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EVALUATION OF RESURF CR

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16. Abstract

This report examines the use of RESURF CR and RESURF II, which are manufactured by POLYMER CONCRETE INC., for the repair of punchouts in continuously reinforced concrete pavement (CRCP). These products were used to repair 43 punchouts on I-55 north of McComb in Pike and Lincoln Counties. These polymer concrete products were used to cement the broken concrete pavement pieces together and restore an acceptable riding surface. One punchout had the reinforcing steel cut before the application of RESURF CR. The usual temporary method of repair is to use asphalt mix to fill the punchout. Traditional permanent repairs involve removal of the failed concrete, re-establishment of the reinforcing steel, and placement of new concrete.

RESURF CR is a variable viscosity, low shrink, pourable polyester compound designed for cracks up to 1/2 inches (12.7 mm). The viscosity can be tailored on the jobsite to the crack widths encountered. The compound reaches a compressive strength of 2,000 psi (13.790 MPa) in two hours, so the completed patch can be opened to traffic shortly after the repair is complete.

RESURF II is a general performance polymer concrete consisting of a styrene diluted modified polyester resin with a select aggregate blend, which is used to restore a smooth riding surface to the patch area once the RESURF CR has been applied. This product has been previously approved as a concrete patching material in Mississippi.

RESURF CR/RESURF II did not prove to be a long-term (greater than one year) solution for punchout repairs and required more effort and time than making a temporary repair by filling the punchout with asphalt.

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CHAPTER 1: INTRODUCTION

Overview

About 7.1 percent of the state maintained highway system in Mississippi, or 834 two-lane miles (1 342 two-lane km), is continuously reinforced concrete pavement (CRCP). Most of this has reached the end of its design life. Many of the punchout repairs done in the last 10-15 years have either failed or developed a punchout on one or both ends within a few months after the repair. The suspected primary causes of the patch failures are:

- Damage caused to the concrete abutting the patch when the concrete and steel were removed in the failed area, and failure to cut back into sound concrete on the boundaries of the repaired area.
- Damage caused by the fracturing of the edge of the concrete bordering the punchout during the removal of the failed concrete. When the concrete below the level of the reinforcing steel in this area is removed by jackhammer to form vertical faces on the concrete to remain in place, the concrete will often break diagonally back under the slab bordering the punchout area. This leaves a zone of weakness that will fail quickly under traffic.

RESURF CR was developed by Polymer Concrete, Inc., in response to a request by the Mississippi Department of Transportation (MDOT) for a material that would re-cement the broken pieces of concrete in a punchout together into a structural unit. This polymer concrete material was used in August 1989, to repair a punchout on I-20 near Brandon, Mississippi. RESURF II was then used as a variable thickness leveling material to restore the riding surface. After 18 months of excellent performance in this application, a decision was made to conduct a more extensive evaluation of these products before the products were adopted for widespread use. An agreement was reached with the manufacturer to repair additional punchouts, and this work was done in the spring of 1991.

Background

"A polymer is a naturally-occurring or synthetic substance consisting of giant molecules formed from smaller molecules of the same substance and often having a definite arrangement of the components of the giant molecules."[1]

Monomers are thin to thick liquids, while polymers are hard, tough solids. The resin can be as little as 10 percent or 11 percent by weight of the polymer concrete. "Polymer concretes that work best are the high-elongation, high-ductility, low-modulus polyesters and a couple of epoxies."[2] A low-modulus and high elongation material, used for bridge overlays, will stretch up to 25 or 50 percent of its length before breaking.[2] Polymer concretes also have a higher coefficient of expansion than Portland cement concrete (PCC), so a repair will tend to come off if it is too brittle.[2]

Polymers have been used to improve the properties of concrete for about 40 years. Polymer concrete uses a polymer binder instead of Portland cement as the glue. "Some of the advantages of polymer concrete over ordinary PCC are:

- Rapid curing
- High strength.
- Good adhesion to other materials.
- Good durability.
- Good resistance to chemicals."[1]

Objectives

Essentially, the RESURF CR is designed to cement the broken pieces of a punchout together in-place. RESURF II, a previously approved concrete patching material, is then used as a feather edged leveling course to restore a smooth riding surface. This study monitored the performance of 43 punchout repairs and provides recommendations concerning adoption of this method for routine punchout repair.

Scope

The field trial of RESURF CR and RESURF II was located on I-55 between mileposts 22 and 30 north of McComb (figure 1). The 43 punchouts were all located in the outside lane and were divided about evenly between north and southbound lanes. Punchout locations, sizes, and descriptions are given in Appendix A. Several of the punchouts had been patched temporarily with asphaltic material by MDOT maintenance forces before this repair work.

CHAPTER 2: DESIGN AND CONSTRUCTION

Description of Materials

RESURF CR is a variable viscosity, low shrink, pourable polyester compound designed for cracks up to ½ in. (12.7 mm). Table 1 lists the percentages of aggregate passing through seven screen sizes.

Table 1. Percent RESURF CR aggregate passing through screen size.

SCREEN SIZE	PERCENT PASSING
4	100
8	73
10	53
12	28
14	15
16	7
20	0.5

The viscosity can be tailored on the jobsite to the crack widths encountered. The compound reaches a compressive strength of 2,000 psi (13.79 MPa) in two hours, so repaired areas can be opened to traffic shortly after the repair is complete.

RESURF II is a general performance polymer concrete consisting of a styrene diluted modified polyester resin with a select aggregate blend. It is used, in this application, to restore a smooth riding surface to the patch area once the RESURF CR has been applied. The final compressive strength of RESURF II is 12,000 to 16,000 psi (82.74 to 110.32 MPa).

RESURF resin is used as a primer and thin crack bonder. RESURF CR and RESURF II are used as polymer concrete mortar and broadcast overlays. Methyl ethyl ketone peroxide (MEKP) is the catalyst. The RESURF resin is formulated by the manufacturer with different levels of promoter and accelerator to facilitate different set times for the various types of applications and environmental conditions that are encountered. The promoter is cobalt naphthenate and the accelerator is dimethyl aniline (DMA). Amounts of promoter and accelerator in the resin are expressed in units of milliliters of each per 55 gallons (208.2 L) drum of resin, in a ratio, with the promoter shown first. For example,

800/400 resin has 27.0 ounces (800 mL) of promoter and 13.5 ounces (400 mL) of accelerator per drum.

Safety

The RESURF resin is flammable and requires extra safety. Smoking is prohibited in areas where resin or catalyst is stored or used. Materials need to be stored in a cool shady area. Workers should wear splash-proof goggles, rubber gloves, boots, and aprons or overalls.

“Unlike ordinary concrete, the use of polymers in construction requires more than the usual amount of care. Some of the materials can be volatile, combustible, or toxic, primarily in the handling state. They can be sensitive to light, moisture, and the atmosphere, all of thick can affect the quality of the end product. Also, unpleasant odor can be a serious problem.

Extra care must be taken to that premature polymerization does not take place. Some components of a polymer system can be extremely volatile and storage must be tended with care. Occasionally initiators can be very toxic or flammable. ACI’s manual says: ”inhaling the vapors and skin contact should be avoided” and “epoxy compounds can cause skin irritation…””[1]

"When using polymers, the work area should be well ventilated. It would be wise for anyone in charge of a polymer concrete project to closely monitor personnel in the area. Only those who are directly involved should be permitted around the stuff. Just as the polymers should be separated from promoters or catalysts, so should the people working with (and knowledgeable in) polymers be kept apart from their less chemically knowledgeable brethren.”[1]

Construction

Polymer Concrete Incorporated (PCI) was the contractor. The work force consisted of a project superintendent and from one to three laborers.

Specialized equipment used on the project included a sandblaster, a 100 $ft.^3$/minute (2.83 m^3/minute) air compressor, and a jackhammer. Other tools and equipment used included shovels, hoes, wheelbarrow, trowels, and 1 and 5 gallon (3.8 and 18.9 L) scribed pails for resin measurement, plastic beakers for catalyst measurement, paint brushes for priming, and solvent for equipment cleanup. Various lengths of dimension lumber 2 in. x 4 in. (50.8 x 101.6 mm) were used for tamps and screeds.

All 43 punchouts were repaired with RESURF CR and RESURF II, except punchout #7 which was repaired with RESURF IIX, which is RESURF II that has been extended with the addition of size #7 aggregate.

Construction began on February 25, 1991, as the contractor began repair of designated failures in the northbound lanes. The construction was completed on March 14, 1991 or approximately 11 workdays for the 43 repairs. Jackhammering (figure 2) and compressed air cleaning (figure 3) removed all asphaltic patching material. It was essential that all asphaltic materials were removed, since the resin dissolves asphalt. Loose material, dirt, and debris were removed down to the base course. Cracks were sometimes widened at the top with the jackhammer to facilitate the installation of the RESURF CR. Sandblasting was done after thorough cleaning of all asphalt, dirt, and debris (figure 4). Sandblasting was necessary to insure complete removal of surface films and give the concrete a roughened surface to insure a good bond between polymer concrete and the existing concrete pavement. Those areas that exhibited visible dampness were dried with a propane torch (figure 5).

The next step in the repair was to mix the resin with the catalyst (figure 6) and to prime the failed area with catalyzed RESURF resin. The application was customarily done with a paintbrush (figure 7). Resin was also painted/poured into the small cracks as long as the crack would take resin. If a crack was not filling with continued resin application, a very runny RESURF CR mixture was used. More effort was spent on the longitudinal cracks than the transverse cracks. The emphasis was placed in getting maximum penetration of catalyzed RESURF resin and soupy RESURF CR in both types of cracks.

RESURF CR was then mixed (figure 8) to a pourable but grainy texture, by mixing about six double handfuls of RESURF CR aggregate with ½ gallon (1.9 L) of RESURF resin. It was critical, but not particularly difficult, to mix the RESURF CR and then pour it quickly into the spaces between the broken pieces of concrete (figure 9). The high levels of fast

acting shrink control additive/flexibilizer took only minutes to stiffen the mix. All these spaces were filled with RESURF CR until the width of the space exceeded ½ in. (12.7 mm). Thick or stiff RESURF CR was made to flow into narrow spaces by painting the mixture with catalyzed resin, thus effectively lowering the viscosity.

RESURF II was then used to finish the repair. One bag of RESURF II aggregate blend, 60.5 pounds net (27.44 kg) was mixed with one gallon (3.8 L) of catalyzed resin (figure 10) to yield 0.5 $ft.^3$ (0.014 m^3) of polymer concrete. Two to three ounces (59.2 to 88.7 mL) of catalyst (MEKP) was mixed with one gallon (3.8 L) of resin and it was important to have the catalyst well mixed with the resin before adding to the aggregate. Mixing was done in a wheelbarrow using a pick for stirring (figure 11). After the RESURF II was placed in the failed area (figure 12), it was tamped and screeded with a wooden board 2 in. x 4 in. (50.8 x 101.6 mm) (figure 13). Screeding was always done in the longitudinal direction.

For many short patches, no additional effort was necessary after screeding. Some patches were broadcast immediately after screeding with RESURF II aggregate blend to fill shallow pores and provide a skid resistant surface. Other areas needed another leveling course to give a good riding surface. This was often accomplished by one or more applications of RESURF II using the broadcast method. This involves brushing catalyzed resin onto the patch area (figure 14) and then broadcasting (by hand) RESURF II aggregate blend into the resin (figures 15). This method adds approximately ¼ in. (6.4-mm) thickness per application. Another method that was used involved applying a skin patch of a wet mixture of RESURF II and feather edging the patch boundaries. Set time for the completed patch was approximately two hours.

Areas that had large numbers of narrow cracks, or narrow cracks with surface spalling, that had not yet reached the full punchout stage were often filled with “wet” RESURF II (up to 25 percent more resin that normal). Sometimes the RESURF II was made to flow into the smaller cracks by brushing with resin and/or tamping with the brush.

Different ratios of promoter/accelerator in the resin were used for different applications, such as 800/400 for general use in RESURF CR and in the broadcast overlay, and 600/200 for general use in RESURF II.

If there was any rain after the broken concrete was removed, the hole was dried and kept dry until the repair was finished or a temporary repair was made using RESURF II

only. When weather permitted the RESURF II temporary patch was removed with the jackhammer and a proper repair was made.

There were occasions where a punchout repair was done adjacent to a punchout previously repaired. Eight of the polymer concrete patches were adjacent to a concrete patch. Two were adjacent to an asphalt patch. When repairing next to one of these areas, the vertical edge of the previously repaired punchout was not sandblasted. This created a weak bond between the repaired area and the other area that was not repaired. This procedure allowed the area that was not repaired to move independently of the repaired area so the crack that forms between the two areas would not weaken the repaired area. On punchout #18, the reinforcing steel was cut before the application of RESURF CR, to see if the continuity of reinforcement is a critical parameter in the success of this method. A piece of cardboard was then used for a bond breaker. A construction joint at the edge of the punchout was then installed. Several of these punchouts were slightly above grade.

Traffic control and surface preparation required well over 90 percent of the time. In one closure, 15 areas were repaired and traffic control moved only once in a two-day period. In other areas, traffic control had to be moved much more often and often only one patch could be worked on at a time (with one compressor and only 200' (61 m) of hose).

Economics

RESURF II aggregate blend costs about \$58/ft.^{3} (\$2,049.47/m^3) and the resin costs \$17.50/gallon (\$4.62/L), F.O.B. Jackson, MS, when purchased in bulk orders by the MDOT. The contractor was paid \$20,000 to do the 43 patches, which totaled 481.25 ft.^{2} or 53.47 SY (44.71 m^2). The total cost per patch for PCI to do the repair was \$465.12/patch or \$374.03/SY (\$447.35/m^2). This cost covered all items of work, including traffic control.

The cost of a "traditional" punchout repair averages, from 0.1 to 9.0 SY (0.08 to 7.52 m^2), about \$157.78/SY (\$188.71/m^2). This includes removal of the damaged concrete, repair and/or replacement of reinforcement, new concrete, and traffic control . A copy of the MDOT specification for this "traditional" punchout repair is included as Appendix C.

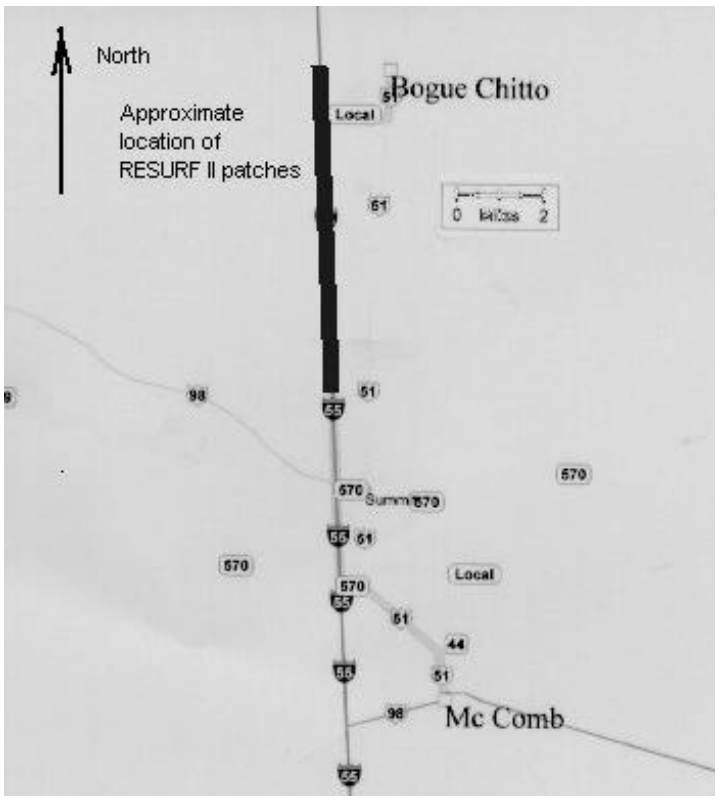


Figure 1. Project location

Figure 2. Jackhammering holes.

Figure 3. Cleaning out with air.

Figure 4. Sandblasting holes.

Figure 5. Drying with a burner.

Figure 6. Mixing resin with catalyst.

Figure 7. Painting resin on the patch.

Figure 8. Mixing RESURF CR with resin.

Figure 9. Filling the cracks with RESURF CR.

Figure 10. Combining RESURF II mix with the resin.

Figure 11. Mixing RESURF II.

Figure 12. Filling the clean hole.

Figure 13. Screeding.

Figure 14. Painting the patch with resin.

Figure 15. Broadcasting RESURF II aggregate.

Figure 16. Dynaflect testing.

CHAPTER 3: TEST RESULTS AND DISCUSSION

Data collection consisted primarily of two sets of Dynaflect deflection tests, listed in Table 2, visual observations, and photographic documentation for more than a three-year period.

Dynaflect Testing

The Dynaflect measures pavement deflection induced by an applied load (figure 16). It is an electro-mechanical system consisting of a dynamic force generator and a motion measuring system, which is mounted on a towed trailer. The generator produces a vertical force, which varies at the rate of eight cycles/second.[3] This is applied to the pavement through a pair of rigid steel wheels, which are 20 in. (0.51 m) apart. The total force applied to the pavement consists of the static load of the instrument trailer, which is 1,600 pounds (7.1 kN), plus the dynamic force which is consecutively added to and subtracted from this load. The peak to peak excursion of the dynamic force is 1,000 pounds (4.4 kN).

The geophones measured the concrete pavement and RESURF CR/RESURF II repair deflections from the repetitive force. The five motion sensing geophones are suspended from the towing arm of the trailer. The first geophone is between the steel wheels and the other four geophones are at 12 in. (0.30-m) intervals in front of the first geophone.

Deflection measurements from only the first geophone were used in this study, because most of the RESURF CR/RESURF II repairs were not large enough for all five geophones to be placed on the repair. The deflection measurements, from the first geophone, are the maximum deflection measurement and are indicative of probable pavement performance. The amplitudes of the vertical motion were recorded on a portable computer.

For the first set of deflections, the force wheels were positioned about 4 in. (101.6 mm) upstream of the patch, so the deflection of the surrounding pavement could be measured. The second set of deflections was taken with the force wheels on the patch, about 8 in. (203.2 mm) from the location of the first set of deflections, on the RESURF CR/RESURF II repair.

Table 2. Dynaflect Measurements.

	CONCRETE PAVEMENT Dynaflect MAXIMUM DEFLECTION (Mils)	RESURFII/RESURF CR PATCH Dynaflect MAXIMUM DEFLECTION (Mils)	CONDITION	CONCRETE PAVEMENT Dynaflect MAXIMUM DEFLECTION (Mils)	POLYMER CONCRETE PATCH Dynaflect MAXIMUM DEFLECTION (Mils)
PATCH #	#1 11 Apr 91	#1 11 Apr 91	#2 15 Jul 92	#2 15 Jul 92	#2 15 Jul 92
1	52.0	55.0	GOOD	52.0	65.0
2	44.0	55.0	GOOD	59.0	79.0
3	34.0	40.0	GOOD	89.0	94.0
4	45.0	65.0	GOOD	111.0	155.0
5	79.0	154.0	asphalt filled	74.0	57.0
6	47.0	95.0	asphalt filled	139.0	134.0
7	86.0	65.0	GOOD	84.0	58.0
7a	63.0	93.0	asphalt filled	47.0	172.0
8	35.0	57.0	GOOD	42.0	35.0
9	39.0	67.0	asphalt filled	49.0	75.0
10	55.0	70.0	GOOD	84.0	182.0
11	62.0	72.0	asphalt filled	54.0	167.0
12	37.0	41.0	GOOD	39.0	32.0
13	43.0	64.0	GOOD	36.0	68.0
14	38.0	52.0	GOOD	79.0	188.0
15	52.0	62.0	asphalt filled	39.0	55.0
16	52.0	54.0	GOOD	44.0	44.0
17	59.0	61.0	GOOD	48.0	59.0
18	46.0	60.0	asphalt filled	106.0	117.0
19	36.0	49.0	GOOD	63.0	118.0
20	53.0	61.0	GOOD	73.0	88.0
21	65.0	63.0	GOOD	70.0	88.0
22	56.0	59.0	GOOD	45.0	54.0
23	47.0	50.0	GOOD	46.0	60.0
24	44.0	56.0	GOOD	39.0	47.0
25	87.0	93.0	asphalt filled	43.0	120.0
26	75.0	96.0	GOOD	193.0	156.0
27	95.0	117.0	asphalt filled	119.0	258.0
28	51.0	77.0	GOOD	56.0	94.0
29	40.0	50.0	GOOD	42.0	64.0
30	46.0	51.0	GOOD	47.0	45.0
31	62.0	69.0	GOOD	73.0	82.0
32	60.0	66.0	GOOD	73.0	77.0
33	57.0	67.0	GOOD	77.0	76.0
34	65.0	92.0	asphalt filled	65.0	129.0
35	49.0	74.0	GOOD	41.0	76.0
36	64.0	63.0	GOOD	49.0	74.0
37	63.0	76.0	GOOD	63.0	83.0
38	55.0	54.0	GOOD	80.0	83.0
39	44.0	59.0	GOOD	58.0	73.0
40	102.0	116.0	concrete	0.0	0.0
41	40.0	62.0	GOOD	52.0	66.0
42	78.0	127.0	concrete	0.0	0.0
AVERAGE	55.9	70.4		63.8	89.5

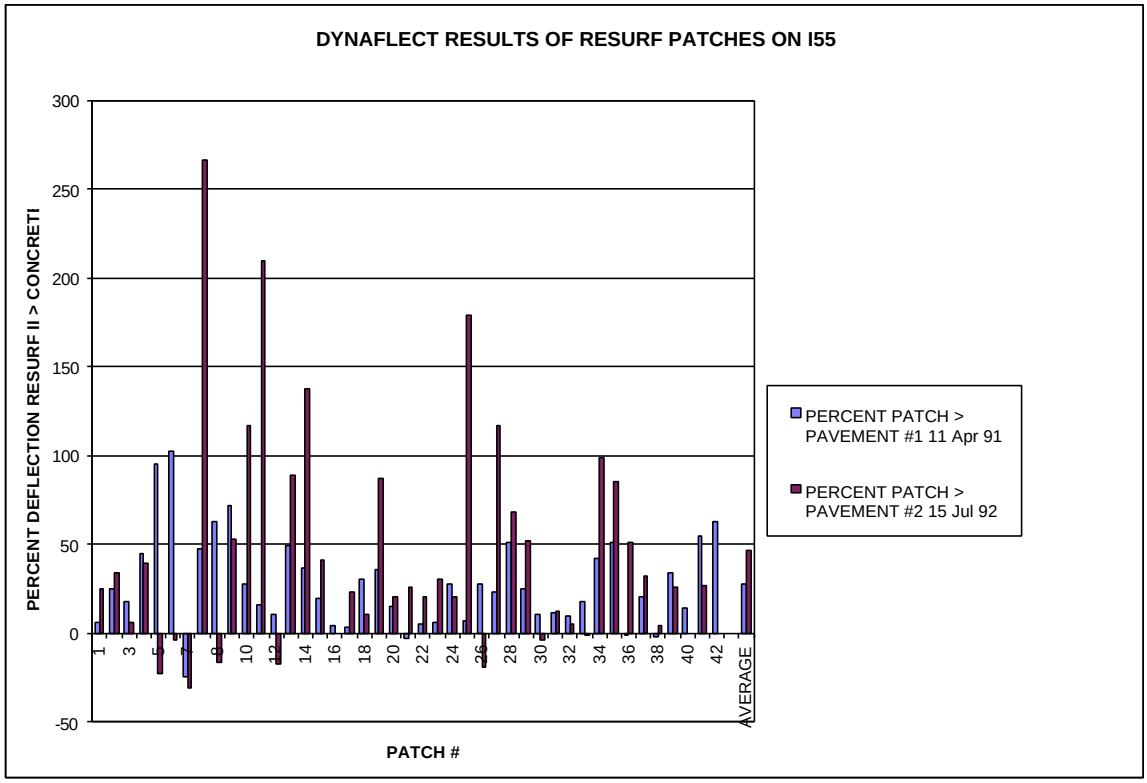
Table 3 lists:

- the percentage amounts that the deflections on the patches are greater than the concrete for the two test data sets, which is plotted in Figure 17,
- the amount the deflection on the concrete is greater on the second test data set than the first,
- and the amount the deflection on the RESURF II/RESURF CR is greater on the second test data set than the first.

Table 3. Dynaflect calculations.

PATCH #	PERCENT RESURFII/RESURF CR PATCH > CONCRETE PAVEMENT #1 11 Apr 91	PERCENT RESURFII/RESURF CR PATCH > CONCRETE PAVEMENT #2 15 Jul 92	PERCENT CONCRETE PAVEMENT 15 Jul 92 > 11 Apr 91	PERCENT RESURFII/RESURF CR 15 Jul 92 > 11 Apr 91
1	5.77%	25.00%	0.00%	18.18%
2	25.00%	33.90%	34.09%	43.64%
3	17.65%	5.62%	161.76%	135.00%
4	44.44%	39.64%	146.67%	138.46%
5	94.94%	-22.97%	-6.33%	-62.99%
6	102.13%	-3.60%	195.74%	41.05%
7	-24.42%	-30.95%	-2.33%	-10.77%
7a	47.62%	265.96%	-25.40%	84.95%
8	62.86%	-16.67%	20.00%	-38.60%
9	71.79%	53.06%	25.64%	11.94%
10	27.27%	116.67%	52.73%	160.00%
11	16.13%	209.26%	-12.90%	131.94%
12	10.81%	-17.95%	5.41%	-21.95%
13	48.84%	88.89%	-16.28%	6.25%
14	36.84%	137.97%	107.89%	261.54%
15	19.23%	41.03%	-25.00%	-11.29%
16	3.85%	0.00%	-15.38%	-18.52%
17	3.39%	22.92%	-18.64%	-3.28%
18	30.43%	10.38%	130.43%	95.00%
19	36.11%	87.30%	75.00%	140.82%
20	15.09%	20.55%	37.74%	44.26%
21	-3.08%	25.71%	7.69%	39.68%
22	5.36%	20.00%	-19.64%	-8.47%
23	6.38%	30.43%	-2.13%	20.00%
24	27.27%	20.51%	-11.36%	-16.07%
25	6.90%	179.07%	-50.57%	29.03%
26	28.00%	-19.17%	157.33%	62.50%
27	23.16%	116.81%	25.26%	120.51%
28	50.98%	67.86%	9.80%	22.08%
29	25.00%	52.38%	5.00%	28.00%
30	10.87%	-4.26%	2.17%	-11.76%
31	11.29%	12.33%	17.74%	18.84%
32	10.00%	5.48%	21.67%	16.67%
33	17.54%	-1.30%	35.09%	13.43%
34	41.54%	98.46%	0.00%	40.22%
35	51.02%	85.37%	-16.33%	2.70%
36	-1.56%	51.02%	-23.44%	17.46%
37	20.63%	31.75%	0.00%	9.21%
38	-1.82%	3.75%	45.45%	53.70%
39	34.09%	25.86%	31.82%	23.73%
40	13.73%			
41	55.00%	26.92%	30.00%	6.45%
42	62.82%			
AVERAGE	27.70%	46.22%	27.72%	39.84%

Figure 17. Dynaflect results.



Inspections

All of the RESURF CR/RESURF II patches were examined for failures from May 1991 to November 1994. The inspection results are listed in the Table 4 and Table 5. Table 6 lists the percentages of patches rated "GOOD" and this data is plotted figure 18.

Table 4. Northbound patch inspections.

	6-May-91	10-Jun-91	24-Jul-91	7-Jan-92	5-Mar-92	15-Jul-92	21-Jan-93	19-Apr-93	6-Aug-93	10-Nov-93	14-Feb-94	19-May-94	4-Aug-94	7-Nov-94	16-Feb-95
1	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete
2	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete
3	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	South side has a broken edge.	South side has a broken edge, which is now filled with asphalt.	concrete	concrete	concrete	concrete	concrete	concrete	concrete
4	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	¼th asphalt	asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete
5	GOOD	GOOD	GOOD	The failed area on patch #5 was about 304 x 609 x 76 mm.	asphalt	asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete
6	GOOD	GOOD	GOOD	GOOD	GOOD	asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete
7	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete
7A	GOOD	GOOD	GOOD	GOOD	GOOD	asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete
8	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete
9	GOOD	GOOD	GOOD	GOOD	broken up	asphalt	asphalt	asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete
10	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	Cracked and ¼th asphalt	asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete
11	GOOD	GOOD	GOOD	GOOD	GOOD	asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete
12	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	Good and about 1/3 of north part of the patch had broken.	Good and some asphalt had been added.	Good and more asphalt had been added.	About 1/3 asphalt and has a crack across the middle of the remaining patch.	About 1/3 asphalt and has a crack across the middle of the remaining patch and was later replaced with concrete.	concrete
13	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete
14	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	broken edge	Has a broken edge and now had asphalt in the southeast corner.	concrete	concrete	concrete	concrete	concrete	concrete	concrete
15	GOOD	GOOD	GOOD	GOOD	GOOD	asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete
16	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete
17	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete
18	GOOD	GOOD	GOOD	GOOD	GOOD	asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete
19	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete
PERCENT RATED GOOD	100%	100%	100%	95%	90%	65%	35%	35%	5%	5%	5%	5%	0%	0%	0%

Table 5. Southbound patch inspections.

	6-May-91	10-Jun-91	24-Jul-91	7-Jan-92	5-Mar-92	15-Jul-92	21-Jan-93	19-Apr-93	6-Aug-93	10-Nov-93	14-Feb-94	19-May-94	4-Aug-94	7-Nov-94	16-Feb-95
20	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete
21	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	South side is broken.	Good with the south side now asphalt.	concrete	concrete	concrete	concrete	concrete	concrete	concrete
22	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	2/3 asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete
23	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete
24	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	Asphalt is in the center.	Asphalt in the center.	concrete	concrete	concrete	concrete	concrete	concrete	concrete
25	GOOD	GOOD	GOOD	GOOD	broken up	asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete
26	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete
27	GOOD	GOOD	GOOD	GOOD	broken up	asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete
28	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	½ asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete
29	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete
30	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete
31	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete
32	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete
33	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	asphalt	asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete
34	GOOD	GOOD	GOOD	GOOD	GOOD	asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete
35	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	south side broken	concrete	concrete	concrete	concrete	concrete	concrete	concrete
36	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete
37	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete
38	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete
39	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	Cracked edges filled with asphalt.	Cracked edges filled with asphalt.	concrete	concrete	concrete	concrete	concrete	concrete	concrete
40	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete
41	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	broken	north side asphalt	concrete	concrete	concrete	concrete	concrete	concrete	concrete
42	GOOD	GOOD	GOOD	GOOD	GOOD	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete
PERCENT RATED GOOD	100%	100%	100%	100%	91%	78%	57%	39%	0%	0%	0%	0%	0%	0%	0%

Table 6. Percentage of RESURFCR/RESURF II patches rated GOOD.

	6-May-91	10-Jun-91	24-Jul-91	7-Jan-92	5-Mar-92	15-Jul-92	21-Jan-93	19-Apr-93	6-Aug-93	10-Nov-93	14-Feb-94	19-May-94	4-Aug-94	7-Nov-94	16-Feb-95
southbound patches	100%	100%	100%	95%	90%	65%	35%	35%	5%	5%	5%	5%	0%	0%	0%
northbound patches	100%	100%	100%	100%	91%	78%	57%	39%	0%	0%	0%	0%	0%	0%	0%
ALL	100%	100%	100%	98%	91%	72%	46%	37%	3%	3%	3%	3%	0%	0%	0%

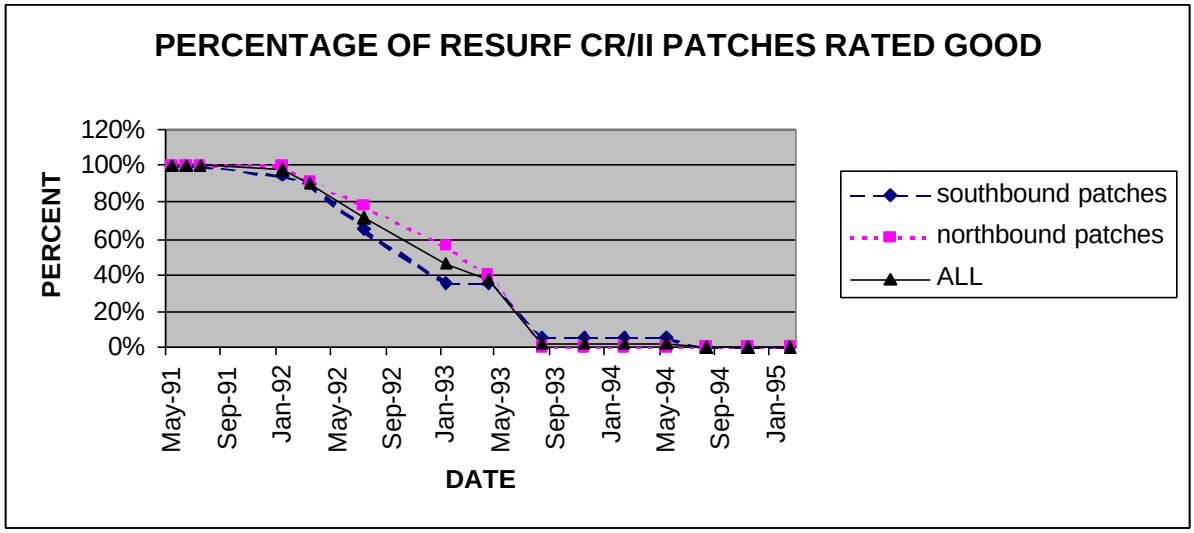


Figure 18. Percentage of RESURF CR/RESURF II patches rated GOOD.

DISCUSSION OF RESULTS

Tables 7 and 8 list the location, size, and initial description of the 43 repairs.

Table 7. Initial notes on northbound repairs.

REPAIR NUMBER	MILE MARKER	AREA ft^2 (m^2)	DESCRIPTION
#1	24.058	9 (0.84)	3' x 3' (0.91 x 0.91 m) with asphalt patch approximately 18 in. (0.46 m) from right pavement edge. North of a concrete patch.
#2	24.070	6.5 (0.60)	5' (1.52-m) longitudinal crack approximately 4' (1.22 m) from right pavement edge also 1' x 1.5' (0.30 x 0.46-m) asphalt patch approximately 1' (0.30 m) from right pavement edge.
#3	24.196	6 (0.56)	1.5' x 4' (0.46 x 1.22 m) with asphalt patch starting at right pavement edge. #3 was repaired with a temporary patch, because of poor weather and poor cleaning, using only RESURF II and was redone the next day.
#4	24.204	4 (0.37)	1' x 4' (0.30 x 1.22 m) with asphalt patch starting at right pavement edge. #4 was repaired with a temporary patch, because of poor weather and poor cleaning, using only RESURF II and was redone the next day.
#5	25.485	6 (0.56)	1.5' x 4' (0.46 x 1.22 m) with ½ asphalt patch starting at right pavement edge.
#6	25.518	16 (1.49)	4' x 4' (1.22 x 1.22 m) with ½ asphalt patch starting at right pavement edge. Holes 1 to 6 used 25 bags of RESURF II and 18 gal. (68.1 L) or RESURF CR mix.
#7	25.680	24 (2.23)	4' x 6' (1.22 x 1.83 m) with ¾ asphalt patch starting at right pavement edge. South of an asphalt patch. Holes this large should be fixed with polymer concrete only in emergencies or if you have to fix it. After jackhammered clean, it was noted that the reinforcement was missing. Several #6 reinforcing bars were obtained from the McComb project office. The north side of the hole had bad concrete that was crumbly. Patch #7 was the first hole that RESURF IIX was used, which contained #7 aggregate. 20 buckets of RESURF IIX, 10 $ft.^3$ (0.28 m^3), of RESURF IIX were first used. The reinforcing steel was cut and placed on top of it. Then 12 more buckets, 6 $ft.^3$ (0.17 m^3), of RESURF IIX were added. RESURF CR was placed in the part that still had concrete and then RESURF II was added over the entire patch. It was then painted with resin and broadcast.

Table 7. Initial notes on northbound repairs (continued).

REPAIR NUMBER	MILE MARKER	AREA ft^2 (m^2)	DESCRIPTION
#7A	25.763	40 (3.72)	4' x 10' (1.22 x 3.05 m) with ¾ asphalt patch.
#8	27.054	24 (2.23)	4' x 6' (1.22 x 1.83 m) with ½ asphalt patch starting at centerline and continues right of centerline.
#9	27.061	8 (0.74)	8' (2.44-m) longitudinal crack approximately 4' (1.22 m) off right pavement edge.
#10	27.512	12 (1.11)	3' x 4' (0.91 x 1.22 m) with asphalt patch starting at right pavement edge.
#11	28.545	6 (0.56)	1.5' x 4' (0.46 x 1.22 m) starting 0.5' (0.15 m) from right pavement edge.
#12	28.706	8 (0.74)	2' x 4' (0.61 x 1.22 m) with ¼ asphalt patch approximately starting at right pavement edge.
#13	28.711	4 (0.37)	1' x 4' (0.30 x 1.22 m) with asphalt patch starting at right pavement edge.
#14	28.720	4 (0.37)	1' x 4' (0.30 x 1.22 m) with asphalt patch starting at right pavement edge.
#15	28.732	24 (2.23)	2' x 12' (0.61 x 3.66 m) with ¾ asphalt patch starting at right pavement edge. The north end of patch #15 was not sandblasted or primed. The north west side was saw cut. South of a concrete patch.
#16	28.745	4 (0.37)	1' x 4' (0.30 x 1.22 m) with asphalt patch starting at right pavement edge.
#17	28.752	12 (1.11)	3' x 4' (0.91 x 1.22 m) with asphalt patch starting at right pavement edge.
#18	28.770	18 (1.67)	3' x 6' (0.91 x 1.83 m) with asphalt patch starting at right pavement edge. The steel was cut on #18 and divided into two sections. South of a concrete patch.
19	28.777	12 (1.11)	3' x 4' (0.91 x 1.22 m) with asphalt patch starting at right pavement edge. North of a concrete patch.

Table 8. Initial notes on southbound repairs.

REPAIR NUMBER	MILE MARKER	AREA ft^2 (m^2)	DESCRIPTION
#20	29.222	5 (0.46)	1' x 5' (0.30 x 1.52 m) with asphalt patch starting at right pavement edge.
#21	29.215	16 (1.49)	4' x 4' (1.22 x 1.22 m) with ¾ asphalt patch starting 0.5' (0.15 m) from right pavement edge.
#22	29.194	5 (0.46)	1' x 5' (0.30 x 1.52 m) with asphalt patch starting 0.5' (0.15 m) from right pavement edge.
#23	29.186	12 (1.11)	Transverse cracking from right pavement edge to centerline.
#24	29.178	2 (0.19)	1' x 2' (0.30 x 0.61 m) with asphalt patch starting 1.5' (0.46 m) from pavement edge.
#25	29.171	6 (0.56)	1' x 6' (0.30 x 1.83 m) with ¼ asphalt patch starting at right pavement edge. Patch #25 had the worst concrete. RESURF CR was diluted with catalyzed resin and poured into the north and south side cracks.
#26	29.169	0.75 (0.07)	0.5' x 1.5' (0.15 x 0.46 m) with ½ asphalt patch starting 1.5' (0.46 m) from right pavement edge.
#27	29.163	6 (0.56)	1' x 6' (0.30 x 1.83 m) with ½ asphalt patch starting at right pavement edge.
#28	29.127	5 (0.46)	1' x 5' (0.30 x 1.52 m) with asphalt patch starting at right pavement edge.
#29	29.122	6 (0.56)	1' x 6' (0.30 x 1.83 m) with asphalt patch starting at right pavement edge.
#30	29.068	12 (1.11)	2' x 6' (0.61 x 1.83 m) with asphalt patch, starting at right pavement edge. Patch #30 was hollow underneath and it took 1 gal. (3.8 L) of mix. It was doubted that the void was filled.
#31	29.050	5 (0.46)	1' x 5' (0.30 x 1.52 m) with asphalt patch, starting at right pavement edge.
#32	29.049	12 (1.11)	2' x 6' (0.61 x 1.83 m) with ½ asphalt patch, starting at right pavement edge. The south side face up against a concrete patch was not cleaned.
#33	29.045	2 (0.19)	1' x 2' (0.30 x 0.61 m) starting at centerline and continues to right centerline. The south side face up against a concrete patch was not cleaned.
#34	29.012	12 (1.11)	Transverse cracking from right pavement edge to centerline.

Table 8. Initial notes on southbound repairs (continued).

REPAIR NUMBER	MILE MARKER	AREA ft^2 (m^2)	DESCRIPTION
#35	26.479	32 (2.97)	4' x 8' (1.22 x 2.44 m) with ½ asphalt patch, starting at right pavement edge.
#36	26.470	12 (1.11)	2' x 6' (0.61 x 1.83 m) with asphalt patch, starting at right pavement edge. South of a concrete patch.
#37	26.456	10 (0.93)	2' x 5' (0.61 x 1.52 m) with ½ asphalt patch, starting at right pavement edge. North of a concrete patch.
#38	22.576	3 (0.28)	1' x 3' (0.30 x 0.91 m) with asphalt patch, starting at right pavement edge. Patch #38 was cleaned out and it started raining. A temporary patch or RESURF II was installed. This was removed the next day and the permanent patch was put in.
#39	22.569	6 (0.56)	Transverse cracking from right pavement edge to midlane.
#40	22.551	50 (4.65)	50' (15.24-m) longitudinal crack at midlane. On hole #40 RESURF CR was spread with a paintbrush and mixed with the resin.
#41	22.530	4 (0.37)	2' x 2' (0.61 x 0.61 m) with asphalt patch, starting 1' (0.30 m) from right pavement edge.
#42	22.473	10 (0.93)	10' (3.05-m) longitudinal crack at midlane. North of an asphalt patch.

Total area: 481.25 $ft.^2$ or 53.47 SY (44.71 m^2)

On Apr 11, 1991, two sets of Dynaflect readings were taken on all 43 patches. The patches averaged 27.70 percent more deflection than the adjacent concrete. Only eight of the patches had deflections more than 50 percent greater than the adjacent concrete. These results indicate an acceptable level of load carrying ability for the patched areas.

On July 15, 1992, Dynaflect readings were taken on the 41 remaining patches. Ten of the patches were partially filled with asphalt, but the Dynaflect measurements were taken on the RESURFCR/RESURF II. Two of the RESURFCR/RESURF II patches had been replaced with concrete. The patches averaged 46.22 percent more deflection than the adjacent concrete. Thirteen of the patches had deflections more than 50 percent greater than the adjacent concrete.

The average deflection, on July 15, 1992 on the concrete was 27.72 percent greater than the deflections taken on April 11, 1991. This may have been caused by differences in calibration and temperature. The average deflection on the patches was 39.84 percent greater than the deflections taken on April 11, 1991

Patch #7 had the largest negative percentage Dynaflect reading decrease. On April 11, 1991, patch #7 had 24.42 percent less deflection than the adjacent pavement and on July 15, 1992, it had 30.95 percent less deflection. This patch used RESURF IIX, which is RESURF II that has been extended with the addition of size #7 aggregate, due to the large quantity of polymer concrete needed for this repair. (RESURF IIX is not currently being sold by PCI because freight costs for the aggregates make it uneconomical to use. Extending RESURF II with quality local aggregate is an option sometimes used when larger quantities of concrete mix are needed).

CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS

Final Conclusions

The small 100-cfs (2.83-m^3/minute) air compressor and small sandblaster used by PCI were excellent for mobility and small projects, but they significantly increased the repair time for each punchout. Sandblasting time could be cut by 80 percent (or more) if a larger compressor and sandblaster were employed. This would definitely be a recommendation for a contractor. For MDOT maintenance crews, mobility would still be relatively important, but the goal is to catch these breaks before years of asphalt and non-compressibles have been pounded into them. MDOT maintenance crews have already used these products on a bridge deck repair with good results.

A mechanical mixer for mixing the resin and aggregates might also be recommended. Often with the wheelbarrow and pick method there was some dry aggregate dumped when filling the hole. PCI tried several small concrete mixers, but had difficulty in keeping the mixers clean.

The wheelbarrow mixing process was relatively simple, but required some experience with the materials. Although the repair techniques are not particularly complex, a successful repair is dependent on closely following the manufacturer's directions and attention to detail. Surface preparation and the amounts of the materials to use for the correct setting time are a couple important factors. The contractor on this project did an excellent job in these areas.

The high Dynaflect results on the patches (figure 17) indicate that some, of the RESURF CR/RESURF II patches, may have unbonded from the pavement, perhaps from thermal expansion. The materials may have been too brittle and the rocking movement from truckloads caused cracks, and eventually failure of the repairs.

Recommendations

RESURF CR/RESURF II did not prove to be a long-term solution for punchout repairs. The RESURF CR/RESURF II repairs required more effort and time than making a temporary repair by filling the punchout with asphalt, and were more than four times as expensive as removing and replacing the concrete pavement.

While 91 percent of the RESURF CR/RESURF II patches were rated GOOD after one year, only 37 percent were rated GOOD after two years, and only patch, #12, lasted three years. It is recommended that RESURF CR/RESURF II be used only for punchout repairs in which it is not necessary for the patch to last longer than one year.

APPENDIX A

PCI'S RECOMMENDED DIRECTIONS

DIRECTIONS
Sound, clean, and dry concrete is required.

1. Measure 7.5-lbs (3.40-kg) (3.8-L) resin per ½-ft.^{3} (0.014-m^3) aggregate (scribed pails supplied)

2. Catalyze resin at 1-4 percent level for approximately 15 minutes working time:

Hot weather - 1 percent = 33-mL.* catalyst per 7.5-lbs. (3.40-kg) resin.

Warm weather - 2 percent = 65-mL. catalyst per 7.5-lbs. (3.40-kg) resin.

Cool weather - 3 percent = 100-mL. catalyst per 7.5-lbs. (3.40-kg) resin.

Cold weather - 4 percent = 135-mL. catalyst per 7.5-lbs. (3.40-kg) resin.

Example: For 2-cu. ft. (0.057 m^3) polymer concrete at 2 percent catalyst use 30-lbs. (13.61-kg) resin, 260-mL catalyst, and 4 pails aggregate.

3. Prime surface and 2 in. (50.8-mm) apron with catalyzed resin and 4 in. (101.6-mm) brush—avoid puddling (primer is usually mixed separately).

4. Mix catalyzed resin with aggregate until wetted (2-3 minutes).

5. Fill hole, tamp (vibrate), trowel, screed—it is okay if primer coat gels prior to filling hole.

Return to traffic in 2 hours. * 1 ounce = 30 mL.

The lot numbers for the products used were RESURF RESIN LOT #MM910224, RESURF CR LOT #91215, RESURF IIX LOT #90011, and RESURF II LOT #90121.

PCI'S SUMMARIZATION OF QUANTITIES

PCI POLYMER CONCRETE, INC.

MARCH 27, 1991

Repair sites: 43

Workdays: Approximately 11 (average 2.5 workers)

RESURF Resin: Approximately 215 gallons (813.8 L), which includes approximately 30 gallons (113.6 L) as primer and poured into cracks.

Approximately 45 gallons (170.3 L) mixed with RESURF CR.

Approximately 115 gallons (435.3 L) mixed with RESURF II aggregate blend.

Approximately 25 gallons (94.6 L) mixed with RESURF IIX aggregate blend. Used only in one full depth hole.

RESURF CR: Polymer Concrete: Approximately 125 gallons (0.47 m^3) as measured by number of gallons of aggregate blend used (25 – 5 gal. pails (18.9 L) pails).

RESURF II: Polymer Concrete: Approximately 60 ft.3 (1.70 m3) (120 bags) includes 3 ft.3 (0.09 m3) used in temporary repairs.

RESURF IIX: Polymer Concrete: Approximately 18 $ft.^3$ (0.51 m^3) (36 pails).

Blasting Sand: 78 – 100# (45.36-kg) bags

Diesel: Approximately 130 gallons (492.1 L)

Approximately 30 gallons (113.6 L) for arrow board

Approximately 100 gallons (378.5 L) for compressor

Tools worn: Seven – 3/16 in. (4.8-mm) ceramics nozzles

Six – 1 in. (25.4-mm) bits for 16# (7.26-kg) hammer

Two – 3 in. (76.2-mm) bits for 16# (7.26-kg) hammer

Approximately 12 paint brushes

One abrasive saw blade

Various hoses, fittings, gaskets, valves, parts, etc., (all minor)

60' (18.3-m) rebar used in one full depth repair (supplied by MDOT)

APPENDIX B

SPECIFICATIONS

SPECIFICATION FOR “TRADITIONAL” PUNCHOUT REPAIR
MISSISSIPPI STATE HIGHWAY DEPARTMENT

SPECIAL PROVISION NO. 907-503-2 CODE: (IS)

DATE: 4/4/91

SUBJECT: Replacement of Concrete Pavement

Section 907-503, Replacement of Concrete Pavement, is added to the 1990 Edition of the Mississippi Standard Specifications for Road and Bridge Construction as follows:

907-503 - REPLACEMENT OF CONCRETE PAVEMENT

907-503.01--Description. This work consists of replacing continuously reinforced and/or reinforced (jointed) concrete pavement and the removal and replacement of base materials at locations designated on the plans or as determined by the Engineer all in accordance with the plans and specifications.

907-503.02--Materials. Materials shall meet the requirements of Subsection 700.01 and the following Subsections of Division 700, Materials and Tests.

Portland Cement	701.01 and 701.02
Fine Aggregate	703.01 and 703.02
Coarse Aggregate	703.01 and 703.03
Concrete Admixtures	713.02
Water	714.01
Concrete Reinforcement Bars	711.02
Longitudinal Joint Filler	707.02
Curing materials	713.01

907-503.03--Construction Requirements.

907-503. 03.01--Equipment. Equipment shall meet the requirements set out in Section 501 for hand placement and finishing Portland cement concrete pavement. Batching and mixing equipment shall meet the applicable requirements of Section 8094. On-site mixers or truck mixers will be permitted.

907-503.03.2--Removal of Existing Pavement.

907-503.03.2.1-- General. Existing pavement shall be removed in accordance with details shown on the plans and as specifically set out herein. Removal will be measured for payment as set forth in Section 202. The Contractor shall dispose of the concrete in accordance with Section 201.

Equipment and methods used in all of the work shall not damage any of the underlying base and materials that are to remain in place. All materials, which are removed from the roadway, shall be disposed of daily.

907-503.03.2.2--Reinforced Concrete Pavement. The removal of existing reinforced concrete pavement shall be accomplished by sawing the full thickness of the pavement

along the edge of the repaired areas as shown on the plans an/or as directed by the Engineer.

907-503.03.2.3--Continuously Reinforced Concrete Pavement. The pavement within the lap area shall not be disturbed, damaged, or removed until the continuity of the concrete and steel has been severed between the failed area and the lap area. This shall be accomplished by sawing the fill thickness of the pavement along the edge of the lap area. Jackhammers used for cutting and removal of the concrete in the lap area shall not exceed 9.07 kg.

The concrete in the lap area shall be removed in such a manner to result in a near vertical face at the saw line of the repair area. A chipping type removal is required to prevent spalling the bottom of the pavement to remain. Any spalling in excess of one and one-half inches shall be corrected by enlarging the repair area at no additional cost to the State. All shattered and damaged concrete shall be removed and the exposed faces cleaned.

The reinforcing steel in the lap area shall not be bent more than four inches in twenty inches from its original position. Where more than 10 percent of the steel is damaged in the lap area along any one edge of a removed area, the patch shall be enlarged at no additional cost to the State to provide the specified lap. Where less than 10 percent of the steel is damaged, the bars may be repaired by welding.

The steel shall be inspected for excessive rusting and evidence of distress during the removal process. The engineer may enlarge the patch to remove deteriorated steel from the lap area. When the patch is enlarged by the Engineer, payment will be made for such removal.

907-503.03.3--Removal of Base Material. Base material referred to herein and on the plans shall be all types of material below the pavement that requires removal and backfill. The material shall be removed to the dimensions and depths designated by the Engineer. Removal of all undercut material shall be in accordance with Section 202 and measured for payment by the square yard of base. The Contractor shall dispose of the material in accordance with Section 201.

907-503.03.4--Installation of Smooth Dowel Bars. Smooth dowel bars shall be installed in accordance with details shown on the plans and as specifically set out herein.

The commercial grout system used shall be one of the systems specified in 714.11.7. Installation and acceptance procedures are also included therein.

After the dowel bars are installed, the placement of reinforcing steel and any other work that may disturb the setting of the grout will not be permitted.

907-503.03.5--Installation of Tie Bars. The tie bars, except when directed otherwise on the plans, shall be No. 5 deformed bars, 30 inches (762.0 mm) long, placed on 24-inches (609.6-mm) centers and grouted using a commercial grout. The drilled holes shall be partially filled with an epoxy grout and the tie bars inserted to ensure that the holes are completely filled.

The commercial grout system used shall be one of the systems specified in 714.11.7. Installation and acceptance procedures are also included therein.

After the tie bars are installed, the placement of reinforcing steel and any other work that may disturb the setting of the grout will not be permitted.

907-503.03.6--Base and Pavement Replacement. Repair of the base and pavement shall conform to the requirements set forth herein and details shown on the plans. The exposed faces of the concrete pavement, the soil cement base, and/or polyethylene covering the base repair shall be sprayed with water just prior to pouring the new slab.

The applicable provisions of Section 501 shall be adhered to with the following exceptions:

(a) Concrete. Class A structural concrete for pavement repair shall be made of Portland cement (Type III) or Type I used with water reducing and accelerating admixtures. The usage of admixtures shall be in accordance with manufacture's instructions. When required, concrete for base repair may be class "C" or any other class designated elsewhere in the contract.

(b) Forms. The forms may be metal or wood. Where at all possible, the forms shall be metal. Metal form shall meet the requirements of 501.03.6.2 and the wood forms shall be made of 2 X 8 (50.8 mm 203.2 mm) lumber. Forms shall be graded to a specified elevation as directed by the Engineer.

(c) Longitudinal Joints. Where a repair area is required to extend across a longitudinal joint, a performed or sawed longitudinal joint shall be constructed and sealed as shown on the plans or as directed by the Engineer.

(d) Consolidating and Finishing. All concrete shall be thoroughly consolidated by internal vibration. Finishing may be performed by either machine or hand methods. All patches less than 20 feet (6.096 meters) in length shall be screeded longitudinally unless otherwise permitted by the Engineer.

The surface of the pavement shall be finished as designated elsewhere in the contract and in accordance with the applicable portions of Section 501.

The screed shall be metal of a type used on bridges for finishing short patches and may be a mechanical or bridge type on long patches exceeding 20 feet (6.096 meters). All replacement concrete shall be checked longitudinal with a 10-foot (3.048) meters straightedge in accordance with 501.03.19 for concrete pavement other than main-line pavement.

(e) Curing and Protection. Curing and protection shall be in accordance with 501.03.20, except the white pigmented membrane may be hand sprayed. The sprayer shall be equipped with a container having a capacity of not less than five gallons (18.9 L) and maintain a constant pressure by mechanical means.

(f) Concrete Saw Cuts. The saw cut shall be at the locations and depth shown on the plans.

(g) Concrete Placement. Limitations on placing continuously reinforced concrete pavement are set forth in the following schedule:

CONCRETE PAVING SCHEDULE

Predicted High Temperature	Hours of Placement
Below 70°F (21°C)	Daylight hours
70°F-84°F (21°C-29°C)	12:00 Noon to Sundown
85°F- 89°F (29°C-32°C)	1:30 PM to Sundown
90°F & Above (32°C)	3:00 PM to Sundown

Note: The National Weather Service's predicted high temperature for the day shall govern. Sufficient time must be allowed for the finishing operation prior to sundown but no less than 30 minutes will be permitted.

907-503.03.7--Opening to Traffic. Upon approval of the Engineer and a minimum 72-hour curing period, the traffic lane shall be opened as soon as possible. Side forms shall be removed and the shoulder repaired with hot bituminous pavement, and the area cleared of equipment and waste materials prior to opening to traffic.

907-503.04--Method of Measurement. Replacement of the concrete pavement will be measured for payment by the square yard complete in place. Saw cuts will be measured for payment by the linear foot when a pay item is included in the contract proposal. Concrete for base repair will be measured by the cubic yard complete in place. Smooth dowel bars and tie bars will be measured per each complete in place.

No separate measurement will be made for reinforcing steel, wire mesh, longitudinal joints, polyethylene sheeting, and hot bituminous pavement for repair of shoulders and maintenance of traffic items required.

The plans may also provide for welding of the reinforcing steel as an optional method available to the Contractor. This method reduces the width of the lap area from 20 inches (0.508 m) to eight inches (0.203 m), which will reduce the size of the repair areas. If the Contractor elects to use the optional method, the subsequent reduction in plan quantities will not be justification for adjustment of contract unit prices as provided in 104.02.

907-503.05--Basis of Payment. The accepted quantities of saw cuts, concrete for base repairs, smooth dowel bars, tie bars, and concrete pavement will be paid for at the contract unit prices which shall be full compensation for completing the work, furnishing all labor, equipment, tools, materials, and bituminous plant mix required for shoulder repair. Removal and disposal of pavement and base materials shall be made under appropriate items under Section 202.

The price for each item of work shall include the cost of continuous maintenance of traffic and protective services as required by the Department's Traffic Control Plan. This shall include all required individual traffic control devices.

Payment will be made under:

907-503-A	____" and Variable _____ Concrete Type Pavement (____ Finish) Type	- per square yard
907-503-B:	Saw Cut (Longitudinal Joints)	- per linear foot
907-503-C:	Saw Cut (____ inch) -	- per linear foot
907-503-D:	Concrete for Base Repair	- per cubic yard
907-503-E:	Tie Bars (No. _____ Deformed) (Drilled and Epoxied or Grouted)	- per each
907-503-F:	_____ Smooth Dowel Bars (Drilled (Size) and Epoxied or Grouted)	- per each

MISSISSIPPI STATE HIGHWAY DEPARTMENT

SPECIAL PROVISION NO. 907-512-1 CODE: (SP)

DATE:

SUBJECT: Repair of Continuously Reinforced Concrete Pavement using RESURF II Polymer concrete, RESURF CR Polymer Concrete, additional catalyzed RESURF Resin, and Labor.

Section 907-512, Repair of Continuously Reinforced Concrete Pavement using RESURF II Polymer Concrete, RESURF CR Polymer Concrete, additional catalyzed RESURF Resin, and Labor is added to the 1990 Edition of the Mississippi Standard Specifications for Road and Bridge Construction as follows:

907-512.01--Description. This work shall consist of the removal of asphalt patching material whether full or partial depth, cleaning of all concrete faces, widening of cracks in concrete, sandblasting, airblasting and cleaning, repair of reinforcement and placement of RESURF II Polymer Concrete, RESURF CR Polymer Concrete and additional catalyzed RESURF resin in full or partial depth, and all other incidentals, all in accordance with these specifications.

907.512.02--Materials. The polymer concrete shall be RESURF II and RESURF CR. RESURF II is a general performance polymer concrete consisting of a styrene diluted modified polyester resin with a select aggregate blend (RESURF II aggregate blend). RESURF CR is a variable viscosity, low shrink, and pourable polyester compound design for any width crack. Viscosity is tailored on the construction site by varying the amount of RESURF CR aggregate blend added the RESURF resin. The Catalyst for the RESURF resin is methyl ethyl ketone peroxide (MEKP).

907-512.03--Construction Requirements.

907-512.03.1--Full Depth Repair. In areas where most or all of the broken concrete has been removed and repaired full depth with asphalt pavement material, all the asphalt material and any remaining small pieces of concrete shall be removed by jackhammer or other equipment. It is important to thoroughly remove all asphalt material since the RESURF resin dissolves asphalt, which would result in contaminated patching material. The reinforcement shall be repaired or restored if sufficient length is available for welding.

The vertical edges of the sound concrete surrounding the failed area as well as the surface of the surrounding concrete for a minimum distance of 2 inches (50.8 mm) outside the failed area shall be sandblasted until the concrete exhibits an obvious color change. Air blasting shall then be done to remove all debris.

In instances where the failed area is bounded on one or more side by concrete that exhibits sign of movement or is otherwise not sound and durable, the vertical edges meeting this description shall be cleaned by removal of all asphalt and other deleterious materials and not sandblasted. This procedure will insure that surrounding concrete that is not stable, sound, and durable will bond poorly with the patch and be able to move in response to loadings. Thorough bonding of the polymer concrete to this type concrete will result in further weakening of the surrounding concrete and hasten its complete failure.

RESURF II shall be mixed according to the manufacturer's recommendations and/or as directed in this specification and placed in accordance with subsection 907-512.03.3 of this special provision.

907-512.03.2--Partial Depth Repair of Failed Areas. Partial depth repair of failed areas shall be done where the broken concrete has been left inplace and asphalt material or other failed patching material has been placed over the failed concrete. Partial depth repair shall also be done in areas where a punchout has developed in the concrete pavement and no patching material has been placed.

All the asphalt material as well as all other deleterious materials shall be removed from the failed area. Removal of asphalt material shall be done with a jackhammer with a maximum weight of 90 pounds (40.82 kg) using sharp bits of 1 inch (25.4 mm) and 3 inches (76.2 mm) size. Smaller weight jackhammers are preferred.

After all asphalt and other deleterious materials have been removed from the failed area, all cracks shall be widened to a width of ¼ inches (6.4 mm) down to the level of the reinforcement. All concrete faces in the failed area, both top and sides, and the surface of the surrounding concrete for a minimum distance of 2 inches (50.8 mm) outside the failed area shall be sandblasted until the concrete exhibits an obvious color change. Air blasting shall then be done to remove all debris. Special attention shall be given to the removal of all sand and other debris from the cracks.

After cleaning, sand blasting, and air blasting, all concrete surfaces shall be checked to insure a surface dry condition exists for all concrete surfaces. If necessary, a propane burner or other approved device shall be used to dry any surface moisture. Once this has been completed, all concrete surfaces in the failed area and the surface of the surrounding concrete for a distance of 2 inches (50.8 mm) outside of the failed area shall be primed with catalyzed RESURF resin applied with a paint brush, avoiding puddling of the resin. RESURF resin and catalyst shall be mixed according to the manufacturer's recommendations.

After all surfaces have been primed, RESURF CR shall be mixed to a pourable but grainy texture. A rough guideline is to mix 8 to 10 double handfuls of RESURF CR aggregate blend with 2 to 3 quarts (1.9 to 2.8 L) of catalyzed RESURF resin. All cracks shall be filled with RESURF CR until the crack reaches a width of 0.5 inches to 0.75 inches (12.7 mm to 19.1 mm). Thick or stiff RESURF CR can be made to flow into cracks by painting and tamping with catalyzed RESURF resin.

After all cracks have been filled to a width of 0.5 inches to 0.75 inches (12.7 mm to 19.1 mm), with RESURF CR, RESURF II shall be mixed according to the manufacturer's recommendations and/or this specification and place in accordance with subsection 907-512.03.3 of this special provision.

907-512.03.3--Mixing and Placing of RESURF CR Polymer Concrete, RESURF Resin and RESURF II Polymer Concrete. Before placing any RESURF CR Polymer Concrete or RESURF II Polymer Concrete, all asphalt and other deleterious materials shall be removed from all surfaces of the failed area. Sandblasting for all applicable surfaces shall be done until the concrete exhibits an obvious color change. Air blasting shall be used to remove all debris. Sandblasting shall be done on all surfaces of partial depth patches including the surface of the surrounding concrete for a distance of 2 inches (50.8 mm) outside the failed area. The vertical edges of the surrounding concrete on full depth patches shall not be sandblasted.

All surfaces of failed areas shall be completely dry prior to placement of any RESURF product. RESURF resin shall be catalyzed according to the manufacturer's recommendations. For full depth repairs, the vertical edges of the surrounding concrete shall not be primed. For partial depth patches, all concrete surfaces shall be primed with catalyzed resin, including the surface of the surrounding concrete for a distance of 2 inches (50.8 mm) outside the failed area. Catalyzed resin shall be applied with a paintbrush and reasonable care shall be taken not to waste resin. Priming resin may be allowed to gel prior to placing RESURF CR Polymer Concrete or RESURF II Polymer Concrete.

Catalyzed resin shall be mixed with the RESURF CR aggregate blend or RESURF II aggregate blend according to the manufacture's recommendations until the aggregate is thoroughly wetted with resin.

RESURF CR Polymer Concrete shall be place in cracks until the crack reaches a width of 0.5 inches to 0.75 inches (12.7 mm to 19.1 mm). Thick or stiff RESURF CR Polymer Concrete can be made to flow into cracks by painting and tamping with catalyzed resin.

Once RESURF CR Polymer Concrete has been placed into cracks as described in the paragraph above, RESURF II Polymer Concrete shall be mixed, place, tamped, troweled and screeded with a straightedge. Screeding shall be done parallel to the centerline. Immediately after screeding, the patched area shall be checked with a straightedge or a string for areas too long for a straightedge. If sufficient additional leveling is needed, RESURF II Polymer Concrete can be applied and feather edged as a grout. If leveling of 0.5 inches (12.7 mm) or less is needed, the broadcast method of leveling shall be used. For the broadcast method, RESURF II aggregate blend shall be broadcast evenly and lightly into a heavy coat of catalyzed RESURF resin, application rate of 1 gallon (3.8 L) of catalyzed resin per 22 to 25 feet^2 (2.04 to 2.32 meters^2), until the aggregate blend maintains a slightly dry surface appearance with further broadcasting. An additional layer can be added after two hours. Each application adds approximately 0.25-inches (6.4-mm) thickness.

For all patches where further leveling is not needed, the patch area shall receive a topcoat of RESURF II aggregate blend broadcasted onto the patch surface to provide a skid resistance finish.

The patched area shall be allowed to cure for two hours prior to opening the area to traffic.

907-512.03.5--Repair of Longitudinal Cracks Adjacent to Failed Areas. All longitudinal cracks intersecting the failed area which are generally parallel to the centerline shall be repaired as follows. Other longitudinal cracks as directed by the engineer shall be repaired by this same procedure.

The repair shall begin by widening of the crack with a jackhammer to a width of 0.5 inches to 0.75 inches (12.7 mm to 19.1 mm) and a depth of approximately 1 inch (25.4 mm) to create a reservoir for catalyzed resin. The faces of the crack and the surrounding concrete for a distance of 2 inches (50.8 mm) outside the crack shall be sandblasted until the concrete exhibits an obvious color change. The crack shall then be air blasted.

Catalyzed resin shall then be painted/poured into the crack. If the resin does not quickly fill the crack, RESURF CR Polymer Concrete shall be used to fill the crack; RESURF CR Polymer Concrete shall be used to fill the crack. The viscosity of the RESURF CR Polymer Concrete can be varied by changing the ratio of aggregate blend to resin to fit

field conditions. After the crack has been filled, RESURF II aggregate blend shall be broadcast onto the top of the RESURF material.

907-512.04--Method of Measurement. RESURF II Polymer Concrete will be measured by the cubic foot of aggregate blend; however, for each one cubic foot (0.028 cubic meters) of aggregate blend, two gallons (7.6 L) of RESURF resin together with the manufacturer's recommended amount of catalyst for two gallons (7.6 L) of resin shall be furnished. No separate payment will be made for the resin and catalyst.

RESURF CR Polymer Concrete will be measured by the gallon of RESURF CR aggregate blend; however, for each one gallon (3.8 L) of aggregate blend, ½ gallon (1.9 L) of RESURF resin together with the manufacturer's recommended amount of catalyst for ½ gallon (1.9 L) of resin shall be furnished. No separate payment will be made for the resin and catalyst.

Additional RESURF Resin, in addition to amounts included in the pay items for RESURF II and RESURF CR, will be measured by the gallon (3.8 L), with no separate payment for the manufacturer's recommended amount of catalyst for each one gallon (3.8 L) of resin.

The pay item, Labor-lump sum, will include all labor for the repair of the concrete pavement, to include mobilization, maintenance of traffic in accordance with requirements of the FHWA document "Manual of Uniform Traffic Control Devices", disposal of all surplus materials, and all labor, equipment and miscellaneous materials required for the proper prosecution of the pavement repair. All item of work not specifically mentioned are included in this item.

907-512.05--Basis of Payment. RESURF II Polymer Concrete, RESURF CR Polymer Concrete, Additional RESURF Resin, and Labor-Lump Sum will be measured as provided in 907-512.04 and will be paid for at the contract unit price which shall be full compensation for all materials, mobilization, maintenance of traffic, surface preparation, cleaning, priming, placement of polymer concrete, disposal of all surplus material; and for all equipment tools, labor and incidentals necessary to complete the work.

Payment will be made under:

907-512-A:	RESURF II Polymer Concrete	- per 1 cubic foot (0.028 m^3)
907-512-B:	RESURF CR Polymer Concrete	- per 1 gallon (3.8 L)
907-512-C:	Additional RESURF Resin	- per 1 gallon (3.8 L)
907-512-D:	Labor-Lump Sum	- Lump Sum

REFERENCES

1. Pagan, Alfred R., “Polymer Concrete: and engineer’s overview,” Better Roads April 1991, pp. 42-46.

2. “Polymer concrete speeds repairs,” Better Roads, April 1991, pp. 22-26.

3. Teng, T.C., “PAVEMENT REHABILITATION USING DYNAFLECT DATA,” Mississippi State Highway Department, June 1981, p. 8.