavement Crack Sealing
Cleaning / Drying

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
High Pressure Air Blast	62	<ol style="list-style-type: none"> 1. Easy to Use 2. Cleans & Dries 3. Availability 4. Removes Debris 	<ol style="list-style-type: none"> 1. Noisy 2. Old Sealant Not Removed 3. Doesn't Widen Crack 4. Inadequate Cleaning 5. Can Add Moisture 6. Dusty, Can Prevent Bond 7. Debris Hazard
Hot Air Lance	42	<ol style="list-style-type: none"> 1. Cleans & Dries Well 2. Heats Pavement 3. Improves Bond 	<ol style="list-style-type: none"> 1. Safety Hazard 2. Noisy 3. Removes Oils From Sidewalls 4. Can Burn Pavement 5. Fuel Source Requirement
Back Pack Blowers	13	<ol style="list-style-type: none"> 1. Mobility 2. Small & Compact 	<ol style="list-style-type: none"> 1. Inadequate Cleaning 2. Lack of Power
Sand Blasting	3	<ol style="list-style-type: none"> 1. Cleans Sidewalls Well 	<ol style="list-style-type: none"> 1. Cost 2. Slow Production
Hand Tools	5	<ol style="list-style-type: none"> 1. Inexpensive 	<ol style="list-style-type: none"> 1. Slow Production
Wire Brush	2	<ol style="list-style-type: none"> 1. Easy to Follow Crack 	<ol style="list-style-type: none"> 1. Insufficient Cleaning Depth

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

Back-Pack Blowers

Thirteen percent of the respondents noted using back-pack blowers for this type of cleaning. While increasing the mobility of the operator, most respondents felt that this method furnished too little power to provide effective cleaning.

Sand Blasting

Sand blasting was noted by 3 percent of the respondents as a method for cleaning. The nozzles of some sand blasting equipment have been modified with deflectors to direct the sand against the sidewalls to provide a clean surface. Sand blasting not only removes dirt and dust but also strips away loose fragments, and is particularly adept at removing the sticky laitance left after wet sawing operations.⁽⁸⁾ Slow production rates and high first cost were noted as deficiencies of this method. This method should be carefully considered since it involves specialized equipment and materials.

Summary

In sum, the most significant deficiencies of equipment used for final cleaning of the crack reservoir are slow production rates, inadequate cleaning and safety hazards.

Backer Rod Installation

A backer rod may be installed after the crack has been dried and cleaned. The backer rod, used as a separating material, must be a non rigid, non absorptive material. Its functions are to provide the desired shape factor, to prevent the sealant from bonding to the bottom of the reservoir, and to prevent the hot liquid sealant from running down into the crack.

Table 25 is a summary of the equipment used for placing backer rods. Only 8 percent of the respondents noted the use of backer rods prior to sealant installation, with the vast majority using shop-made depth rollers to install the backer rods. These rollers are reported as being inexpensive and very simple to use but often place the backer rods at an uneven depth along the length of the crack. Hand placement was noted as used by 13 percent of the respondents. This placement method was reported used on only small jobs.

Summary

The shop-made depth rollers appear to provide reasonable results, but problems in achieving and maintaining the proper depth of the backer rod remain. This may be due to several

Table 25
Equipment Questionnaire Summary
Asphalt Pavement Crack Sealing
Backer Rod Installation

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Shop Made Depth Roller	88	1. Easy to Use 2. Inexpensive	1. Uneven Depth
Hand Placement	13	1. Inexpensive	1. Small Quantities Only

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

factors, including inadequate depth of the reservoir, debris in the reservoir, and operator inattention.

Sealant Heating, Mixing, and Application

Sealant heaters are available in the form of kettles and distributors. Propane or diesel fuel is commonly used to heat a transfer oil which is circulated around the sealant. This process melts the sealant material, if in block form, and heats it to a specified temperature. It is essential to attain the recommended temperature when heating in order for the sealant to react properly and to ensure no overheating.⁽⁸⁾ Sealant heaters may also be equipped with agitators to provide uniform heating and mixing. The use of diesel heated kettles is much preferred from a safety standpoint since propane has a tendency to explode.

The sealant must be installed in a uniform manner, filling the reservoir from the bottom upward to avoid trapping any air bubbles. The crack reservoir must not be overfilled during the filling operation, and it is commonly recommended that the surface of the sealant be at least 0.06 to 0.12 in (1.5 to 3.0 mm) below the surface of the pavement. This allows room for sealant expansion during the summer when the crack closes to its minimum size, without extruding the sealant above the pavement surface where traffic can pull it from the crack.

There is an increasing use of the band-aid type sealant application configuration. Two variations of this method are the standard and recessed band-aid. The standard band-aid is essentially a cap of controlled width and thickness that covers the crack. A recessed band-aid consists of applying sealant in crack reservoirs such that the sealant is brought flush with the pavement surface.⁽¹¹⁾ A wipe zone, extending onto the pavement, is characteristic of both types.

Throughout all phases, the pavement surface should be kept as clean as possible to reduce the potential of debris entering the crack, causing problems in the future. Power broom and power blower equipment are recommended, although manual sweeping can be used. The importance of cleaning during the sealant removal and refacing portions of the project cannot be overemphasized.

Equipment used in applying the sealant into cracks includes pour pots and applicator wands. The use of applicator wands, connected to the sealant machine by hoses, is generally recommended over pour pots. With the applicator wands, sealant material can be re-circulated to ensure proper placement temperature while pour pots may allow the material to cool before application.⁽⁸⁾ Table 26 lists the response summary for heating and application equipment.

Table 26
Equipment Questionnaire Summary
Asphalt Pavement Crack Sealing
Sealant Preparation & Application

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Asphalt Kettles With Applicator Hoses	90	<ol style="list-style-type: none"> 1. Keeps Material Workable 2. Good Capacity 3. Compatible With Rubber Sealants 4. Maintains Uniform Temperature 5. Easy to Handle 6. Keeps Open Flame Away if Double Jacketed 	<ol style="list-style-type: none"> 1. Dangerous, Open propane Flames 2. Uneven Heating Without Double Jacketing 3. Requires Cleaning Often 4. Slow Heat-Up Times 5. Clogging Hoses 6. High Fuel Consumption 7. Expensive
Distributors	19	<ol style="list-style-type: none"> 1. Large Quantities 	
Pour Pots	5	<ol style="list-style-type: none"> 1. Good For Small Areas 2. Can Trace Small Cracks 	<ol style="list-style-type: none"> 1. Slow Production 2. Dangerous

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

Asphalt Kettles

Ninety percent of the respondents noted the use of asphalt kettles for sealant heating prior to application, typically in the 200 to 400 gallon (757 to 1514 l) range. Those with direct heating or open flames are reported as dangerous, with uneven heating and local hot spots which can burn the asphalt. The majority of respondents reported the kettles to be deficient with slow start up times to attain proper sealant temperature. The larger, 400 gallon (1514 l) units are particularly prone to this problem. Nineteen percent of the respondents also noted the use of distributors for heating and application. However, no deficiencies were listed.

Pour Pots

Pour pots were noted used by five percent of the respondents. Slow production rates and safety hazards were the major deficiencies noted.

Summary

In sum, the major deficiencies of heating and application equipment include uneven heating, slow start-up times and inadequate temperature controls.

Final Shaping or Tooling

During the filling operation, hot-poured sealants may overfill the joint and must be finished to the proper depth. This is typically done using hand-held squeegees. These devices come in a variety of shapes and materials. One particular device, the band-aid squeegee, is designed to produce the standard band-aid seal discussed previously.⁽¹¹⁾ A summary of the responses for this operation is found in Table 27.

Squeegees

Ninety-five percent of the respondents noted the use of squeegees for final finishing of the crack sealing operation. Of these, twenty-two percent reported using a V-shaped squeegee, noted as being simple to use and providing good coverage. However, the squeegees were described as being slow and often messy, leaving sealant material spread on the slab surfaces adjacent to the crack.

One-tenth of the respondents noted the use of the band-aid squeegee box. Slow production rates, continuous cleaning needs, and inadequate sealant penetration were the major deficiencies noted.

Table 27
Equipment Questionnaire Summary
Asphalt Pavement Crack Sealing
Shaping / Finishing

EQUIPMENT TYPE	% USAGE	ADVANTAGES	DISADVANTAGES
Hand Held Squeegees	64	<ol style="list-style-type: none"> 1. Easy to Operate 2. Inexpensive 3. Different Widths Possible 	<ol style="list-style-type: none"> 1. Messy 2. Labor Intensive 3. Uncontrolled widths
Hand Held V-Squeegees	21	<ol style="list-style-type: none"> 1. Inexpensive 2. Material Containment 3. Easy to Use 4. Variable Width 5. Places Material Down in Crack 	<ol style="list-style-type: none"> 1. Slow Production 2. Spreads Material on Surface 3. Labor Intensive
Band Aid Squeegee Box	10	<ol style="list-style-type: none"> 1. Leaves Surface Application 2. Different Widths Possible 	<ol style="list-style-type: none"> 1. Doesn't Penetrate Crack 2. Continuous Cleaning Needs 3. Labor Intensive
Applicator Tips	4	<ol style="list-style-type: none"> 1. Works Well 2. Inexpensive 3. Places Material in Crack 4. Completed During Application 	<ol style="list-style-type: none"> 1. Can Produce Bumps

Note: Due to Multiple Equipment Usage Within a Given Agency, Total Percent Usage May Exceed 100%.

The use of silicone sealants for asphalt pavement crack sealing was not indicated by any of the respondents. The initial cost of silicone sealants is significantly higher than conventional asphaltic materials, but the application equipment is much less expensive.⁽⁸⁾ Furthermore, silicone sealants are placed cold and therefore do not need the initial heat up time that kettles do.⁽⁸⁾ Fine cleaning is essential and final tooling is usually required with conventional silicone materials. Self-leveling silicone sealants are now available which have been specifically designed for use on asphalt pavements.

Procedures for Crack Filling

A separate questionnaire for crack filling was not included in the questionnaire packages sent out to the transportation agencies. Therefore, no feedback on equipment or materials used in this operation is available.

The filling operation is performed on cracks that have deteriorated past the point at which sealing would be effective. The operation is much simpler than sealing and consists of the following steps:

1. Cleaning (May or may not be required)
2. Application (Required)
3. Sanding (May or may not be required)

The operation can be mechanized or by hand depending on available equipment and cost-effectiveness.

Cleaning

Depending on the material and the condition of the surface to be sealed, cleaning may or may not be needed. When it is done, power blowers or power brooms are utilized.

Application

Mechanized operations use a distributor with a converted spray bar to apply the filler material. A U-shaped squeegee is mounted behind each nozzle or pair of nozzles. The spray bar operator maintains a puddle of material in the squeegees. The squeegees force the material into the cracks and wipe the surface of excess material.

Hand operations are only slightly different in that they utilize hand application and squeegee action.

Sanding

In situations when it is warranted, a standard sanding unit is used to distribute sand over the filler material. It is used as a blotting material to prevent tracking or skid problems.

7

Summary and Conclusions

Information on the deficiencies of equipment currently used to perform several pavement maintenance activities was collected for this study. State and local agencies throughout the United States, Canada, and abroad were queried through a literature search and questionnaires covering the types of equipment used and the advantages and disadvantages of each.

There currently exists a wide variety of equipment used for pavement surface repairs. The state-of-practice has not changed significantly in the last several years, with the possible exception of pothole repair techniques and equipment.

This report has been prepared based on the results of this survey and discussions with equipment manufacturers, industry representatives, and knowledgeable end users. Many deficiencies of currently used equipment were identified and discussed. The information obtained and presented in this report provided the framework for the development of functional specifications for equipment to be developed under SHRP Contract H-107, "Fabrication and Testing of Maintenance Equipment Used for Pavement Surface Repairs."

The widespread use of deficient and unsuitable materials, equipment, and procedures has caused poor performance of pavement surface repairs. As a result, there has been an acceleration in pavement deterioration with a related increase in maintenance costs. Emergency maintenance during cold weather is an annual recurring area of repair deficiency. Emergency pothole repairs during wet and/or cold weather probably have the poorest performance of any emergency repair. This is particularly troublesome since emergency pothole repairs, particularly during inclement weather, have one of the highest danger exposure rates of any maintenance activity.

One of the underlying problems preventing the adoption of more effective pavement repair materials and procedures is the reluctance of many agencies to invest in unproven, but

innovative equipment. As a result, well-accepted and inadequate equipment is routinely specified or selected for cavity maintenance. Since this equipment cannot always handle the available, better performing materials, the less expensive and poorer performing materials are used. Specialized equipment, usually needed for the available better performing materials, is often expensive and typically can only be used for a limited number of maintenance activities.

Worker safety has become a paramount concern throughout the country. In addition, extended closures of traffic lanes for maintenance has become a major problem from a cost, public safety, and political standpoint. The use of robotics or remote-controlled maintenance equipment is gaining increased support to improve the efficiency and to facilitate the move of the maintenance worker off the pavement surface and on to either the shoulder or behind the wheel of the maintenance truck. To date, however, little progress has been made in this area, with the possible exception of pothole repair equipment. Combination equipment, capable of completing all phases of the pothole repair activity, have been introduced and are providing acceptable levels of repair. No such equipment is available for crack sealing or filling or for the partial-depth repair of concrete pavements.

The SHRP Project H-107, "Fabrication and Testing of Maintenance Equipment Used for Pavement Surface Repairs," will fund the development of equipment to improve a highway agency's ability to:

1. Perform pothole repairs in asphalt pavements, and
2. Perform joint and crack sealing/filling in concrete and asphalt pavements.

Expected equipment improvements will lead to enhanced speed, efficiency, quality and safety of repair efforts. The equipment to be developed will have the following characteristics:

1. Affordability, since multiple units will be required within a highway district.
2. Reliability and ruggedness for field use.
3. Safety and ease of use by maintenance personnel.
4. Compatibility with the existing and/or new materials to be developed and tested in SHRP Project H-106, "Innovative Materials Development and Testing."

Appendices D, E and F provide details on the functional specifications of each equipment to be developed.

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Appendix A

Equipment Questionnaires

EQUIPMENT AND PROCEDURES FOR PARTIAL-DEPTH SPALL REPAIRS ON PORTLAND CEMENT CONCRETE (PCC) PAVEMENTS

— SHAPING THE SPALL EDGES —

1. Please list the equipment used for shaping or establishing the edges of spalls on PCC pavements prior to removal of the deteriorated pavement. Provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(Kayshun Saw, Model #100)	(easy to maneuver)	(none)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

SHRP PROJECT H-105

"INNOVATIVE MATERIALS AND EQUIPMENT FOR PAVEMENT SURFACE REPAIRS"

Equipment Questionnaire

The purpose of this questionnaire is to obtain user feedback on the performance characteristics of equipment used in pavement surface repairs. We are especially interested in what you feel are the advantages and disadvantages of the equipment and whether your agency has made any modifications to the equipment to improve its performance or safety. The results of this research will benefit the entire pavement community.

Overall, specific questionnaires have been developed to address the variety of equipment used for different maintenance activities. The five maintenance activities of interest are:

- (1) Concrete pavement spall repairs (partial depth),
- (2) Concrete pavement joint resealing,
- (3) Concrete pavement crack sealing,
- (4) Asphalt pavement pothole repair (permanent), and
- (5) Asphalt pavement crack sealing.

The information requested in these questionnaires is very basic. In addition to some brief idea of the advantages and disadvantages of the different equipment, we would like to receive a copy of all applicable equipment specifications and guidelines for the use of this equipment in the maintenance procedures. Also of any available training tapes and a contact person to obtain those tapes would also be extremely useful. To assist us in contacting you later for follow-up information or clarification of a response, please provide your name and address below.

Your assistance in completing this questionnaire is greatly appreciated. If you have any questions, please feel free to contact me or one of the engineers listed below at (217) 356-4500. We would like to receive your response by April 30 at the latest. Thank you in advance for your valued assistance.

Michael I. Darter, P.E.
Principal Investigator

Name: _____

Title: _____

Address: _____

Phone: _____

RETURN TO:

ERES Consultants, Inc.
1401 Regency Drive East
Savoy, Illinois 61874

David Peshkin
Project Manager

Samuel Carpenter
Material Specialist

James Crovetti
Equipment Specialist

EQUIPMENT AND PROCEDURES FOR PARTIAL-DEPTH SPALL REPAIRS
ON PORTLAND CEMENT CONCRETE (PCC) PAVEMENTS

— CLEANING DETERIORATED AREAS —

1. Please list the equipment used for removing the deteriorated pavement after the spall boundaries have been established. Provide the manufacturer and model number if available. Briefly note any advantages/disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(sand blast)	(promotes bond)	(takes time)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR PARTIAL-DEPTH SPALL REPAIRS ON PORTLAND CEMENT CONCRETE (PCC) PAVEMENTS

— PLACEMENT OF PATCH MATERIAL —

1. Please list the tools or equipment used to heat, mix, or place the patch material. Provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(small mixer for patch mix)	(very portable)	(none)
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR PARTIAL-DEPTH SPALL REPAIRS
ON PORTLAND CEMENT CONCRETE (PCC) PAVEMENTS

— CONSOLIDATION / COMPACTION —

1. Do you currently use tools or equipment for consolidating or otherwise compacting the patch material after it is placed in the spalled area? If so, please list the equipment used and provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(1" diameter spud vibrator)	(removes voids)	(none)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR PARTIAL-DEPTH SPALL REPAIRS
ON PORTLAND CEMENT CONCRETE (PCC) PAVEMENTS

— FINISHING / SEALING —

1. Do you currently use tools or equipment for finishing or sealing the surface of the patched spall? If so, please list the equipment used and provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(none- screed by hand)	(none)	(none)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR RESEALING JOINTS
ON PORTLAND CEMENT CONCRETE (PCC) PAVEMENTS

— SAWING / ROUTING —

1. Please list the equipment used for preparing joints on PCC pavements prior to resealing, including sealant removal and refacing equipment. Provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(Kayshun Saw, Model #100)	(easy to maneuver)	(doesn't remove old seal well)
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR RESEALING JOINTS
ON PORTLAND CEMENT CONCRETE (PCC) PAVEMENTS

— CLEANING —

1. Please list the equipment used for cleaning routed and/or sawed joints on PCC pavements prior to resealing. Provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(sand blasting equipment)	(none)	(damages joint face)
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURS FOR RESEALING JOINTS
ON PORTLAND CEMENT CONCRETE (PCC) PAVEMENTS

— BACKER ROD INSTALLATION —

1. Do you currently use tools or equipment for installing backer rods or filler material to limit the amount of sealant placed in the joint or to improve the shape factor of the sealant? If so, please list the equipment used and provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(maint. shop made eqpt)	(very inexpensive)	(uneven depth)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

**EQUIPMENT AND PROCEDURES FOR RESEALING JOINTS
ON PORTLAND CEMENT CONCRETE (PCC) PAVEMENTS**

— SEALANT PREPARATION AND APPLICATION —

1. Please list the tools or equipment used for mixing, heating, and applying joint sealant material. Provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(Ramary Applicator, modified)	(maintains uniform temp)	(takes too long)
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR RESEALING JOINTS
ON PORTLAND CEMENT CONCRETE (PCC) PAVEMENTS

— FINAL SHAPING / TOOLING —

1. Please list any tools or equipment used for shaping or finishing the sealant material after installation (such as squeegees). Provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(none- use self-leveling seal)	(none)	(none)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR SEALING CRACKS ON
PORTLAND CEMENT CONCRETE (PCC) PAVEMENTS)

— ROUTING / SAWING —

1. Please list the equipment used for routing and/or sawing cracks on PCC pavements prior to sealing. Provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(Roman Router, #3)	(follows crack well)	(excessive spalling)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR SEALING CRACKS ON PORTLAND CEMENT CONCRETE (PCC) PAVEMENTS)

— CRACK CLEANING —

1. Please list the equipment used for cleaning out cracks on PCC pavements prior to sealing. Provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(high speed air blast eqpt.)	(none)	(does not clean adequately)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR SEALING CRACKS ON
PORTLAND CEMENT CONCRETE (PCC) PAVEMENTS)

— BACKER ROD INSTALLATION —

1. Do you currently use tools or equipment for installing backer rods or filler material to limit the amount of sealant or to improve the shape of the sealant? If so, please list the equipment used and provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(maint. shop made eqpt.)	(very inexpensive)	(none)
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR SEALING CRACKS ON
PORTLAND CEMENT CONCRETE (PCC) PAVEMENTS)

— SEALANT MIXING, HEATING, AND APPLICATION —

1. Please list the tools or equipment used to mix, heat, and apply crack sealant material on PCC pavements. Provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(Ramary Applicator, modified)	(maintains uniform temp)	(takes too long)
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR SEALING CRACKS ON
PORTLAND CEMENT CONCRETE (PCC) PAVEMENTS)

— FINAL SHAPING / TOOLING —

1. Please list any tools or equipment used for shaping or finishing the crack sealant material after installation. Provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(applicator tip on wand)	(can use different widths)	(none)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR POTHOLE REPAIRS ON
ASPHALT CONCRETE (AC) PAVEMENTS

— SHAPING THE POTHOLE EDGES —

1. Please list the equipment used for shaping or establishing the edges of potholes on AC pavements prior to removal of the deteriorated pavement. Provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(Kayshun Saw, Model #100)	(easy to maneuver)	(none)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

— CLEANING / DRYING POTHOLE —

[illegible]

EQUIPMENT AND PROCEDURES FOR POTHOLE REPAIRS ON
ASPHALT CONCRETE (AC) PAVEMENTS

— PRIMING —

1. Do you currently use tools or equipment for placing primer in the pothole before placing the patch material? If so, please list the equipment used and provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(sprayer)	(provides good coverage)	(none)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR POTHOLE REPAIRS ON
ASPHALT CONCRETE (AC) PAVEMENTS

— MATERIAL PLACEMENT —

1. Please list any tools or equipment used to heat, mix, or place the patch material for potholes in AC pavements. Provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(Stanley Hot Box, #60)	(keeps mix hot)	(takes too long to heat)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR POTHOLE REPAIRS ON
ASPHALT CONCRETE (AC) PAVEMENTS

— COMPACTION / CONSOLIDATION —

1. Do you currently use tools or equipment for compacting or otherwise consolidating the patch material after it is placed in the pothole? If so, please list the equipment used and provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(none— compacted by traffic)	(none)	(none)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR POTHOLE REPAIRS ON
ASPHALT CONCRETE (AC) PAVEMENTS

— FINISHING / SEALING —

1. Do you currently use tools or equipment for finishing or sealing the surface of a patched pothole? If so, please list the equipment used and provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(none) _____	(none) _____	(none) _____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR SEALING CRACKS
ON ASPHALT CONCRETE (AC) PAVEMENTS

— ROUTING / SAWING —

1. Please list the equipment used for routing and/or sawing cracks on AC pavements prior to sealing. Provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(Roman Router, #3)	(follows crack well)	(bits don't last)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURS FOR SEALING CRACKS
ON ASPHALT CONCRETE (AC) PAVEMENTS

— CLEANING / DRYING —

1. Please list the equipment used for cleaning out and drying cracks on AC pavements prior to sealing. Provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(Smith Hot Lance. #2100)	(cleans crack well)	(hard to control, burns hot)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR SEALING CRACKS
ON ASPHALT CONCRETE (AC) PAVEMENTS

— BACKER ROD INSTALLATION —

1. Do you currently use tools or equipment for installing backer rods or filler material to limit the amount of sealant or to improve the shape of the sealant? If so, please list the equipment used and provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first line is an example of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(maint. shop made eqpt)	(very inexpensive)	(none)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

EQUIPMENT AND PROCEDURES FOR SEALING CRACKS
ON ASPHALT CONCRETE (AC) PAVEMENTS

— SEALANT HEATING, MIXING, AND APPLICATION —

1. Please list the tools or equipment used for heating, mixing, and applying crack sealant material. Provide the manufacturer and model number if available. Briefly note any advantages and/or disadvantages of each piece of equipment. If you do not use this procedure, please briefly explain why. The information in parentheses in the first two lines are examples of the type of information that is being requested.

Equipment Type	Advantages	Disadvantages
(Ramary Applicator, modified)	(maintains uniform temp)	(takes too long)
(Wright Hot Kettle)		(dangerous, burns sealant)

2. Has your agency made any performance/safety modifications to this equipment? Please describe the modifications and their degree of success.

3. Are you aware of any research or evaluations on the performance of this equipment? Please provide details or attach reports.

Appendix B

Descriptive Summaries of Equipment Used for Joint and Crack Sealing

Category: Crack Sealing

Pavement Type: AC

Function: Infra-red Heating

Product Name: HE-PR-8DW Crack Sealer, HE-PR-8DW Twin Crack Sealer and Patcher

Manufacturer: Aeroil Products Company, Inc.
69 Wesley Street
South Hackensack, NJ 07606
Phone: 201-343-5200

Description: HE-PR-8DW Crack Sealer

The HE-PR-8DW is a wheel mounted infra-red heater. The heating unit has a length of 48" and a width of 10". The unit produces 120,000 BTU from two stainless steel, propane-fired infra-red generators. The unit has a weight of approx. 100 lbs, excluding the 20 lb vapor cylinder. The unit comes complete with lighting torch, hose, regulator and bottle connector.

HE-PR-8W TWIN

The HE-PR-8DW TWIN is a wheel mounted infra-red heater. The heating unit has a length of 48" and a width of 20". The unit produces 240,000 BTU from four stainless steel, propane-fired infra-red generators. The unit has a weight of approx. 190 lbs, excluding vapor cylinder. The unit comes complete with lighting torch, hose, regulator and bottle connectors.

Category: Crack Sealing

Pavement Type: AC, PCC

Function: Preparation

Product Name: Joint Cleaner
Models BC-16, BC-30

Manufacturer: Berry Corporation
P.O. Box 12785
1070 Brentwood Court
Lexington, KY 40583
(606) 255-1149

Description: The Joint Cleaners are designed to remove previous sealants from joints or relatively straight cracks. The cleaners from Berry are offered in 16 and 30 horsepower sizes and are capable of widening and cleaning joints before resealing. The machines have an eight bit radial cutting head, 12 inches in diameter, with bit sizes of 1/2, 5/8, 3/4, and 1 inch available. The cutter head is located on the right side of the machine in full view of the operator. The cutting action of the head tends to pull the machine along, relieving the operator of pushing.

Category: Joint Sealing

Pavement Type: AC, PCC

Function: Sealant Applicator, Random Crack Router, Power Brush,
Carbide Tip Joint Cleaning Machine

Product Name: BMA Joint/Crack Sealer
BVR-8 Random Crack Router
BB-10 Power Brush
BC-30/BC-16 Carbide Tip Joint Cleaning Machine

Manufacturer: Berry Corporation
P.O. Box 12785
1070 Brentwood Court
Lexington, KY
606-255-1149

Description: BMA Joint/Crack Sealer

This is a hydraulically driven melter/applicator system. The unit includes a flushing system, agitation system, heated hose cabinet and oil heated hose with wand. No other information available.

BVR-8 Random Crack Router

Used for routing and cleaning random cracks in both AC and PCC surfaces. Carbide tips are available in 1/2", 5/8", 3/4" and 1" sizes. No other information available.

BB-10 Power Brush

Full twist wire brush used for cleaning joints and cracks prior to sealant application.

BC-30/BC-16 Carbide Tip Joint Cleaning Machine

Joint cleaning and grooving machine for use with carbide tips in the range of 1/2" to 2-1/2".

Category: Crack Sealing

Pavement Type: AC, PCC

Function: Preparation

Product Name: BB-10 Power Brush Machine

Manufacturer: Berry Corporation
P.O. Box 12785
1070 Brentwood Court
Lexington, KY 40583
(606) 255-1149

Description: The BB-10 Power Brush machine is designed to clean pavement joints after primary cleaning with a joint cleaning and grooving machine. It is necessary to power brush the joint of any dust film or remaining loose material on the sides and bottom to insure proper bonding of new sealer to the concrete or asphalt. The rotation of the brush throws the excess debris to the front of the machine leaving a clean joint. The machine is carefully balanced on two main wheels with a swivel wheel in the rear to provide a rest point and remove pressure from the brush when the machine is idle. The 10 inch diameter, full twist steel wire brush is powered with a 9.5 horsepower gasoline engine.

Category: Crack Sealing

Pavement Type: AC, PCC

Function: Preparation

Product Name: Pavement Crack Saws

Manufacturer: Cimline Inc.
P.O. Box 680
Hopkins, MN 55343
(612) 944-9511
(800) 328-3874

Description: The Cimline Crack saws are a hand-pushed gasoline powered saw with an 8 inch diameter blade. The saw is capable of a 1 inch width and an electronic fingertip toggle switch controls the depth to a 1-5/8 inch maximum. The saws can be equipped with watering for sawing bituminous or concrete pavements. Electric start engines with alternator are offered in the 20 and 30 horsepower sizes.

Category: Crack Sealing

Pavement Type: AC, PCC

Function: Preparation

Product Name: Random Crack Saw

Manufacturer: Cimline Inc.
P.O. Box 680
Hopkins, MN 55343
(612) 944-9511
(800) 328-3874

Description: The Cimline Random Crack Saw is a hand-pushed gasoline powered saw with an 8 inch diameter blade. The saw is capable of up to 1 inch joint widths and an electronic fingertip toggle switch controls the depth to a 1-5/8 inch maximum. The saw is equipped with a self-contained proportional air/water cooling system for sawing bituminous or concrete pavements. The 30 horsepower electric start engine, with alternator, is mounted on a three wheel frame with a front caster wheel.

Category: Crack Sealing, Joint Sealing

Surface Type: AC, PCC

Function: Preparation

Model Name: HOT ROD

Manufacturer: Cimline
P.O. Box 680
Hopkins, MN 55343
612-944-9511
800-328-3874

Description: The HOT ROD uses hot compressed air to clean and dry joints and cracks to prepare them for sealant. No specifications are available in the literature.

The HOT ROD is moved over the joint or crack to clean the surface and prepare the area for sealant.

Category: Joint Sealing

Pavement Type: AC, PCC

Function: Preparation

Product Name: CRACK PLOW

Manufacturer: L/A Manufacturing Inc.
1000 Mary Laidley Dr.
Covington, KY 41017
606-356-1222
FAX 606-356-5513

Description: The CRACK PLOW is a rigid tool designed to remove existing crack filler material from cracks and joints by plowing prior to resealing. The CRACK PLOW is circular in shape and is attached to a tractor bucket with a modified vise. The CRACK PLOW has several different teeth sizes that may be selected by the operator in order to clean the proper width and depth.

Category: Crack Sealing, Joint Sealing

Pavement Type: AC, PCC

Function: Preparation (Crack/Joint cleaning and drying)

Product Name: L/A Hot Air Lance

Manufacturer: L/A Manufacturing Inc.
Box 5681
Bellingham, WA 98227
206-671-3375

Description: The L/A Hot Air Lance utilizes compressed air (minimum 40 psi, 40 cfm and maximum 150 psi, 100 cfm) and propane to produce high velocity hot air for cleaning and drying cracks and joints. The heated air temperatures range from 600° F to 2200° F. The air and fuel are ignited in a burner chamber, so there is no open flame at the exit. Compressed hot air is used for cleaning and drying. The lance weighs about 11 pounds.

The only equipment that is needed to operate the hot air lance is an air compressor that has a capacity of 40 to 100 cfm and pressure of 75 to 150 psi and a striker or other form of ignition to light the burner chamber.

Category: Crack Sealing

Pavement Type: AC

Function: Combination (Preparation, Melter, Sealer)

Product Name: Overseal Banding Unit
Model OSB-200

Manufacturer: Linear Dynamics Incorporated
79 Montgomery Street
Montgomery, PA 17752
(717) 547-1621

Description: The OSB-200 is a trailer-mounted, self-contained unit for crack cleaning, sealant melting and application. The OSB-200 uses LP gas for all fuel needs. An 18 horsepower engine drives the compressor and hydraulic system. The heated compressed air lance (HCA LANCE) is included for cleaning, drying and heating the asphalt pavement. The sealant melter has a 200 gallon capacity and is heated by two flame-baffled LP gas burners rated at 175,000 BTU with automatic temperature control. According to the manufacturer, the OSB-200 will melt 200 gallons of material in 2 hours. A SPEEDBANDER is included with the Unit, which is a 3 gallon dollied kettle used to apply a 3 inch wide overseal band of sealant.

Category: Crack Sealing, Joint Sealing, Pothole Repair

Surface Type: AC, PCC

Function: Preparation

Model Name: Prismo HCA Lance

Manufacturer: Linear Dynamics Inc.
Redland Prismo Corporation
300 Lanidex PLaza
Parsippany, NJ 07054
201-884-0300

Description: The Prismo HCA Lance consists of a combustion chamber which is fueled by compressed air and propane. This generates a high temperature (3,000° F), high velocity (3,000 feet per second) blast of air. The flame is contained within the combustion chamber; only hot gas is emitted. An air compressor with a 35 cubic feet per minute displacement and 100 pound LP propane tank are recommended for use with the Prismo HCA Lance.

The HCA Lance is moved over the joint, crack or pothole repair area to clean the surface and prepare the area for sealant or repair material.

Category: Crack Sealing, Joint Sealing

Pavement Type: AC, PCC

Function: Preparation

Product Name: Series 1700 Surface Dryer

Manufacturer: Modern Asphalt Tools
3 Main Road
Holbrook, Ipswich
Suffolk, IP9 2QX
0473 328034

Descriptio This piece of equipment is designed for drying pavement surfaces prior to pavement striping. Propane bottles supply fuel to two burners that discharge heated air into a heater hood.

Category: Crack Sealing, Joint Sealing

Pavement Type: PCC

Function: Preparation - Crack Routing

Product Name: SINCO C-8 Crack Chaser

Manufacturer: SINCO Products Inc.
One SINCO Place
P.O. Box 361
East Hampton, CT 06424
203-267-2545

Description: The SINCO Crack Chaser uses a dry diamond blade mounted on a chassis that moves on swivel casters. The saw can cut within 5 inches of a curb or other obstruction. One person is needed to operate the saw. Advertised production is an average of 2,000 feet of crack per day (3/4" depth, 5-1/2" per minute, 6 hours).

The saw is powered by a 7.5 HP gasoline engine. The standard blade working speed is 5,000 RPM for a 7-inch diameter blade. The width of cut can be varied by selecting different saw blades.

Category: Joint Sealing

Pavement Type: AC, PCC

Function: Preparation

Product Name: Super Quadramatic Pavement Saw
Model 6505

Manufacturer: Target Products Division
4320 Clary Boulevard
Kansas City, MO 64130
800-821-2261
816-923-5040

Description: The Super Quadramatic Pavement Saw is a gasoline powered pavement saw. The 65 horsepower saw has a hydrostatic transmission for speeds up to 200 feet per minute. The one-piece welded frame is supported on four wheels with the weight of the engine balanced over the saw blade. Blade diameters of 14 to 36 inches may be used for cutting depths up to 14-3/4 inches. Blade height is adjusted by an electrically controlled hydraulic unit. The watering system has an automatic engine shut-off for when the water supply fails. The saw weighs approximately 1300 pounds.

Category: Joint Sealing

Pavement Type: AC, PCC

Function: Preparation

Product Name: Pro 65 Pavement Saw
Model 6510

Manufacturer: Target Products Division
4320 Clary Boulevard
Kansas City, MO 64130
800-821-2261
816-923-5040

Description: The Pro 65 Pavement Saw is a gasoline powered pavement saw. The 65 horsepower saw has a hydrostatic transmission for speeds up to 150 feet per minute. The engineered box frame is supported on four spoked wheels with the weight of the engine balanced over the saw blade. Blade diameters of 18 to 36 inches may be used for cutting depths up to 14-3/4 inches. Blade height is adjusted by an electrically controlled hydraulic unit. The watering system has an automatic engine shut-off for when the water supply fails. The saw weighs approximately 1400 pounds and uses heavier components for longer life and straighter cuts.

Category: Joint and Crack Sealing

Pavement Type: AC, PCC

Function: Sealant Heating, Mixing and Application

Product Name: KERA-200H, KERA-60H Rubberized Asphalt Kettles

Manufacturer: Aeroil Products Company, Inc.
69 Wesley Street
South Hackensack, NJ 07606
Phone: 201-343-5200

Description: KERA-60H

The KERA-60H kettle is a 60 gallon, double vat, oil jacketed kettle mounted on a single axle trailer. The unit is capable of melting, agitating, circulating, pumping and dispensing materials requiring indirect heat. A 20 gallon supply of heating oil is pumped through 4 convection tubes in the sealant vat providing for 504 sq.in. of internal contact area and 1719 sq.in. of external contact area. The oil is heated by a single, 190,000 BTU propane fired burner equipped with automatic pilot and outfire shut-off controls. An optional 1500W, 110V electric heating element can be used for overnight heating. The sealant is delivered by a 20 gpm rotary gear pump through a 25' teflon lined hose to a 5' double plumbed hose and wand with hot oil recirculation. The KERA-60H has a melting rate of 40 gph.

KERA-200H

The KERA-200H kettle is a 200 gallon, double vat, oil jacketed kettle mounted on a single axle trailer. The unit is capable of melting, agitating, circulating, pumping and dispensing materials requiring indirect heat. A 75 gallon supply of heating oil is pumped through a 2" recirculating tube in the sealant vat providing for 1531 sq.in. of internal contact area and 3873 sq.in. of external contact area. The oil is heated by two 375,000 BTU propane fired burners equipped with electric igniters and automatic pilot and outfire shut-off controls. Two 1500W, 110V electric heating elements can be used for overnight heating. The sealant is delivered by a 20 gpm rotary gear pump through a 25' teflon lined hose to a 5' double plumbed hose and wand with hot oil recirculation. The KERA-200H has a melting rate of 125 gph.

Category: Crack Sealing

Pavement Type: AC, PCC

Function: Heating, Application

Product Name: Kracker Crack-Sealing Machines
Models BK-250D, BK-350D, BK-250

Manufacturer: BearCat Mfg.
P.O. Box 2059
Wickenburg, Arizona 85358
(602) 684-7851

Description: The Kracker sealing machines are a combination sealant heating and application unit mounted on a trailer. The 250D and 350D units use diesel fuel for both the engine and burners, whereas the 250 uses a gasoline engine with propane burners. Both the 250 and 350 gallon units have a heating rate of 250 gallons per hour independent of the burner fuel. All sealant tanks have twin augers for continuous mixing. The heating is accomplished with heated oil passing through pipe coils around the augers. The coil spacing allows sealant to melt through the coils to the augers for adequate mixing, but prevents unmelted blocks from jamming the augers. The sealant is pumped through a hose and hand-held wand for application. The hose is stored in a heated cabinet capable of melting clogged sealant.

Category: Crack Sealing

Pavement Type: AC, PCC

Function: Application

Product Name: Melter, Models BM-10, BM-20

Manufacturer: Berry Corporation
P.O. Box 12785
1070 Brentwood Court
Lexington, KY 40583
(606) 255-1149

Description: The BM-10, 20 melters are 10 and 20 gallon kettle capacity sealant melters, with either hand-crank or optional 3 horsepower gasoline engine power agitators. Heating is supplied with a propane gas system with automatic temperature controls. Heating rates are 10 and 20 gallons per hour for the BM-10 and BM-20 respectively. A quick opening, positive shutoff 2 inch valve is used to draw off melted sealant. The units may be obtained stationary with lifting arms or on a three wheel chassis. The units weigh 250 pounds for the BM-10 (137 pounds without wheels), and 316 pounds for the BM-20.

Category: Crack Sealing

Pavement Type: AC, PCC

Function: Application

Product Name: Model BA-P Pressure Applicator

Manufacturer: Berry Corporation
P.O. Box 12785
1070 Brentwood Court
Lexington, KY 40583
(606) 255-1149

Description: The BA-P pressure applicator is a self contained melter/applicator on a three-wheeled walk-behind chassis. The melting kettle has a 20 gallon sealant capacity and is capable of melting at a rate as high as 60 gallons per 8 hour day. Heat transfer oil is heated by combustion of bottle gas with automatic temperature control. A steel paddled agitator is welded to a vertical shaft for continuous mixing of the sealant in the kettle. The material is dispensed into the crack through a patented anti-clogging pouring spout on the bottom right-hand side of the machine. The company offers the BM-10 and BM-20 auxiliary melters to increase production capacity.

Category: Crack Sealing

Pavement Type: AC, PCC

Function: Application

Product Name: BMA-20 Pressure Applicator

Manufacturer: Berry Corporation
P.O. Box 12785
Brentwood Court
Lexington, KY 40583
(606) 255-1149

Description: The BMA-20 pressure applicator is a self contained melter/applicator on a three-wheeled walk-behind chassis. The melting kettle has a 20 gallon sealant capacity and is capable of melting and dispensing material at a rate as high as 10 gallons per hour. Heat transfer oil is heated by combustion of bottle gas with automatic temperature control. A steel paddled agitator is welded to a vertical shaft for continuous mixing of the sealant in the kettle. The material is dispensed through a patented anti-clogging pouring spout. The company offers the BM-10 and BM-20 auxillary melters to increase production capacity.

Category: Crack Sealing

Pavement Type: AC, PCC

Function: Melter/Applicator

Product Name: Melter-Applicators Models 50, 100 (B230-20), 200 (B250-20)

Manufacturer: Cimline Inc.
P.O. Box 680
Hopkins, MN 55343
(612) 944-9511
(800) 328-3874

Description: The Cimline melter-applicators are trailer mounted and have kettle capacities of 50, 100, and 200 gallons. Melting is accomplished by propane heated air passing through flues in the kettle and oil reservoir. Convection heat from the flues heat the sealant material and the oil jacket. There are no pumps for circulating the heating oil. A vertical shaft rotates the horizontal agitator, sweeping the bottom of the cylindrical tank. A propane fueled engine drives the hydraulic system for the agitator and pumping the sealant through the insulated hose and applicator nozzle. The hose and nozzle are stored in a heated cabinet.

Category: Crack Sealing

Pavement Type: AC, PCC

Function: Melter/Applicator

Product Name: Ghausse Model TPS Melting Kettle

Manufacturer: Ghausse Manufacturing Company, Inc.
8100 Joy Road
Detroit, Michigan 48204
(313) 834-7373

Description: The Model TPS Melting Kettle is a trailer mounted kettle with a hose and wand applicator for sealing. The units are available in 115, 170, 225, 325 and 500 gallon capacities. The kettle is bottom-fired with two 500,000 BTU propane burners, with kerosene optional. A 5 h.p. engine drives an 18 G.P.M. material pump. A 2 inch draw off valve is located at the rear of the trailer for hand poured applications. Melting rates are not available.

Category: Crack Sealing

Pavement Type: AC, PCC

Function: Melter/Applicator

Product Name: Mobil Hot Bitumen Kettle

Manufacturer: Modern Asphalt Tools
3 Main Road
Holbrook, Ipswich
Suffolk, IP9 2QX
Telephone: 0473-328034

Description: The Constant Flow Hot Bitumen Mobile Kettle is a small 13.5 litre capacity manually propelled sealant melter/applicator. The kettle uses a Dry Steam system to melt the sealant material. The design and layout of all components are such that they are constantly under observation by the operator. The applicator is mounted on the lower right-hand side of the cart, nearest the operator.

Category: Crack Sealing

Pavement Type: AC, PCC

Function: Combination (Preparation, Melter, Sealer)

Product Name: Melter/Blaster Crackfill Unit
Model NEYRA 50 M.P.C.T.

Manufacturer: Neyra Industries, Inc.
10700 Evendale Drive
Cincinnati, Ohio 45241
513-733-1000

Description: The Neyra 50 M.P.C.T. is a self-contained combination Melter/Blaster Crackfill Unit which is mounted on a trailer. The unit is capable cleaning cracks, melting and applying sealant. The air compressor and hydraulic system are powered by an 18 horsepower gasoline engine. A THERMO-BLASTER heated compressed air lance is provided to heat, dry and prepare the crack for sealing at a temperature of 2000 F and 300 MPH velocity. The sealant melter has a 50 gallon capacity and is heated using propane. The company provides two THERMO-BANDERS with the unit, which are small dollied hand-pulled kettles used to apply a 3 inch wide overseal band of sealant.

Category: Crack Sealing

Pavement Type: AC, PCC

Function: Filling

Product Name: FALCON 400

Manufacturer: R.L. Sales
1207 E. Bogart Road
Sandusky, OH 44870
419-627-2626

Description: The Falcon 400 Crack Filler is a unit for heating and applying sealant materials. The unit consists of a 450 gallon capacity tank heated by hot oil with automatic temperature control and a full sweep agitator. The applicator lines consist of 20' long flexible hose and a 54" applicator tube with shut off valve. A second applicator line is optional.

Category: Crack Sealing

Pavement Type: AC, PCC

Function: Melter/Applicator

Product Name: SBF-200, SBF-240, SBF-300 Bottom Fired Kettles

Manufacturer: SBF Mfg. Co, Inc.
12325 River Road
North Branch, MN 55056
Telephone: 612-674-4491

Description: SBF-200 Bottom Fired Kettle

The SBF-200 is a 205 gallon melter/applicator. The kettle uses a 500,000 BTU single torch burner operating on kerosene or LP gas. The SBF-200 has a loading height of 44 inches and is insulated with a 2 inch fiberglass layer. Options include kerosene torches, pumping systems, automatic controls, 1/2 ton material loading hoist, hood vents, electric brakes and towing accessories.

SBF-240 Bottom Fired Kettle

The SBF-240 is a 246 gallon melter/applicator. The kettle uses a 500,000 BTU single torch burner operating on kerosene or LP gas. The SBF-240 has a loading height of 44 inches and is insulated with a 2 inch fiberglass layer. Options include kerosene torches, pumping systems, automatic controls, 1/2 ton material loading hoist, hood vents, electric brakes and towing accessories.

SBF-300 Bottom Fired Kettle

SBF-300 is a 328 gallon melter/applicator. The kettle uses 500,000 BTU torch burners operating on kerosene or LP gas. The SBF-300 has a loading height of 44 inches and is insulated with a 2 inch fiberglass layer. Options include kerosene torches, pumping systems, automatic controls, 1/2 ton material loading hoist, hood vents, electric brakes and towing accessories.

Category: Crack Sealing, Pothole Repair

Pavement Type: AC, PCC

Function: Asphalt Distributors

Product Name: STD-600, STD-750, STD-1000, STD-1200, STD-2000, STD-2500 Truck Mounted Distributors; STRD-600, STRD-750, STRD-100, STRD-1200 Tow-Type Trailer Mounted Distributors; SSD-600, SSD-750, SSD-1000, SSD-1200 Slip-in Distributors; STRD-2500, STRD-4000, STRD-5000 Transport Trailer Mounted Distributors

Manufacturer: Stepp Mfg. Co, Inc.
12325 River Road
North Branch, MN 55056
Telephone: 612-674-4491

Description: STD-600, STD-750, STD-1000, STD-1200, STD-2000, STD-2500 Truck Mounted Distributors

The STD series truck-mounted distributors are numerically coded by their total capacity, in gallons. Each unit is heated by two 500,000 btu burners and insulated with a 2 inch fiberglass layer. A 30 hp Viking pump is submerged in the distributor tank on the 600 and 750 gallon units. The larger units employ a submerged 89 hp Viking pump. The 30 hp pumps may be replaced by the trucks hydraulic system while the 89 hp pumps may be replaced by hydrostatically driven models. The pumps are submerged to allow for heating with the material to prevent freeze-up. Internal pump parts may be removed from the outside for maintenance. The pump system allows for filling from an outside source into the tanker, circulation within the tanker, circulation within the spray bar or hand held spray wand, and draining of the tanker to an outside receptacle. 8-12 foot full circulating spray bars can be operated from the operators platform or from the remote control panel in the truck cab.

STRD-600, STRD-750, STRD-1000, STRD-1200 Tow-Type Trailer Mounted Distributors

The STRD series tow-type trailer-mounted distributors are numerically coded by their total capacity, in gallons. Each unit is heated by two 500,000 btu burners and insulated with a 2 inch fiberglass layer. A 30 hp Viking pump is submerged in the distributor tank on the 600, 750 and 1000 gallon units. The 1200 gallon unit employs a submerged 89 hp Viking pump. The pumps may also be driven by the truck's hydraulic system. The pumps are submerged to allow for heating with the material to prevent freeze-up. Internal pump parts may be removed from the outside for maintenance. The pump system allows for filling from an outside source into the tanker, circulation within the tanker, circulation within the spray bar or hand held spray wand, and draining of the tanker to an outside receptacle. 8-12 foot full circulating spray bars can be operated from the operator's platform or from the remote control panel in the truck cab.

STRD-2500, STRD-4000, STRD-5000 Transport Trailer-Mounted Distributors

The STRD series transport trailer-mounted distributors are numerically coded by their total capacity, in gallons. Each unit is heated by two 500,000 btu burners. The 2500 gallon unit is insulated with a 2 inch fiberglass layer while the larger units employ a 4 inch layer. An 89 hp Viking pump is submerged in the distributor tank on all units. The pumps are submerged to allow for heating with the material to prevent freeze-up. Internal pump parts may be removed from the outside for maintenance. The pump system allows for filling from an outside source into the tanker, circulation within the tanker, circulation within the spray bar or hand held spray wand, and draining of the tanker to an outside receptacle. 8-12 foot full circulating spray bars can be operated from the operator's platform or from the remote control panel in the truck cab.

SSD-600, SSD-750, SSD-1000, SSD-1200 Slip-in Distributors

The SSD series slip-in distributors are numerically coded by their total capacity, in gallons. Each unit is heated by two 500,000 btu burners and insulated with a 2 inch fiberglass. A 30 hp Viking pump is submerged in the distributor tank on all units. The pumps may be powered by the truck's hydraulic system. The pumps are submerged to allow for heating with

the material to prevent freeze-up. Internal pump parts may be removed from the outside for maintenance. The pump system allows for filling from an outside source into the tanker, circulation within the tanker, circulation within the spray bar or hand held spray wand, and draining of the tanker to an outside receptacle. 8-12 foot full circulating spray bars can be operated from the operators platform or from the remote control panel in the truck cab.

Category: Crack Sealing

Pavement Type: AC, PCC

Function: Sealing

Product Name: Highway Joint Sealant Pump
Model 700-55-S

Manufacturer: Pyles Division
Sealed Power Corporation
28990 Wixom Road
Wixom, MI 48096
(313) 349-5500
Telex: 23-5693

Description: The Highway Joint Sealant Pump is an air operated pump for sealants. The unit has a 38:1 ratio chop-and-check pump and is designed for 55 gallon drums but can be easily fitted for 5 gallon pails. The unit is sold with a dispensing wand that has a 1/4 inch I.D. hole in a 1 1/2 inch O.D. troweling ball as the applicator tip. Compressed air has to be supplied to the unit from an outside source. The manufacturer recommends a pressure of 80 p.s.i. with 10 c.f.m. and a maximum of 20 c.f.m. A smaller 5 gallon size is also available, as well as units in both sizes with special seals for silicone and two-part epoxies.

Category: Joint and Crack Filling

Pavement Type: AC, PCC

Function: Melter/Applicator

Product Name: Patchman Rubberized Asphalt Melter
Series 2015

Manufacturer: Western Industries, Inc.
1405 Sinclair Street S.
Bottineau, ND 5831
701-228-3757
FAX 701-228-2127

Description: The Rubberized Asphalt Melter is a trailer-mounted kettle with an applicator wand. The kettle has a capacity of 75 gallons and is wrapped in an oil jacket on all sides except the top. The oil jacket is heated with propane burners fitted with a flame-out gas shut-off device. Thermometers are fitted in the heat transfer oil and the material discharge line. The agitator and material pump are hydraulic, powered by an 8 h.p. gasoline engine. As an option, a heated applicator hose and wand are available.

Category: Joint and Crack Filling

Pavement Type: AC, PCC

Function: Melter/Applicator

Product Name: Patchman New Technology Asphalt Melter/Applicator
Series 2021

Manufacturer: Western Industries, Inc.
1405 Sinclair Street S.
Bottineau, ND 5831
701-228-3757
FAX 701-228-2127

Description: The Series 2021 Melter/Applicator is a 230 gallon capacity kettle and wand applicator trailer. The kettle is jacketed in oil which is heated with two 600,000 BTU propane burners. As an option, a heat transfer oil circulation pump is available. With the circulation pump, the machine will melt pounds of material in one hour at 60 F. If a heated hose is used, the hardened material in the hose will be remelted in 7 minutes. The agitator, circulation pump and material pump are hydraulic, powered by an 18 h.p. gasoline engine.

Category: Joint and Crack Filling

Pavement Type: AC, PCC

Function: Melter/Applicator

Product Name: Patchman Tar Kettle Trailer
Series 415, 434

Manufacturer: Western Industries, Inc.
1405 Sinclair Street S.
Bottineau, ND 5831
701-228-3757
FAX 701-228-2127

Description: These trailer mounted tar kettles are available in 220 and 300 gallon capacities. The units are heated with propane burners mounted beneath the insulated kettles. A gasoline engine drives the asphalt pump, and the material may be pumped through an applicator wand or spray bar. For manual applications, the material may be drawn off the kettle through a 1-1/2 inch valve. A twelve gallon solvent tank is connected for flushing the pump and applicators.

Category: Crack Sealing, Pothole Repair

Pavement Type: AC, PCC

Function: Melter/Applicator

Product Name: Tar and Asphalt Heating Kettles
Models: F-1, F-2, F-3, F-4, F-6, F-10

Manufacturer: White Asphalt Equipment
Midwest Tank & Mfg. Co. Inc.
2075 S. Belmont Ave.
Indianapolis, Ind. 46221
317-632-9326

Description: White tar and asphalt kettles are used to heat material for filling cracks or applying a tack coat to patches. The kettles are trailer mounted, with 500,000 BTU kerosene burners standard, but LPG burners are optional. Temperature control of the heating oil jacket is manually maintained and it is monitored with optional thermometers. The sealant material is placed through a 16 inch diameter opening in the top of the kettle, and the brackets are designed to allow for pre-heating of barrels. An optional barrel warming hood and lifting hoist are available. Kettle capacities from 80 to 325 gallons are available, with four to six hours required for melting. Agitators are the paddle-type and are hand-turned or optional engine-driven. Material may be pumped through the hose and spray either by a hand pump or optional 3 h.p. gasoline engine.

Appendix C

Descriptive Summaries of Equipment Used for Pothole and Spall Repairs

Category: Pothole Patching

Pavement Type: AC

Function: Combination (Preparation, Filling, Compaction, Finishing)

Product Name: Currently No Trade Name-under Development

Manufacturer: Perma Patch Company
Littleton, Colorado

Description: A third prototype is operational and consists of (1) a self contained one-operator unit, (2) heated supply hopper for asphalt concrete patch material, (3) 36 gallon heated tack oil supply tank, (4) 12 gallon diesel oil tank, (5) 125 gallon propane tank, (6) hydraulically controlled articulated work arm which includes an asphalt distribution hopper, tamper, tack oil spray and propane burners. The unit is 17 feet long and 12,000 lbs. fully loaded.

A typical pothole repair sequence includes:

1. Swing arm under supply hopper and fill distribution hopper.
2. Heat area to be repaired.
3. Spray area with tack coat.
4. Heat area again.
5. Place asphalt repair material from distribution hopper.
6. Tamp repair material.

The work crew consists of one person. The most recent information dates back to 1976. The Colorado State Highway Department has used the machine.

Category: Pothole Patching

Pavement Type: AC

Function: Combination (Preparation, Filling, Compaction, Finishing)

Product Name: P-B Slip-In Patcher,
P-B Unitized Patcher

Manufacturer: PB Loader Manufacturing Company
3275 E. Central Avenue
P.O. Box 341
Fresno, CA 93708
(209) 268-8521

Description: Fully equipped for asphalt patching and mounts on any single axle truck chassis. The unitized patcher includes a (1) container box, (2) radiant heater, (3) shovelling apron, (4) hand torch, and (5) emulsion spray unit. Optimal equipment includes a (1) butane/propane tank, (2) hydraulic jackhammer, (3) vibratory plate, (4) vibratory roller, or (5) air compressor. The slip-in patcher is a scaled down version of the unitized patcher. The slip-in patcher is designed to slide into a dump truck as needed for patching.

Crew size and patching procedure are not described in the manufacturer literature. Some specifications for the equipment are listed for the components. Production rates are not available.

Category: Pothole Patching

Pavement Type: AC

Function: Preparation, Material Transport

Product Name: Poweray Infrared Asphalt Heaters
Combination
Poweray Infrared Heat and Serve

Manufacturer: Poweray Infrared Corp.
P.O. Box 1473
Claremont, N.H. 03743
603-542-5185

Description: Three Infrared Asphalt Heater models (CS models, TR-36 and TR-48) are available for repairing asphalt pavements. Infrared heat is created by premixed gas and air and used to heat the asphalt concrete pavement. This process softens the repair area and eliminates the need for squaring the repair area with a compressor and jack hammer and a tack coat. The heating process reduces the cold joint between the repair area and existing pavement.

The heating chambers range in size from 15 inches to 30 inches wide and 95.5 inches to 114 inches long for the smaller units to 6 feet by 8 feet for the larger unit. The heating units can be towed behind a truck.

The Combination is an asphalt reclamation storage unit that is capable of heating and storing up to 4 tons of asphalt concrete at a temperature of 300° F.

The Poweray Infrared Heat and Serve contains both heating chambers and an asphalt concrete heating and storage unit.

Category: Pothole Repair

Pavement Type: AC, PCC

Function: Preparation

Product Name: Super Quadramatic Pavement Saw
Model 6505

Manufacturer: Target Products Division
4320 Clary Boulevard
Kansas City, MO 64130
800-821-2261
816-923-5040

Description: The Super Quadramatic Pavement Saw is a gasoline powered pavement saw used for sawing around potholes and patches for both asphalt and concrete pavements. The 65 horsepower saw has a hydrostatic transmission for speeds up to 200 feet per minute. The one-piece welded frame is supported on four wheels with the weight of the engine balanced over the saw blade. Blade diameters of 14 to 36 inches may be used for cutting depths up to 14-3/4 inches. Blade height is adjusted by an electrically controlled hydraulic unit. The watering system has an automatic engine shut-off for when the water supply fails. The saw weighs approximately 1300 pounds.

Category: Pothole Repair

Pavement Type: AC, PCC

Function: Preparation

Product Name: Pro 65 Pavement Saw
Model 6510

Manufacturer: Target Products Division
4320 Clary Boulevard
Kansas City, MO 64130
800-821-2261
816-923-5040

Description: The Pro 65 Pavement Saw is a gasoline powered pavement saw used for sawing around potholes and patches for both asphalt and concrete pavements. The 65 horsepower saw has a hydrostatic transmission for speeds up to 150 feet per minute. The engineered box frame is supported on four spoked wheels with the weight of the engine balanced over the saw blade. Blade diameters of 18 to 36 inches may be used for cutting depths up to 14-3/4 inches. Blade height is adjusted by an electrically controlled hydraulic unit. The watering system has an automatic engine shut-off for when the water supply fails. The saw weighs approximately 1400 pounds and uses heavier components for longer life and straighter cuts.

Category: Concrete Spall, Pothole

Pavement Type: PCC, AC

Function: Pavement Cutting

Product Name: CC-135 Concrete Cutter, OCC-135 Offset Concrete Cutter

Manufacturer: Vermeer Manufacturing Company
P.O. Box 200
Pella, Iowa 50219
Phone: 515-628-3141

Description:

CC-135 Concrete Cutter
The CC-135 is a concrete and asphalt wheel saw. The unit is powered by a 135 hp turbo charged 3-53T Detroit diesel engine. The operator is positioned at the front end of the vehicle with full access to the control panel. Either a 40" wheel for milling or an 84" wheel for cutting down to 31" may be used. Cutting widths range from 3-1/2" to 18". The CC-135 is 95-1/2" wide with the cutting wheel positioned along the centerline. A 200 gallon water tank is provided for dust control and cooling of the cutting wheel. The cutting wheel speed ranges from 0-1840 feet per minute depending on cutting wheel size. The transport speed of this unit ranges from 3 to 12 mph.

OCC-135 Offset Concrete Cutter
The OCC-135 Offset concrete cutter is similar to the CC-135 with the exception that the cutter wheel is located along one side of the unit, making the edge of machine to center of cutting distance equal to 14". The unit is powered by a 3-53T Detroit diesel engine and uses an 84" cutting wheel. Cutting widths of 3-1/2" to 9" are possible to a depth of 31". A conveyor system is mounted to the side and front of the unit to allow for the removal of all spoil. The OCC-135 has a cutting wheel speed of 0-1920 feet per minute and a transport speed of 5 to 15 mph.

Category: Pothole Patching

Pavement Type: AC

Function: Preparation

Product Name: Asphalt Milling Unit
Model SQB 95

Manufacturer: Western Industries, Inc.
1405 Sinclair Street S.
Bottineau, ND 5831
701-228-3757
FAX 701-228-2127

Description: The Western Asphalt Milling Unit utilizes a 20 inch wide carbided-tipped cutter head mounted on a trailer towed by a utility type tractor. Power for the cutter head, between 60 and 120 h.p. required, is supplied by the PTO from the tractor. The cutter head can rotate 90 degrees enabling transverse cuts up to 78 inches across the pavement. Single pass depths up to 4-1/2 inches are possible. The cutter head assembly is hydraulically raised above the trailer for rapid mobilization.

Category: Pothole Repair

Pavement Type: AC, PCC

Function: Material Transport

Product Name: Patchman All in One Asphalt Transport
Series 4250

Manufacturer: Western Industries, Inc.
1405 Sinclair Street S.
Bottineau, ND 5831
701-228-3757
FAX 701-228-2127

Description: The Patchman All-In-One Asphalt Transport and Repair Unit is a 2.5 cubic yard trailer hopper. The hopper is wrapped in a heat transfer oil jacket which is heated by thermostatically controlled propane burners. Material is augered to the rear of the hopper and discharged into a tray for manual shoveling. The auger is hydraulically driven, with an outside hydraulic source required. As an option, an on-board gasoline engine is available to drive the hydraulic system. A hydraulic jackhammer is also available to aid in preparation of the pothole. Rear platforms are strong enough to transport a vibrating plate compactor, and an electric loading winch is available.

Category: Pothole Patching, Crack Sealing

Pavement Type: AC, PCC

Function: Combination (Preparation, Filling, Compaction, Finishing)

Product Name: AMZ Magnum

Manufacturer: Zimmerman Equipment Corp.
1000 South Thompson Lane
Nashville, TN 37211
615-833-5705

Description: The AMZ Magnum is an trailer mounted patching machine. The unit consists of 1) a heated, pressurized 250 gallon asphalt emulsion tank, 2) a hydraulically powered aggregate feeder, 3) a Ridley rotor gun, and 4) related compressors, hoses, blowers and nozzles.

Pothole repairs are made with the AMZ following a three step procedure.

Step 1: The area to be repaired is cleaned using forced air supplied at the rate of 260 cu. ft. per minute.

Step 2: Heated asphalt emulsion is sprayed over the area to act as a tack coat.

Step 3: A mixture of asphalt emulsion and aggregate is sprayed into the repair area at approximately 64 mph.

The AMZ work crew consists of two men, one directing the nozzle and one operating controls/driving. The AMZ is reported to be effective for repairing many surface defects, including potholes, small depressions, spalled cracks and alligator cracked areas. The pressurized application of the aggregate/emulsion mix is reported to provide adequate compaction of the filler material from the bottom up, alleviating the need for further compaction after filling. Patch thicknesses laid by the AMZ are reported from 3/8 in. to 1 ft.

deep. Daily production rates of up to 15,000 lb. of chips and 150 gal. of emulsion, including travel and loading times, are purported. The AMZ is compatible with all emulsion types and aggregate 3/8 in. or smaller. The aggregate is contained in the towing dump truck and supplied via the aggregate feeder.

The emulsion tank is heated by a 6,000 Watt electric heat exchanger positioned inside the tank. The heating element is placed inside a pressure tube which isolates it from direct contact with the emulsion.

Optional equipment includes a crack filling attachment and an electrical generator to power the tank heating element and emulsion line.

Category: Pothole Repair

Pavement Type: AC

Function: AC Removal

Product Name: PR-75, PR-105 Pavement Profilers

Manufacturer: Caterpillar Paving Products, Inc.
9401 85th Avenue North
Minneapolis, MN 55440-1362
Phone: 612-425-4100

Description: PR-75 Pavement Profiler

The PR-75 is a 4-wheel drive profiler powered by a 4 cylinder diesel engine capable of producing 77 hp at 2300 rpm. The PR-75 uses a 3.5 to 14.5" long, 30.5" dia. cutting mandrel which can cut up to 6" deep with a cross fall angle up to 5 degrees. Hydrostatic drive powers the cutting mandrel and both axles. Two axle steering allows for turning radii of the cutter down to 13". The operating speed ranges from 0 to 145 fpm while the transport speed ranges from 0 to 11 mph. A 90 gallon gravity fed sprinkler system is supplied for dust control and cutter tooth cooling. The PR-75 has an operating weight of 13,000 lbs.

PR-105 Pavement Profiler

The PR-105 is three wheel profiler powered by a 4 cylinder diesel engine capable of producing 90 hp at 2400 rpm. The PR-105 uses a 12" long, 28" dia. main cutting mandrel which can cut up to 6" deep with a cross fall angle up to 4.25 degrees. A optional auxiliary front cutter 3.5" to 24" wide can cut up to 5.5" depth of 5.5". Hydrostatic drive powers the ground drive and control systems. Independent front (2 wheel) and rear (1 wheel) steering allow for turning radii down to 8". The cutter is powered by a mechanical side drive system. The operating speed ranges from 0 to 440 fpm while the transport speed ranges from 0 to 5 mph. A 100 gallon centrifugal pump sprinkler system is supplied for dust control and cutter tooth cooling. The PR-105 has an operating weight of 17,000 lbs.

Category: Pothole Patching

Surface Type: AC, PCC

Function: Preparation, Cleaning

Product Name: 1900 C Cold Planer

Manufacturer: Cedarapids Inc
916 16th Street NE
Cedar Rapids, IA 523402
319-363-3511

Description: The 1900 C Cold Planer is a track mounted milling machine capable of milling up to 6" in asphalt and concrete pavements. The CR-1900C is powered by a 736 cu.in. diesel engine capable of developing 480 hp at 2100 rpm. The CR-1900C features a fully hdrostatic system to drive three independent crawler tracks, the milling drum, loadout conveyors and water pump. Milling widths of 4"-75.6" are possible at speeds up to 110 fpm. Travel speed is 3.7 mph. The milling drum may be tilted independently of the crawler track up to a 5 degree maximum. A 750 gallon water tank can supply up to 600 gph of water for dust control and carbide tip cooling.

The control console is centrally located and utilizes electric-over-hydraulic controls. The rear-loaded conveyor swivels 45 degrees in either direction to allow for side or end loading. An independent, 5 hp, gasoline-powered air compressor and air hammer are supplied for changing cutting tools. An independently powered dc motor is also provided for safely rotating the milling drum while the main engine is shut off.

Category: Pothole Patching

Pavement Type: AC

Function: Combination (Preparation, Filling, Compaction, Finishing)

Product Name: Highway Patching Repair System

Manufacturer: Econ Planers LeRoy R. Lutz & Assoc.
Boroughbridge Road 501 Ford Street
Ripon, North Yorks, HG4 1UE Oregon, IL 61061
0765 5321 815-732-2383

Description: The patching repair system is comprised of the following pieces of equipment:

- Highway tractor
- ECON planer
- ECON sweeper collector/loader
- Hydraulic jack hammer and ECON trailer
- ECON IBS insulated body
- Roller on trailer

Typical pothole repair sequence includes:

1. Set depth of cut on planer and transverse repair area with planer.
2. Transverse repair area with sweeper.
3. Trim repair edges with jack hammer.
4. Apply emulsion to repair area.
5. Shovel new material into repair area.
6. Compact new material with roller.

A one person crew is required for preparation of the repair area. However, a two person crew is required for application of the repair material. The planer and sweeper equipment can be mounted on an existing tractor. The ECON IBS insulated body is used to store new asphalt concrete repair material. A demountable hot-box is also available.

Category: Pothole Repair

Pavement Type: AC, PCC

Function: Preparation

Product Name: Econoline Saw

Manufacturer: Target Products Division
4320 Clary Boulevard
Kansas City, MO 64130
800-821-2261
816-923-5040

Description: The Econoline saw is a gasoline powered pavement saw used for sawing around potholes. The saw has a hydrostatic transmission for speeds up to 100 feet per minute. The one-piece welded frame is supported on four wheels with the weight of the engine balanced over the saw blade. Blade diameters of 12 to 18 inches may be used for cutting depths up to 6 5/8 inches. A locking blade depth screw control and automatic depth indicator are also attached. The watering system has an automatic engine shut-off for when the water supply fails. An electric 10 H.P. motor is available as well as 18 and 20 H.P. gasoline engines. The saw weighs approximately 600 pounds.

Category: Spall Repair

Pavement Type: PCC

Function: Concrete Removal

Product Name: FLOW Hydromill

Manufacturer: FLOW Services
21440 68th Ave S.
Kent, WA 98032
Phone: 800-446-3569 Ext.900

Description: The FLOW hydromill is a ultrahigh-pressure waterjet-based patented method for removing concrete from above and below rebar. The machinery operates at pressures of approx 35,000 psi, resulting in a jet velocity of 2000 fps. Water flowrates of 13 to 20 gpm are used. The jet angles, rotation and traverse speeds are controlled by the operator to vary the degree of cutting. The hydromill can be mounted on the rear of a tractor and must be equipped with an outside water source.

Category: Pothole repair

Pavement Type: AC, PCC

Function: Preparation

Product Name: Floor Cutter

Manufacturer: Partner Industrial Products
907 West Irving Park Road
Itasca, IL 60143
800-323-3353
312-773-2801

Description: The K50 floor cutter is a manually propelled pavement saw that uses an air motor. The saw blade rotates at 4800 rpm when connected to a 100 psi air supply at 125 cfm. Either abrasive or diamond blades may be used, with 12 or 14 inch diameters. An inline oiling system lubricates the air motor. A watering system is also installed for dust suppression. The saw is lightweight at only 56 pounds.

Category: Pothole repair, Spall repair

Pavement Type: AC, PCC

Function: Preparation

Product Name: K40 Hand Held Air Saw

Manufacturer: Partner Industrial Products
907 West Irving Park Road
Itasca, IL 60143
800-323-3353
708-323-2801

Description: The K40 Hand Held Air Saw can be used for sawing pothole edges and spalls. The saw uses a 12 inch diameter blade, either abrasive or diamond, and is powered by an air motor. The saw will develop 4 H.P. when connected to a 100 psi air source at 125 cfm. The saw weighs 21 pounds.

Category: Pothole Patching

Pavement Type: AC

Function: Combination (Preparation, Filling, Compaction, Finishing)

Product Name: Boy Asphalt Maintainer

Manufacturer: B.R. Lee Industries, Inc.
P.O. Box 370
Denver, NC 28037
704-483-9721

Description: The LEE-Boy Asphalt Maintainer is equipped with the following components:

- Towing attachment
- Rotary Grinder
- 100 gallon heated tack distributor
- Shoulder buildup attachment
- Auxiliary coupling

A typical pothole patching procedure includes:

1. Grind out the deteriorated area
2. Clean out the repair area
3. Apply tack coat to repair area
4. Place new material in repair area
5. Compact new material

The Asphalt Maintainer can be towed behind a truck to the worksite. The unit is approximately 12 feet long, 8.5 feet wide, and weighs 8,500 pounds. The rotary grinder is 24 inches wide and consists of 51 replaceable carbide bits.

Category: Pothole Patching

Pavement Type: AC

Function: Combination (Preparation, Filling, Compaction, Finishing)

Product Name: P-B Slip-In Patcher,
P-B Unitized Patcher

Manufacturer: PB Loader Manufacturing Company
3275 E. Central Avenue
P.O. Box 341
Fresno, CA 93708
(209) 268-8521

Description: equipped for asphalt patching and mounts on any single truck chassis. The unitized patcher includes a (1) container box, (2) radiant heater, (3) shovelling apron, (4) hand torch, and (5) emulsion spray unit. Optimal equipment includes a (1) butane/propane tank, (2) hydraulic jackhammer, (3) vibratory plate, (4) vibratory roller, or (5) air compressor. The slip-in patcher is a scaled down version of the unitized patcher. The slip-in patcher is designed to slide into a dump truck as needed for patching.

Crew size and patching procedure are not described in the manufacturer literature. Some specifications for the equipment are listed for the components. Production rates are not available.

Category: Pothole Patching

Pavement Type: AC

Function: Combination (Preparation, Filling, Compaction, Finishing)

Product Name: Currently No Trade Name-under Development

Manufacturer: Perma Patch Company
Littleton, Colorado

Description: A third prototype is operational and consists of (1) a self contained one-operator unit, (2) heated supply hopper for asphalt concrete patch material, (3) 36 gallon heated tack oil supply tank, (4) 12 gallon diesel oil tank, (5) 125 gallon propane tank, (6) hydraulically controlled articulated work arm which includes an asphalt distribution hopper, tamper, task oil spray and propane burners. The unit is 17 feet long and 12,000 lbs. fully loaded.

A typical pothole repair sequence includes:

1. Swing arm under supply hopper and fill distribution hopper.
2. Heat area to be repaired.
3. Spray area with tack coat.
4. Heat area again.
5. Place asphalt repair material from distribution hopper.
6. Tamp repair material.

The work crew consists of one person. The most recent information dates back to 1976. The Colorado State Highway Department has used the machine.

Category: Concrete Spall Repair, Pothole Patching

Pavement Type: PCC, AC

Function: Preparation, Compaction

Product Name: Pionjar 120/130 Drill/Breaker

Manufacturer: Berema Incorporated
10 Fitch Street
P.O. Box 775
Norwalk, CT 06856
Telephone: 800-243-5005
203-838-2822
Telex: 964395 ABEMA INK NLK

Description: The PIONJAR 120/130 is a gasoline powered drill/breaker combination tool that is operated and handled by one man. The two-cylinder gasoline engine supplies the power, so no auxiliary air compressor or hydraulic unit are required. This self-contained feature makes the tool extremely portable, yet weighs only 57 pounds. The 120 Model may either be used for breaking (vertical percussion action) or rotary drilling by simply flipping a lever. The 130 Model does not have the percussion mechanics, therefore it is smaller and weighs four pounds less. A large variety of attachments are available which make the unit capable of breaking, digging, compaction, grinding and drilling operations.

Category: Concrete Spall

Pavement Type: PCC

Function: Concrete demolition

Product Name: Hydraulic Hand Held Breaker
Model HB-25

Manufacturer: Tamrock Tools Inc.
3501 Woodhead Drive
Northbrook, IL 60062
Phone: 312-291-0040
Telex: 27-0319

Description: A Tamrock HB-25 breaker is a hydraulic powered hand-held 70-pound class concrete paving breaker. The HB-25 is used to break old concrete into smaller pieces for removal prior to placing new concrete. The are to be removed needs to be sawcut first, as the breaker leaves a rough and uneven edge. The hydraulic source may be either a portable hydraulic pumping unit or a connection to a backhoe quick-connect, with a 6 GPM oil supply.

Category: Pothole Repair

Pavement Type: AC

Function: Pavement Milling

Product Name: CC-135 Asphalt Mill

Manufacturer: Vermeer Manufacturing Company
P.O. Box 200
Pella, Iowa 50219
Phone: 515-628-3141

Description: CC-135 Asphalt Mill
The CC-135 asphalt mill is powered by a 135 hp turbo charged 3-53T Detroit diesel engine. The operator is positioned at the front end of the vehicle with full access to the control panel. Cutting widths range from 12" to 26" at depths to 20". A spoilbox is mounted along the sides of the cutting wheel to confine the spoil within the milled area. A 200 gallon water tank is provided for dust control and cooling of the cutting wheel. The cutting wheel speed ranges from 0-1840 feet per minute depending on cutting wheel size. The transport speed of this unit ranges from 3 to 12 mph.

Category: Pothole Repair

Pavement Type: AC

Function: Preparation

Product Name: Asphalt Milling Unit
Model SQB 95

Manufacturer: Western Industries, Inc.
1405 Sinclair Street S.
Bottineau, ND 5831
701-228-3757
FAX 701-228-2127

Description: The Western Asphalt Milling Unit utilizes a 20 inch wide carbided-tipped cutter head mounted on a trailer towed by a utility type tractor. Power for the cutter head, between 60 and 120 h.p. required, is supplied by the PTO from the tractor. The cutter head can rotate 90 degrees enabling transverse cuts up to 78 inches across the pavement. Single pass depths up to 4-1/2 inches are possible. The cutter head assembly is hydraulically raised above the trailer for rapid mobilization.

Category: Pothole Patching

Pavement Type: AC, PCC

Function: Preparation

Product Name: VACM Potholer

Manufacturer: Roadbadger Inc.
13796 Spring Street, P.O. Box 73
Burton, Ohio 44021
216-834-1395

Description: The VACM Potholer is a backhoe attachment designed to grind out asphalt or concrete pavement. The unit requires a medium-size backhoe or loader with a hydraulic pump capacity of 25 gpm at 2,500 psi. The unit has a 40 horsepower motor and is equipped with a cutting head that has a 10.5-inch diameter and 16 cutting spikes with carbide bits. The cutting head rotates up to 250 rpm.

The VACM Potholer requires one person to operate the equipment and grind out pavement from the repair area. On asphalt concrete pavements, the unit can grind out a 4'x12'x6" area in about 10 minutes. In Portland cement concrete pavements, the unit can drill a vertical hole through a 9" slab, 12" in diameter in 4 to 5 minutes.

The unit reduces asphalt to a gravel-like consistency so that removal of the material can be accomplished manually or with a vacuum.

Category: Pothole Patching

Pavement Type: AC

Function: Combination (Preparation, Filling, Compaction, Finishing)

Product Name: Wildcat ROADPATCHER

Manufacturer: Wildcat Manufacturing Co., Inc.
Highway 81
P.O. Box 523
Freeman, South Dakota 57029
605-925-4512

Description: The ROADPATCHER consists of a combination of equipment mounted on a mid-size truck. The ROADPATCHER consists of three separate systems: 1) hydraulic system, 2) rock delivery system, and 3) emulsified asphalt delivery system. The hydraulic system provides the power and control for the ROADPATCHER operation. The rock system is responsible for the storage of aggregate and its delivery to the mixing nozzle which is mounted at the end of a boom. The emulsified asphalt system provides for storage of the asphalt and its delivery to the mixing nozzle.

Pothole repairs are made using the following procedure:

1. Position truck.
2. Position boom and nozzle over pothole and blow out pothole area using compressed air.
3. Raise nozzle and apply tack coat of asphalt emulsion to pothole area.
4. Activate rock delivery system and blow asphalt emulsion and aggregate into pothole area.
5. Coat repair area with dry aggregate.

Wildcat ROADPATCHER, Cont.

General specifications:

Length:

Boom in travel position, 22 ft., 10 in.

Boom down, retracted, 31 ft., 4 in.

Boom down, extended, 37 ft., 10 in.

Aggregate hopper - 5 cubic yard capacity

Air delivery capable of 300 cfm

Aggregate delivery hose - 2-1/2" inside diameter

Emulsified asphalt delivery - 300 gallon asphalt storage tank, 70 psi delivery

Flush tank - 30 gallon air pressurized

Warning Lights - includes arrow board

Category: Pothole Patching
Pavement Type: AC
Function: Combination (Preparation, Filling, Compaction, Finishing)
Product Name: Roadpatcher ("PUFF")

Manufacturere: ONE MAN, Inc. MARMON TRANSMOTTIVE
7301 Jefferson N.E. 3001 Gov. John Sevier Hwy.
Suite A-113 P.O. Box 1511
Albuquerque, NM 87109 Knoxville, TN 37901
(505) 898-1900 (615) 525-6224

Description: The Roadpatcher is an integrated patching machine which consists of (1) an aggregate hopper body, (2) aggregate feeder, (3) air delivery unit, (4) delivery nozzle, (5) air filter, and (6) boom.

Potholes are repaired using the following procedure: (1) clean repair area with high velocity air, (2) blow liquid asphalt emulsion into repair area, (3) fill hole with asphalt/aggregate mix (blown into hole), and (4) apply a thin layer of aggregate on the completed patch to prevent tire drag-out.

The Roadpatcher crew consists of one operator. The operator controls all aspects of the patching operation from within the truck's cab. The air delivery for cleaning is capable of producing 300 cubic feet per minute. The emulsified asphalt delivery uses pressurized air at 60 psi. The asphalt storage tank has a 300 gallon capacity and is heated with a 10 kw immersion heater. The truck is equipped with warning lights and a lighted arrow board.

Category: Pothole Patching

Pavement Type: AC

Function: Preparation, Material Transport

Product Name: Poweray Infrared Asphalt Heaters
Combination
Poweray Infrared Heat and Serve

Manufacturer: Poweray Infrared Corp.
P.O. Box 1473
Claremont, N.H. 03743
603-542-5185

Description: Three Infrared Asphalt Heater models (CS models, TR-36 and TR-48) are available for repairing asphalt pavements. Infrared heat is created by premixed gas and air and used to heat the asphalt concrete pavement. This process softens the repair area and eliminates the need for squaring the repair area with a compressor and jack hammer and a tack coat. The heating process reduces the cold joint between the repair area and existing pavement.

The heating chambers range in size from 15 inches to 30 inches wide and 95.5 inches to 114 inches long for the smaller units to 6 feet by 8 feet for the larger unit. The heating units can be towed behind a truck.

The Combination is an asphalt reclamation storage unit that is capable of heating and storing up to 4 tons of asphalt concrete at a temperature of 300° F.

The Poweray Infrared Heat and Serve contains both heating chambers and an asphalt concrete heating and storage unit.

Category: Pothole Repair

Pavement Type: AC

Function: Asphalt Transport Truck

Product Name: 4000 Man Asphalt Patching Truck
Series 4000

Manufacturer: Western Industries, Inc.
1405 Sinclair Street South
Bottineau, North Dakota 58318
(701) 228-3757

Description: The 4000 Asphalt Patching Unit is a single-axle truck with an insulated, heated 4 cubic yard hopper. The heating system consists of a oil jacket around the hopper, with the heat transfer oil being heated with two propane burners. An auxiliary hydraulic port is provided for attaching a jackhammer or saw. The material is loaded into the truck from the top, and is augered out the rear with an 8 inch diameter auger. A rear hydraulic lift platform is provided for lifting compaction equipment for transit.

Category: Pothole Repair

Pavement Type: AC

Function: Mix Storage

Product Name: Do-Al Hydraulic Dump/Spreader

Manufacturer: Highway Equipment Company
616 D Avenue Northwest
Cedar Rapids, IA 52405
Phone: 319-363-8281

Description: The Do-Al Dump Spreader is a "no-hoist" dump body which spreads and stockpiles materials without raising the hopper. Spreader lengths of 9', 10', 12' and 14' are available with standard truck capacities of 5.7, 6.5, 7.6 and 9.0 cubic yards, respectively. A 34" wide conveyor may be mounted to move material from the dump body directly into holes, spreaders, hot boxes, wheelbarrows, etc.

Category: Pothole Patching

Pavement Type: AC, PCC

Function: Filling

Product Name: Flow Boy TB-500

Manufacturer: Flow Boy MFG.
P.O. Box 720660
Norman, Oklahoma 73070-4500
405-329-3765

Description: The Flow Boy TB-500 horizontal discharge truck body can be used to transport hot mix asphalt. The walls and floor are insulated with fiberglass to retain material temperatures. Materials are discharged from the rear of the truck at a controlled rate by a patented drag "chain-conveyor" system in the floor of the unit.

Category: Pothole Repair

Pavement Type: AC

Function: Material Transport

Product Name: Asphalt Hot Box Trailer
Series 310

Manufacturer: Western Industries, Inc.
1405 Sinclair Street S.
Bottineau, ND 5831
701-228-3757
FAX 701-228-2127

Description: This unit is used to transport hot mix asphalt to a repair section, and maintain the material temperature. Two trailers are offered, with 1 and 2.5 cubic yard capacities, and are heated with propane. The burner heats underneath and on the sides of the box, with the exhaust vented on the top of the box sides. The units will allow material to be added to the box through the top, while a rear gate opens for access during patching. Optional equipment includes automatic temperature ignition and controls and a heated tank for prime.

Category: Pothole Patching
Pavement Type: AC
Function: Reheating of Asphalt
Product Name: Series 1100 Asphalt Craze Remover

Manufacturer: Modern Asphalt Tools
3 Main Road
Holbrook, Ipswich
Suffolk, IP9 2QX
Telephone: 0473-328034

Description: The CRAZE REMOVER is a heating plate used to reheat alligatored asphalt before it has potholed. By adding a heavy bitumen and reheating the asphalt, the CRAZE REMOVER rectifies the alligatored pavement. The heating plate is attached to a handle which contains the kerosene burner. The unit can also be used to reheat asphalt which has cooled before final rolling. Plate diameters of 11 and 16.5 inches are available.

Category: Pothole Repair

Pavement Type: AC

Function: Asphalt reheating, recycling

Product Name: Patchman Mobile Asphalt Reheater/Recycler
Series 600, 720

Manufacturer: Western Industries, Inc.
1405 Sinclair Street South
Bottineau, North Dakota 58318
(701) 228-3757

Description: The Patchman asphalt reheater/recycler is a trailer-mounted drum with its own heating and power supply. The insulated steel drum is capable of reheating cold mix, cooled hot mix, or broken asphalt removed from the repair section. Production rates from four to nine tons per hour with the Series 600, and up to twelve tons per hour with the Series 720, are possible. The drum rotation is reversible for either mixing or discharge. The drum pitch is variable to aid in controlling the discharge rate of the heated mix. A heated tank, pump, hoses and hand sprayers are provided for applying prime or tack coat materials. Other options include a POWR-FEEDER for augering material into the drum, and a POWR-ENDGATE for regulation of feed material leaving the dump truck. Various sizes of gasoline engines and hydraulic units are available. Propane heating is used with a 1,250,000 BTU burner for the drum.

Category: Pothole Repair

Pavement Type: AC

Function: Asphalt reheating, recycling

Product Name: Patchman Portable Asphalt Plant
Series 820

Manufacturer: Western Industries, Inc.
1405 Sinclair Street South
Bottineau, North Dakota 58318
(701) 228-3757

Description: The Patchman Portable Asphalt Plant is a small trailer unit with a rear mounted pugmill. A 42 cu. ft. rotating drum is used for heating aggregates before discharging into the pugmill. The pugmill has a replaceable liner and is where the asphalt cement is sprayed onto the aggregate. After mixing, the new hot mix is discharged onto a tray for manual application. Propane burners are used to heat the asphalt cement tank (150 gallon capacity) and the aggregate.

Category: Pothole Patching

Pavement Type: AC

Function: Asphalt Heating

Product Name: Series 1000 Asphalt Welding Irons

Manufacturer: Modern Asphalt Tools
3 Main Road
Holbrook, Ipswich
Suffolk, IP9 2QX
Telephone: 0473-328034

Description: The Welding Iron is used to reheat and smooth cold joints in asphalt pavements. The Iron is heated with a propane burner and is manually pulled along the cold joint. A smaller iron is available for getting into tight corners such as in a pothole or patch.

Category: Pothole Patching

Surface Type: AC, PCC

Function: Compaction

Product Name: B50 Static 1 Ton, B100 Static 1-1/2 Ton, B200 Static 2 Ton, B200T Static 2 Ton w/Transport Attachment, B300 Vibratory 2 Ton, B300T Vibratory 2 Ton w/ Transport Attachment and B400 Articulated Vibratory 5 Ton Rollers.

Manufacturer: BEUTHLING Manufacturing Co., Inc.
837 17th Avenue South
Minneapolis, MN 55404
612-338-3144

Description:

B 50 Static 1 Ton Compactor:
The B 50 is a dual-drum static roller with a 28 inch wide split front drum, a 34.75 inch wide rear drum and a 2,000 pound operating weight. The unit is powered by a Kohler 8 hp Magnum single cylinder engine and has a maximum travel speed of 5 mph.

B 100 Static 1-1/2 Ton Compactor
The B 100 is a dual-drum static roller with a 30 inch wide split front drum, a 37 inch wide rear drum and a 3,000 pound operating weight. The unit is powered by a Kohler 14 hp Magnum single cylinder engine and has a maximum travel speed of 5 mph.

B 200 Static 2 Ton Compactor
The B 200 is a dual-drum static roller with a 30 inch wide split front drum, a 41 inch wide rear drum and a 4,150 pound operating weight. The unit is powered by a Kohler 18 hp Magnum twin cylinder gasoline engine and has a maximum travel speed of 5 mph.

B 200T Towable Static 2 Ton Compactor
The B 200T is a dual-drum static roller with a 30 inch wide split front drum, a 41 inch wide rear drum and a 4,700 pound operating weight. The unit is powered by a Kohler 20 hp Magnum twin cylinder gasoline engine and has a maximum travel speed of 5 mph. A two position tow pole

Beuthling Compactors, Cont.

and retractable 15 inch towing wheels are provided to eliminate the need for a transport trailer.

B 300 Vibratory 2-1/4 Ton Compactor

The B 300 is a dual-drum vibratory roller with a 30 inch wide split front drum, a 36 inch wide rear drum and a 4,450 pound operating weight. The unit is powered by a Kohler 20 hp Magnum twin cylinder gasoline engine and has a maximum travel speed of 5 mph. The total applied force is 6,200 pounds operating at a vibrating frequency of 1,200 to 1,800 VPM.

B 300T Towable Vibratory 2-1/4 Ton Compactor

The B 300 is a dual-drum vibratory roller with a 30 inch wide split front drum, a 36 inch wide rear drum and a 4,950 pound operating weight. The unit is powered by a Kohler 20 hp Magnum twin cylinder gasoline engine and has a maximum travel speed of 5 mph. The total applied force is 6,480 pounds operating at a vibrating frequency of 1,200 to 1,800 VPM. A two position tow pole and retractable 15 inch towing wheels are provided to eliminate the need for a transport trailer.

B 400 Articulated Vibratory 5 Ton Compactor

The B 400 is a dual-drum vibratory roller with 52 inch wide front and rear drums and a 9,860 pound operating weight. The unit is powered by a Kubota 52 hp diesel engine and has a maximum travel speed of 6 mph. The total applied force is 9,684 pounds on the front drum and 10,177 pounds on the rear drum.

Category: Pothole Patching

Pavement Type: AC, PCC

Function: Compaction

Product Name: AVR 4000
Two-ton tandem articulated vibratory roller

Manufacturer: Stone Construction Equipment, Inc.
Corporate Offices/ Northern Mfg. Plant
32 East Main Street, P.O. Box 150
Honeoye, NY 14471-0150
Telephones: 800-888-9926
FAX: 716-229-2363

Description: The AVR 4000 is an articulated frame, two-ton vibratory roller for compaction of asphalt. The drums are 40 inches wide, with the front vibrating. The 20 h.p. Kohler Magnum engine powers the hydraulic system which drives the drums and vibrator. A 65 gallon polyethylene tank provides the water supply for the gravity feed drum sprinklers. The drums vibrate at 3400 VPM with a centrifugal force of 3500 pounds.

Category: Pothole Patching

Surface Type: AC

Function: Compaction

Product Name: Bartell Vibratory Plate Compactor

Manufacturer: Bartell Industries, Inc.
31 Sun Pac Blvd.
Brampton, Ontario L6S 5P6
416-458-5455

Description: Several models of the plate compactor are available. The smallest has a plate size of 13"x18" and centrifugal force of 2,000 pounds. The largest has a plate size of 18"x24" and a centrifugal force of 4,500 pounds. All models are available with an optional water reservoir system.

Category: Pothole Repair

Pavement Type: AC

Function: Compaction

Product Name: CB-214B, CB-224B Double Drum Vibratory Compactors

Manufacturer: Caterpillar Paving Products, Inc.
 9401 North Avenue North
 Minneapolis, MN 55440-1362
 Phone: 612-425-4100

Description: **CB-214B Vibratory Compactor**
 The CB-214B is a dual drum vibratory compactor powered by a 2 cylinder diesel engine capable of producing 33 hp at 2600 rpm. The CB-214B uses twin 27.5" dia, 39.4" wide drums with operating weights of 2535 lbs each. The eccentric weight drive operates at a frequency of 3000 vpm and an amplitude of 0.022", producing a centrifugal force of 4500 lb per drum. Vibration may be selected on the front, rear or both drums. The CB-214B has an inside turning radius down to 8'3" and an outside turning radius down to 11'7". A 42 gallon spray system, employing an electric centrifugal water pump, provides either continuous or intermittent spray. The CB-214B has an operating speed of 0 to 6.5 mph and a gross gradability of 35%.

CB-224B Vibratory Compactor
 The CB-224B is a dual drum vibratory compactor powered by a 2 cylinder diesel engine capable of producing 33 hp at 2600 rpm. The CB-224B uses twin 27.5" dia, 47.2" wide drums with operating weights of 2700 lbs each. The eccentric weight drive operates at a frequency of 3000 vpm and an amplitude of 0.022", producing a centrifugal force of 5400 lb per drum. Vibration may be selected on the front, rear or both drums. The CB-224B has an inside turning radius down to 7'11.5" and an outside turning radius down to 11'11". A 42 gallon spray system, employing an electric centrifugal water pump, provides either continuous or intermittent spray. The CB-

224B has an operating speed of 0 to 6.5 mph and a gross gradability of 35%.

Category: Pothole Patching

Pavement Type: AC

Function: Infra-red Heating

Product Name: HE-PR-96V Resurfacer, HE-PR-52V Resurfacer, HE-PR-36 Portable Hand Patcher

Manufacturer: Aeroil Products Company, Inc.
69 Wesley Street
South Hackensack, NJ 07606
Phone: 201-343-5200

Description: HE-PR-96V Resurfacer

The HE-PR-96V is a trailer mounted infra-red heater. The heating unit has a length of 48" and a width of 96" providing a coverage area of 32 sq.ft. The unit produces 1,200,000 BTU from twenty propane-fired infra-red generators. The unit has a weight of approx. 1550 lbs, excluding the four 100 lb vapor cylinders. The unit comes complete with lighting torch, regulator and bottle connectors. The heating grid can be adjusted from a horizontal position up to and past vertical for use in heating stockpiles, etc.

HE-PR-52V Resurfacer

The HE-PR-52V is a trailer mounted infra-red heater. The heating unit has a length of 48" and a width of 52" providing a coverage area of 17.3 sq.ft. The unit produces 600,000 BTU from ten propane-fired infra-red generators. The unit has a weight of approx. 1100 lbs, excluding the two 100 lb vapor cylinders. The unit comes complete with lighting torch, regulator and bottle connectors. The heating grid can be adjusted from a horizontal position up to and past vertical for use in heating stockpiles, etc.

HE-PR-36 Resurfacer

The HE-PR-36 is a wheel mounted infra-red heater. The heating unit has a length of 36" and a width of 36" providing a coverage area of 9 sq.ft. The unit produces 360,000 BTU from six propane-fired infra-red generators mounted beneath stainless steel parabolic reflectors. The unit has a weight of approx. 120 lbs, excluding the 100 lb vapor cylinder. The unit comes complete with lighting torch, regulator and bottle connectors.

Category: Pothole Patching

Pavement Type: AC, PCC

Function: Compaction

Product Name: Stone Deluxe EZ Roller
1-1/4 ton asphalt roller

Manufacturer: Stone Construction Equipment, Inc.
Corporate Offices/ Northern Mfg. Plant
32 East Main Street, P.O. Box 150
Honeoye, NY 14471-0150
Telephones: 800-888-9926
716-229-5141
FAX: 716-229-2363

Description: The EZ Roller is a 1-1/4 ton static drum roller for the compaction of asphalt. The roller has unit body construction and is powered by an 8 h.p. gasoline engine coupled to a variable speed hydrostatic drive system. The hydrostatic drive allows smooth starting and stopping without marring the asphalt. The controls for the watering system are in the drivers compartment, and water is stored in a 30 gallon epoxy coated water tank.

Category: Pothole Patching, Spall Repair

Pavement Type: AC, PCC

Function: Compaction

Product Name: Vibratory Plate Compactor

Manufacturer: Stone Construction Equipment, Inc.
Corporate Offices/ Northern Mfg. Plant
32 East Main Street, P.O. Box 150
Honeoye, NY 14471-0150
Telephones: 800-888-9926
716-229-5141
FAX: 716-229-2363

Description: Vibratory Plate compactors are small manually-propelled compactors used for compacting various granular materials, including hot or cold mix asphalt. A self-contained watering system for the plate is attached when used with hot mix asphalt. Two sizes are equipped for asphalt compaction, the S-28A and the S-38A, both with a 5 horsepower gasoline engine. The respective operating weights of 160 and 190 pounds deliver a compaction force of 3000 and 4000 pounds the S-28A and S-38A. The plates have approximately the same dimensions of 19" width and 24" length. The rotation of the eccentric vibrator pulls the machine forward at a maximum rate of 75 to 100 feet per minute.

Category: Pothole Patching

Pavement Type: AC

Function: Compaction

Product Name: Series 1200 Asphalt Punner

Manufacturer: Modern Asphalt Tools
3 Main Road
Holbrook, Ipswich
Suffolk, IP9 2QX
Telephone: 0473-328034

Description: The PUNNER is used for tamping the asphalt surface around and close to projections where rollers cannot reach. The PUNNER is a heated plate that is manually lifted and dropped for compaction. The burner is fuel by propane gas and is housed inside the handle. The base is profiled for tamping along either straight or curved surfaces.

Category: Pothole Patching

Pavement Type: AC, PCC

Function: Compaction

Product Name: STONE STOMPER Compactor

Manufacturer: Stone Construction Equipment, Inc.
Corporate Offices/ Northern Mfg. Plant
32 East Main Street, P.O. Box 150
Honeoye, NY 14471-0150
Telephones: 800-888-9926
716-229-5141
FAX: 716-229-2363

Description: The STONE STOMPER is a compaction shoe with a vertical vibrator. Compaction is accomplished by the shoe lifting off and then impacting back onto material, thus the slang name of "jumping jack". The STONE STOMPER vibrator is driven by a gasoline engine, and the total height is 43 inches from shoe to top. The operator controls the compactor from a roll-bar wrapped around the engine. Various sizes are available from 112 pound machines with 1900 pound compactive force, to 208 pound machines with 3850 pounds compactive force.

The STONE STOMPERS have smaller shoes than the vibratory plate compactors and are not equipped for watering, therefore these machines are more suited for compaction of subgrade materials than asphalt materials.

Appendix D

Functional Specifications - AC Pothole Repair

The equipment design for pothole repairs must be capable of completing or assisting in the completion of the following work tasks:

- Cavity preparation.
 - Determining the pothole repair boundaries.
 - Shaping the edges of the pothole repair boundaries.
 - Cavity cleaning and drying.
- Patch material application.
- Compaction or consolidation of the patch material.
- Finishing the surface or sealing the edges of the patch.

It is intended that the edge shaping capability of the repair equipment be an optional add-on component or provided as a separate piece of equipment. This would allow a user the choice of employing this aspect of the repair method, thus converting the equipment from a permanent to temporary repairs equipment status.

Preparatory Tasks

Before work can begin to repair potholes on the pavement, the equipment must be started and loaded with the necessary supplies. The entire system shall be self loading. All liquid materials (primers, binders, etc.) shall be loaded by pump while raw aggregate or pre-mixed materials shall be loaded by conveyor, dump buckets or other means.

Storage for aggregates and asphalt shall be provided of sufficient capacity to store materials for a normal day's production. The storage units shall be capable of being refilled or emptied on site in an automated manner to accommodate a full days production. The aggregate/pre-mix storage unit should be capable of maintaining the materials at the appropriate working temperatures.

Two basic alternatives may be utilized to provide patching materials of sufficient quality for pothole repairs. The first alternative provides for the preparation of the asphalt and aggregate mixture at the work site. The mixing may be accomplished 1) on a continual basis as required by patching operations or 2) in a batch mode of sufficient quantity to provide at least 2 ft³ of patch material. The second alternative provides for adequate storage of a pre-mixed patch material. Depending on material requirements, either alternative shall be capable of producing or maintaining the patch mix at acceptable working and placement temperatures. The choice of alternative configuration in the proposed equipment design must account for, among other things, repair productivity, material waste potentials, material quality.

Heating systems which may be required for the repair materials (including asphalt, prime, sealant, aggregate, and premixed materials) must be capable of maintaining the materials within the commonly specified temperature ranges of 120 °F to 350 °F, to a maximum tolerance of +/- 25 °F even when the ambient air temperature is as low as 0°F. The heating system(s) shall carry enough fuel to heat the materials for a minimum 10 hour time period. If an ignition system is required for the heating source, it should be of the electronic ignition type to minimize operator exposure to open flames and potential explosions. Automatic temperature control and outfire protection must be provided.

Determination of Repair Boundaries

Establishing pothole boundaries can be a difficult task. Existing cavities and visibly fatigue cracked areas are obvious candidates for patching. However, because fatigue cracking begins at the bottom of the AC layer, typically due to base support failure, there may be adjacent areas of deterioration surrounding the pothole that are greatly weakened but do not yet show surface fatigue cracking. These areas should also be included for patching for optimum pavement and patch performance. Likewise, crack deterioration may exist both at the top (visible) and the bottom (hidden) of the AC layer.

There are several methods that may be acceptable for determining the repair boundaries in pothole repair. The first and usual method is to use on-site judgement based on visual inspection. This is typically accomplished as part of the repair procedure or in advance, in which case paint markings are usually used to convey the repair borders to the maintenance crew. This method, while being largely subjective, may also require additional personnel and involve unnecessary exposures to traffic hazards. The equipment design should investigate the incorporation of a remote camera and monitor system which would allow the equipment operator to view the pavement surface during repairs. The camera should have zoom features and lighting to facilitate close up and night time operations and be inclosed in a protective shroud to protect it from debris, vehicle moisture spray, and snow/rain.

A second alternative arrangement would allow the operator to positively mark the repair boundary directly on the monitor. This information would then be automatically relayed to remotely controlled pothole edge shaping equipment, through some appropriate means such as digital information processing.

A third alternative, suitable especially for night time operations, would provide the operator a means for tracing the boundary of the pothole repair with a feeler/guide finger or spot laser while the equipment is positioned for repair. The tracing procedure would then program a

"robotic" control system for the edge shaping equipment, providing automatic guidance control.

The equipment design should explore the potentials for successful implementation of these increases in technological sophistication during repair boundary determinations. The technological increases would modify the operator's function from complete equipment control to supervision and quality control via the remote camera monitoring system.

Preparation of the Pothole Cavity for Repair

There are three acceptable alternatives for the preparation of the pothole cavity for repair. The first method is the mechanical method. The equipment used to shape the edges of the pothole cavity and form the boundaries of the patch should be capable of producing straight, vertical cuts into the surface of the surrounding pavement to a depth of up to 4 in. The cutting equipment shall be capable of operating under dry conditions and not cause any damage to the surrounding pavement through surface spalling or radiating cracks. The cutting equipment may be either a saw capable of cutting a minimum of 125 lineal feet per minute or a small rotomill, 8 in diameter, capable of cutting the required depth at a minimum of 50 lineal feet per minute. The cutting equipment shall be equipped with automatic depth controls and so designed that the depth can be changed at any time during the cutting operation. The cutting equipment shall also be constructed so that the forward speed can be varied and controlled by the operator at all times during the cutting operation. Propulsion of the equipment should be automatic, either assisted by the cutting action of the equipment or provided by some external force.

Provisions must be made to allow for all unsound material within the pothole cavity to be loosened for removal to a depth up to 12 in from the pavement surface. The equipment must be capable of efficiently breaking down all spoil material without enlarging the repair beyond the previously established boundaries or disturbing sound pavement materials below the depth of repair. The breaking down of the material may be done by any appropriate means, such as with a 30 lb pneumatic hammer, rotary mill, or a vertical miller.

The use of a mandrel type milling head or vertical mill may facilitate the shaping of the pothole edges and cleaning of the cavity in one operation. The cutting head diameter should be such that a near vertical face, approximately one-half the depth of the pothole cavity, results on the traffic approach and leave faces, as shown in figure 1. The equipment should be capable of forming a patch with a width varying from 1 to 4 ft in increments of approximately 1 ft and so designed that the cutting equipment can be automatically moved

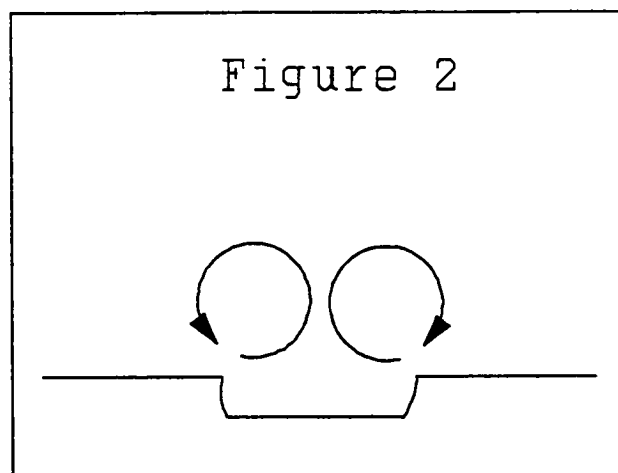
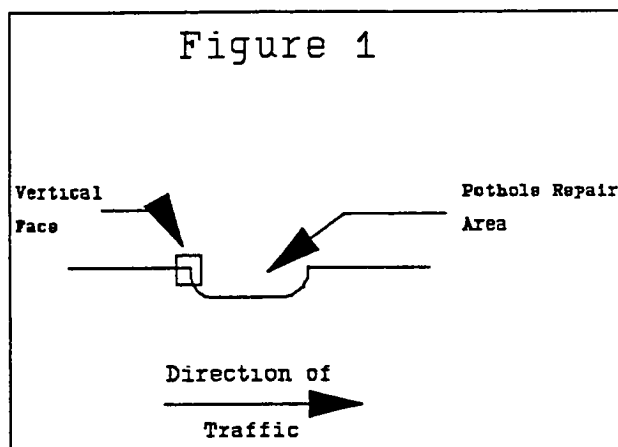
laterally to any position within a 12 ft traffic lane. The forward movement should be automatic and the equipment should be capable of cutting to the required depth at a forward rate of at least 3 ft/min. It shall be equipped with automatic depth controls and so designed that the depth can be changed at any time during the cutting operation.

The cutting head shall be designed so that it rotates and cuts down into the pavement material as shown in figure 2. This can be achieved in two different ways, either by being able to reverse the direction of the cutting head, or by rotating the cutting head a minimum of 180 degrees. Maximum maneuverability would be obtained by a combination of the two methods and would be the preferred method.

The spoil material must be removed from the cavity either by vacuum or a sweeping/auger/conveyor type system. The spoil material should be transferred directly to a container on the pothole patching equipment or to a separate truck for later disposal. If a separate truck is provided, the equipment should be capable of transferring the spoil to the truck when the truck is positioned to any side of the removal equipment.

After spoil removal, surfaces within the cavity should be dried by a hot air blast of at least 3000 °F at 3000 ft/sec. An alternative method is to use an infrared heater system with a minimum size of 6 ft wide by 3 ft in length. Either method shall have a production rate of 2 ft²/min.

A second acceptable method for the preparation of the pothole cavity for patching may be feasible, without having to establish a vertical face. All loose material within and surrounding the cavity will be removed using a vacuum or sweeping/conveyor system. The surfaces within the cavity shall be dried using a hot air blast or infrared heater meeting prior



specifications mentioned above. An infrared heater shield would then be used to soften the irregular edges of the pothole to a point that would facilitate compaction of the filler material and the surrounding existing material. The infrared heating device shall be a non flame contact operation to ensure Federal Clean Air Standards are met and that visibility of passing traffic is not inhibited. The heater shall also have a minimum production rate of 2 ft²/min.

The third method for preparation of the pothole cavity for patching is also feasible without having to mechanically establish the vertical face. The use of a heat lance capable of delivering a hot air blast of at least 3000 °F at 3000 ft/sec may be used in conjunction with the injection method of repair. The heat lance should be mounted on the same mechanism that delivers the aggregate and emulsion material on the injection type equipment.

Priming Operation

The equipment must be capable of applying a prime or tack coat to promote bonding between the patch material and the existing substrate. Equipment for applying prime or tack materials should be capable of producing a thin, even coating of prime material over the entire pothole cavity, including the boundary edges, at a rate of approximately 0.1 gal/yd². The equipment must be capable of spraying the primer over the cavity at low pressures and have a minimum capacity of 50 gallons.

The equipment shall be capable of maintaining the primer material at the proper application temperature. Hot applied primers are generally applied at temperatures of approximately 325 °F while cold applied application temperatures are approximately 120 °F. Automated temperature controls visible to the operator shall be provided.

To prevent burning or oxidation of the primer materials, the heating must be done in a controlled and uniform manner using an indirect heat source. A heat transfer material, such as oil or air, should be heated and circulated around or through, but not in contact with, the primer material. The volume of heating material should be compatible with the volume of primer material such that adequate temperatures within the primer materials are maintained to a tolerance of ± 10 °F throughout.

Typically, primer application is an intermittent operation combining application and prolonged waiting times until the next patch is prepared. The equipment should be capable of flushing the applicator nozzle with solvent to prevent clogging during waiting periods. The applicator shall have a satisfactory method to ensure the flushing material will not contaminate the

primer material. It also should be equipped with a recirculating system to prevent the hose and remainder of the applicator mechanism from becoming clogged during waiting periods.

Cavity Filler Material Preparation

The equipment shall be able to either proportion and mix ingredients on-site or use pre-mixed materials stored within the equipment. The equipment design must recognize the inherent advantages of each method and thus provide the user the ability to complete cavity filling operations throughout the entire year with the best suited materials. The equipment must be able to maintain patch materials at selected temperatures, even with ambient air temperatures as low as 0 °F to ensure proper working temperatures during compaction and placement. The equipment shall be equipped with automatic temperature controls and be capable of maintaining the mix at a temperature within ± 25 °F throughout the working day. The equipment should be able to deliver a continuous stream of patch material to the pothole cavity and have sufficient capacity to provide adequate material for a typical day's production. It should be designed so that it can be rapidly recharged in the event that additional material is needed in any working day.

Material Placement

The patch material must be dispensed from storage to the pothole cavity using an efficient transfer system, such as conveyor, bucket, auger type, air flow, etc. The delivery point of the feeder mechanism should be easily maneuverable to provide for efficient placement. If injection equipment is used, which sprays an aggregate/binder mix directly into the patch cavity, a controlled method of obtaining specified proportions of binder and aggregate will be required. In addition, provisions must be made to ensure the aggregates are coated in excess of 95 percent with binder. If pre- or batch-mixed patch materials are placed into the cavity which require further compaction, a strike off or luting device should be provided that can be automatically adjusted to dress the surface of the patch material sufficiently above the existing pavement so that the patch will be flush with the pavement when compacted. The size of the screed should be at least 4 ft in length and able to work in forward, reverse, and at 90 degree angles. Additional material should be able to be dispensed in low areas after initial strike off. A variable flow control to the cavity will be essential to reduce hand work.

Compaction or Consolidation

Depending on cavity placement method, the mix may require compaction after placement and initial strike off to attain proper density. In cold weather, the compaction should be completed within 5 minutes to ensure that adequate density can be obtained before the mix temperature cools.

The compaction equipment should be capable of providing a minimum of 300 lbs of vertical compactive force per inch width of footprint to achieve adequate density of the patch material. The equipment should provide a variable sized footprint, not to exceed the cavity dimensions, and be able to achieve at least 95 percent of the Marshall laboratory density (ASTM D 1559). The compaction footprint should be changeable in under one minute, to sizes ranging from 1 to 10 ft². Alternatively, multiple, small footprint compactors may be appropriate.

The compaction equipment should have adequate mobility to ensure complete cavity coverage. It should be capable of being automatically moved laterally to any position across a 12-ft pavement lane. Its operation should be automated to relieve worker fatigue.

Once the patch material is in place, provisions should be made for the repair area shall to be cleaned of any excess materials which remain on the surrounding pavement. This may be accomplished by an air blast or sweeping directed away from the operator and open traffic lanes or a vacuum pickup system.

Finishing or Sealing Edges

The edges of the pothole may be sealed with a thermoplastic material, either hot or cold applied. An alternative method is to chip seal the entire area. The sealant acts to inhibit water infiltration into the underlying substrate. Sealant reservoirs are not formed as in crack sealing procedures, therefore the quantities of material required per lineal foot are greatly reduced. The equipment should be capable of maintaining the sealant at the proper application temperature. Hot applied sealants are generally applied at temperatures of approximately 325 °F while cold applied sealant application temperatures are approximately 120 °F. Temperatures must be maintained within a tolerance of ± 10 °F to avoid sealant damage. Automated temperature controls should be provided.

The sealant machine should provide for recirculation or agitation of the sealant materials within the storage reservoir to ensure uniform consistency of the materials. The sealant material should be supplied to an applicator mechanism in such a way as to provide for recirculation of the sealant materials within the applicator and storage tank during periods

when sealants are not being applied directly into the patch edges. The complete travel length between the storage tank and the exit point of the applicator should be heated in an indirect manner to maintain sealant temperatures to a tolerance of ± 10 °F.

Typically, edge sealing is an intermittent combination of sealant application and prolonged waiting times until the next patch is prepared. The equipment should be capable of flushing of the applicator nozzle with solvent to prevent clogging during waiting periods. Application equipment should be capable of operation at speeds of approximately 100 lin ft/min during sealant application. The applicator mechanisms should be equipped with adjustable pressure sensors which effectively allow for the operator to control the sealant feed rate into the patch edge to avoid using excess sealant material which has been found to be detrimental to the performance of the pothole patch. A squeegee type attachment should be provided to direct excess sealant material into the patch edge.

Appendix E

Functional Specifications - Transverse Crack and Joint Filling/Sealing in Asphalt Pavements

This section presents the functional specifications for multi-tasked equipment to be developed to perform sealing and filling operations on AC transverse cracks. As mentioned earlier, the two operations differ by objective, thereby necessitating different materials and installation procedures. The procedures listed below are typical for crack sealing operations. Crack filling operations, on the other hand, are not as extensive but do follow these procedures to a certain degree.

- Cavity preparation.
 - Refacing the crack/joint to produce a uniform reservoir.
 - Cleaning of the reservoir to remove deleterious materials.
 - Conditioning of the crack and surround surfaces using heated air devices such as a heat lance (for AC pavements only).
- Sealant application.
 - Initial loading and recharging of the sealant machine.
 - Heating of the sealant materials to proper working temperatures.
 - Mixing of the materials within the sealant machine to ensure consistency.
 - Discharge of materials to applicator mechanism recirculation between applicator and storage during stopping periods.
 - Actual application of the sealant into the crack reservoir.
 - Finishing or strike-off of the material to attain proper configuration (if necessary).
- Finishing of the sealant material.
 - Placement of blotter materials over exposed material (i.e., band-aid configured material).

General Specifications

The equipment unit(s) to be fabricated shall be capable of conducting the sealing operation across the full width of a standard 12-ft lane without having to make lateral adjustments. Furthermore, the unit(s) must be able to operate stably, either within the lane of repair or remotely from a shoulder. Equipment built to operate from shoulders should be equipped with booms and hoses capable of extending the full width of the adjacent traffic lane.

Operational mechanisms (i.e. refacing devices, cleaning devices) must be developed such that they are free to work individually or in unison with other mechanisms. For instance, in a

crack filling operation where refacing is not done, the saw mechanism must be programmed such that it does not operate. Individual equipment components should be distributed on one or more travelling vehicles to achieve optimum performance and economy.

Cavity Preparation

Prior to sealant application, the transverse crack must be adequately prepared to ensure the best performance of the sealant/filler. This is the first phase of sealant installation and is very critical.

Refacing Operation

In sealing operations, old sealant remaining in cracks must be removed or displaced. This is accomplished through the use of the refacing mechanism. Crack refacing (routing or sawing) mechanisms must be capable of providing a crack/joint reservoir up to 1 in deep and 1.5 in wide. The reservoir must be formed without causing damage, manifested either by surface spalling or micro-cracking, to the pavement surround. Because it has been found that rotary impact router devices create spalling and cracking, they shall not be used as a refacing mechanism. The refacing mechanism must be circular in shape and must rotate about an horizontal axis. The cutting head shall either be carbide- or diamond-tipped and must be variable in width from 1.0 to 1.5 in.

Due to the irregular directions associated with transverse AC cracks, the cutting operation of the refacing device must be able to closely follow the irregularities to minimize cavity bypass and limit the volume of material removed. Hence, a minimum maneuverability of 60°/in of travel is required by the equipment.

Refacing mechanisms shall be furnished with automated depth and width controls to minimize operator error. Such controls are desirable to allow for the automatic positioning of the device at a prescribed distance from the pavement surface. This positioning will be user selectable based on the speed of operation, surface condition of the pavement, sealant materials used, etc. Automatic tracking devices would also be desirable to follow meandering crack patterns.

Cleaning

Cleaning of the crack reservoir after refacing operations must be thoroughly accomplished. The reservoir must be free of dust, water, and other residues in order to ensure proper bonding of the sealant material to the sidewalls.

Cleaning mechanisms shall operate under the recorded path taken by the refacing mechanism and shall be capable of operating effectively at speeds of 2 mph. This will provide a sufficient productivity level should refacing operations become faster. A minimum blast velocity of 3000 ft/sec is required of airblasting equipment. Hot compressed air lances shall be capable of providing a heat source of 3000 °F at a blast velocity of 3000 ft/sec. Direct contact of an open flame with the asphalt pavement surround will be prohibited. Depth controls and guidance systems should be automated to minimize operator error.

Cleaning activities done in filling operations typically include air blasting and brooming. Surface preparation with a heat lance is appropriate for unrouted and routed or sawn transverse crack sealing in asphalt pavements when using polymer modified sealant materials. Regardless of method, the preparation activity must take place as closely as possible to the time of sealant application to reduce the possibility of recontamination.

Air Blasting

Blowing of cracks with compressed air is common to many crack filling operations. Air lances are generally effective in removing debris and sandy soils but are ineffective in removing cement laitance or soils containing clays, organic matter or moist materials. Air lances are inappropriate for AC crack sealing operations and removal of residue from wet saw operations.

Air blasting must be accomplished using air velocities, air volumes and nozzle configurations adequate to ensure complete cleaning. The exit nozzle(s) should be positioned in close proximity to the pavement surface and directed at an angle that will force materials from within the cracks to be ejected in a forward manner, reducing or eliminating contamination of already cleaned areas. A deflector shield is recommended to minimize the potential of material being thrown into an operating traffic lane. The deflector should be capable of being rotated to either side.

Broom Cleaning

A stiff bristled broom has shown good results in removing surface and reservoir debris. The head should be rotated in such a way as to propel crack debris ahead of the direction of travel. The head should be swivel mounted to allow for rotation to further direct debris to one side or the other. A deflector shield is recommended to minimize the potential of material being thrown into an operating traffic lane. The deflector should be capable of being rotated to either side. Adequate vertical pressure must be maintained on the broom head for effective cleaning.

Cleaning/Conditioning with Hot Compressed Air

The hot compressed air (HCA) lance has been shown to be an effective preparation tool for use in asphalt pavement crack sealing. Again, the HCA lance must be capable of providing a hot air blast of 3000 ft/sec at 3000 °F. Operation of the heat lance is regulated by color change of the adhesive surface and the presence of smoke. The color change must occur over the full-width of the sealant band. Small quantities of light (transparent) smoke is acceptable while opaque smoke is not acceptable. This may be the only preparation tool used to date that has the ability to effectively remove both moisture and contaminants from the pavement or channel bond surfaces. When properly used, this tool has the potential for creating a clean, dry surface under the adverse conditions which can occur during cold or wet weather sealing.

The exit nozzle(s) should be positioned in close proximity to the pavement surface and directed at an appropriate angle to force materials from within the cracks to be ejected in a forward manner, reducing or eliminating contamination of already cleaned areas. A deflector shield or other mechanism is required to prevent any material being thrown into an operating traffic lane. The deflector should be capable of being rotated to either side.

Application

The second phase of installation is the application of the sealant material. This too is a very critical phase in that the material must be mixed, heated, and placed in ways suitable to the material.

Initial Loading

The sealant capacity should must be adequate to maintain the sealant at the manufacturer's recommended application temperature throughout the sealing operation. Excess capacity is

not necessarily desirable since most hot-pours are time-temperature dependent and begin to degrade shortly after being brought to application temperature or reheated.

The product tank must be equipped with adequate couplings so that liquids may be pumped into the product tank directly from stationary or mobile sources. Hand loading of solid sealant materials may also be required. Adequate steps, hand rails and working platform(s) should be provided for safe access to the opening of the product tank for hand loading. The opening should be equipped with a hinged safety cover which prevents splash-out of sealant during loading. The opening must be of adequate size to provide safe and efficient material loading and interior cleaning of the product tank.

Heating

Sealant machines shall be capable of agitating, recirculating, and dispensing thermoplastic sealing materials. These include fiber-, rubber-, and polymer-modified asphalts. Melting units must provide an external heat source to heat the material to its proper application temperature. Heating must be done in a controlled and uniform manner using an indirect heat source such that the material is not burned or oxidized. A heat transfer fluid, such as air or oil, shall be heated in a remote chamber and circulated through, but not in contact with, the sealant material. The volume of heating material should be compatible with the sealant volume such that adequate temperatures within the sealant materials are maintained to a tolerance of ± 10 °F throughout the sealant material volume.

The melting unit must be able to accurately maintain operating temperatures between 125 °F and 400 °F. Actual heating temperatures will depend on the material to be placed. For instance, cold-applied asphaltic filling materials occasionally install easier and perform better when slightly heated (i.e., 130 - 140 °F).

The melting equipment shall be capable of increasing the sealant temperature from ambient to applicable in a period of not more than 30 minutes under ideal weather conditions and 60 minutes under adverse weather conditions. Ignition of the heat source shall be of the electronic ignition type so that no open flames are required.

Mixing

Many thermoplastic materials have poor heat transfer properties. Therefore, mixing equipment will be required to maintain the maximum temperature tolerance of 10 °F. The sealant machine should provide for recirculation and agitation of the sealant materials within

the product tank to ensure uniform consistency and temperature of the materials. The mixing may be completed by internal recirculation or from agitation, such as through a rotated paddle, provided no air entrainment is produced in the sealant materials.

Discharge & Application

The sealant material should be supplied to an applicator mechanism in such a way as to provide for recirculation of the sealant materials within the applicator and product tank during periods when sealants are not being applied into the cracks. The complete travel length between the product tank and the exit point of the applicator should be heated in an indirect manner to maintain sealant temperatures to a tolerance of ± 10 °F.

The equipment must be capable of efficiently discharging the sealant materials from the product tank to the point of application. The discharge mechanism must be furnished with suitable controls such that materials are recirculated from the application point to storage during periods of application stoppage.

The applicator mechanism shall be directed by computer or electronics such that it follows the same path as the refacing mechanism and cleaning mechanisms. It must be capable of operating at speeds to 2 mph. Finally, applicator mechanisms shall be equipped with adjustable pressure sensors which effectively allow for the operator to control the sealant feed rate into the crack reservoir.

The position and feed rate to the applicator mechanism should be controlled in such a way as to minimize the operator fatigue during operation. It may therefore be advantageous to use applicator "carriages" which are positioned by the sealant machine during travel and directed into the crack by the operator/driver or by an automated tracking device. This may enable the sealing operation to be performed at speeds in excess of 2 mph.

The applicator mechanism(s) and related feed lines must be equipped with an easily accessed and used flushing system which allows the operator to purge all flow lines from the exit point of the product tank to the applicator mechanism(s) at any desired time. Flushing operations should use the minimum solvent to be effective. Solvent recovery is not essential but may be desirable, particularly in urban or environmentally sensitive areas. An adequate supply of flushing solvent should be provided to allow for at least 2 complete cleanings of the flow lines.

The flush or purge system must have lock-outs requiring manual override (preferably continuous manual override) to prevent the solvents from contaminating sealant materials within the product tank. (When the lock-out is overridden, solvent will pass into the product tank for cleaning purposes.) It is recommended that a lock-out delay be provided into the manual override system which provides a minimum of 2 seconds audible warning before lock-out is activated.

Finishing/Strike Off

Equipment used for final shaping and tooling should be coupled with the applicator mechanism(s) as an attachment so that both actions are completed concurrently. In no case, however, should the shaping/tooling attachment restrict the operator's view of the sealant application point. Common types of shaping equipment include "V" or "U" shaped squeegees or formed metal scraper boxes.

Finishing

Although generally not as crucial as the first two phases, finishing can be important when materials, such as emulsions, with poor tracking characteristics are placed exposed to traffic.

Blotter Placement

Once the sealant/filler is in place in the crack reservoir a final finishing of the surface may be applied to fill larger cavities and to prevent tracking. After application of the filler materials, a uniform thin coating of clean blotter material is typically applied to prevent tracking and perhaps increase surface friction. Common materials include clean medium to fine sand, crushed rock screenings, paper materials, etc. The potential for recycled material usage (paper, rubber) should be investigated. Regardless of material choice, the equipment must be capable of providing for a uniform coverage over the entire width of the applied filler. The feed rate of the materials should be synchronized with the speed of the blotter placement device to ensure a uniform depth of coverage.

Appendix F

Functional Specifications - Longitudinal Crack and Joint Filling/Sealing in Asphalt and Concrete Pavements

The types of cracks/joints which will be part of this activity include:

1. Lane-lane construction joints.
2. Lane-shoulder construction joints.
3. Various types of meandering cracks within the lane width.
4. Lane-widening construction joints (typically near the outside wheelpath).

It is quite possible that both PCC and AC pavement types will exist on either side of the crack/joint being filled. Therefore, material/pavement compatibility must be addressed for each repair section.

The complexity of the longitudinal crack and joint filling/sealing repair activity is based on the type, number and intricacy of the operations that must be performed. Relative levels of complexity for the mechanization of the various longitudinal crack and joint filling/sealing activities which may be addressed in this study are as follows, beginning with the least complex activity:

1. Asphalt pavement longitudinal crack filling.
2. Concrete pavement un-sawn longitudinal joint sealing.
3. Asphalt pavement un-routed longitudinal crack sealing.
4. Asphalt pavement area crack filling (alligator cracks).
5. Concrete pavement dry-sawn longitudinal joint sealing.
6. Asphalt pavement routed or sawn longitudinal crack sealing.

The relative levels of activity complexity shown above are based on materials, design configurations and choice of operations. Different material types or sealant configurations may effect the preparation, application or finishing requirements. Modifications to these requirements, which could result from findings of the H-106 test sites, might significantly alter equipment needs and change rankings. Similarly, major advances in control technology, which may already exist, could significantly change the rankings and substantially reduce expected cost differentials between low complexity activities and high complexity activities.

Cavity Preparation

Prior to sealant application, the longitudinal crack/joint must be adequately prepared to ensure the best performance of the sealant/filler.

The general term, cavity preparation, can include the following:

1. Creating a new reservoir or modifying an existing reservoir by routing, sawing or some other appropriate method.
2. Cleaning the adhesion surfaces of the pavement or reservoir to remove any deleterious material which would inhibit bonding of the sealant,
3. Conditioning of the surface of the reservoir or pavement bond surfaces, such as with a heat lance, to improve the adhesion characteristics of the pavement bond surfaces.

Individual equipment components must be developed to perform each of the above.

However, the distribution of the components on one or more travelling vehicles should be done to achieve optimum performance and economy.

Reservoir Creation

Old sealant remaining in cracks and joints must be removed or displaced. On cracks, this must be accomplished through the use of the refacing mechanism. As an option, a plow or hook mechanism may be incorporated for removal of old sealant from PCC joints. The sealant removal device(s), whether it be a plow, a hook, or the cutting (refacing) mechanism, must not cause any damage to the pavement surround. V-shaped plows are prohibited from use as they tend to spall the pavement edges.

Crack refacing (routing or sawing) mechanisms must be capable of providing a crack/joint reservoir up to 1 in deep and 1 in wide. The reservoir must be formed without causing damage, manifested either by surface spalling or micro-cracking, to the pavement surround. Because it has been found that rotary impact router devices create spalling and cracking, they shall not be used as a refacing mechanism. The refacing mechanism must be circular in shape and must rotate about an horizontal axis. The cutting head shall either be carbide- or diamond- tipped and must be variable in width up to 1.5 in.

Refacing mechanisms should be furnished with automated depth and width controls to minimize operator error.

Cleaning

Cleaning of the crack/joint reservoir after refacing operations must be fully accomplished. The reservoir must be free of dust, water, and other residues in order to ensure proper bonding of the sealant material to the sidewalls.

Cleaning mechanisms shall operate under the recorded path taken by the refacing mechanism and shall be capable of operating effectively at speeds up to 2 mph. This will provide a sufficient productivity level should refacing operations become faster. A minimum blast velocity of 3000 ft/sec is required of airblasting equipment. Hot compressed air lances shall be capable of providing a heat source of 3000 °F at a blast velocity of 3000 ft/sec. Direct contact of an open flame with the asphalt pavement surround is prohibited. Depth controls and guidance systems should be automated to minimize operator error.

The most common preparation methods for filling operations include air blasting and brooming. Surface preparation with a heat lance is appropriate for unrouted and routed or sawn longitudinal crack sealing in asphalt pavements when using polymer modified sealant materials. Regardless of method, the preparation activity must take place as closely as possible to the time of sealant application to reduce the possibility of recontamination. The cleaning task shall be capable of operating at a minimum speed of 5 mph.

It is desirable that the cavity preparation equipment requiring depth control be equipped with depth controls which allow for the automatic positioning of the device at a prescribed distance from the pavement surface. This positioning will be user selectable based on the speed of operation, surface condition of the pavement, sealant materials used, etc. Automatic tracking devices would also be desirable to follow meandering crack patterns.

Air Blasting

Compressed air blowing of cracks is common to many crack filling operations. Air lances are generally effective in removing debris and sandy soils but are ineffective in removing cement laitance or soils containing clays, organic matter or moist materials. Air lances are inappropriate for AC crack sealing operations and removal of residue from wet saw operations.

Air blasting must be accomplished using air velocities, air volumes and nozzle configurations adequate to ensure complete cleaning. The exit nozzle(s) should be positioned in close proximity to the pavement surface and directed at an angle that will force materials from within the cracks to be ejected in a forward manner, reducing or eliminating contamination of already cleaned areas. A deflector shield is recommended to minimize the potential of material being thrown into an operating traffic lane. The deflector should be capable of being rotated to either side.

Broom Cleaning

A stiff bristled broom has shown good results in removing surface and reservoir debris. The head should be rotated in such a way as to propel crack debris ahead of the direction of travel. The head should be swivel mounted to allow for rotation to further direct debris to one side or the other. A deflector shield is recommended to minimize the potential of material being thrown into an operating traffic lane. The deflector should be capable of being rotated to either side. Adequate vertical pressure must be maintained on the broom head for effective cleaning.

Hot Compressed Air Lance

The hot compressed air (HCA) lance has been shown to be an effective preparation tool for use in asphalt pavement crack sealing. The HCA lance must be capable of providing a hot air blast of 3000 ft/sec at 3000 °F. Operation of the heat lance is regulated by color change of the adhesive surface and the presence of smoke. The color change must occur over the full-width of the sealant band. Small quantities of light (transparent) smoke is acceptable while opaque smoke is not acceptable. This may be the only preparation tool used to date that has the ability to effectively remove both moisture and contaminants from the pavement or channel bond surfaces. When properly used, this tool has the potential for creating a clean, dry surface under the adverse conditions which can occur during cold or wet weather sealing.

The exit nozzle(s) should be positioned in close proximity to the pavement surface and directed at an appropriate angle to force materials from within the cracks to be ejected in a forward manner, reducing or eliminating contamination of already cleaned areas. A deflector shield or other mechanism is required to prevent any material being thrown into an operating traffic lane. The deflector should be capable of being rotated to either side.

Sealant Application

The application of the sealant onto the pavement or into the reservoir includes all aspects from the time of loading the sealant machine to actual application. This can include the following:

1. Initial loading and recharging of the sealant machine.
2. Heating of the sealant materials to proper working temperatures.
3. Mixing of the materials within the sealant machine to ensure consistency.
4. Discharge of the materials to the applicator mechanism and recirculation between applicator and storage during periods of work stoppage.
5. Actual application of the sealant into the reservoir or onto the pavement.
6. Finishing or strike-off of the material to attain the proper configuration.

Loading

The sealant capacity should must be adequate to maintain the sealant at the manufacturer's recommended application temperature throughout the sealing operation. Excess capacity is not necessarily desirable since most hot-pours are time-temperature dependent and begin to degrade shortly after being brought to application temperature or reheated.

The product tank must be equipped with adequate couplings so that liquids may be pumped into the product tank directly from stationary or mobile sources. Hand loading of solid sealant materials may also be required. Adequate steps, hand rails and working platform(s) should be provided for safe access to the opening of the product tank for hand loading. The opening should be equipped with a hinged safety cover which prevents splash-out of sealant during loading. The opening must be of adequate size to provide safe and efficient material loading and interior cleaning of the product tank.

Heating

Sealant machines used to apply most thermoplastic materials must provide an external heat source to melt the sealant materials. To prevent burning or oxidation of the sealant materials, this heating must be done in a controlled and uniform manner using an indirect heat source, such as air or oil, which is heated and circulated through or around, but not in contact with, the sealant material. The supply of heating material should be compatible with the sealant volume such that the manufacturer's recommended application temperatures within the sealant materials are maintained to a maximum tolerance of ± 10 °F throughout the sealant material volume, even when the ambient air temperature is as low as 0 °F.

It is desired that the equipment be capable of heating the sealant materials to manufacturers recommended working temperatures in a period of not more than 30 minutes, provided ambient air temperatures are above 0 °F. If an ignition system is required for the heating source, it should be of the electronic ignition type to minimize operator exposure to open flames and potential explosions. Automatic temperature control and outfire protection must be provided.

Mixing

Many thermoplastic materials have poor heat transfer properties. Therefore, mixing equipment will be required to maintain the maximum temperature tolerance of 10 °F. The sealant machine should provide for recirculation and agitation of the sealant materials within the product tank to ensure uniform consistency and temperature of the materials. The mixing may be completed by internal recirculation or from agitation, such as through a rotated paddle, provided no air entrainment is produced in the sealant materials.

The sealant material should be supplied to an applicator mechanism in such a way as to provide for recirculation of the sealant materials within the applicator and product tank during periods when sealants are not being applied into the cracks or joints. The complete travel length between the product tank and the exit point of the applicator should be heated in an indirect manner to maintain sealant temperatures to a tolerance of ± 10 °F.

Discharge

The equipment must be capable of efficiently discharging the sealant materials from the product tank to the point of application. The discharge mechanism must be furnished with suitable controls such that materials are recirculated from the application point to storage during periods of application stoppage.

Application

The sealant activity shall be able to maintain a minimum application speed of 5 mph. The position and feed rate to the applicator mechanism should be controlled in such a way as to minimize the operator fatigue during operation. For longitudinal joint resealing operations, all resealing is done in the direction of travel of the sealant machine. It may therefore be advantageous to use applicator "carriages" which are positioned by the sealant machine during travel and directed into the crack or joint location by the operator/driver or by an automated tracking device. This may enable the sealing operation to be performed at speeds in excess of 5 mph.

The applicator mechanism(s) should be equipped with a monitor system which effectively allows the operator to control the sealant feed rate into the crack or joint reservoir. Applicator mechanisms should incorporate a finishing/storage device (squeegee) immediately behind the applicator. This finishing device shall be capable of providing the design surface configuration at the specified speeds throughout the activity period, typically 5 to 7 hours.

Equipment used for final shaping and tooling should be coupled with the applicator mechanism(s) as an attachment so that both actions are completed concurrently. In no case, however, should the shaping/tooling attachment restrict the operator's view of the sealant application point. Common types of shaping equipment include "V" or "U" shaped squeegees or formed metal scraper boxes.

The applicator mechanism(s) and related feed lines must be equipped with an easily accessed and used flushing system which allows the operator to purge all flow lines from the exit point of the product tank to the applicator mechanism(s) at any desired time. Flushing operations should use the minimum solvent to be effective. Solvent recovery is not essential but may be desirable, particularly in urban or environmentally sensitive areas. An adequate supply of flushing solvent should be provided to allow for at least two complete cleanings of the flow lines.

The flush or purge system must have lock-outs requiring manual override (preferably continuous manual override) to prevent the solvents from contaminating sealant materials within the product tank. (When the lock-out is overridden, solvent will pass into the product tank for cleaning purposes.) It is recommended that a lock-out delay be provided into the manual override system which provides a minimum of 2 seconds audible warning before lock-out is activated.

Filler Application

The application of a filler onto the pavement and into cracks includes all aspects from the time of filling the product tank to actual application. This can include the following:

1. Initial loading and recharging of the product tank.
2. Heating of the filling materials to proper working temperatures.
3. Mixing of the materials within the machine to ensure consistency.
4. Discharge of the materials to the applicator mechanism and recirculation between the applicator and product tank during periods of work stoppage.
5. Actual application of the filler into the crack reservoir.
6. Finishing or strike-off of the material to attain the proper configuration.

Loading

The filler capacity must be adequate to maintain the material at the manufacturer's recommended application temperature throughout the filling operation. Excess capacity is not necessarily desirable since most hot-pours are time-temperature sensitive and begin to degrade shortly after being brought to application temperature or reheated.

The product tank must be equipped with adequate couplings so that liquids may be pumped into the product tank directly from stationary or mobile sources. Hand loading of solid filler materials may also be required. Adequate steps, hand rails and working platform(s) should be provided for safe access to the opening of the product tank for hand loading. The opening should be equipped with a hinged safety cover which prevents splash-out of material during loading. The opening must be of adequate size to provide safe and efficient material loading and interior cleaning of the product tank.

Heating

Filling machines used to apply most thermoplastic materials must provide an external heat source to melt the filler materials. To prevent burning or oxidation of the filler materials, this

heating must be done in a controlled and uniform manner using an indirect heat source, such as air or oil, which is heated and circulated through or around, but not in contact with, the filler material. The supply of heating material should be compatible with the volume of the product tank such that the manufacturer's recommended application temperatures within the filler materials are maintained to a maximum tolerance of ± 10 °F throughout the sealant material volume, even when the ambient air temperature is as low as 0 °F.

Filler materials may or may not require a heat transfer system. For instance, fiber modified AC's and the various crumb rubbers require heat transfer. These materials may be considered as high quality fillers. Asphalt cements and emulsions, with or without performance modifiers generally do not require heat transfer. These materials are applied in significantly larger quantities and at faster application rates than the sealers which require more sophisticated placement techniques.

It is desired that the equipment be capable of heating the filler materials to manufacturers recommended working temperatures in a period of not more than 30 minutes, provided ambient air temperatures are above 0 °F. If an ignition system is required for the heating source, should be of the electronic ignition type to minimize operator exposure to open flames and potential explosions. Automatic temperature control and outfire protection must be provided.

Mixing

Filler materials may or may not require mixing. For instance, fiber modified AC's and the various crumb rubbers require mixing. Asphalt cements and emulsions do not. The equipment should provide for recirculation or agitation of the filler materials within the storage reservoir to ensure uniform consistency of the materials. The mixing may be completed by internal recirculation or from agitation, such as through a rotated paddle, provided no air entrainment is produced in the sealant materials.

The filler material should be supplied to an applicator mechanism in such a way as to provide for recirculation of the filler materials within the applicator and storage tank during periods when fillers are not being applied into the cracks. The complete travel length between the product tank and the exit point of the applicator should be heated in an indirect manner to maintain filler temperatures to a tolerance of ± 10 °F.

Discharge

The equipment must be capable of efficiently discharging the filler materials from storage to the point of application. The discharge mechanism must be furnished with suitable controls such that materials are recirculated from the application point to storage during periods of application stoppage. The entire travel path from the product tank to the application point must be heated in such a way as to preserve filler temperatures to within ± 10 °F of product tank temperatures.

Application

The filling activity shall be able to maintain a minimum application speed of 5 mph. The position and feed rate to the applicator mechanism should be controlled in such a way as to minimize the operator fatigue during operation. It may be desirable to use applicator "carriages" which are positioned by the machine during travel and continually directed over the cracked location by the operator/driver or by an automated tracking device. The carriages must be developed to allow for either single crack filling or, in the case of area crack filling, uniform filling over an area up to 3 feet wide. This will enable the filling operation to be performed for single meandering cracks, longitudinal joints or wheelpath alligator cracking at speeds in excess of 5 mph. The applicator mechanism(s) should be equipped with a monitor system which effectively allows the operator to control the filler feed rate into the crack.

Applicator mechanisms should incorporate a finishing storage device (squeegee) immediately behind the applicator. This finishing device shall be capable of providing the design surface configuration at the specified speeds throughout the activity period, typically 5 to 7 hours.

Equipment used for final shaping and tooling may be coupled with the applicator mechanism(s) as an attachment so that both actions are completed concurrently. In no case, however, should the shaping/tooling attachment restrict the operator's view of the sealant application point. Common types of shaping equipment include "V" or "U" shaped squeegees or formed metal scraper boxes.

Finishing of Fillers and Sealants

Once the sealant/filler is in place in the crack/joint reservoir a final finishing of the surface may be applied to fill larger cavities and to prevent tracking. After application of the filler materials, a uniform thin coating of clean blotter material is typically applied to increase the surface friction and prevent tracking. Common materials include clean medium to fine sand, crushed rock screenings, paper materials, etc. The potential for recycled material usage

(paper, rubber) should be investigated. Regardless of material choice, the equipment must be capable of providing for a uniform coverage over the entire width of the applied filler. The feed rate of the materials should be coupled with the forward speed of the equipment to ensure a uniform depth of coverage.

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