IMPROVED WINTER POTHOLE PATCHING

State Planing And Research Project Number 538

by

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for

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16. Abstract

This report is a summary of the findings from a literature search and survey to investigate winter pothole patching equipment and methods utilized by other state and local transportation agencies. An informal survey of nine transportation agencies was conducted to determine what types of specialized equipment were being used to perform pothole repairs. The results of the literature search and survey revealed that spray injection patching is a widely used and accepted method for pothole and related road repairs. There are three types of spray injection patching equipment: trailer type units, modified truck units and self-contained units. Four different manufacturers are currently producing this spray injection equipment in the United States. Each of the manufacturers was contacted and their equipment specifications and catalog information obtained. The equipment data is included as appendices in the report. Based on the information obtained from recent literature, other transportation agencies and equipment manufacturers, the spray injection process has been widely endorsed as an effective and efficient method for road repair. A recommendation was made for Oregon Department of Transportation Maintenance Managers to review this report and investigate using a spray injection patching unit on a trial basis for 3-4 months.

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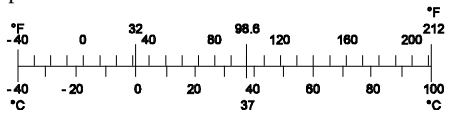
SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	Inches	25.4	Millimeters	mm
ft	Feet	0.305	Meters	m
yd	Yards	0.914	Meters	m
mi	Miles	1.61	Kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	Acres	0.405	Hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	Milliliters	mL
gal	Gallons	3.785	Liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
NOTE: Volumes greater than 1000 L shall be shown in m^3.				
		MASS		
oz	Ounces	28.35	Grams	g
lb	Pounds	0.454	Kilograms	kg
T	short tons (2000 lb)	0.907	Megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



***** SI is the symbol for the International System of Measurement (4-7-94 jbp)

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DISCLAIMER

IMPROVED WINTER POTHOLE PATCHING

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

1.1 PROBLEM

During the winter months, asphalt pavements are subjected to traffic, moisture penetration and in many areas of Oregon, repetitive freeze-thaw cycles. Under traffic loads, the more brittle colder pavement and the moisture trapped in the pavement base often lead to the formation of potholes.

Methods for repair of a pothole vary. They include:

a) Throw and roll -- the hole is filled with a cold mix material and compacted using the tires of the maintenance truck.
b) Edge seal -- the cold mix throw-and-roll patch is sealed around the edges with an asphalt based sealant material.
c) Semi-permanent -- the pothole is properly milled to square edges and is patched with cold mix, or in some cases, hot mix. It is compacted using a steel drum or rubber tired roller.

Even with a properly constructed cold mix patch, a pothole is likely to fail before the pavement is resurfaced or rehabilitated. Further exacerbating the problem, is limited manpower availability to do the patching and the impacts to the traveling public when the highway is partially closed for pothole patching. To maintain an acceptable pavement ride quality, ensure motorist safety and to minimize vehicle damage, potholes must be filled more efficiently and effectively.

Alternate methods are available to quickly, safely and permanently patch potholes in the late fall, winter, and early spring months. Although not employed in Oregon, a successful method used in many other states is spray injection. Spray injection is a process where using specialized equipment, aggregate is simultaneously premixed with a heated asphalt emulsion and sprayed through a hose and nozzle into the pothole. Specifically, the steps taken to fill the pothole when using this equipment include:

1) Blowing water and debris from the pothole.
2) Applying a tack coat of asphalt emulsion on the sides and bottom of the pothole.
3) Spraying the emulsion and aggregate mixture into the pothole.
4) Covering the repaired area with a thin layer of uncoated aggregate.
5) Opening the repair to traffic as soon as workers and equipment are clear.

Figure 1.1 illustrates the process. The spray injection method requires no compacting after the cover aggregate is placed.

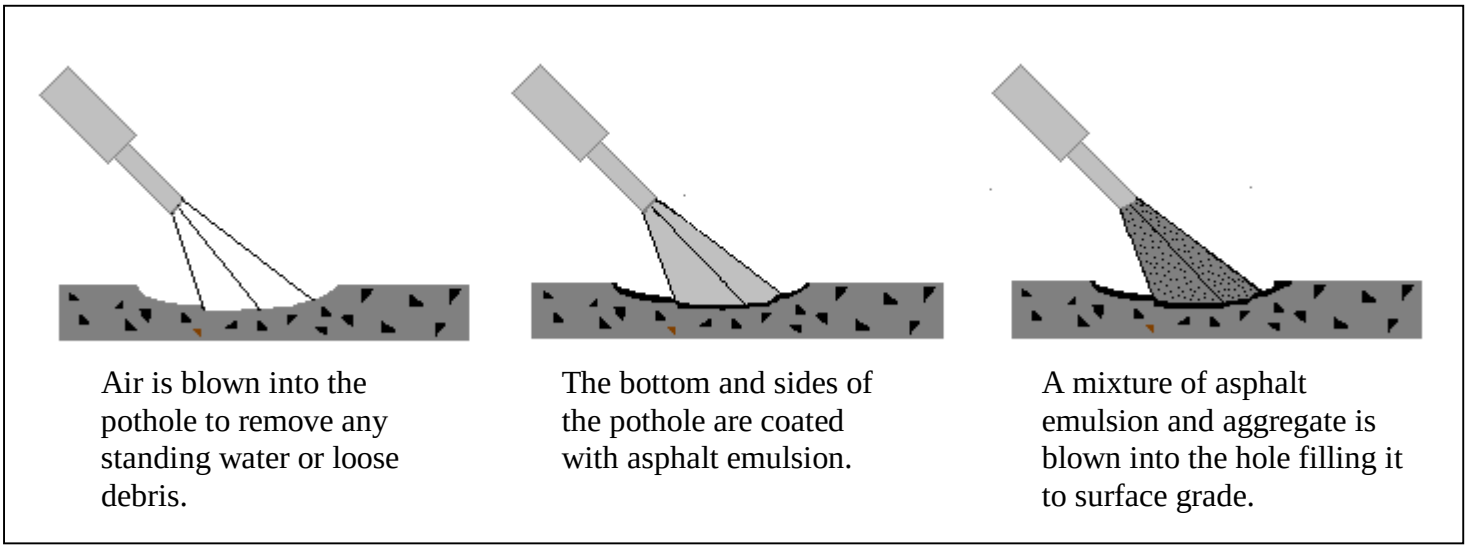

Figure 1.1: Spray Injection Pothole Patching Procedures

The spray injection equipment offers potential for much greater productivity and efficiency and can operate in extreme cold weather. Effective road repair operations are possible in the winter months when adverse weather prevents traditional pothole repairs from lasting through the season.

Oregon continues to use the throw-and-roll technique as the primary method for temporary road repairs. This process is labor intensive and repairs can easily fail if the repair is not done correctly or if the repair must be made in wet conditions. Proven specialized spray injection patching equipment is available to improve road repair capability in Oregon. This report presents results from recent studies of pothole patching equipment as well as relevant information obtained from other states that are using spray injection patching equipment. The report can be used by the Oregon Department of Transportation (ODOT) and local agencies as a basis for making operational decisions about the type and make of patching equipment available to best meet the agencies' needs.

1.2 PROJECT OBJECTIVES

This project involved information gathering and a literature search to determine the feasibility of employing spray injection patching equipment for road repairs in Oregon. The literature search consisted of reviewing current publications on pothole repair methods and contacting other state departments of transportation (DOT) who are using spray injection equipment. It also involved contacting manufacturers for information about costs, equipment types and their operating characteristics. The objective of the search was to provide ODOT Maintenance Managers and local agencies information about the spray injection process, including:

- Previous study results regarding automated pothole patching;
- Manufacturers of the equipment and costs;

- Features and characteristics of different equipment types; and
- Names of DOT representatives from other states using the equipment and the extent of their usage.

ODOT Maintenance Managers and local agencies can use this information to make decisions on obtaining spray patching equipment to improve their highway maintenance program efficiency and effectiveness.

1.3 TYPES OF SPRAY INJECTION EQUIPMENT

There are three types of units that are widely used by DOTs and local agencies for spray injection pothole patching. These include:

- Trailer type unit;
- Modified truck unit; and
- Self-contained unit.

In the trailer type unit, a dump truck pulls the trailer and feeds the aggregate through a modified tailgate into the trailer unit. At least two people, the truck driver and a person to operate the patching spray injector hose and nozzle are required. The spray injection operator works behind the trailer to control a delivery hose suspended from a boom on the rear of the unit.

With the modified truck unit, the patching equipment is reconfigured so that it can be mounted on the chassis or dump truck bed of an existing DOT truck. This eliminates the need for pulling a trailer, although the spray injection hose and boom are still operated from the rear of the truck.

In the self-contained unit, only one person is required to patch the pothole. The spray injection equipment is factory built onto a truck chassis. The patching is done by the truck operator inside the truck's cab using a joystick to remotely control the spraying operations. The boom and attached hose extend from the front of the truck.

2.0 LITERATURE SEARCH

2.1 TRANSPORTATION RESEARCH BOARD (TRB) REPORT

A previous Strategic Highway Research Program (SHRP) study, H-106, evaluated the effectiveness of several pothole patching materials and techniques at eight sites in the United States and Canada. One of the sites was in Oregon on U.S. 97 in Modoc Point. All sites except Oregon used a spray injection method for pothole patching. The results of the study indicated that the most productive method in terms of tons/person-day was the spray injection method (*Wilson, 1993*). Additionally, the study demonstrated that spray injection pothole patches were more durable when compared to those made using the throw-and-roll, edge seal and semi-permanent methods.

2.2 SHRP INFORMATION

The Federal Highway Administration (FHWA) has published news bulletins highlighting actual case studies regarding the use of spray injection pothole equipment in various locations throughout the United States. Overall, these reports indicate that the spray injection method is highly efficient, productive, and effective (*FHWA, 1996*).

2.3 OTHER STUDIES

Northwestern University

In 1991, The Basic Industries Research Laboratory (BIRL) at Northwestern University received a $1.2 million grant from the National Research Council to develop an Automated Pavement Repair Vehicle (APRV). The APRV research attempted to solve the pothole repair problem through complete automation of the repair procedure. The APRV uses a more advanced process than spray injection in that the APRV is fully automated using a computerized vision system and robotics to perform the repair operations under complete computer control. The APRV was designed to cut and shape a pothole, vacuum the hole, heat and dry the bonding surfaces and spray an asphalt emulsion and aggregate patch material into the hole. The end result is a flat and dense patch requiring no additional roller compaction. Repairs with an APRV were expected to last several years (*Blaha, 1993*).

The Northwestern University BIRL study has not achieved the anticipated results. The prototype machine was not effective in field trials. The APRV was used on the streets of Evanston, Illinois. It operated slowly and was costly to use. Jim Dorava, the supervisor for Evanston's Department of Streets and Sanitation commented about the APRV, "It's so

expensive for such equipment. It's actually slower than doing it by hand" (*Krishmurthy, 1995*). The BIRL

researchers have refocused their efforts to obtain additional funding from the private sector and concentrate on development of less sophisticated equipment that can be commercially produced and marketed.

Illinois Department of Transportation (IDOT)

A paper presented at the Eighth AASHTO/TRB Maintenance Management Conference documented the pothole patching efforts in Illinois using the spray injection method. The report highlighted IDOT's Bureau of Operations recent focus on using a self-contained truck unit (remotely controlled from the cab) to fill potholes. Since the early 1980s, IDOT has been using spray injection trailer type equipment. Research by the Strategic Highway Research Program and Illinois' field forces indicated the spray injection process produced patches with superior life when compared to the common throw-and-roll pothole repair method (*File and Hunter, 1997*).

IDOT procured a self-contained unit, valued in excess of $120,000, plus an asphalt emulsion storage tank costing $30,000. The up front equipment purchase costs became a critical consideration in implementing a patching program involving the spray injection process. The report described IDOT's approach to justify purchase of self-contained spray injection machines and of their plan to test, evaluate, and verify in the field the effectiveness of the new technology. IDOT has estimated that using one self-contained truck unit in seven maintenance districts would result for each district, in a labor savings of 53 person years over a 10-year cycle; material and equipment savings would be $1.05 million (*File and Hunter, 1997*).

IDOT is in the process of completing the field study evaluating the equipment's effectiveness. In doing their field evaluation, they rotated the self-contained truck unit among three maintenance districts. They are evaluating durability of the spray-injected patches with control patches that were made using the throw-and-roll method. Additionally, IDOT will determine actual costs and efficiencies then compare them with the projected savings.

Their field-testing was performed on asphalt and portland cement concrete (PCC) pavements on sections of interstate and state highways. Quantitative data has not been fully developed. However, early results from interviews with the equipment operators were very positive. The operators like the equipment, especially the capability to place patches on high volume roads without having to be outside the truck cab. This was viewed as a significant safety enhancement.

The final report's publication is expected to be in the last quarter of 1998. ODOT will be furnished a copy of the report.

3.0 INFORMATION OBTAINED FROM OTHER STATES

State and local transportation agencies were contacted about their use of spray injection patching equipment. Table 3.1 provides a summary of agencies contacted and related information about their equipment usage. Overall, each agency provided favorable endorsements about spray injection patching equipment. The majority of agencies are using trailer units. Self-contained units are being used in Illinois, Colorado and Minnesota.

Regardless of type or model of equipment, each agency reported that they use a washed, 9.5 mm or 6.3 mm uniformly graded crushed aggregate with their equipment. For the binder, a CRS-2 asphalt emulsion is used in the spring and summer months. A medium set emulsion, such as a CMS-2, is used for patching in colder conditions (<10° C).

There was quite a variation in how the spray injection patching units are employed among the nine agencies. Half of the states are comfortable using the equipment to patch PCC pavements. All were using the units to patch asphalt pavements. On PCC pavements, the patching equipment is used to repair spalled areas, corner breaks, transverse cracks and faults. On asphalt pavements, the equipment is being used to patch potholes, as well as to repair alligator cracking, transverse cracking, edge breaks, depressions and rutting.

Highway agencies varied in where their machines were utilized. For instance, South Carolina and North Carolina DOTs almost exclusively use their equipment state highways and local roads. Other states use their equipment on primary, secondary and interstate highways. Regardless of location, the appropriate work zone traffic control is used to protect the workers and equipment.

The agencies differed somewhat on their preferences for type of equipment. The ones using the self-contained units are pleased with their operation. It allows them to reduce their crew size by one person. Additionally, they believe the units are much safer for their employees to operate because of the remote cab controls. A significant disadvantage of the self-contained units is the initial capital expenditure ($120,000+).

The agencies using the trailer type units are extremely satisfied with their operation. The trailer units are versatile and can be utilized for a variety of highway repairs. Since the operator is on the ground close to the distressed pavement area, a more exact repair can be made. The down side of this is the increase in crew size since a truck driver is needed in addition to the patcher operator. Furthermore, even with proper work zone traffic control, the operator is exposed to errant traffic. Another disadvantage is the potential for coating the operator and parked vehicles with over spray. Several of the agencies indicated the way to minimize an over spray condition is to use equipment where the hose and nozzle can be placed close to the pavement. The closer the nozzle gets to the pavement, the less chance of over spray.

Another caution expressed by some agencies concerned the aggregate delivery system inside the unit. Some models use a hydraulically driven auger to deliver the aggregate to the hose mechanism. Other models use a low-pressure air system. Several of the agencies reported that in using a unit with an auger delivery system, the auger was wearing out because of abrasive aggregate. They recommend using a less abrasive aggregate or a unit with an air delivery system.

Each agency expressed a need to have good operators using the equipment. They also indicated that there would be a learning curve and productivity gains would not be seen until the operators became proficient. In most cases, they felt that 4-6 weeks would be needed before an operator would feel comfortable with the equipment.

Table 3.1 – Summary of Information Obtained from Other State and Local Agencies

AGENCY	CONTACT POINT	TITLE	PHONE NUMBER	TYPE EQUIPMENT	EQUIPMENT TRADE NAME	REMARKS
Minnesota DOT	Roger Olson Randy Resnicek	Research Engineer District Maint. Engineer	612-779-5517 320-255-4177	2 trailers 2 self contained	Dura Patcher Rosco RA-300	Used for asphalt and PCC pavement repairs.
Lassen County, California	Bill Harvey	Superintendent of Roads	916-251-8288	1 trailer	Dura Patcher	Used to fill in potholes, depressions, alligator cracking, wheel ruts.
Colorado DOT	Ahmad Ardani Les Vickers	Concrete Research Engineer Fleet Administrator	303-757-9978 303-757-9536	1 self contained 3 trailer	Wildcat Road Patcher Dura Patcher	Video produced by CDOT. Units used on asphalt pavements. Trailers are underutilized.
South Carolina DOT	Huley Shumpert	State Maint. Engineer	803-737-1290	49 trailers 4 truck mounted	Dura Patcher AMZ Magnum	Used to patch asphalt pavements; good results on trial section of I-20 PCC pavement. Truck mounted units better on high volume roads.
North Carolina DOT	Lacey Love	State Maint. Engineer	919-733-3725	50 trailers	Dura Patcher AMZ Magnum	Prefer to use on low volume roads.
Wyoming DOT	Tim McGary	District Maint. Engineer	307-745-2100	1 trailer	Dura Patcher	In trial stages. Have used on interstate, primary and secondary highways (PCCc and asphalt pavements).
Idaho DOT	Barry Gwinn	State Bridge Repair. Engineer	208-334-8478	2 trailers	Dura Patcher	Used in Boise and Eastern Idaho, patching on asphalt pavements including interstate highways.
Nebraska Dept. of Roads	Larry Peterson	District Maint. Engineer	308-345-8490	2 trailers	Dura Patcher AMZ Magnum	Used on PCC and asphalt pavements, the Dura Patcher is a demonstration model.
Illinois DOT	Dennis File	State Maint. Engineer	217-782-7228	23 trailers 1 self contained	Rosco RA-300 Dura Patcher AMZ Magnum	Used in 7 of 9 districts on asphalt and PCC pavement

4.0 SPRAY INJECTION EQUIPMENT MANUFACTURERS

Table 4.1 contains information about available spray injection patching equipment manufacturers and the type of equipment they produce. Each of the manufacturers was contacted and can provide a field demonstration. All have arrangements for leasing equipment. The trailer type units' purchase price is around $38,000-$41,000. The modified truck units (unit adapted to fit on an agency owned vehicle chassis or dump truck bed) are about the same price. The self-contained units are in the $125,000 range. The costs are estimated based on quoted dealer prices. State of Oregon contracting rules require equipment purchases of this type to be accomplished using a competitive solicitation. In a competitive environment, the actual price should be lower than the quoted dealer price.

Appendices A-D contain copies of equipment catalog information from each manufacturer listed in table 4.1.

Table 4.1 – Spray Injection Equipment Manufacturers

MANUFACTURER	TRADE NAME	TYPE	ADDRESS	TELEPHONE	PURCHASE PRICE	LEASE PRICE	PROVIDE DEMO?	CATALOG INFO
Duraco Industries	Dura Patcher	Trailer, Modified truck unit	330 Gilchrist Dr., Pearl, MS 39208	601-932-2100	$39,600	$3,500/month	Yes	See Appendix A
Wildcat Manufacturing	Road Patcher	Self-contained	Wildcat Manufacturing Freeman, SD 57029	605-925-4512	$125,000	$6,500/month	Yes	See Appendix B
Rosco Manufacturing	RA 200 RA-300	Trailer, Self-contained	1001 SW 1st Street Madison, SD 57042	605-256-6942	$45,000 (trailer) $120,000 (self-contained unit)	$8,000 – 9,000 per month for the self contained	Yes	See Appendix C
Zimmerman Equipment Co.	AMZ Magnum	Trailer, Modified truck unit	1000 South Thompson Lane Nashville, TN 37211	615-227-7112	$45,000 (auger fed trailer) $38,000 (air fed trailer) $43,000 (modified truck unit)	$3,000 – 4,000 per month (1 year minimum)	Yes	See Appendix D

5.0 RECOMMENDATIONS

It is recommended that ODOT Maintenance Managers review this report and closely examine the feasibility of using spray injection patching equipment. Each of the manufacturers can provide demonstrations. Demonstrations will provide a good orientation for maintenance personnel about the equipment capabilities. Additionally, it is recommended that ODOT maintenance crews try using the equipment under a short-term lease (3-4 months) and then evaluate its effectiveness before making any long term financial commitments.

The trailer type units are the most logical choice for an initial equipment procurement. The units are significantly lower in price, and although not as sophisticated as the self-contained units, the agencies operating them in other states have favorably endorsed their use.

6.0 REFERENCES

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Thomas Wilson. Strategic Highway Research Program Pothole Repair Materials and Procedures. Transportation Research Record 1392, TRB, National Research Council, Washington D.C., 1993.

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APPENDIX A

EQUIPMENT CATALOG INFORMATION FROM DURACO INDUSTRIES, INC.

APPENDIX B

EQUIPMENT CATALOG INFORMATION FROM ROSCO MANUFACTURING COMPANY, INC.

APPENDIX C

EQUIPMENT CATALOG INFORMATION FROM WILDCAT MANUFACTURING COMPANY, INC.

APPENDIX D

EQUIPMENT CATALOG INFORMATION FROM ZIMMERMAN EQUIPMENT CORPORATION