PB2000-105045

EVALUATION OF PATCHING MATERIALS AND PLACEMENT TECHNIQUES FOR RIGID PAVEMENTS AND BRIDGE DECKS

FINAL REPORT

Submitted to

Florida Department of Transportation
(BB452-WPI 0510861)

by

Shiou-San Kuo, Lucas Carlo, Chris Kuenzli

Department of Civil and Environmental Engineering
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1. Report No. WPI 0510861	2. Government Accession No.	3. Recipients Catalog No.

4. Title and Subtitle
EVALUATION OF PATCHING MATERIALS AND PLACEMENT TECHNIQUES FOR RIGID PAVEMENTS AND BRIDGE DECKS

5. Report Date
September 1999

6. Performing Organization Code

7. Author(s)
SHIOU-SAN KUO, LUCAS CARLO, CHRIS KUENZEL

8. Performing Organization Report No.

9. Performing Organization Name and Address
Department of Civil and Environmental Engineering
University of Central Florida
Orlando, Florida 32816-2450

10. Work Unit No. (TRAIS)

11. Contract or Grant No.
BB452

12. Sponsoring Agency Name and Address
Florida Department of Transportation
605 Suwannee Street
Tallahassee, Florida 32399-0450

13. Type of Report and Period Covered
FINAL REPORT
August 1998-September 1999

14. Sponsoring Agency Code

15. Supplementary Notes
Prepared in cooperation with the U.S. Department of Transportation and Federal Highway Administration

16. Abstract
The objective of this research study was to evaluate the performance of various types of advanced materials available on the market for use in partial depth repairs of potholes and spalls from concrete pavement. Three major material categories used for high strength and fast set criteria are: polymer concrete, elastometric concrete, and cementitious mortar. Several types of composite specimens were tested from various patching materials.
Laboratory compressive tests were first conducted for the composite specimens. Results were used to select the types of material to be tested for the performance evaluation at UCF accelerated circular test track. Six patching materials along with Type II cement for a control section were identified. Fourteen potholes and two joint spalls were constructed on the test track.
A total of 500,000 load repetitions of 44.5 KN (10 kips) wheel load was applied to the patches and spalls at the end of the testing project. This is equivalent to 762,000 load repetitions of 18 kips ESAL.
Some Patching distresses such as de-bonding failure have been observed in the early stage of testing. The failures occurred because of obvious shrinkage due to temperature change throughout the day. Elastomeric and polymer concretes particularly had shrinkage problems and caused early de-bonding from the concrete slab.
Failure from severe wearing, cracking and spalling was not observed in any of the patch materials. The two feathered-edged potholes, which are simulating realistic pothole conditions on the highway, have performed well.
Recommendations for guidelines of patching materials are also included in this report.

17 Key Words
Characterization of patching materials, laboratory compressive testing of composite specimens, accelerated performance of partial depth potholes and spalls. guidelines and recommendations

18. Distribution Statement
No restriction
This report is available to the public through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

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EVALUATION OF PATCHING MATERIALS AND PLACEMENT TECHNIQUES FOR RIGID PAVEMENTS

This report is prepared in cooperation with the State of Florida Department of Transportation.

Executive Summary

One of the most disturbing and frustrating pavement distresses encountered by motorists is the potholes and spalls on concrete pavements. Vehicle speed will reduce significantly on a road where many potholes and spalls exist, possibly creating a traffic hazard. It is estimated that over one billion dollars is spent annually in the United States on pothole and spall repair. A priority for pavement engineers is to develop patching techniques, and to discover new quality materials to repair potholes and spalls on concrete pavements. Traditional repair techniques on the roads with heavy traffic congestion and high traffic volume are not feasible. Industry today has produced many high strength, fast cure patching materials to enhance the concrete pavement performance. Therefore, new concepts are needed to incorporate and apply recent advances in material technology into pothole and spall repairs.

The objective of this research study was to evaluate the performance of various types of advanced materials available on the market for use in partial depth repairs of potholes and spalls from concrete pavement. Several types of composite specimens were tested from various patching materials. Laboratory compressive tests were first conducted for the composite specimens. Results were used to select the types of material to be tested for the performance evaluation at UCF accelerated circular test track. Six patching materials along with Type II cement for a control section were identified. Fourteen potholes and two joint spalls were constructed on the test track. Meanwhile, UCF also conducted the testing materials for the noise reduction in joint

pavement slabs and analyzed the decibel levels on the test track with and without a material filling the joint.

The accelerated test facility at UCF used to simulate actual traffic load applied to all tests was a dual wheel loading of 44.5N (10,000lbs). During testing, every distress is monitored closely by visual inspection for any signs of debonding near cracks, or complete failure. The sum of load repetitions endured on the test track was used to equate the simulated life expectancy (SLE) of the materials. Recommendation and guidelines for the repairs of patchings and spalls will be established for FDOT Materials Office.

Following is the summary of the results obtained from this research project:

Literature Review of Partial-Depth Repair Techniques and Materials

Literature review was conducted on the investigation of current specifications and guidelines, performance, and life-cycle cost of partial-depth patching techniques and materials. Reports by American Concrete Pavements Association (ACPA) in 1989, and by Darter et.al. in 1985 have contributed a good knowledge on the procedures of patching repairs. Peshkin (1993) studied the effectiveness, equipment, and procedures of partial-depth spall repair in concrete pavement. The material used in his several million dollar research study included Type III PCC, Duracal, Set-45, Five Star HP, MC-64, SikaPronto II, Percol FL, Penatron R/M-3003, Pyrament 505, UPM High Performance Cold Mix, and spray-injection bitaminous cold mix. Parker and Shoemaker (1991) conducted studies on laboratory and field performance on three rapid-strength PCC pavement patch materials with three materials on rapid-setting PCC and fibrous PCC mixture and Road Patch II. Ramey et.al. (1984) conducted a laboratory study on the bonding strength and weathering characteristics of selected rapid-setting PCC pavement patching compounds. Parker et.al. (1984) conducted field studies to evaluate the effects of bonding agents, mechanical anchors, and consolidation and curing techniques on the performance of surface pavement patchings. Spotts (1998) reported on the cost the US spends on fixing streets and highways. Belisie (1997) studied the effects of the damage of potholes to motorists, and new technology to prevent reoccurring potholes. Darter (1985) studied the life-cycle cost of patching and spall repairs.

Characteristics of Patching Materials and Laboratory Testing

Three major categories used for high strength and fast set criteria are: polymer concrete, elastomeric concrete, and cementitious mortar. Polymer concrete (PC) uses a high reactive resin as the sole binder. It consists of an aggregate mixed with a monomer and allowed to polymerize in place. Polymer concrete possesses the properties of rapid curing, high tensile, compressive, and flexural strengths, good adhesion to concrete, and long term durability to free-thaw cycling. Elastomeric concrete combines most of the properties of structural concrete with a rubber-like nature. It consists of a base elastomer blended with a pre-bagged aggregate, sand, and chemical mixture. The elastomer is a two-component liquid compound. Elastomeric concrete is easy mixing, rapid setting, excellent bonding to concrete and excellent resistance to impact and moisture. Rapid-setting high-strength cementitious mortar provides the properties of impact resistance, high compression, flexural, and tensile strengths, freeze-thaw resistance, cracking resistance, and good bonding to existing concrete.

There were eight (8) different materials provided by the participating manufactures plus one Type II cement used for control section. In order not to identify the trade name they were labeled alphabetically from A to H. The physical properties of compressive and tensile strength of these materials are given in Table 3. A total of sixteen composite specimens were cast in cylinders for compressive testing. Various composite configurations are shown in Figure 4. The shape of patching configurations was designed to simulate a likely scenario potholes and spalls may encounter on most of the concrete pavement roads. Type I PCC was used for the concrete part in the composite specimens with 28 days curing time. The curing time for the patching materials was set up for 24 hours because of the accelerated performance test. The average compressive strength from the laboratory testing is given in Table 6. The compressive strength and fracture pattern of each composite specimen from the laboratory test were carefully examined and analyzed, the results were then used to determine which of the materials would be used for accelerated performance testing at the UCF test track. It was concluded that materials D, E, and H along with three FDOT recommended products were selected for the performance test.

Test Facility at UCF

The test track is 15.2m (50ft) in diameter to the centerline of a 1.83m (6ft) wide concrete pavement. The test machine has three sets of dual wheels that travel around in a circular path guided by radial arms with a speed up to 43.3Km/Hr (30mph). The loading on the dual wheel assemblies is ranged between 133.5KN (30,000lbs) to 356KN (80,000lbs). This load is evenly distributed to the three dual wheels. In this test study, the machine applied a dual wheel load of 44.5KN (10,000lbs) and traveled an average speed of 14.4Km/Hr (10mph).

Artificial Pothole Construction and Material Placement

Figure 6 illustrates the locations of fourteen (14) potholes and two (2) spalls at the pavement joints. three different pothole sizes were created. Seven (7) at the size of 30.4 x 30.4 x 12.7cm (1 x 1 x 0.4 ft) (Detail 1), seven (7) at the size of 60.96 x 30.48 x 12.7cm (2 x 1 x 0.4ft) (Detail 2), and two (2) feathered edged at the size of 30.48 x 30.48 x 12.7cm (1 x 1 x 0.4ft) (Detail 3). Each patching material was placed in two of the pothole molds as seen in Detail 1 and Detail 2 in Figure 6. The purpose of placing the same material in two different potholes was that one pothole is placed under a single tire that may cause the edge of the patching to detach, while the other pothole is under the dual tires that may cause a higher displacement of patching. The placement of the patching materials onto the pre-formed potholes was not an easy task for this project. Leveling the materials with the track surface became somewhat difficult with the cementitious materials and the control section due to the large size of the aggregate involved. This was the reason that the patchings with cementious materials caused uneven levels with the concrete track surface. If the size of the aggregate can be reduced in these materials, then patching will be easier.

Results of Accelerated Performance Testing

A total of 500,000 load repetitions of 44.5KN (10kips) wheel load was applied to the patches and spalls at the end of the testing project. This is equivalent to 762,000 load repetitions of 18 kips ESAL. The equivalency calculation is presented in Chapter V. By assuming that an average daily traffic (ADT) volume of 10,000 for a typical medium-heavy traffic highway with a 6% truck traffic, the simulated life expectancy (SLE) of 500,000 test track load repetitions is equivalent to 17.7 years life.

During the course of testing, the performance of each patching material and spall repair material was closely monitored at all times. The photographs were taken at the load repetitions starting at 50,844 and approximately every 50,000 repetition increments until the end of 500,000 repetitions. The distresses of patching materials and spalls are described in Table 9 and Figure 10. Some patching distresses such as de-bonding failure have been observed in the early stage of testing. The failures occurred because of obvious shrinkage due to temperature change throughout the day. Elastomeric and polymer concretes particularly had shrinkage problems and caused early de-bonding from the concrete slab. Cracking also occurred in one of the cementitious mixes due to excessive water content in the mix design. However, failure from severe wearing, cracking, and spalling was not observed in any of the patch materials and spalls. The two feathered-edged potholes, which are simulating realistic pothole conditions on the highway, have performed well to this point. This has proven to be valuable, because if crews do not have to square-cut partial-depth patches, placing the material directly into the distress can save time and money. Recommendations for guidelines of patching materials are also included in this report.

ACKNOWLEDGEMENTS

The research reported herein was sponsored by the Florida Department of Transportation. Sincere thanks are due to Dr. Jamshid Armaghani, State Pavement Evaluation Engineer, State Materials Office, Gainesville, Florida for his guidance, support, and encouragement.

The authors also acknowledge the help and services of FDOT State Materials Office in Gainesville for coordinating the acquisition of patching materials from manufacturers.

Thanks are also due to the following companies for their donation of patching materials to be tested at the UCF-CATT:

PCI
Bonsal Company
(Delpatch)
(Silpec 900)
Harris Specialty Chemicals, Inc.
D.S. Brown
E-poxy
Capital Services
SSI

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CHAPTER I

INTRODUCTION

There is a trend of growing traffic on interstate and urban highway systems today. The heavily traveled urban sections have begun to show effects of far exceeded traffic volumes, and environmental problems. Many Portland cement concrete (PCC) pavements are getting older and showing rapid deterioration. Cracks, spalls, and other distresses are occurring on most roadways. To maintain the serviceability of the highway systems, materials with advanced technology must be applied to repair these distresses.

One of the most disturbing and frustrating pavement distresses encountered by motorists is the potholes and spalls on concrete pavements. A pothole is defined as a localized failure in a surface pavement; a spall is defined as cracking, breaking, or chipping of the slab edges in the vicinity of a joint. Vehicle speed will also reduce significantly on a road where many potholes and spalls exist, possibly creating traffic hazards. A great amount of money is spent annually in the United States on pothole and spall repair. A priority for pavement engineers is to develop patching techniques, and to discover new quality materials to repair potholes and spalls on concrete pavements.

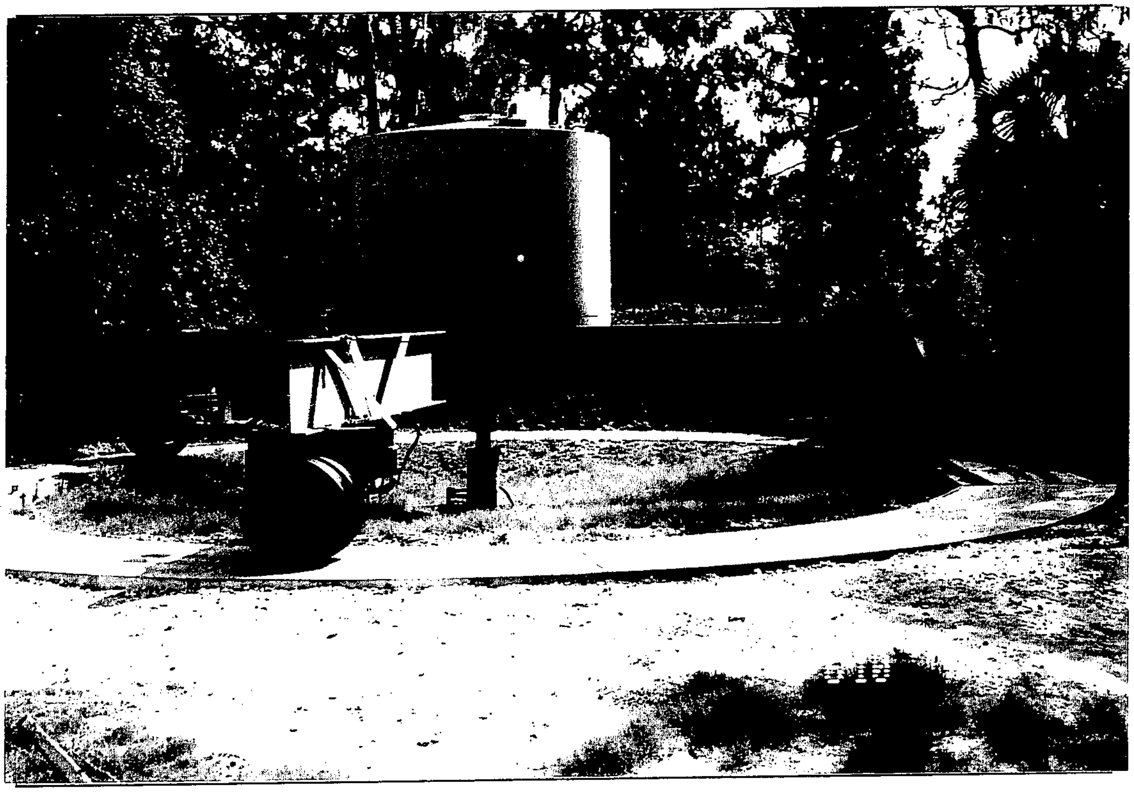
Pothole and spall repair can be improved by using quality materials in conjunction with proper patching procedures. Traditional repair techniques of potholes and spalls required crews to square-cut the edges of the distress. By square-cutting potholes crews risk damaging the original pavement in the vicinity of the repair. Extremely high intensity vibrations caused by the diamond blade saw may propagate cracks along the pavement. In addition, 90-degree corners are very difficult for road crews, and over extending a saw cut on the corners occurs frequently. This leads to the initiation of cracking in the future. However, with new high strength patching materials the straight edge cutting of concrete may not be necessary. New concepts are needed to incorporate and apply recent advances in material technology to improve the performance and service life of highway pavements. Industry have produced many high strength, fast cure patching materials to enhance concrete pavement performance. Along with these materials, companies have been able to keep mixing and application procedures simplified. These fast set materials are able to minimize curing time allowing for less traffic congestion.

The University of Central Florida (UCF) tackled the task of researching for quality patching materials to test the performance for the rehabilitation of potholes and spalls on concrete pavements as a project funded by the Florida Department of Transportation (FDOT). UCF was also responsible for new guidelines in laboratory testing and material placement techniques, so appropriate materials can effectively be used in field application. The performance of the patching materials was tested at UCF and its Circular Accelerated Test Track (CATT) facility (Photograph 1).

The objective of this research study was to evaluate the performance of various types of advanced materials available on the market for partial depth repairs of potholes and spalls from concrete pavements. Several types of composite specimens were tested using many different patching materials. The control sections, consisting of a fast set Type II cement, was compared and contrasted with the test data. Laboratory compressive tests were first conducted of the composite specimens in order to determine strength and bond of the patching material to PCC. Results were then used to determine which of the materials would be used in the final experimental phase. Six patching materials and the Type II cement were identified and then applied to a full-scale accelerated test track at UCF. Fourteen potholes were constructed on the University of Central Florida Circular Accelerated Test Track (UCF-CATT). This consisted of seven 30.5 cm x 30.5 cm x 12.7 cm (1' x 1' x 5"), and seven 70 cm x 30.5 cm x 12.7 cm (2' x 1' x 5") potholes. Each material was subjected to the two different sized distresses. Two joint spalls were also constructed on the test track. The spalls, 28 cm x 10.2 cm x 3.8 cm (11" x 4" x 1.5") in size were filled with materials tested from the laboratory experiments.

UCF was also responsible for testing materials for the use of noise reduction in jointed pavement slabs. The decibel level was recorded for the wheel passing at two joints, one with joint filler, and one without. The results were compared to determine if decibel levels will decrease when the joint is filled.

The facility used to simulate actual traffic loads applied to all tests, was a dual wheel loading of 44.5 kN (10,000 lbs). During testing, every distress is monitored closely by visual inspection to detect if any signs of de-bonding, wear, cracks, or complete failure have occurred. The sum of load repetitions endured on the concrete pavement will then be used to equate the simulated life expectancy (SLE) of the materials. The results of the patching techniques and materials used can be evaluated, and recommendation of field implementation to the FDOT Materials Office can follow.



PHOTOGRAPH 1. University of Central Florida Circular Accelerated Test Track

CHAPTER II

LITERATURE REVIEW

Even though many high strength and fast set repair materials are manufactured today, there are no real specific national guidelines (by American Society of Testing Materials/American National Standards Institute) that guarantee the quality and performance of patching materials. The following literature review has been conducted with three objectives in mind:

1. Investigate current specifications and guidelines that deal with partial-depth patches and corresponding products.
2. Report on the performance of projects that involved the use of patching materials for the rehabilitation of concrete pavements.
3. Study the damage and costs caused by pavement distresses, to the government and motorists.

Partial-Depth Repairs

The American Concrete Pavement Association (ACPA) in 1989 reported on the guidelines for partial-depth repair. Partial-depth patches are placed to repair spalls either at pavement joints or at mid-slab locations. Spalls create a rough ride and can accelerate further deterioration. Spalling is a localized distress, and therefore, warrants a localized repair procedure for the pavement to be restored. Repair of this distress is needed to improve rideability, deter further deterioration, and provide proper edges so that the joints and cracks can be resealed effectively. It was learned that a good performance of partial-depth repairs can be obtained by:

- Limiting use of the technique to the top one-third of the slab and not extending repairs to a depth that allows the patching material to bear directly on dowel bars or reinforcing steel.
- Inserting a compressible material in all working joints and cracks or adjacent to the patch. The compressible material should extend 25.4 mm (1 in) below and 76.2 mm (3 in) laterally beyond patch boundaries.
- Using a bonding agent compatible with the selected patching material. Incompatibility will likely result in delaminating.
- Sealing the patch/slab perimeter interface using cement: water grout for cementitious patch materials to prevent moisture infiltration.
- Resealing the joint after repair to prevent water and incompressibles from causing further damage.

Darter et. al. (1985) reported on the design guidelines of partial-depth patches. It was stated that the type of patch material to use for partial-depth patching depended on such factors as amount of time before opening to traffic, ambient temperature, cost, size, and depth of patches. The success of partial-depth patching depends on a adequate bond to existing concrete, therefore it is important that proper surface preparation to the concrete be done. Procedures for surface preparation include:

1. Check out the delaminated area with a steel rod by tapping the surface.
2. Saw cuts should be made 50.8 mm (2 in) from the distress.
3. At least a 50.8 mm (2in) deep saw cut should be made around the perimeter of the patch area to provide a vertical face at the edge, and sufficient depth for the patch. Avoid feathered edges.
4. To prevent fracture of the sound concrete below the repair, the maximum size pneumatic hammer should be 13.6 kg (30 lbs).

Figure 1 shows a typical partial-depth spall patch, removal, procedure, and joint inserts. In order to eliminate failure of the patch, it is intended for the edges of the partial-depth patch area be reasonably straight and vertical. Figure 2 depicts an incorrectly installed patch and a correctly installed patch. The exposed faces of the concrete should then be sandblasted and air hosed of any loose particles, oil, dust, and other contaminates before patching.

Performance of Patching Materials

Peshkin (1993), as part of the Strategic Highway Research Program's (SHRP) initiative in highway operations area, studied the effectiveness, equipment, and procedures of partial-depth spall repair in Portland cement concrete (PCC) pavements. Test sites for the research were installed in highways across the United States and

Canada. Installation and performance data was compiled and analyzed to provide preliminary indications about distress development and survival rates of various repairs.

Under this project, 1,600 spalls were constructed with the cooperation of 15 different state DOT's, 1 Canadian Province, and 1 city Department of Public Works. Private contractors installed two of the sites; while the sponsoring agency performed the rest of the work. Laboratory tests were performed on the repair materials and the data were used to identify correlation between laboratory test results and field performance.

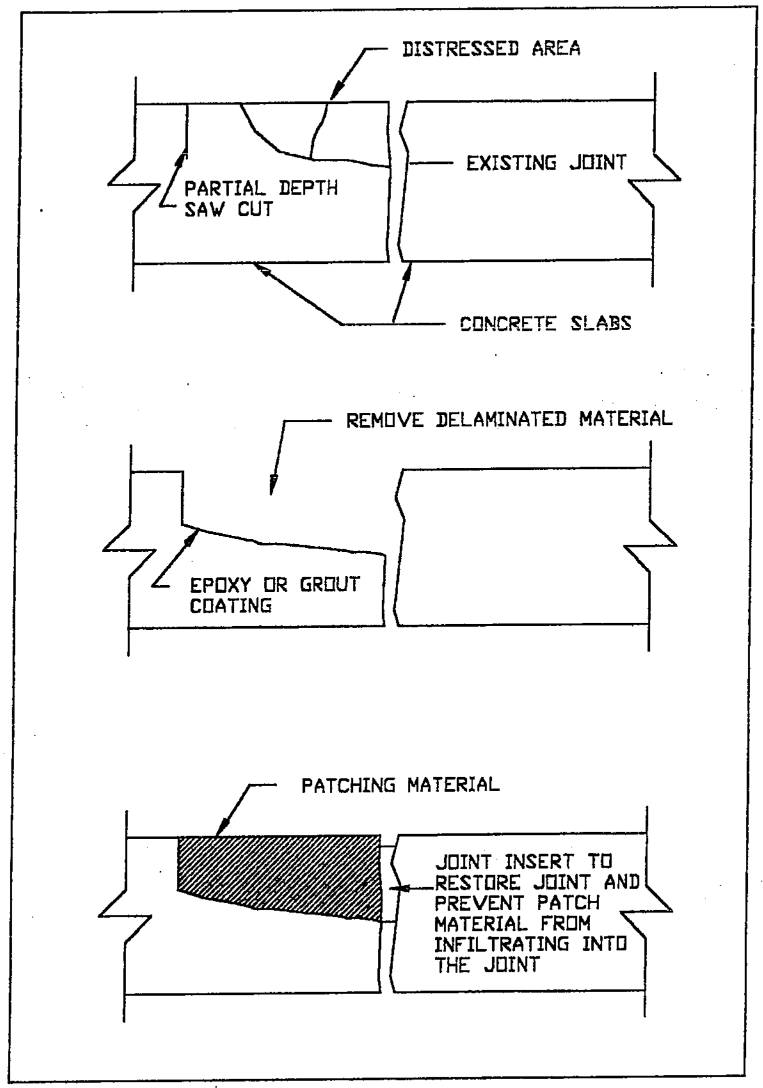
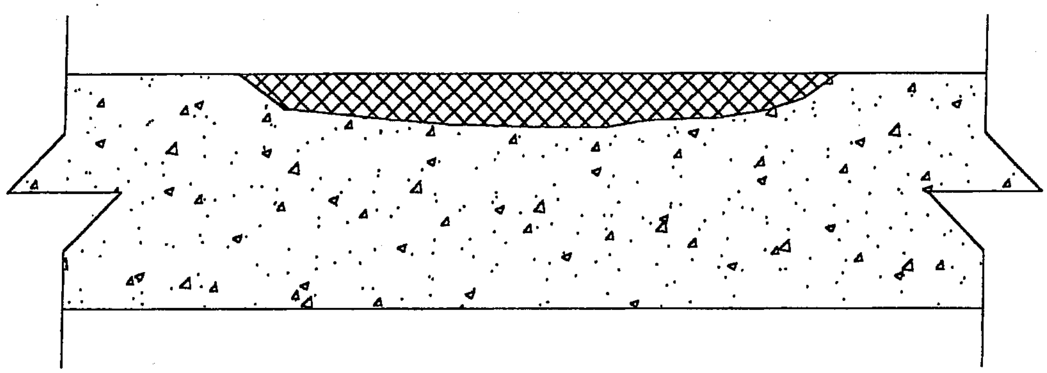
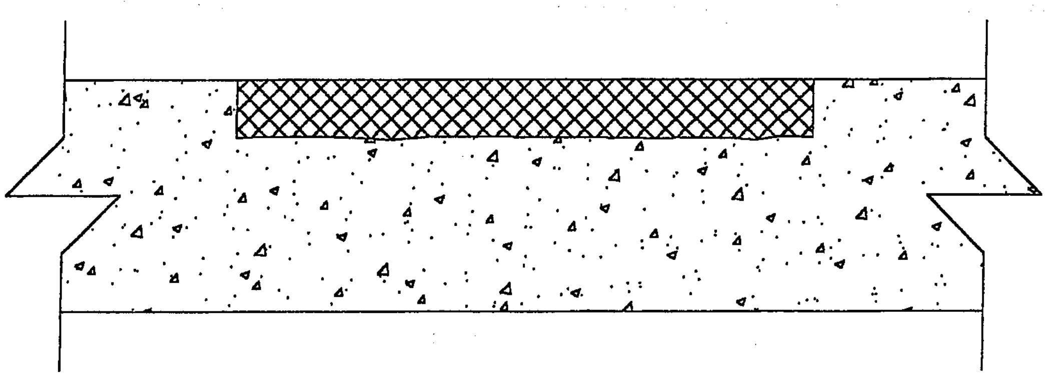


FIGURE 1. Steps for Partial Depth Spall Patching (Darter, 1985)



(A) INCORRECTLY INSTALLES PATCH. THE FEATHERED EDGES WILL BREAK DOWN UNDER TRAFFIC AND WEATHERING.



(B) CORRECTLY INSTALLED PATCH. THE CHIPPED AREA SHOULD BE AT LEAST 3/4 INCH DEEP WITH THE EDGES AT RIGHT ANGLES OR UNDERCUT TO THE SURFACE.

FIGURE 2. Partial Depth Patching Installation by PCA (Kosmatka, 1985)

The materials tested included Type III PCC, Duracal, Set-45, Five Star HP, MC-64, SikaPronto 11, Percol FL, Penatron R/M-3003, Pyrament 505, UPM High Performance Cold Mix, and spray-injection bituminous cold mix. These materials gain strength rapidly, thus allowing repairs to be opened to traffic relatively quickly.

The following findings from the project were summarized as follows:

- The only significant effect of installation temperature was on the longitudinal cracking rating of cementitious and polymer materials placed in the dry-freeze region. The site had the lowest minimum installation temperature of all sites for patches.
- At all sites, Type III PCC performed about the same as the more expensive proprietary cementitious materials.
- The performance of cementitious and polymer patches placed with the chip-and-patch procedure was significantly better than those patches placed with the saw-and-patch procedure in the dry non-freeze region.
- For cementitious and polymer patches in the dry non-freeze and wet-freeze regions, no significant difference was found in the overall rating among milling and patching, sawing and patching, or chipping and patching as a group.
- In the dry non-freeze region, Type III PCC, Five Star HP, MC-64, SikaPronto 11, and Pyrament patches had significantly better overall ratings than Penatron patches.
- In the wet non-freeze region, UPM High Performance Cold Mix patches placed with the chip-and patch procedure had a significantly higher overall rating than spray-injection patches placed with the clean-and-patch procedure.

- Of the sets of repair types placed at all sites, 3 showed significantly poor performance in the survival analysis when compared with repair types with no failures at the same site. These are Percol FL patches placed with the chip-and-patch procedure in the dry non-freeze region, Set-45 patches placed with the chip-and-patch placed with the procedure in the wet-freeze region, and Percol FL patches placed with the saw-and-patch procedure in the dry non-freeze region.

In conclusion, the research concluded that agencies might be able to save significant portions of their maintenance budgets and greatly increase the effectiveness of their repair activities by using higher quality materials. However, in the paper, there was no traffic data reported for their performance analysis, and the report was based on only one year of visual inspection results.

Parker and Shoemaker (1991) conducted studies on laboratory and field performance on three rapid-strength PCC pavement patch materials. The three materials selected for this study were a rapid-setting PCC mixture, a rapid-setting fibrous PCC mixture, and ROADPATCH II, a proprietary material. The fibrous PCC contained discrete steel fibers. Proportions for PCC and fibrous PCC are shown in Table 1.

Laboratory mix designs revealed that PCC with and without steel fibers and ROADPATCH II could produce an early compressive strength adequate for one-day patch construction. Figure 3 indicates the differences in the rate of early strength among ROADPATCH II and PCC with and without steel fibers.

TABLE 1. Mixture Proportions for 1ft^3 Batches

	I-59		I-85	
Ingredients	**PCC**	**Fibrous PCC**	**PCC**	**Fibrous PCC**
Type III cement	33 lbs	40 lbs	36 lbs	45 lbs
Water	16 lbs	18 lbs	15.5 lbs	18 lbs
Coarse aggregate	61 lbs	52 lbs	57 lbs	47 lbs
Fine aggregate	40 lbs	35 lbs	38 lbs	31 lbs
Accelerator	5 oz	6 oz	5.3 oz	6.7 oz
Steel fibers		6 lbs		6 lbs

1 lb = 4.45 N

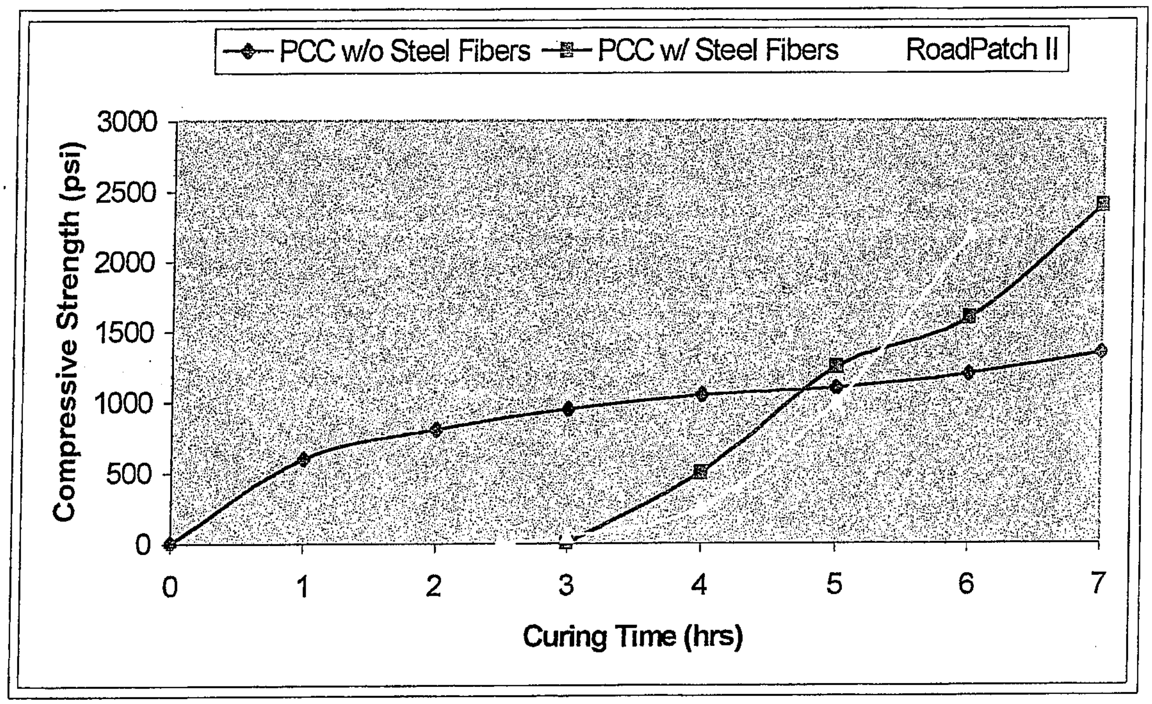


Figure 3. Laboratory Early Strength-Development Curves (Parker et. al, 1991)

Above laboratory tests showed that four-hour compressive strength tests of the PCC materials were higher than the proprietary material. However, after 6 hours, the strengths of PCC were lower. During field investigation, the effects of pavement location and condition, construction temperature, anchors and sawing to outline patch areas were studied. The following conclusions were drawn from their report:

- Patches constructed of fibrous PCC performed best.
- The inclusion of anchors did not improve patch performance.
- Patches constructed during warm weather performed better than those constructed during cool weather.
- Patch performance was influenced by overall pavement condition with better patch performance on pavements with better condition.
- Sawing to outline the patch area improved patch performance and aided patch construction.
- Same as in the previous project, no traffic information or data was collected for their analysis.

Ramey et. al. (1984) reported on the strength and weathering characteristics of selected rapid-setting PCC pavement patching compounds. A laboratory testing program evaluated material and bonding properties, which are fundamentally related to the durability and performance of spall-type patches. Patching materials used for shallow-depth surface repairs of PCC pavements slabs and bridge decks were selected. Polymer concrete, Magnesium Phosphate Cement (MPC), ROADPATCH II with steel fibers, and Epoxy/PCC were the four rapid setting materials chosen. Testing procedures included; compressive strength, tensile strength, direct shear, and impact tests. Three test series described in Table 2 were employed to evaluate the effect of age and simulated weathering exposure.

TABLE 2. Experiment Design

Designation	Age or Exposure of Specimens	Test Series Purpose	Tests Conducted
Group 1	6 hr moist curing in laboratory	Determine early strengths of patching materials and composite patches	Compressive strength, tensile strength, direct shear strength, impact resistance
Group 2	2 days moist curing and 81 additional days in laboratory environment	Determine matured strengths of patching materials and composite patches	Compressive strength, tensile strength, direct shear strength, impact resistance
Group 3	2 days moist curing 1 day soaking in water, and 81 additional days of cyclic temperature changes	Determine durability potential and thermal degradation of patching materials and composite patches	Compressive strength, tensile strength, direct shear strength, impact resistance

The general conclusions concerning the relative performance of the patching materials were based on the trends in the laboratory results. The following was concluded from their research:

- Consideration of the overall test results indicated that strength and bonding properties of the patching materials were directly related. The durability of the homogeneous patching materials appeared to be a good indication of the durability of their bond to base concrete.
- Polymer concrete exhibited the most ideal setting time. Polymer concrete appeared to be the best of the materials tested in terms of early strength, indicating that it would be suitable for making quick-patch repairs. However, it displayed a relatively large loss of energy absorption capacity with age and a loss of strength after exposure to simulated weathering, indicating a problem with long-term durability.

- MPC did not appear to be an attractive early cure material. MPC had the least early age strength; it also had a very low energy absorption capacity.
- Test results indicated Roadpatch final cured strength and energy absorption capacity properties were the best of the rapid-setting materials. Its loss of energy absorption capacity made it susceptible to long-term durability.
- Epoxy-bonded PCC patching materials used in this study were not recommended because of the rate of strength gain were too slow for completing a field patching repair. Additional effort should be made to identify or develop fast curing epoxy and PCC mixture design.
- Early age strengths and energy absorption capacities suggested that polymer concrete is the best choice of the materials tested for making rapid repairs to concrete pavements and bridge decks.

Parker et. al. (1984) conducted field studies to evaluate the effects of bonding agents, mechanical anchors, and consolidation and curing techniques on the performance of surface pavement patches. Roadpatch and rapid-setting PCC materials were used in the research. The experimental program utilized an abandoned section of PCC pavement located near Auburn, Alabama. The following conclusions were summarized in that project:

- The use of bonding agents improved the consistency and reliability of the patch bond with the base concrete. Type III Portland cement (PC) grouts should be used as the bonding agent with rapid-setting PCC. The performance of PC grouts was insensitive to the method of placement. Uniformity of the grout and low water-cement ratios appears to be more important than method of placement.

- The inclusion of mechanical anchors, in general, is beneficial in improving strength and ductility. However, it was stated that optimization of the size and number of anchors to best strengthen a patch was not achieved and should be addressed through additional research.
- Internal vibration and moist curing have a definite positive effect on early patch strength.
- Rapid-setting PCC manufactured with Type III cement and an accelerator or the proprietary product Roadpatch can be successfully used for patching PCC pavements.

Cost Analysis

Spotts (1998) reported on the cost the United States spends on fixing streets and highways. According to the American Public Works Association, each year road maintenance costs exceed $84 billion. Local governments are responsible for 74% of the nations 2.7 million miles of highways. However, they receive only 40% of the money to be spent on maintenance. It was studied that potholes should not even exist. They appear when cities defer maintenance or their highway departments fail to stay in close touch with public utilities, which fail to properly patch holes, when they carve up roadways to repair water, sewer, and gas lines. When the maintenance is poorly managed, a city's residents must pay for the mistake twice: once as taxpayers, and again as motorists, whose car repair bills can rise by as much as $2,000 a year as a result of driving over poorly maintained roads.

It was also reported that manufactures have come up with a variety of exotic materials designed to provide fast, durable patches. These materials have their uses, however effective repairs may lie less in fancy materials and more in technique. The Civil Engineering Research Foundation tested these new materials along with materials already being used. They found, that when materials are properly applied the traditional materials appeared to yield a patch as durable as the new material. It was concluded that educating crews to take the time to patch potholes properly the first time is a crucial procedure for the durability of any material.

Belisie (1997) studied the effects of the damage of potholes to motorists, and new technology to prevent reoccurring potholes. It was estimated that it costs 25 cents to run an average car over a mile of new, smooth highway. It costs 35 cents to drive the same vehicle over a mile of bumpy road. That figure did not include highway and related taxes. However, engineers have developed better methods for smooth pavement. Perhaps the most noticeable improvement in recent years has come in pothole-patching technology. Manufacturers have come up with more water resistant and better bonding materials for cold weather. The Federal Highway Administration (FHWA), as part of research program tested materials in 1,000 potholes in 1991. They found that 60 percent of those patches are still in place. Although these materials are typically two to three times more expensive, their long-term durability means crews do not have to fix the same hole repeatedly.

Darter (1985) stated the expected extension in service life of a pavement caused by the application of repair or preventative technique must be estimated before the average annual cost can be computed. The extension is the increase in life of the pavement beyond that obtained if no rehabilitation work is performed. According to Darter defining the extension life in this way is essential to ensure that the average annual cost computed is due solely to the effect of the rehabilitation technique.

After having conducted this literature search, some general conclusions can be drawn:

1. Certain procedures must be followed in order to have a good performance of partial-depth repairs.
2. Surface preparation of a pavement distress is critical for the bonding of the patching materials
3. Manufacturer recommendations must be followed to insure proper performance of the chosen material.
4. Performance testing of partial-depth patching has shown that quality materials are available for agencies to use, and results have been promising.
5. Road repairs need not be repeated frequently if performed by well-trained crews with quality patching materials.
6. New technology has shown that new materials will be able to provide a long lasting, one-time repair if done properly.
7. Life-cycle cost analysis of patching materials needs to be studied because of higher costs as compared to PCC. Therefore in determining the pavement life extension,

both the life of the individual repair and the life of the pavement shall be accounted for.

CHAPTER III

CHARACTERISTICS OF PATCHING MATERIALS AND LABORATORY TEST RESULTS

There are many types of patching materials manufactured for the repair of pavement distresses. Three major categories used for high strength and fast set criteria are; polymer concrete, elastomeric concrete, and cementitious mortar. The strength and durability are important factors contributing to the performance of the material. The strength of material not only considers its physical strength, but also its bonding to existing pavement. Durability primarily involves the fatigue life. Other factors may include the curing time, mixing, and placement of each material.

The Florida Department of Transportation (FDOT) and other agencies should recognize the suitability of the different patching materials to be used. For instance, the curing time and the material strength must work together in order for the material to reach optimal strength quickly before opening to traffic. The materials used should limit the set times to 2 to 6 hours. Mixing and placement of a material must be detailed, but kept somewhat simplified. Crews should be able to mix and place the material with limited equipment, and within a reasonable amount of time. The duration it takes for crews to place the material will effect the length of time a traffic lane will be closed. The easier, yet most reliable material manufactured is the ideal patching material for rehabilitation in today's highway system. The three types of materials used in this research project are explained individually in this chapter. The following information provides a basic definition and make-up of each material.

Polymer Concrete

Most technical people are familiar with the term plastics. It is a generic name for a wide range of organic materials which, during manufacture, can be molded into any desired shape. Polymers fall under the broad heading of plastics. Polymers are solids made up of long-chain molecules formed by joining together of simple molecules. These simple molecules are known as monomers. Many monomers are derived from hydrogen and carbons (hydrocarbons). Nearly all plastics or polymers are based on organic (carbon containing) molecules. When these relatively simple organic molecules are combined with admixtures and catalysts, a chemical reaction called polymerization occurs, resulting in a polymer or plastic (FHWA, 1986). There is no limit to the number of polymers that can be formulated by combining monomers and additives with other materials such as stone, rubber, asphalt, fibers, etc.

Polymer concrete (PC) uses a high reactive resin as the sole binder. It consists of an aggregate mixed with a monomer, and allowed to polymerize in place. It is mixed and placed by using techniques similar to those used for PCC. Polymer concrete (PC) is an excellent repair material because the strength of this material is similar to PCC. This is accomplished by manufacturers by reducing the modulus of elasticity of PC to that of

PCC (Phan, 1995). In addition, the coefficient of thermal expansion of PC may be about the same as that of PCC.

Characteristics of Polymer Concrete

(a) Rapid curing at ambient temperature of 10° to 95° F.

(b) High tensile, compressive, and flexural strengths.

(c) Good adhesion to concrete and steel surfaces.

(d) Long term durability to freeze-thaw cycling.

(e) Low permeability to water and deicing salts.

(f) Good chemical resistance.

As a result of these characteristics, polymer concrete (PC) appears suitable for use in the repair of concrete structures where traffic conditions restrict closing of the repair site to only a few hours.

Elastomeric Concrete

Elastomeric concrete was first developed in France in the early 1970's. Its primary use has been as a bridge deck joint-header material. It bonds well to both steel and concrete, therefore it is an ideal transition material from the steel armoring of an expansion joint to concrete pavements. Extensive laboratory testing of elastomeric revealed that it has exceptional high bond strength to concrete, asphalt, and steel at high and low temperatures (Watson, 1982).

Elastomeric concrete combines most of the properties of structural concrete with a rubber-like or elastomeric nature. A prospective elastomeric patching material should be able to withstand the heavy loading of traffic while at the same time being able to absorb the impact forces with little or no damage. This due in part to the high degree of similarity between the coefficient of expansion of the two concrete types. The rubber-like properties, elastomeric concrete tends to negate the effect of live load impact stresses and absorbs them like a vibration damper. Thus. It is less susceptible to cracking (Watson, 1982).

Elastomeric concrete consists of a base elastomer blended with a pre-bagged aggregate, sand, and chemical mixture. The elastomer is a two-component liquid compound, which is normally heated at the job site and then mixed with the aggregate. Normally, these compounds are proprietary materials that differ from manufacturer to manufacturer. Most of the newer elastomeric concrete need not to be heated unless a faster cure is required or unless the ambient temperature is below 50° F. Some of the characteristics of an elastomeric concrete are listed below.

Characteristics of Elastomeric Concrete

(a) Easy mixing

(b) Rapid set time

(c) Excellent bond strength to concrete and steel

(d) Excellent thermal shock and abrasion resistance

(e) Excellent impact and moisture resistance

(f) Good chemical resistance

Elastomeric concrete patching material is normally supplied as a kit of three components; Component "A", Component "B", and the ready blended aggregates. This kit of modified elastomeric compound along with aggregates can be used to repair any highway potholes, bridge decks, driveways, and parking garage decks.

The most attractive quality of elastomeric concrete is the excellent impact resistance. With its elastic behavior, an elastomeric concrete cylinder can absorb any axial and impact load. For example, a cylinder being tested during a compressive test will not fail. It absorbs the axial load and expands until the maximum capacity is reached. As a result, it is an ideal header material for an expansion joint and patching material for concrete pavement repair (Phan, 1995).

Rapid Strength Cementitious Mortar

Rapid setting mortar patch materials include rapid setting and /or high early strength materials that are manufactured today. Before specifying any of these products for use on large projects, it is recommended by Darter (1985) that their reliability be tested on an experimental basis over a minimum of two years.

Rapid strength mortars are normally a one component early high strength cementitious material. It provides versatile and durable repairs for horizontal patching, and formed vertical surfaces of any concrete structure. It has a wider temperature of application range than Type III cement mixture. It generally requires 4 to 6 hours of setting time before opening to traffic. For shallow depth repair less than 2.54 cm (1 in), water is the only other component needed for mixing. As for deeper patches; greater than 2.54 cm (1 in), an extension of aggregates can make it very economical to use.

Rapid strength mortars are recommended for many repairs; (1) highway overlays and repairs, (2) parking structure deck and ramp repairs, (3) concrete floor repairs, (4) full depth structural repairs, (5) heavy industrial repairs, (6) concrete pavement joint repairs, (7) wastewater treatment facilities, and (8) airport runways. Some of the characteristics of rapid strength mortars are listed below.

Characteristics of Rapid Strength Cementicious Mortars

(a) Excellent impact resistance

(b) High compression, flexural, and tensile strengths

(c) Fast-setting, traffic bearing in 2 to 4 hours

(d) Freeze-thaw resistant

(e) Very resistant to cracking

(f) Good bonding to existing concrete

(g) Easy mixing with water and/or aggregate

When using a proprietary patching material, the manufacturer's recommendations should be closely followed with regard to mixing , curing, and placing of the patch material. Bonding agents should be used for placement, if stated by manufacturer.

The last type of material that can be used is a fast setting Portland cement mixture. Type II/III cement patches have been in use longer than most other materials. They can be mixed with some accelerators to obtain a minimum strength of 20.68 MPa

(3,000 psi) in 24 hours. However, 24 hours of setting time is still considered a long period for closing traffic lanes. In colder regions, it will even take longer for the patching material to cure. In our research, a Type II cement mixture was used for a control section during the testing of all other materials for comparison.

Patching Material Selection

The materials selected for this research was conducted by using different means. An internet search of companies that manufactured fast-setting materials, and companies already known to produce such materials were invited to participate in the project. Materials supplied to the research test site at UCF included polymer, elastomeric, and cementitious materials. The FDOT Materials Office recommended three materials from their product list. These materials included one polymer concrete, and two cementitious materials. Since the materials had been approved by FDOT, it was decided that these three materials would only be tested with accelerated performance testing. No laboratory testing was conducted.

Table 3 shows physical properties from the materials provided by the participating manufacturers. Material specifications from the manufacturers are presented in Appendix A. In order not to identify the trade name, patching materials were labeled alphabetically from A to H. The first three, A to C, were materials recommended by FDOT. The five additional patching materials donated from manufacturers around the country were cast for composite cylinders. From these results, three product were chosen to be placed for the accelerated performance test.

TABLE 3. Compressive and Tensile Strengths of Patching Materials

Compressive Strength			
	(psi)	(MPa)	ASTM Test
Material			
A	1500 (2 HR)	10.34	C 579-82
B	6000 (24 HR)	41.37	C 109
C	6000 (24 HR)	41.37	C 191
D	1400 (2 HR)	9.65	D 695
E	2600 (3 HR)	18.2	D 695
F	N/A	N/A	N/A
G	2500 (24 HR)	17.24	C 579
H	4583 (24 HR)	31.6	C 109-85

Tensile Strength			
	(psi)	(MPa)	ASTM Test
Material			
A	900	6.21	C 307-77
B	800	5.52	C 190
C	900 (7 DAY)	6.21	C 190
D	600	4.14	N/A
E	600	4.14	D 633
F	N/A	N/A	N/A
G	N/A	N/A	N/A
H	615 (24 HR)	4.24	C 190-84

N/A means no data available

Laboratory Testing of Composite Specimens

A total of sixteen composite specimens from the donated materials were cast in cylinders for compressive testing. The purpose of this test is to simulate conditions patching materials may exhibit during pavement rehabilitation. Various composite configurations are shown in Figure 4. Due to limited materials supplied by the manufacturers and the difficulty in casting the composite specimens, it was decided to only cast 1 or 2 cylinders per configuration. A simple technique for casting composite specimens may need to be studied in the future. The cylinders were standard 152.4 mm x 304.8 mm (6 in x 12 in) size. Type I PCC was used for the concrete part. The mix design of this concrete is given in Table 4. The concrete cylinders were allowed to cure for 28 days in water baths before application of the patching materials (Photograph 2). Thereafter, the five patching materials were prepared and arbitrarily placed in the ready-formed cylinder. Photograph 3 shows the completed composite cylinders with labels for material identification.

TABLE 4. Concrete Mix Design for Composite Specimens

COMPONENT	Specific Gravity	Weight, kg (lb)
Cement Type I (AASHTO M-85)	3.15	284 (625)
Water	9.81 (62.4)	123 (270)
Coarse Aggregate (#57, S-1-A) Rinker #1041	2.42	912 (2010)
Fine Aggregate (FDOT Sand) Rinker #3156	2.6	494 (1088)

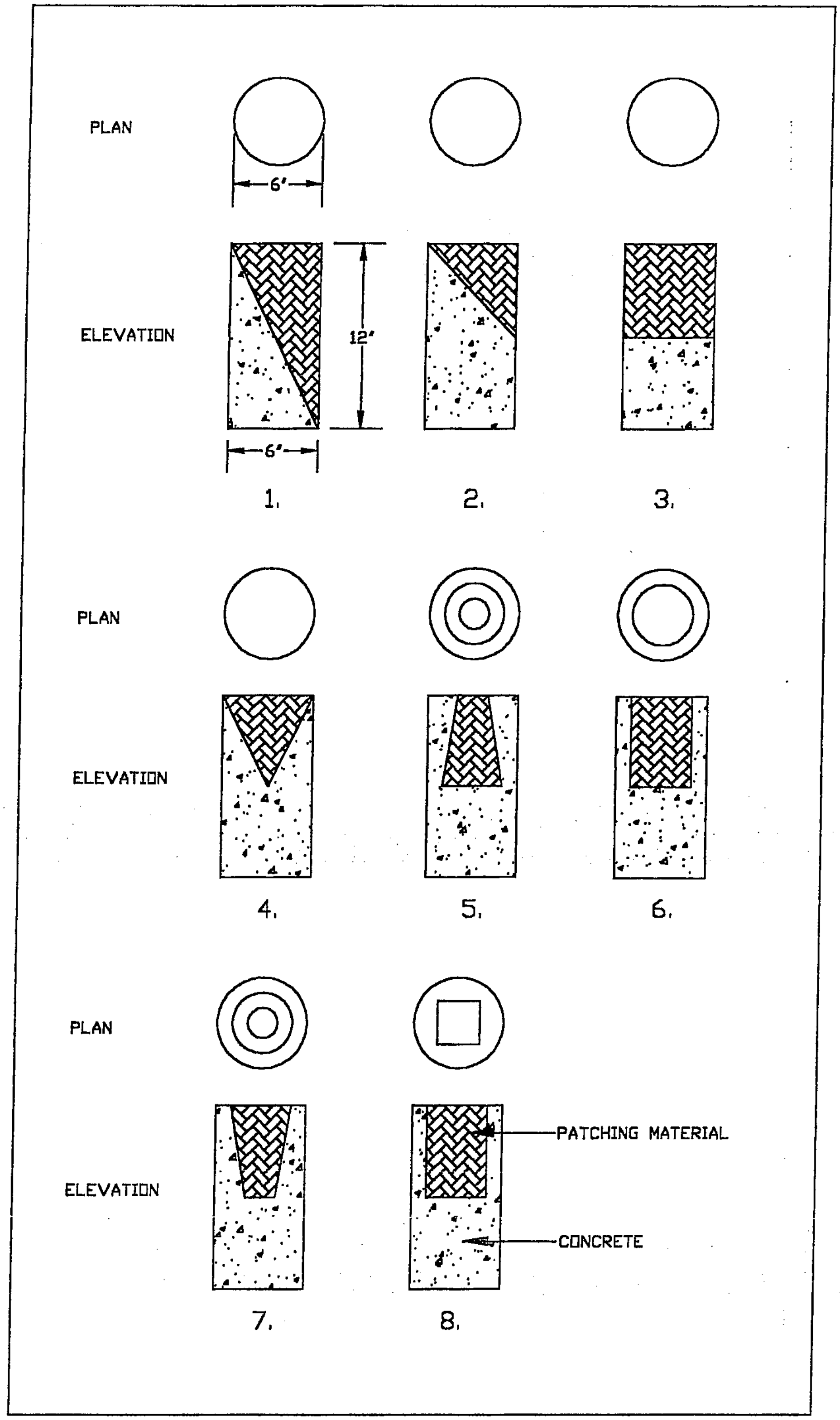
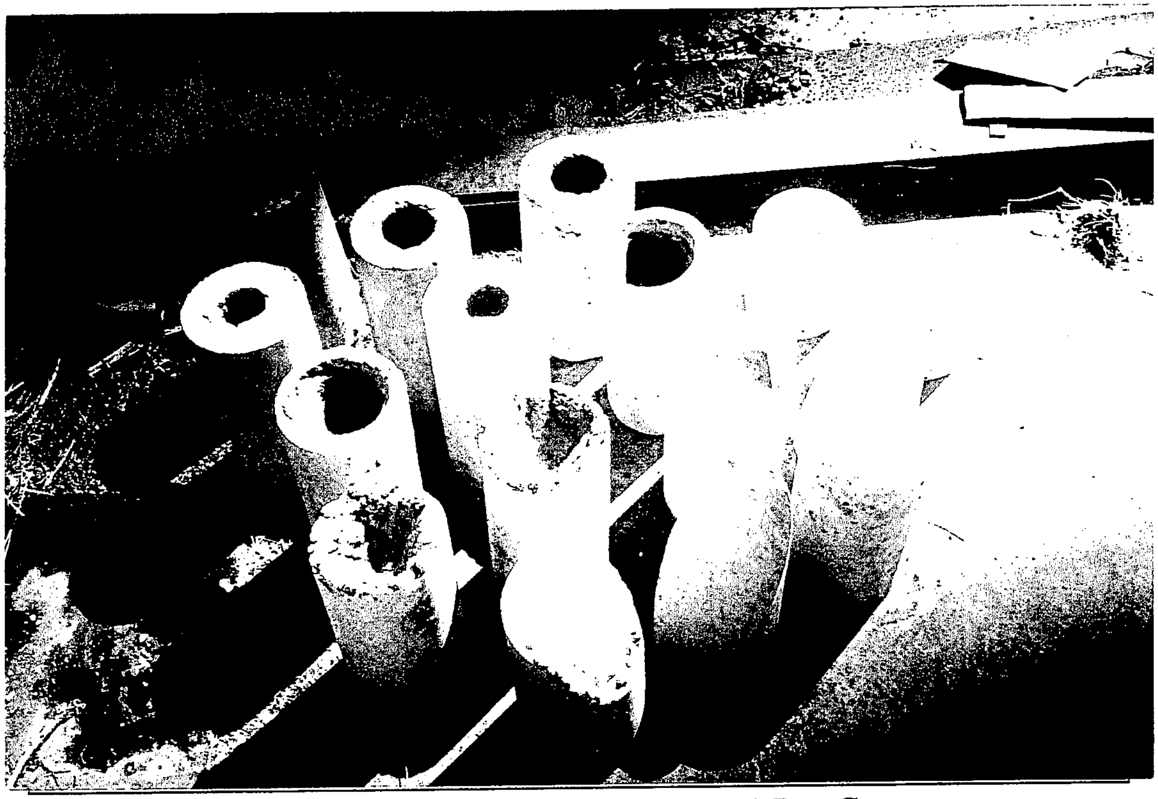


FIGURE 4. Composite Specimen Patching Configurations



PHOTOGRAPH 2. Concrete Configurations after 28 Day Cure

PHOTOGRAPH 3. Composite Specimens before Compressive Testing

Curing time for the patching material in the laboratory testing was set at 24 hours in order to match the curing time for the accelerated performance test. The shape of patching configurations were designed to simulate a likely scenario potholes and spalls may encounter on most of the concrete pavement roads. The test results from these specimens with in-depth analysis may be used by FDOT as guidelines for the preliminary selection of partial-depth patching materials in the future. A control section (Type II cement mix) selected for the accelerated performance was also tested with cylinder specimens in the laboratory. A mix design of Type II cement provided by Florida Rock Industries for the control section is shown in Table 5.

TABLE 5. Fast Set Type II Concrete Mix Design, with w/c = .34

COMPONENT	Specific Gravity	Weight, kg (lb)
Cement Type II (AASHTO M-85)	-	365 (805)
Water	9.81 (62.4)	115 (254)
Coarse Aggregate (#67)	2.43	836 (1844)
Fine Aggregate (Silica Sand)	2.63	373 (822)
Air Entrained Admixture (AASHTO M-154)	-	6.6 oz.
Other Admixture (AASHTO M-194, D)	-	40 oz.
2nd Admixture (AASHTO C-494, C)	-	384 oz.

The patching materials were alphabetically labeled on all composite specimens. Materials D, E, and G were elastomeric concrete, while materials F and H were a cementitious mix. Although duplicate configurations were made, only one cylinder was cast with each composite material. The results of the compressive strength tests are shown in Table 6. Good bonding and high compressive strength of the patching materials in composite specimens were the two criteria for selecting the materials to be later tested using UCF-CATT.

Photograph 4 presents the typical failure of the Type I control sections. Table 6 shows the average compressive strength to be 48.5 MPa (7,034 psi) for the control sections. It is imperative to say that for the composite cylinders, the aspect ratio (L/D) of the concrete part will not be equal to two as is for the ASTM standard cylinders. Therefore, the compressive strength for the composite specimens will be very difficult to predict. However, a curve showing the compressive strength versus the aspect ratio (L/D) is presented in Appendix B.

All patching configurations (PAC) numbers were taken from Figure 4. Materials D and G were both tested from PAC 1. The compressive strengths of material D and G only reached 7.32 MPa (1,061 psi) and 4.88 MPa (707 psi) respectively because of the early failure at the interface. Photographs 5 and 6 show the failure of Material D and G at the interface, indicating a possible weak bond between patching material and PCC. However, composite cylinder G (Photograph 6) shows the cracks occurring at the interface and through the PCC under the compressive test. For this specimen, it was

TABLE 6. Laboratory Compressive Strength Results

Compressive Strength Results			
Composite Specimen	**Configuration No. (From Figure 4)**	**Load kN (lbs)**	**Strength MPa (psi)**
Control Section (Type I Cement) 28-day cure	-	874 (196,500)	47.9 (6,950)
	-	912 (205,000)	50.0 (7,250)
	-	867 (195,000)	47.6 (6,897)
D	1	133 (30,000)	7.32 (1,061)
	5	191 (43,000)	10.5 (1,521)
	8	189 (42,500)	10.4 (1,503)
E	4	534 (120,000)	29.3 (4,244)
	6	478(107,500)	26.2 (3,802)
	8	334 (75,000)	18.3 (2,653)
F	2	156 (35,000)	8.53 (1,238)
	6	698 (157,000)	38.3 (5,553)
G	1	89 (20,000)	4.88 (707)
	3	300 (67,500)	16.5 (2,387)
H	4	423 (95,000)	23.2 (3,360)
	6	778 (175,000)	42.7 (6,189)
	7	756 (170,000)	41.5 (6,013)
Control Section (Type II Cement) 1-day cure	-	945 (212,000)	51.7 (7,498)
	-	923 (207,500)	50.6 (7,339)

PHOTOGRAPH 4. 28-Day Failure of Control Sections

PHOTOGRAPH 5. Bonding Failure at Interface for PAC 1 and Material D

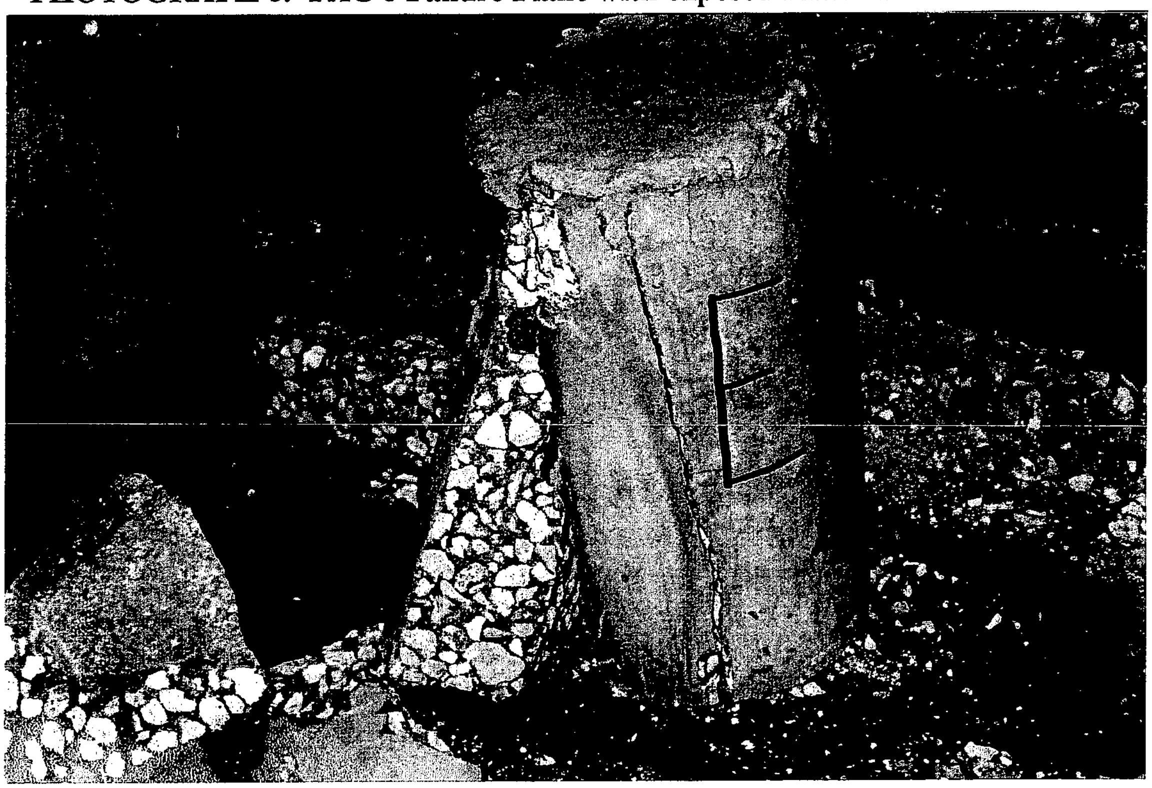
PHOTOGRAPH 6. Bonding and Fracture Failure for PAC 1 and Material G

obvious that the patching material could sustain a higher load than the PCC, but was still weak in bonding.

Material D was also tested on PAC 5 and 8. Photographs 7 and 8 show an interesting fracture of the concrete, but the concrete portion surrounding the patching material remained in its cylinder shape. The compressive strength of both specimens only reached approximately 10.3 MPa (1,500 psi). This may be due to the higher aspect ratio of PCC while the patching material was confined by the concrete. According to Mohr's failure theory, the material can sustain a higher load with application of a confining pressure. This may be the reason why the concrete failed before the patching materials. However, it is difficult to measure the magnitude of the confining pressure for patching configurations. Three other composite samples were tested with material E from PAC's 4, 6, and 8. The compressive strength of composite cylinders was 29.3 MPa (4,244 psi), 26.2 (3,802 psi), and 18.3 MPa (2,653 psi) respectively. As seen in Photographs 9 through 11, the fractures took place along the composite specimen. Since PAC 4, 6, and 8 were partially filled with patching material E, no de-bonding was permitted. A confining pressure contributed by the surrounding concrete may have increased the failure strength of the patching materials. Therefore the fracture would take place in the PCC and not in the patching material. PAC 4, 6, and 8 demonstrated this actually happening. The test further hinted that the high strength patching material could simply fill a typical shaped pothole without worrying about de-bonding.

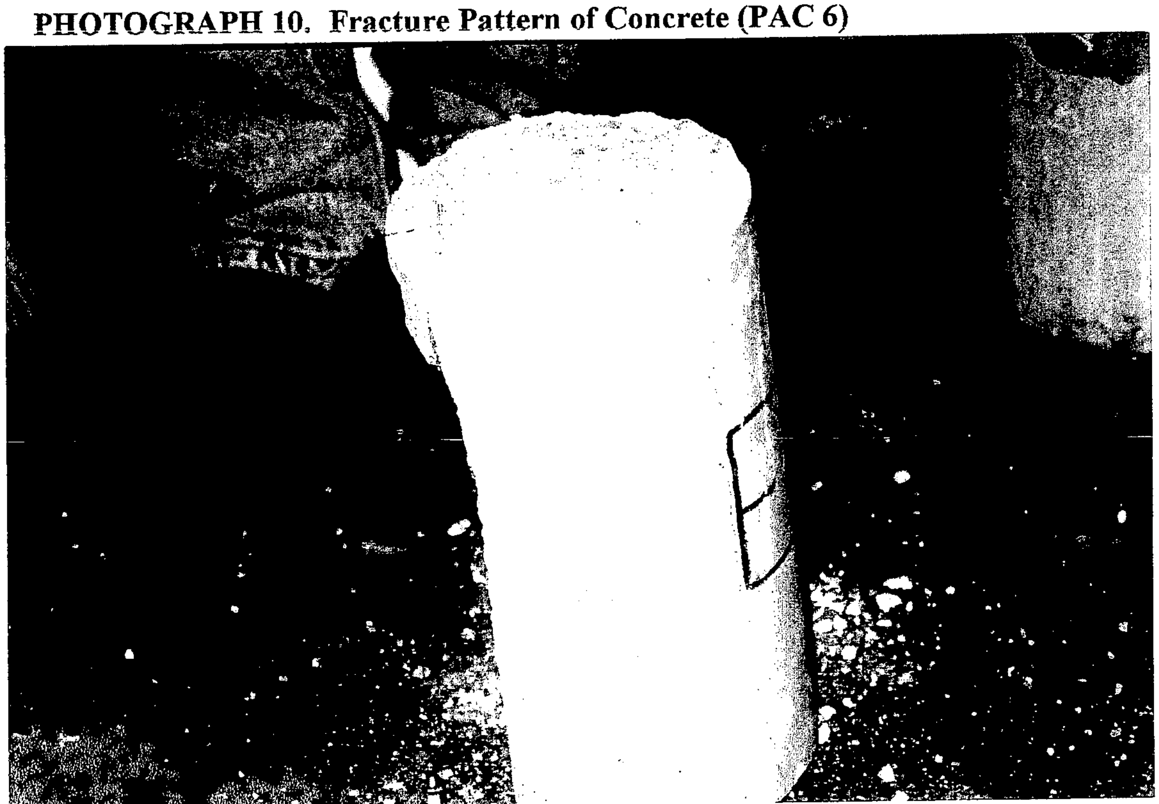
PHOTOGRAPH 7. Complete Fracture of Concrete below Material D (PAC 5)

PHOTOGRAPH 8. PAC 8 Failure Plane with exposed Material



PHOTOGRAPH 9. Fracture Pattern of Concrete (PAC 4)

PHOTOGRAPH 10. Fracture Pattern of Concrete (PAC 6)



PHOTOGRAPH 11. Fracture Pattern of Concrete (PAC 8)

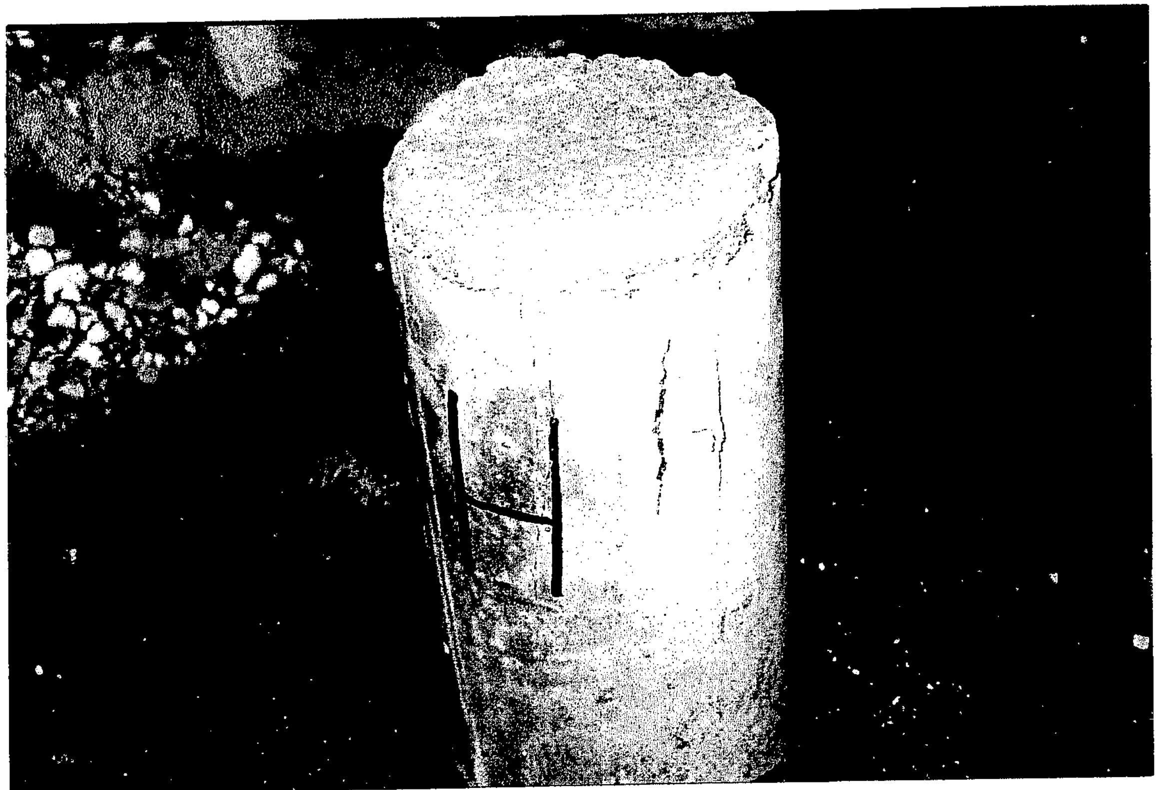
PAC 2 and 6 cylinders were cast with material F. The compressive strength was 8.53 MPa (1,238 psi) and 38.3 MPa (5,553 psi) respectively. PAC 2, as seen in Photograph 12 clearly failed in bonding, which resulted in a low compressive strength. Photograph 13 shows that the entire specimen fractured through patching material F and the PCC. This occurrence is evident because of the higher compressive strength of 38.3 MPa (5,553 psi). This material certainly would not be chosen for the accelerated performance test due to its poor bonding characteristics although it had a relatively high compressive strength. Material G was tested with PAC 1 and 3 cylinders. PAC 1 failed in boding quickly at a very low compressive strength. For PAC 3, the aspect ratio was approximately 1 for the PCC. However, the compressive strength only reached 16.5 MPa (2,387 psi) when the concrete cracked. The strength is expected to be much higher when referring to the figure in Appendix B. Due to this result, it is recommended that more samples be cast and tested in the future. Photograph 14 clearly shows the fractures only occurred on the PCC underneath the patching material. Three composite specimens were cast with material H, in PAC's 4, 6, and 7 cylinders for compressive tests. The compressive strength reached approximately 41.4MPa (6,000 psi) for PAC's 6 and 7, closely achieving the compressive strength of the control sections. However, PAC 4 only sustained a compressive strength of 23.2 MPa (3,360 psi). The lower compressive strength may be attributed to the conical shaped composite specimen, which allowed the higher strength patching material due to the confining pressure to wedge into the lower strength PCC causing failure in the PCC. Photographs 15 and 16 show the interesting fracture patterns of the laboratory samples. The final compressive tests were conducted

PHOTOGRAPH 12. Complete Fracture of Material and Concrete (PAC 2)

PHOTOGRAPH 13. Complete Fracture of Material and Concrete (PAC 6)

PHOTOGRAPH 14. Fracture on Concrete below Material (PAC 3)

on the fast-set Type II cement mix (Table 5). As previously mentioned the Type II cement mix was used for the control section during the accelerated performance testing. The two cylindrical specimens were allowed to cure for only 24-hours. Yet, the average compressive strength for the Type II cement mix was 51.2 MPa (7,419 psi). As seen in Photograph 17, typical failure of the specimen is shown.



PHOTOGRAPH 15. Failure of Composite Specimen H (PAC 4)

PHOTOGRAPH 16. Complete Fracture of Concrete (PAC 7)

PHOTOGRAPH 17. Failure of Type II Cement Control Section

The results from the laboratory compressive tests are experimental data and must be more carefully analyzed to adopt guidelines. A large number of sample testing may be needed for future research in order to qualify material based on their specifications. By carefully examining the test results of each specimen's compressive strength, it was concluded that materials D, E, and H were the best for further investigation. Along with the three FDOT products and the Type II fast-set cement mix, there were a total of seven materials placed on the UCF test track for accelerated performance testing

CHAPTER IV

TEST FACILITY AND MATERIAL PREPARATION

The objective of this research was to investigate and to evaluate various fast-setting patching materials for repair of potholes formed on concrete pavements using experimental testing. The following sections describe the test facility and the process of preparing the distresses for the testing.

UCF-CATT TEST FACILITY

The UCF-CATT was funded by FDOT in 1989 to design a test facility to test all the bridge expansion joints used in Florida bridges. As seen in Figure 5 (Bergeson, 1990), the testing machine is 15.2 meters (50 ft) in diameter to the centerline of a 1.83 meter (6 ft) wide concrete pavement slab that was designed to accommodate a dual wheel assembly consisting of half an axle. The track is divided into two halves, which are separated by two bridge sections that span a length of 3.7 meters (12 ft). The bridges, which are diametrically opposed to have been denoted as "near bridge" and "far bridge" in Figure 6, are 1.8 meters (6 ft) wide and 20.3 cm (8 in) thick. Each bridge is supported by 8 columns which are 929 cm^2 (1 ft^2) by 61 cm (2 ft) long.

The testing apparatus is powered by a 164 kilowatt (220 horsepower) diesel engine. The engine is connected to a variable displacement hydraulic pump, which carries hydraulic fluid to a swivel joint mounted on top of the machine central support. This swivel joint then distributes the fluid to three 44.7 kilowatt (60 horsepower) hydraulic motors which deliver power through a planetary gear speed reducer to the dual-wheel assemblies mounted on tractor drive axles with a capacity to handle up to 133.5 kN (30,000 lbs). The hydraulic transmission provides up to 43.3 kilometers per hour (30 mi/hr) of rotational speed in either clockwise or counter-clockwise direction.

The test machine has three sets of dual truck wheels that travel around in a circular path guided by radial arms. Each arm is a 7.6 meter (25 ft) W36 x 150 I-beam anchored to the center support pivot at 120 degree intervals. The center support and bearing assembly were designed to hold the entire system in place while allowing the machine vertical flotation and small angular movements. This permits a variance in the tracks surface grade (Duxbury, 1997).

The loading on the dual-wheel assemblies is created by a 28.49 m^3 (7,500 gallon) water tank, 3.7 meters (12 ft) in diameter by 2.4 meters (8 ft) high plus the weight of the structural members. The tank is placed on top of the center support, supported by the I-beams. Depending on the water level in the tank, the total load of the structural weight and filled water tank can vary between 133.5 kN (30,000 lbs) and 356 kN (80,000 lbs). This load is evenly distributed to the three dual-wheel assemblies. This facility, which was illustrated in Photograph 1, has been used to test large-scale bridge expansion joints, experimental pavements, and patching materials since 1990.

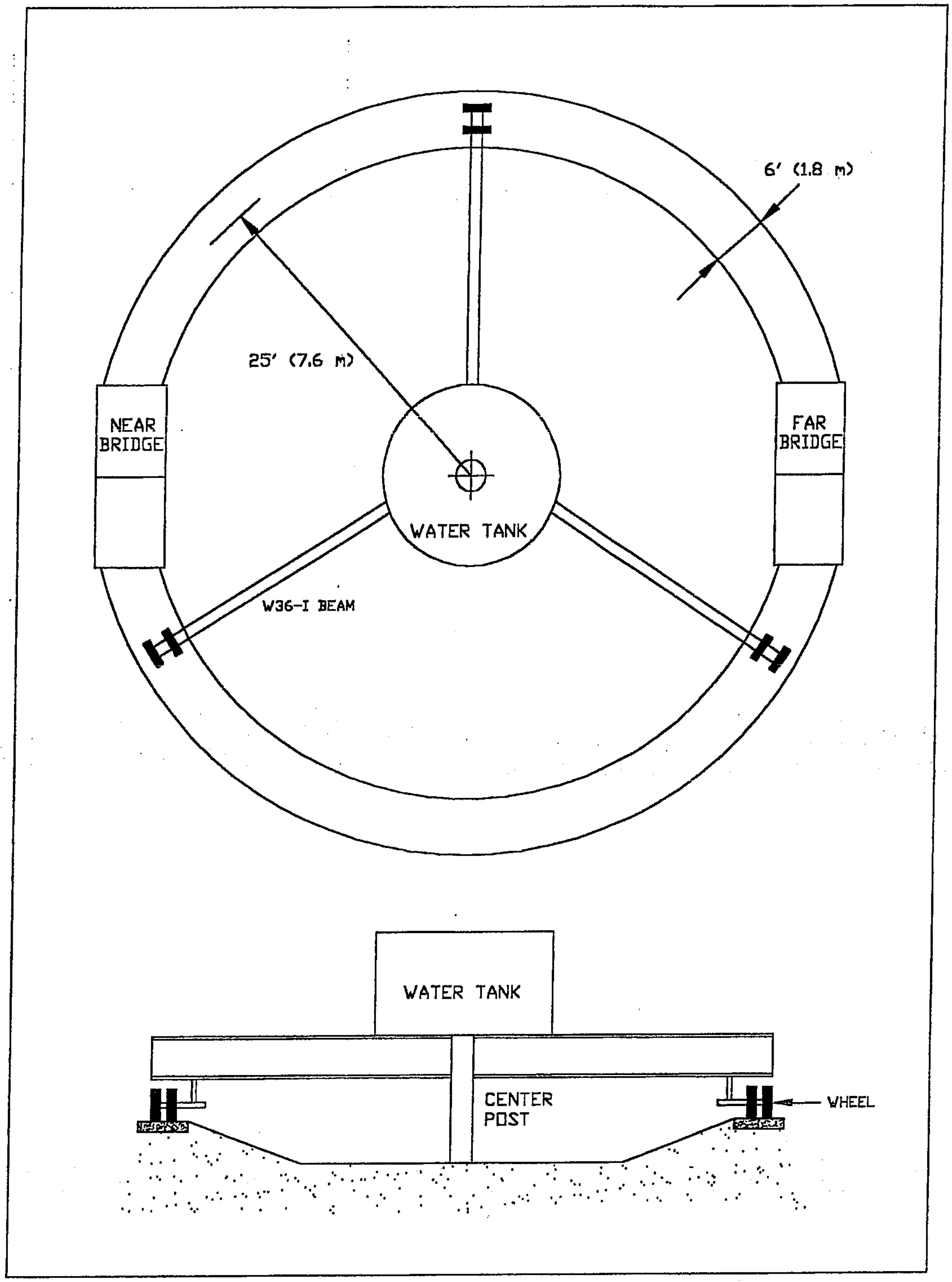


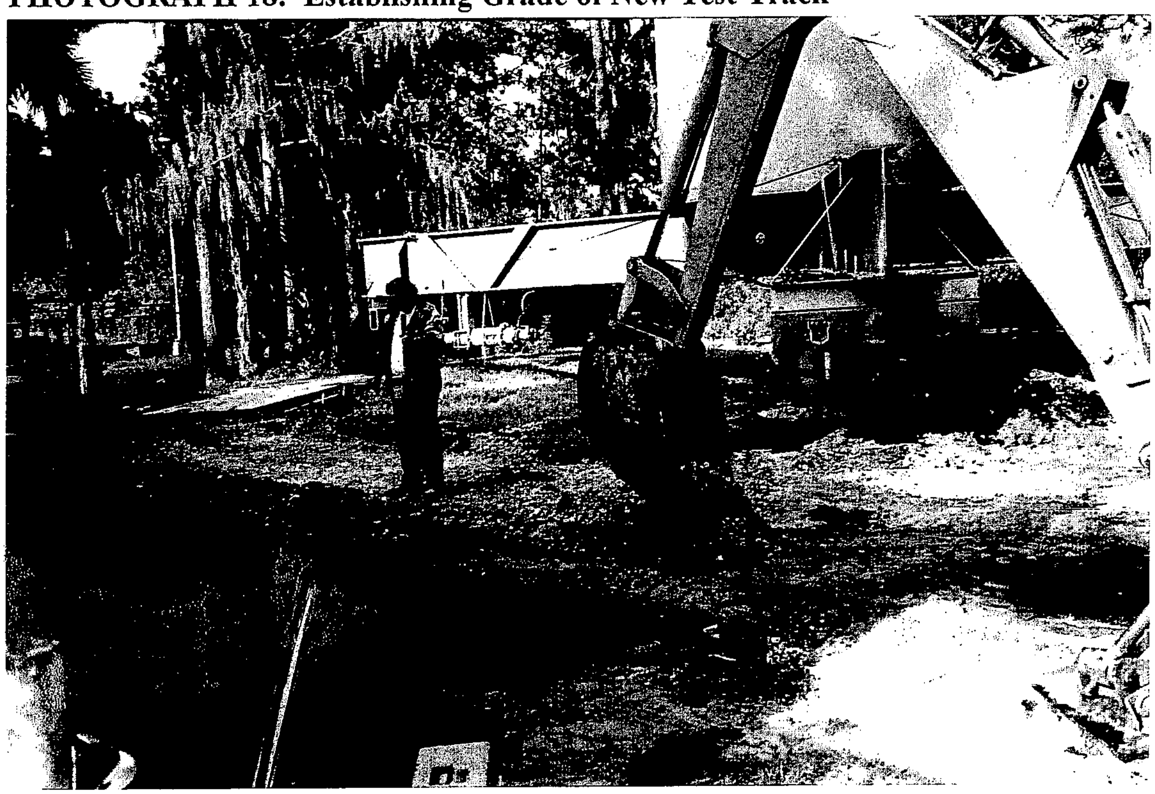
FIGURE 5. UCF Circular Accelerated Test Track

Artificial Pothole Construction

Figure 6 illustrates the new test track with pothole layouts. Half of the track was employed to test the performance of patching materials for pothole distresses. It was proposed to have fourteen such potholes to be used in the accelerated performance test. Three different pothole sizes were created: seven 30.48 cm x 30.48 cm x 12.7 cm (1 ft x 1 ft x 5 in) (Detail 1), seven 60.96 cm x 30.48 cm x 12.7 cm (2 ft x 1 ft x 5in) (Detail 2), and two feathered edged 30.48 cm x 30.48 cm x 12.7 cm (1 ft x 1 ft x 5 in) (Detail 3). As stated earlier, the other half of the test track was still being tested from a previous project.

The concrete pavement was constructed to a 25.4 cm (10 in) in thickness for artificial pothole creation. After the HMA from the previous project was removed, the contractor used the backhoe for getting the base to the appropriate grade for concrete pavement placement, as can be seen in Photograph 18.

PHOTOGRAPH 18. Establishing Grade of New Test Track



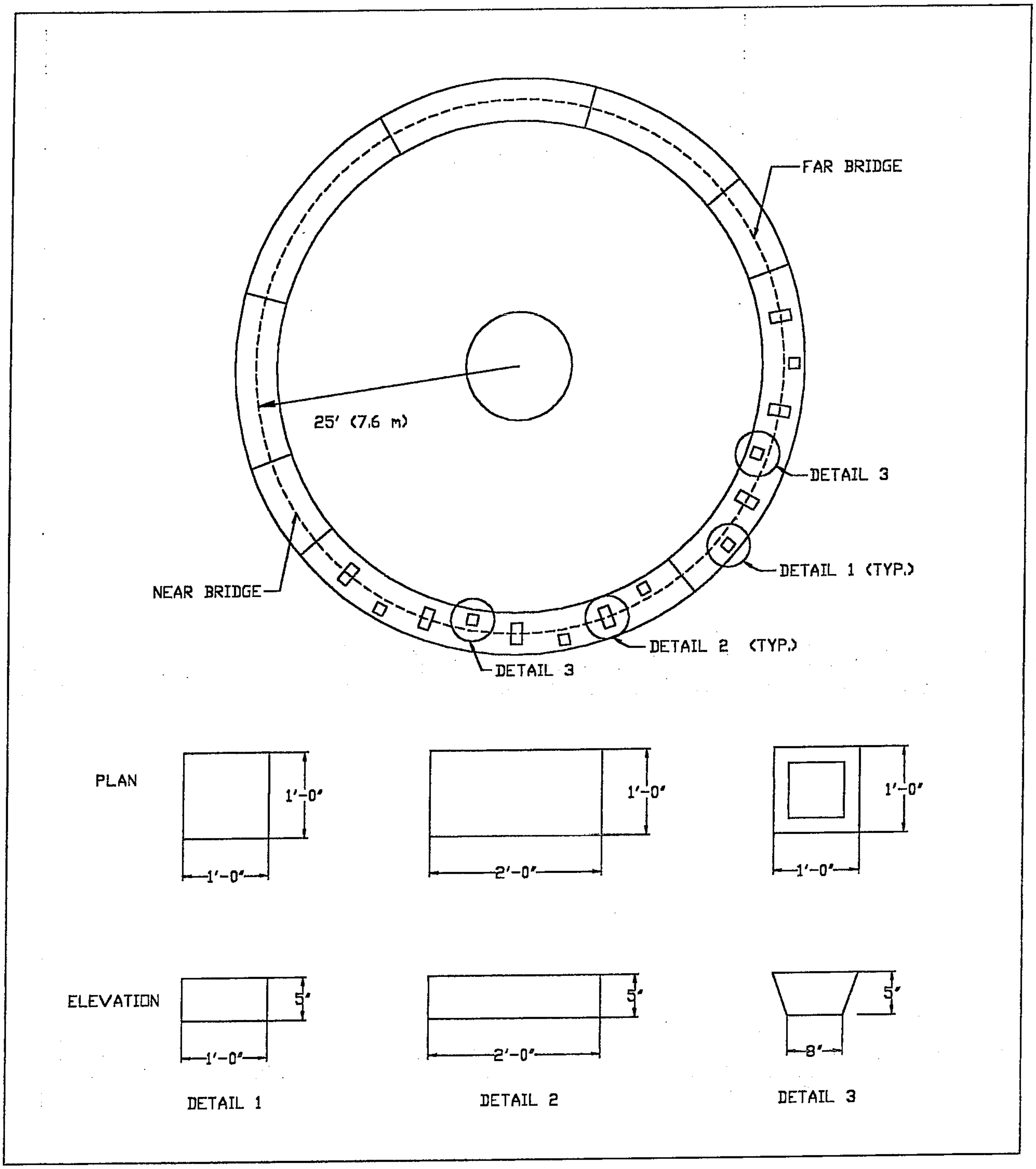


FIGURE 6. Pothole Layout

Base Compaction

The base materials were parts of virgin and recycled aggregate, constructed in a previous project (Duxbury, 1997). It was decided that the existing base materials would be sufficient for the new test track. However, after removing the HMA, the top portion of aggregates were disturbed by the backhoe, thus further compaction was needed for the existing aggregate base. Hunter Concrete Contractor used a 454 kg (1000 lb) vibrating compactor (Photograph 19) to compact the virgin and recycled aggregate bases. Once the material was compacted, the placement of the new concrete slab followed.

PHOTOGRAPH 19. Compaction of Base Material

Placement of Artificial Potholes and Spalls

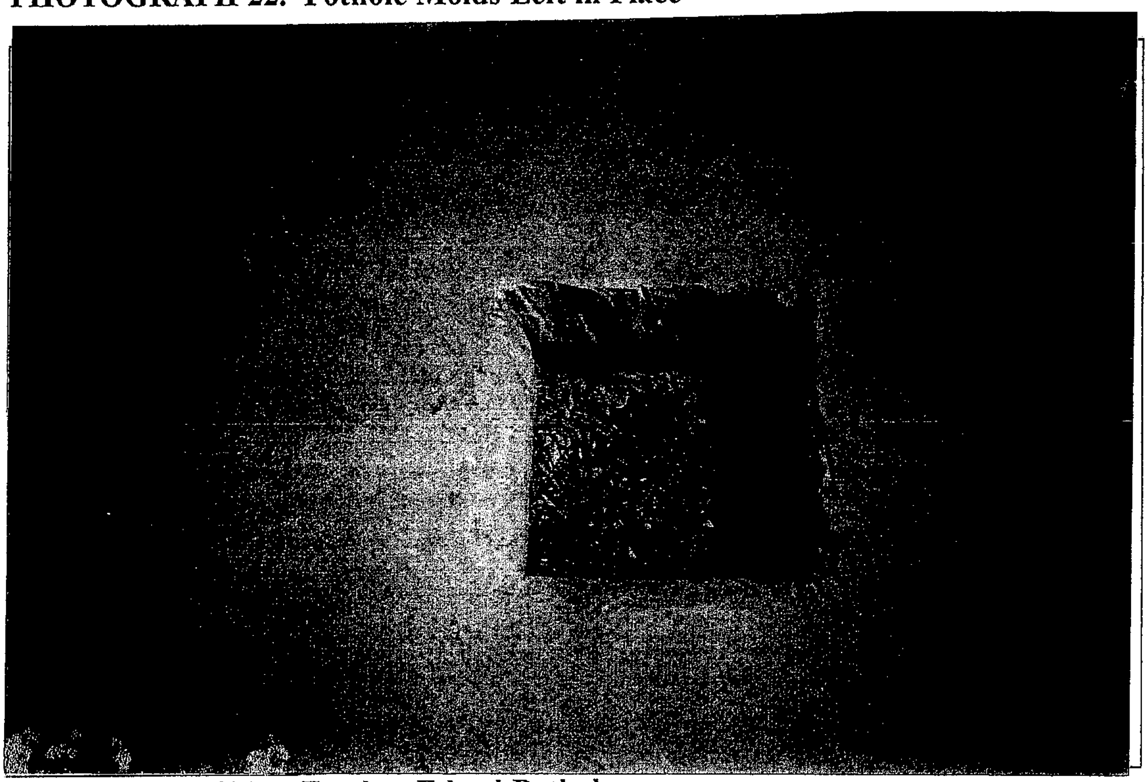
To construct the different configurations of potholes, 2.54 cm x 15.24 cm (1 in x 6 in) pressure treated lumber was used to form the molds. The molds were constructed prior to the pour of the concrete on the test track. The box and rectangular molds were then toe-nailed to 5.1 cm x 25.4 cm (2 in x 10 in) lumber panels that spanned the 1.83 m (6 ft) width of the test track. This was done to stabilize the molds when the concrete was poured (Photograph 20). Two joint spalls were created on opposing sides under the different wheel paths. The concrete pavement was chipped with hammer and chisel to create the spalls. The spalls were approximately 11" x 5" x 1.5" in size (Photograph 24).

PHOTOGRAPH 20. Pothole Construction during Concrete Pour

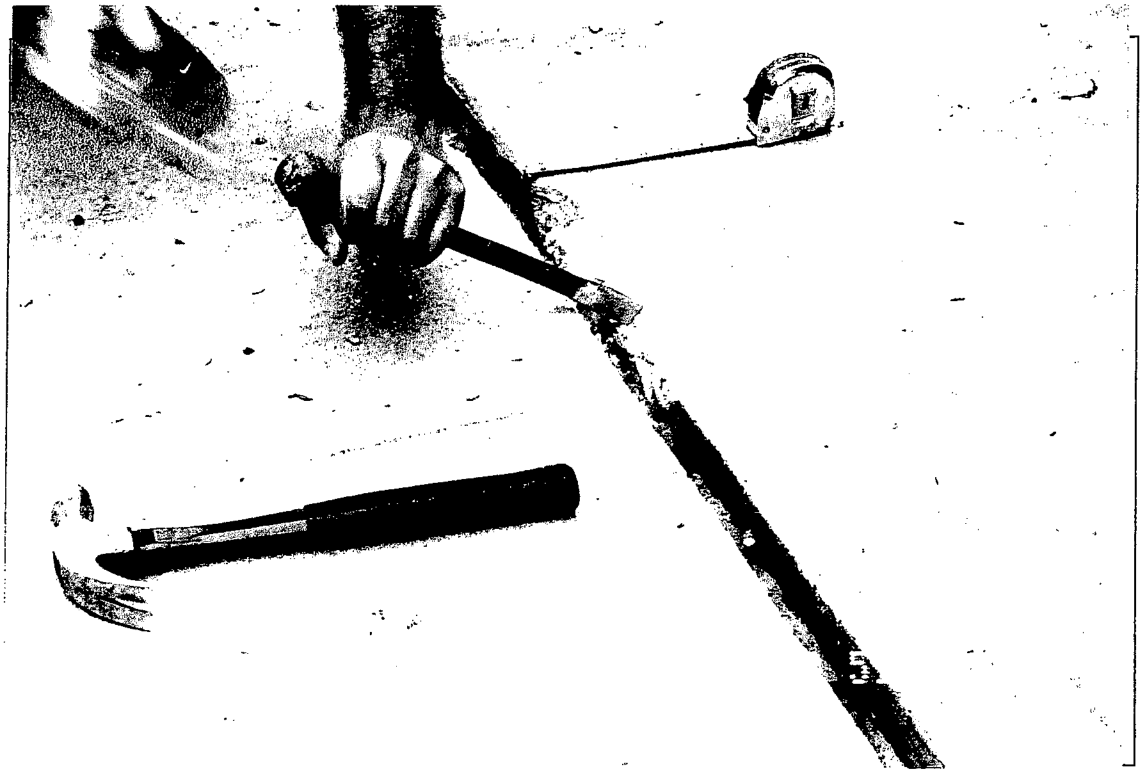
PHOTOGRAPH 21. Concrete Being Removed from Pothole Molds

CSR Rinker Concrete supplied 34.47 MPa (5,000 psi) concrete mix for the formation of the new test track. The potholes were placed approximately .76 m (2.5 ft) apart. Photograph 21 shows the process of the concrete being excavated from the pothole molds. The empty form was then left inside the concrete (Photograph 22) until the next day, when the forms were removed and application of patching materials could begin.

PHOTOGRAPH 22. Pothole Molds Left in Place



PHOTOGRAPH 23. Feather Edged Pothole



PHOTOGRAPH 24. Chipping to Create Joint Spall

PHOTOGRAPH 25. Spall Patching Placement

The finished concrete surface was treated with a curing compound. The concrete pavement was then allowed to cure for 14 days before any fast-setting patching materials were applied to the artificial potholes. Patching materials were selected from the laboratory results discussed in Chapter III. Each material was placed in two of the pothole molds as seen in Detail 1 and Detail 2 in Figure 6. The purpose of placing the same material in two different potholes was that one pothole (Detail 1) is place under a single tire, while the other pothole (Detail 2) is under the dual tire. The single wheel load applied at the boundary of the pothole may cause the edge of the patching to detach, while the dual wheel load applied along the whole patching area may cause a higher displacement. Figure 7 illustrates where the wheel loads were applied in relation to the potholes. For experimental purposes, it was decided that two molds (Detail 3) would have feathered edges, simulating a real highway condition (Photograph 23). Material H and the fast-setting Type II cement (control section) were placed in these two potholes.

Material H and the control section were also placed in the 60.96 cm x 30.48 cm x 12.7 cm (2 ft x 1 ft x 5in) molds. Each of the remaining materials labeled: A, B, C, D, and E, would be subjected to both of the constructed pothole sizes. Material G was placed in one of the joint spalls while Material B was placed in the other spall. Material preparation and placement of the spall is shown in Photograph 25.

Application of Patching Materials

Manufacturer's mixing procedures were strictly followed when applying the materials to the pre-formed artificial potholes on the test track. For instance, if a bonding agent was specifically required before placing the mixed material, the procedures on the application of the bonding agent on the pre-cleaned distress surface was followed. Also, the use of cementitious materials called for an addition of 9.53 mm (3/4 in) clean aggregate. This was necessary for patches that were greater than 2.54 cm (1 in) in depth. Since the patches were 15.24 cm (6 in) deep in this project, cementitious materials B, C, and H required the use of 9.53 mm (3/8 in) clean aggregate.

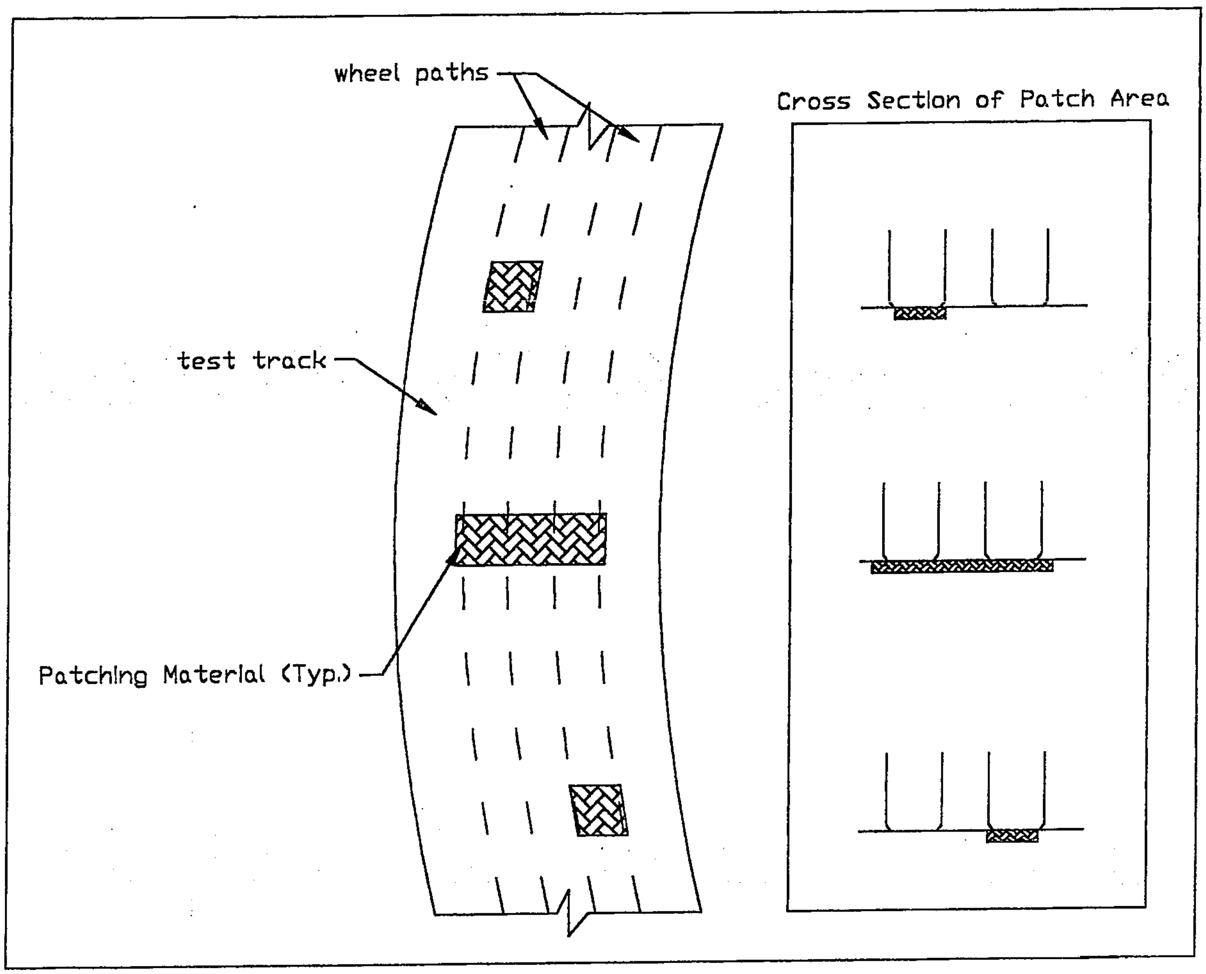


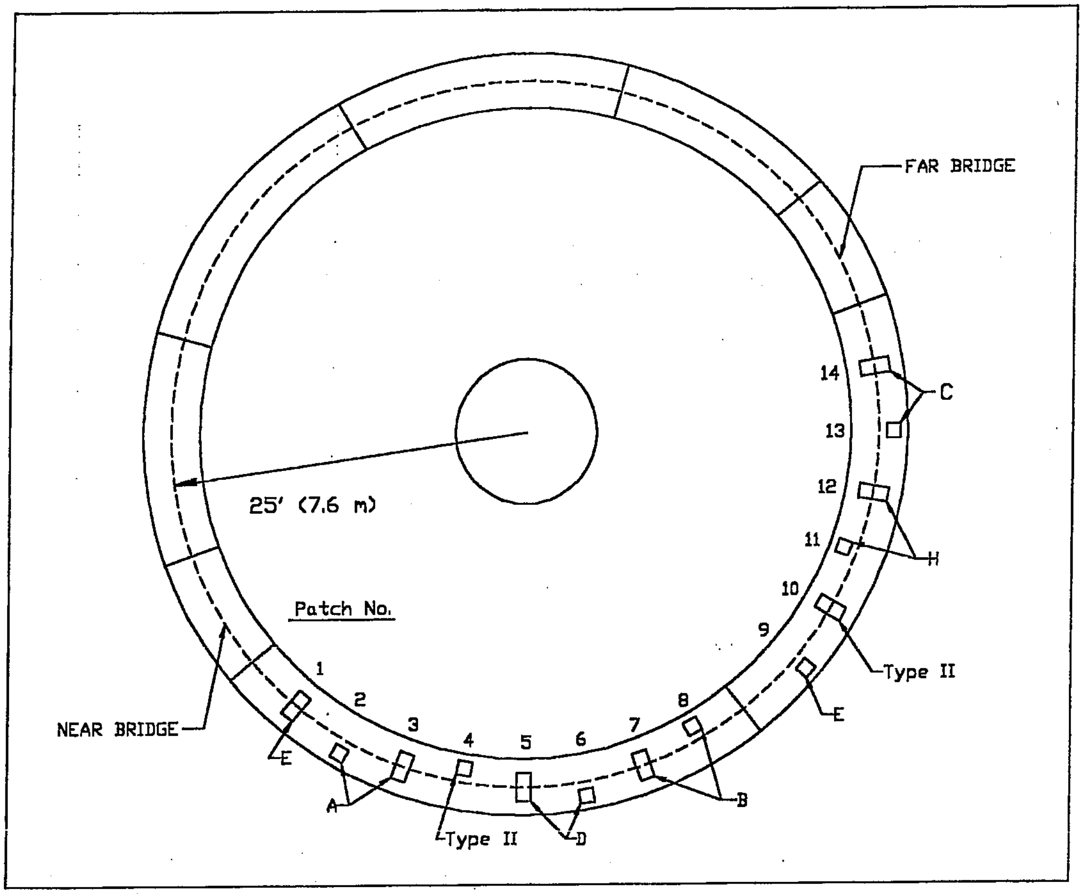
FIGURE 7. Typical Location of Patching Materials on Test Track

The placement of the patching materials onto the pre-formed potholes was not an easy task for this project. Leveling the materials with the track surface became somewhat difficult with the cementitious materials and the control section. The addition of 6.8 kg (15 lb) to 11.3 kg (25 lb) of aggregate to the cementitious materials made for a fairly dry mix. As discussed in Chapter III, the mix design for the fast-setting Type II cement required a 67-stone aggregate, thus the control section with became particularly difficult to place and finish properly. The volume of the aggregate also became a hindrance when leveling the patching material to the surface of the test track. Photographs 26 through 31 show some of the procedures on material placement, trowel finishing, and bonding agent application, while Figure 8 shows the final placement and characteristics of the patching materials selected.

Investigation of Joint Noise Reduction

Saw cuts were made on the existing concrete pavement to create a joint for the noise reduction experiment. The joint was cut to a depth of 10.2 cm (4"), with a width of approximately 3.81 cm (1.5"). A 3.81 cm (1.5") diameter backer-rod was inserted in the joint before Sikaflex 15LM material was placed over the backer-rod (Photograph 32). The material has been used for joint fillers as recommended by Coastal Construction Products, Inc. Many materials were investigated for the joint noise reduction, however most materials have no strength for the wheel load resistance.

An Octave Band Real-Time Analyzer was used to measure the decibel levels while the wheels passed across the joint (Photographs 33 and 34). A microphone was placed on the test track to record the decibel levels. The collected data could be compared with and without material being placed in the joint (Photograph 35).



Material Type	Property	Mixing Procedure	Workability	Aggregate Additives	Curing Time
A	Polymer	moderate	moderate	pre-packaged	2-4 HRS
B	Cementitious	easy	moderate	3/8" clean	2 HR
C	Cementitious	easy	moderate	3/8" clean	4 HR
D	Elastomeric	easy	easy	pre-packaged	4 HR
E	Elastomeric	moderate	moderate	pre-packaged	4 HR
H	Cementitious	easy	moderate	3/8" clean	2 HR
Control Section	Type II (PCC)	hard	difficult	57 stone	24 HR

FIGURE 8. Placement and Characteristics of Selected Patching Materials

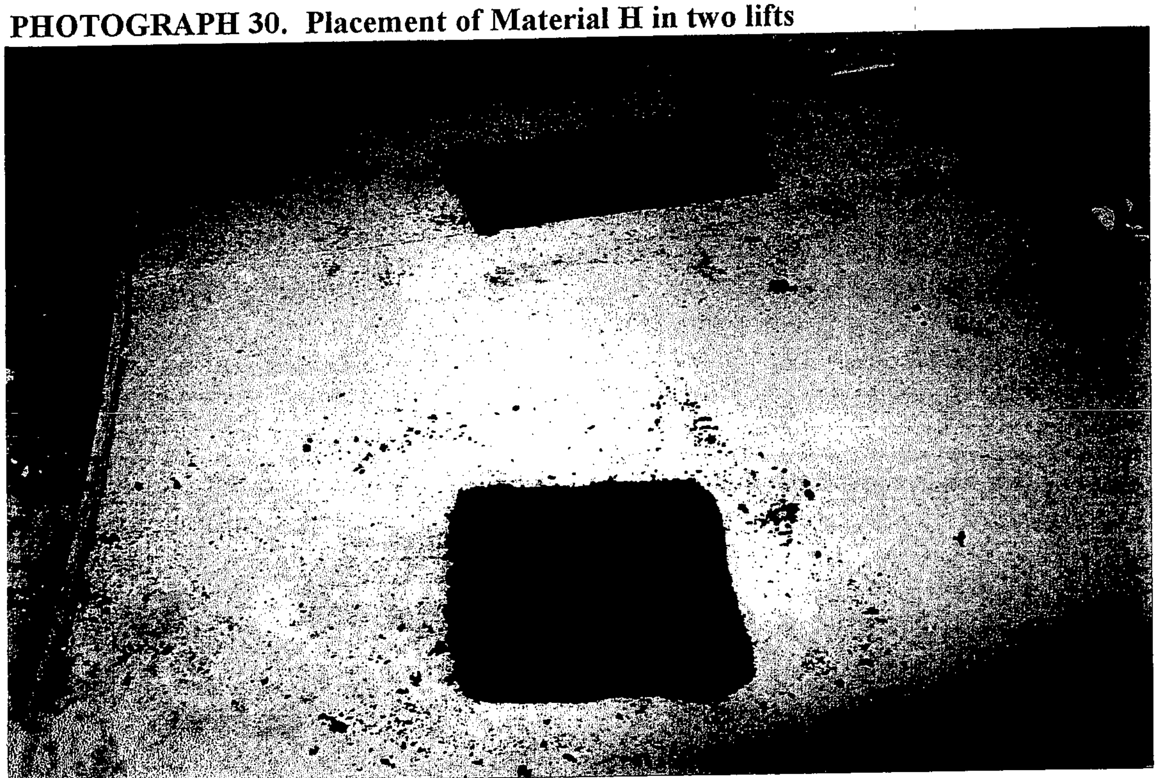
PHOTOGRAPH 26. Placement of Material A into Pothole

PHOTOGRAPH 27. Leveling Material A with Trowel

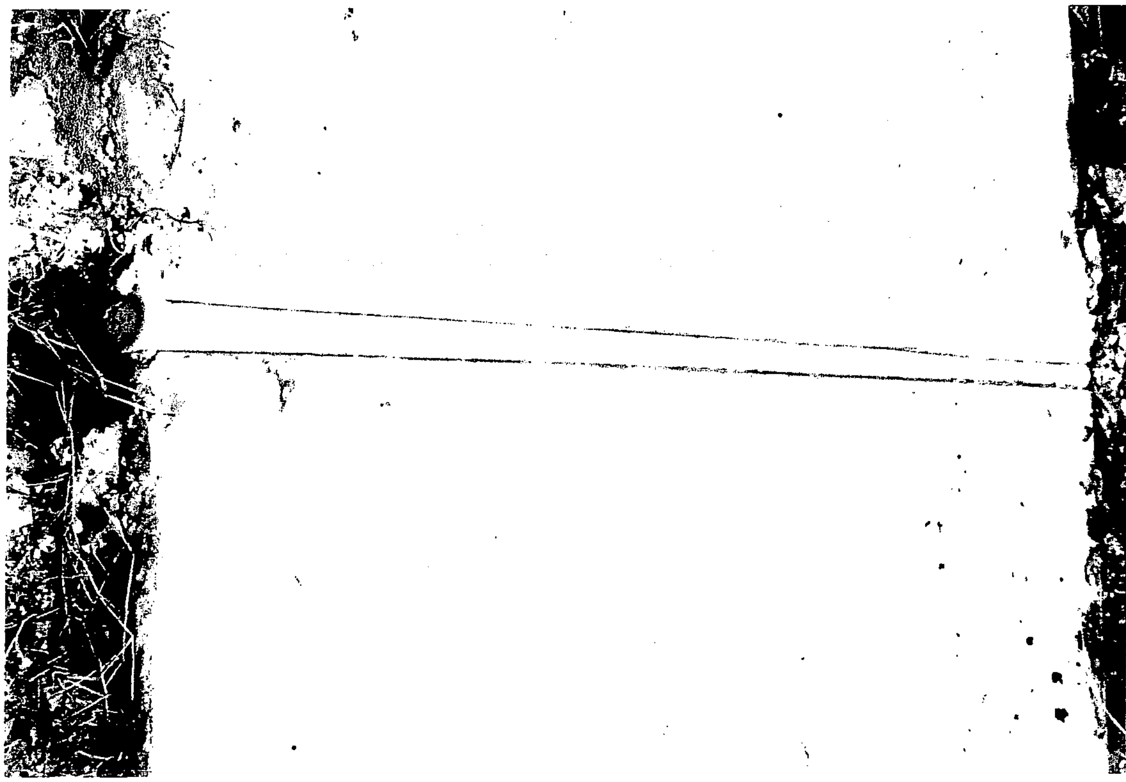
PHOTOGRAPH 28. Placement of Material B

PHOTOGRAPH 29. Placing Material E with Bonding Agent Adhered to Sides

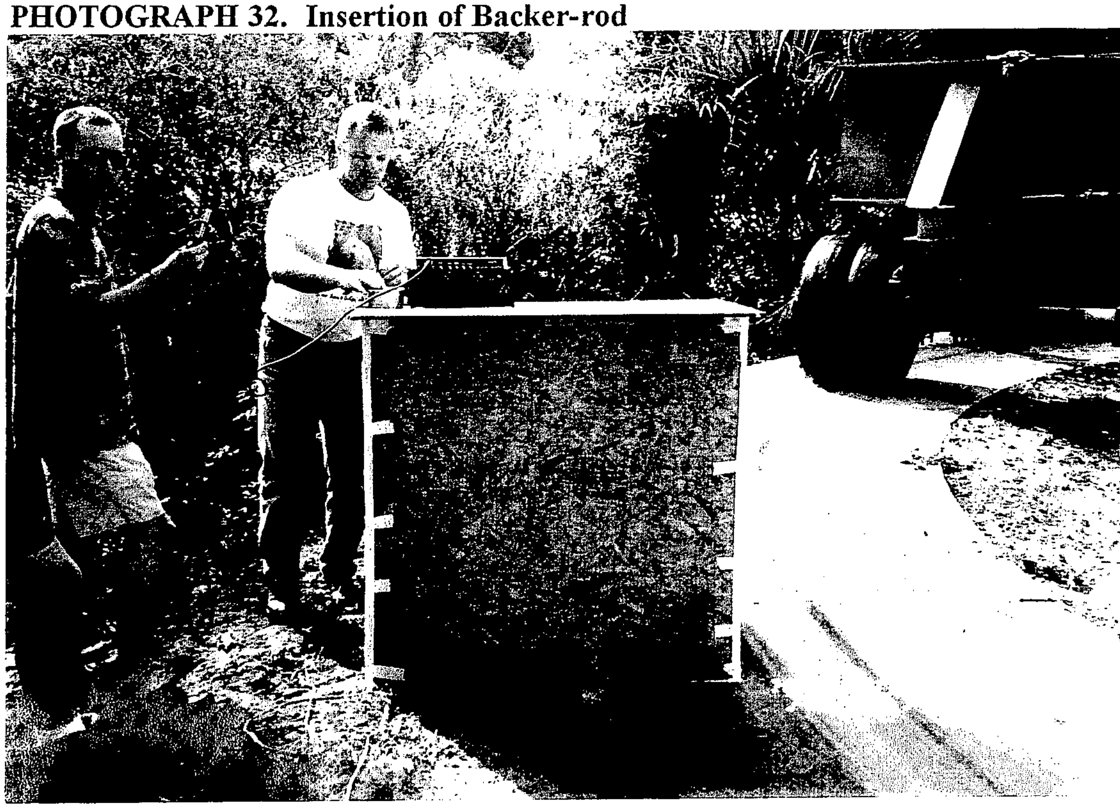
PHOTOGRAPH 30. Placement of Material H in two lifts



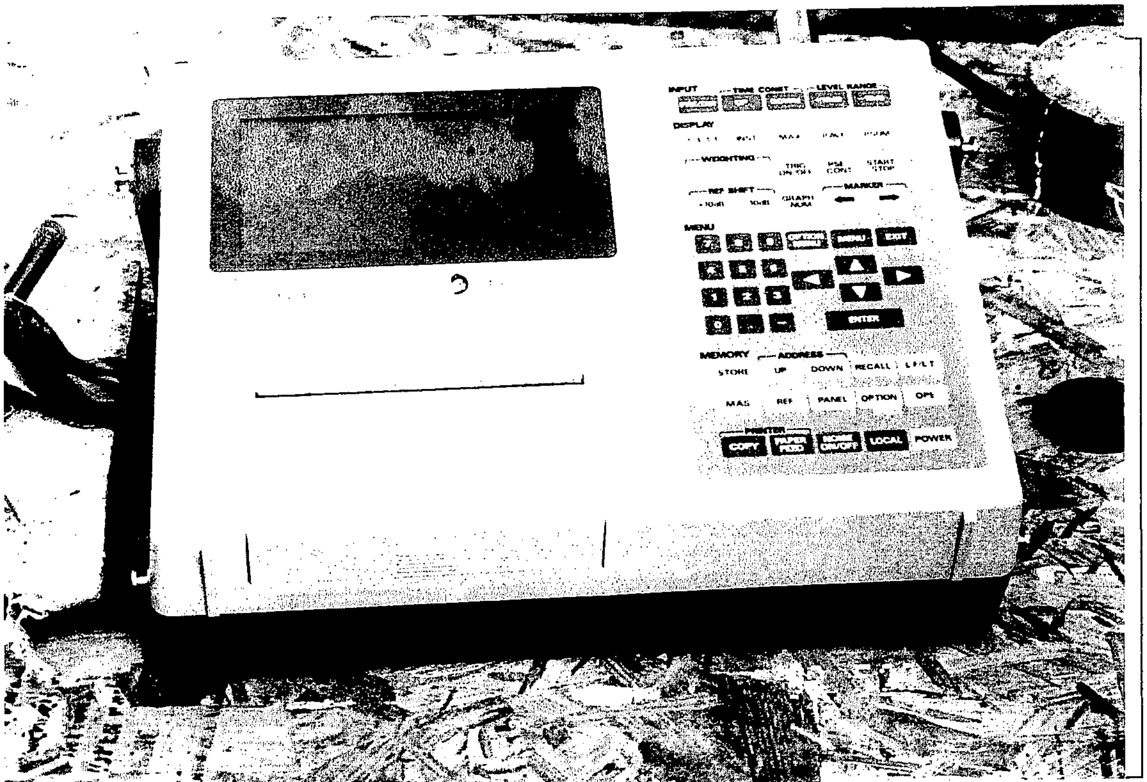
PHOTOGRAPH 31. Sample of Finished and Leveled Material (H)



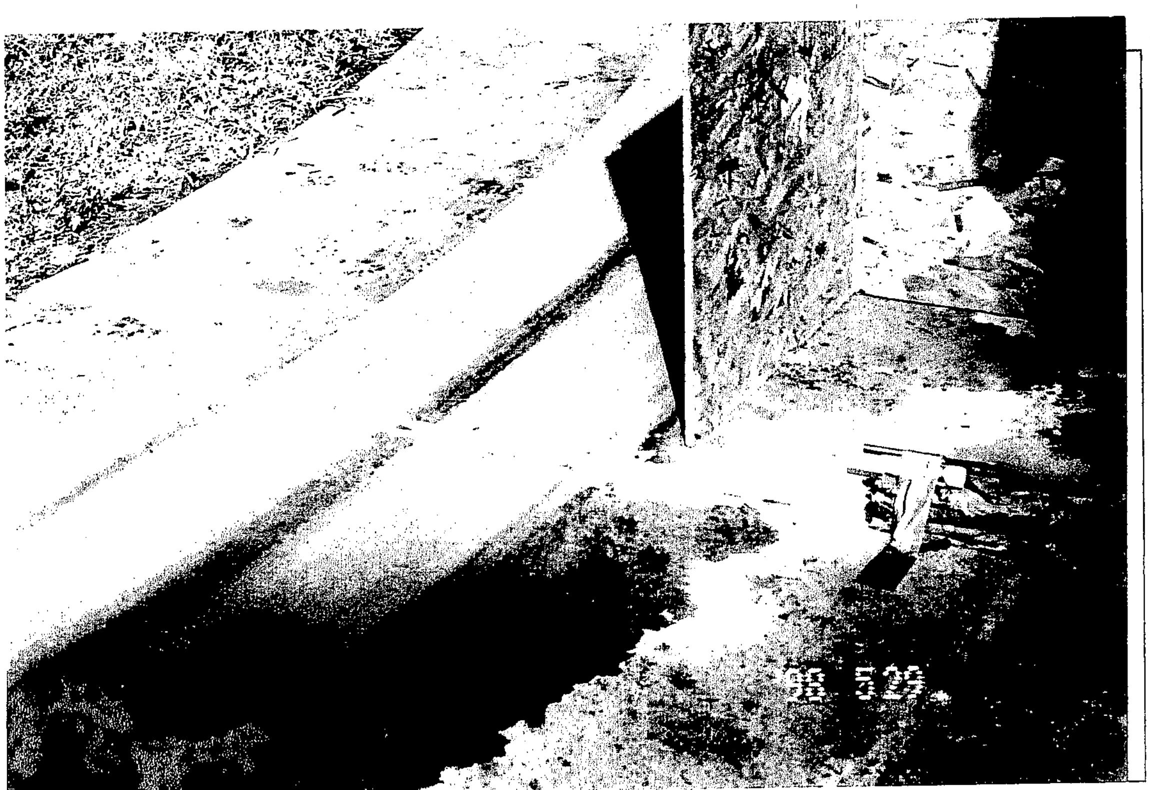
PHOTOGRAPH 32. Insertion of Backer-rod



PHOTOGRAPH 33. Conduction of Joint Noise Tests



PHOTOGRAPH 34. Rion SA-27 Octave Band Real Time Analyzer



PHOTOGRAPH 35. Microphone Placement for Decibel Level Readings

CHAPTER V

RESULTS OF ACCELERATED PERFORMANCE TESTING

Life Expectancy Analysis

Pavement systems are subjected to a wide range of vehicles. To consider the number of load repetitions for mixed traffic and evaluate its damage from different axle loads is considered a tedious task. For the design of pavement systems, a simplified and widely accepted procedure relies on converting each load group into an equivalent 80 kN (18 kip) single axle load as proposed by AASHTO. Huang (1993) states that an equivalent axle load factor defines the damage per pass to a pavement by the axle in question relative to the damage per pass of a standard axle load which is usually the 80 kN (18 kips) single axle load. FDOT authorized single axle load of 97.86 kN (22 kips) for a Florida Legal Load truck. For the accelerated testing, the machine applied a dual wheel load of 44.5 kN (10 kips). This dual wheel loading, which is equivalent to an 88.96 kN (20 kips) single axle load, is heavier than the standard 80 kN (18 kips) single axle load. Therefore, it was necessary to convert the repetitions administered by the 88.96 kN (20 kips) to an equivalent amount of repetitions produced by a standard 80 kN (18 kips) equivalent single axle load (ESAL) as specified by the AASHTO standard truck. An equivalent axle load factor (EALF) can either be defined by utilizing

AASHTO's convention tables from the 1986 manual, or by simply using Equation 1, which is based on the fatigue criterion concept. An $ESAL_{18}$ is defined by Equation 2.

$$EALF = (L_x/18)^4 \tag{1}$$

$$ESAL_{18} = N_{20} * EALF \tag{2}$$

where L_x = load of the applied single axle = 88.96 kN (20 kips)

N_{20} = the number of passes of the 88.96 kN (20 kip) load during the traffic period

$ESAL_{18}$ = the number of 80 kN (18 kips) corresponding to N_{20}

The sum of the repetitions successfully endured at the UCF-CATT can be used to equate the tested patching materials simulated life expectancy (SLE) if it were applied to normal highway conditions. The SLE has been tailored to site specific applications through the use of actual traffic volumes. Therefore, the actual yearly truck traffic must be evaluated. As an example, lets assume an average daily traffic (ADT) volume of 10,000 for a typical medium-heavy traffic highway with an average percent of trucks of 6%. The annual volume of heavy truck traffic can be calculated as follows:

$$ADT \times T \times L \times 365 \text{ days} = AHTT \tag{3}$$

where ADT = average daily traffic

T = percentage of trucks in the ADT

L = lane distribution factor (0.9 for the multi-lane highways)

AHTT = annual heavy truck traffic

Unlike actual field conditions, the test track applied the load over the same path during each revolution. Taking this into account, an assumed probability of occurrence of three can be assumed. This meant, every third dual wheel load was believed to cover the same path along the pavement. Equation 4 equated the test track results to a simulated one-year life expectancy:

$$N \times EALF \times P = AHTT \tag{4}$$

where N = number of test track repetitions required per year

EALF = equivalent axle load factor (Equation 1)

AHTT = annual heavy truck traffic (Equation 3)

P = probability of occurrence = 3

The simulated life expectancy of the patching materials can then be computed through the use of Equation 5:

$$SLE = (CATT_{REPS}/N) \tag{5}$$

where SLE = simulated life expectancy

$CATT_{REPS}$ = total repetitions applied by UCF-CATT

N = number of test track repetitions required per year (Equation 4)

By using the above equations along with the data collected at the UCF-CATT, the computed values from Equations 1 through 5 are obtained and given in Table 7. The $CATT_{REPS}$ is taken from the Test Track Log as shown in Table 8.

TABLE 7. Simulated Life Expectancy Analysis

VARIABLE	EQUATION	OUTPUT
EALF	1	1.524
18-kip ESAL	2	762,000 Reps
AHTT	3	197,100 Trucks
N	4	43,110 Reps
SLE	5	17.7 Years

Performance Test at UCF-CATT

As can be seen on the Test Track Log (Table 8), at approximately 106,000 load repetitions, testing stopped due to damage to the power-driving diesel engine. Although this quantity of repetitions is considered low, noticeable fatigue to some materials is present. Some stresses were observed in two materials. Material D, and E, which are Elastomeric Concrete, were failing due to de-bonding. It was noticed that after placing material D, shrinkage quickly occurred in the morning showing cracks along the interface of the material and concrete slab (Photograph 36). However, the separation due to de-bonding were not seen during the warmer times of the day. In case of Material E, de-bonding failure has occurred due to the fatigue testing, as seen in Photographs 37 and 38. Other problems have been noted on patching materials. As seen in Photograph 39,

TABLE 8. Test Track Log

Date	Start Time (hr)	End Time (hr)	Total Time (hr)	Start Mile	End Mile	Total Mile	Reps*	Total Reps	Notes
04/24/1998	9:28	10:28	1:00	3904.1	3912.6	8.5	857.1	857.1	
04/27/1998	10:10	12:30	2:20	3912.6	3932.8	20.2	2037.0	2894.1	
04/29/1998	9:40	15:15	5:35	3932.8	3980.0	47.2	4759.6	7653.7	
04/30/1998	10:30	15:00	4:30	3980.0	4016.5	36.5	3680.7	11334.4	
05/04/1998	10:10	15:10	5:00	4016.5	4058.5	42.0	4235.3	15569.7	
05/05/1998	9:30	16:00	6:30	4058.5	4115.0	56.5	5697.5	21267.1	
05/06/1998	9:20	16:30	7:10	4115.0	4174.6	59.6	6010.1	27277.2	
05/07/1998	9:25	15:25	6:00	4174.6	4224.8	50.2	5062.2	32339.3	
05/08/1998	10:00	15:00	5:00	4224.8	4268.2	43.4	4376.5	36715.8	
05/11/1998	10:55	13:30	2:35	4268.2	4289.2	21.0	2117.6	38833.4	
05/11/1998	15:00	19:00	4:00	4289.2	4322.3	33.1	3337.8	42171.2	
05/12/1998	9:30	16:00	6:30	4322.3	4376.6	54.3	5475.6	47646.9	
05/14/1998	12:00	16:00	4:00	4376.6	4408.3	31.7	3196.6	50843.5	
05/20/1998	10:30	15:00	4:30	4408.3	4444.9	36.6	3690.7	54534.2	
05/22/1998	9:00	15:30	6:30	4444.9	4493.1	48.2	4860.5	59394.7	Far bridge joint replaced
05/26/1998	8:30	15:30	7:00	4493.1	4546.7	53.6	5405.0	64799.7	
05/27/1998	9:35	19:25	5:00	4546.7	4593.1	46.4	4679.0	69478.7	
05/29/1998	9:30	16:00	6:30	4593.1	4657.5	64.4	6494.1	75972.8	
06/02/1998	9:30	16:00	6:30	4657.5	4716.2	58.7	5919.3	81892.1	Patch of spall #1 placed (SSI)
06/03/1998	9:05	16:05	7:00	4716.2	4782.2	66.0	6655.4	88547.6	
06/04/1998	8:30	15:55	7:25	4782.2	4853.2	71.0	7159.6	95707.2	
06/04/1998	16:05	16:20	0:15	4853.2	4854.8	1.6	161.3	95868.5	
06/04/1998	16:35	16:45	0:10	4854.8	4856.2	1.4	141.2	96009.7	
06/05/1998	10:00	10:25	0:25	4856.2	4858.8	2.6	262.2	96271.9	
06/05/1998	11:45	-	-	4858.8	4860.5	1.7	171.4	96443.3	
06/08/1998	13:25	16:25	3:00	4860.5	4888.9	28.4	2863.9	99307.2	
06/09/1998	8:30	14:30	7:00	4888.9	4958.9	70.0	7058.8	106366.0	Patch of spall #2 placed (RP)
12/04/1998	10:25	15:35	5:10	4960.1	5007.1	47.0	4739.5	111105.5	
12/07/1998	9:00	16:30	7:30	5007.1	5080.7	73.6	7421.8	118527.3	
12/08/1998	8:45	15:20	6:35	5080.7	5136.2	55.5	5596.6	124123.9	
12/09/1998	9:20	15:00	5:40	5136.2	5186.1	49.9	5031.9	129155.8	
12/14/1998	13:00	17:30	4:30	5186.1	5226.0	39.9	4023.5	133179.3	
12/21/1998	8:50	14:50	6:00	5226	5273.1	47.1	4749.6	137928.9	
12/22/1998	8:45	14:45	6:00	5273.1	5321.6	48.5	4890.7	142819.7	

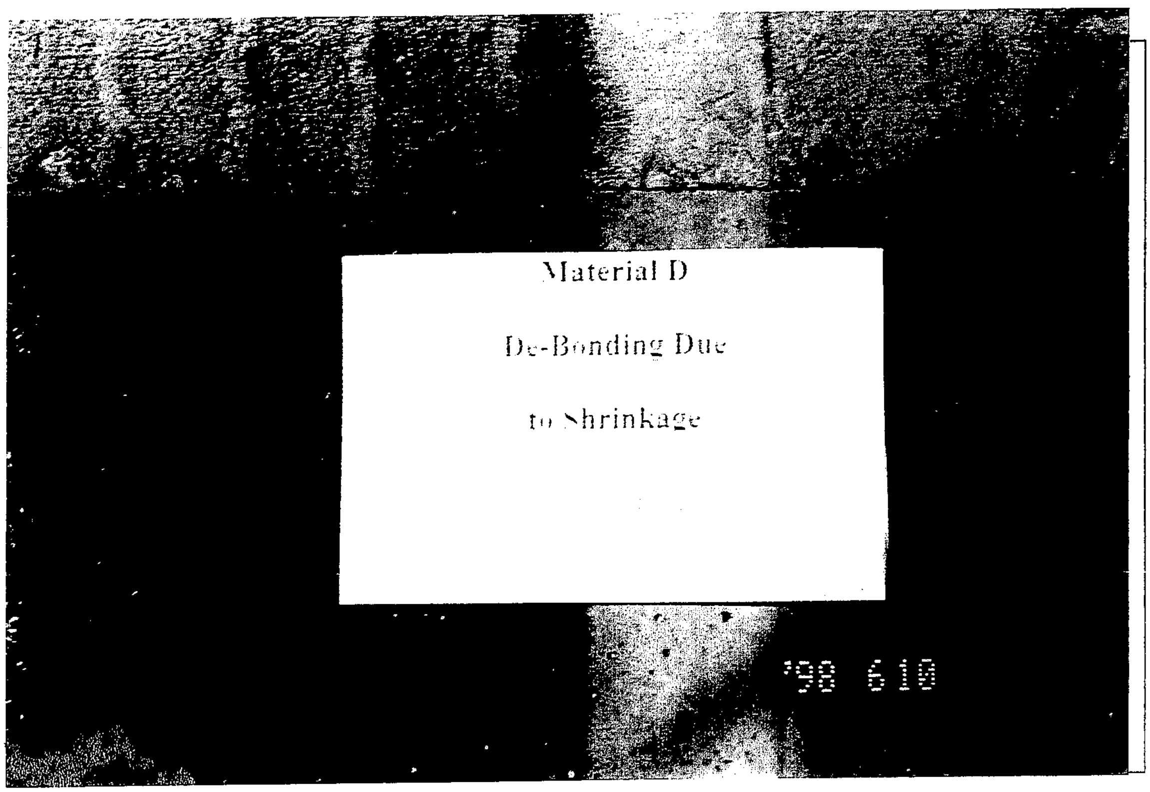
TABLE 8. Test Track Log (cont'd.)

12/30/1998	8:45	14:45	6:00	5321.6	5370	48.4	4880.7	147700.3	
12/31/1998	9:00	15:00	6:00	5370	5429	59.0	5949.6	153649.9	
01/05/1999	9:15	14:45	5:30	5429	5489.6	60.6	6110.9	159760.8	
01/08/1999	10:25	16:25	6:00	5489.6	5547.3	57.7	5818.5	165579.2	
01/14/1999	15:10	16:00	0:50	5547.3	5557.7	10.4	1048.7	166628.0	
01/15/1999	8:50	16:50	8:00	5557.7	5645.2	87.5	8823.5	175451.5	
01/19/1999	8:45	18:25	9:40	5645.2	5753.4	108.2	10910.9	186362.4	
01/20/1999	8:15	16:15	8:00	5753.4	5832.7	79.3	7996.6	194359.0	
01/21/1999	8:50	10:40	1:50	5832.7	5852.8	20.1	2026.9	196385.9	
01/21/1999	12:20	14:40	2:20	5852.8	5877.3	24.5	2470.6	198856.4	
01/22/1999	8:15	18:00	9:45	5877.3	5981.9	104.6	10547.9	209404.3	
01/25/1999	9:10	15:00	5:50	5981.9	6048.5	66.6	6715.9	216120.2	
01/26/1999	8:30	10:40	2:10	6048.5	6072.7	24.2	2440.3	218560.6	
01/26/1999	16:45	18:30	1:45	6072.7	6091.9	19.2	1936.1	220496.7	
01/27/1999	8:40	15:10	6:30	6091.9	6163.8	71.9	7250.4	227747.1	
01/28/1999	9:10	10:40	1:30	6163.8	6180.4	16.6	1673.9	229421.0	
01/28/1999	12:25	14:25	2:00	6180.4	6207.7	27.3	2752.9	232174.0	
02/01/1999	11:20	16:20	5:00	6207.7	6266.7	59.0	5949.6	238123.5	
02/02/1999	10:05	15:05	5:00	6266.7	6324.8	58.1	5858.8	243982.3	
02/03/1999	11:40	16:10	4:30	6324.8	6382	57.2	5768.0	249750.4	
02/04/1999	11:25	18:25	7:00	6382	6471.8	89.8	9055.4	258805.8	
02/08/1999	11:25	16:25	5:00	6471.8	6531.4	59.6	6010.1	264815.9	
02/09/1999	11:20	15:20	5:00	6531.4	6594.4	63.0	6352.9	271168.8	
02/10/1999	11:25	14:55	3:30	6594.4	6635.3	40.9	4124.4	275293.2	
02/11/1999	11:35	2:35	3:00	6635.3	6672.3	37.0	3731.1	279024.2	
02/12/1999	11:15	2:00	2:45	6672.3	6704.9	32.6	3287.4	282311.6	
02/15/1999	11:15	3:15	4:00	6704.9	6752.4	47.5	4789.9	287101.5	
02/16/1999	10:00	3:00	5:00	6752.4	6809.0	56.6	5707.5	292809.1	
02/17/1999	8:30	2:30	6:00	6809.0	6868.5	59.5	6000.0	298809.0	
02/18/1999	8:25	9:55	1:30	6868.5	6883.8	15.3	1542.9	300351.9	
02/18/1999	12:35	2:55	2:20	6883.8	6908.6	24.8	2500.8	302852.7	
02/19/1999	9:05	17:05	8:00	6908.6	6995.0	86.4	8712.6	311565.3	
02/22/1999	8:55	15:25	6:30	6995.0	7071.3	76.3	7694.1	319259.4	
02/23/1999	13:15	14:45	1:30	7071.3	7089.4	18.1	1825.2	321084.6	
02/24/1999	8:30	16:05	7:35	7089.4	7174.8	85.4	8611.7	329696.3	
02/25/1999	8:30	10:50	2:20	7174.8	7198.7	23.9	2410.1	332106.4	
02/25/1999	11:30	18:30	7:00	7198.7	7281.9	83.2	8389.9	340496.3	

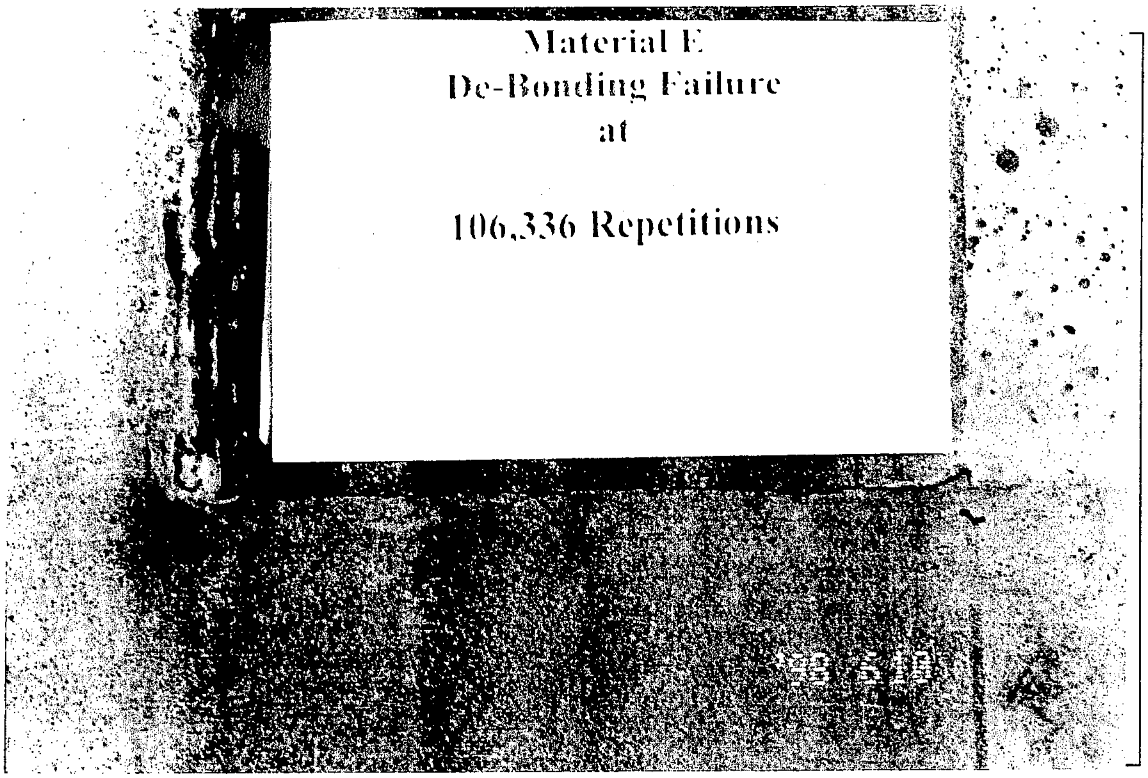
TABLE 8. Test Track Log (cont'd.)

02/26/1999	12:15	18:15	6:00	7281.9	7348.9	67.0	6756.3	347252.6	
03/01/1999	8:55	15:00	6:05	7348.9	7411.3	62.4	6292.4	353545.0	
03/02/1999	10:00	14:00	4:00	7411.9	7450.9	39.0	3932.8	357477.8	
03/03/1999	11:20	14:00	2:40	7450.9	7478.4	27.5	2773.1	360250.9	
03/04/1999	15:05	18:35	3:30	7478.4	7513.6	35.2	3549.6	363800.4	
03/05/1999	9:50	16:50	7:00	7513.6	7602.4	88.8	8954.6	372755.0	
03/08/1999	11:10	15:00	3:50	7602.4	7640.4	38.0	3831.9	376586.9	
03/09/1999	8:30	14:30	6:00	7640.4	7705.2	64.8	6534.4	383121.4	
03/10/1999	8:45	13:00	4:15	7705.2	7744.9	39.7	4003.3	387124.7	
03/17/1999	11:50	14:30	2:40	7744.9	7772.9	28.0	2823.5	389948.2	Tire studs and bolts replaced
03/18/1999	8:45	16:45	8:00	7772.9	7869.7	96.8	9761.3	399709.6	
03/19/1999	9:00	16:00	7:00	7869.7	7949.1	79.4	8006.7	407716.2	
03/22/1999	8:55	13:00	4:05	7949.1	7994.1	45.0	4537.8	412254.0	
03/23/1999	10:25	18:25	8:00	7994.1	8088.2	94.1	9489.0	421743.1	
03/24/1999	9:00	15:00	6:00	8088.2	8149.5	61.3	6181.5	427924.6	
03/25/1999	9:30	10:35	1:05	8149.5	8161.6	12.1	1220.2	429144.7	
03/25/1999	11:55	17:25	6:30	8161.6	8233.5	71.9	7250.4	436395.1	
03/26/1999	9:15	12:15	3:00	8233.5	8266.4	32.9	3317.6	439712.8	
03/29/1999	8:30	15:30	7:00	8266.4	8345.6	79.2	7986.5	447699.3	
03/30/1999	9:00	15:30	6:30	8345.6	8418.7	73.1	7371.4	455070.7	
04/05/1999	11:30	12:45	1:15	8418.7	8432.7	14.0	1411.8	456482.5	
04/07/1999	12:35	14:35	2:00	8432.7	8455.1	22.4	2258.8	458741.3	
04/08/1999	12:30	12:50	:20	8455.1	8458.9	3.8	383.2	459124.5	
04/08/1999	15:00	18:30	3:30	8458.9	8502.3	43.4	4376.5	463500.9	
04/09/1999	12:25	14:25	2:00	8502.3	8527.7	25.4	2561.3	466062.3	
04/12/1999	12:05	14:35	2:30	8527.7	8555.2	27.5	2773.1	468835.4	
04/13/1999	10:05	16:00	5:55	8555.2	8625.1	69.9	7048.7	475884.1	
04/14/1999	14:20	14:40	:20	8625.1	8629.8	4.7	473.9	476358.0	
04/15/1999	9:00	10:40	1:40	8629.8	8645.6	15.8	1593.3	477951.3	
04/15/1999	11:45	12:45	1:00	8645.6	8657.5	11.9	1200.0	479151.3	
04/15/1999	14:25	18:25	4:00	8657.5	8720.7	63.2	6373.1	485524.4	
04/19/1999	10:05	14:05	4:00	8720.7	8766.7	46.0	4638.6	490163.0	
04/20/1999	8:40	13:40	5:00	8766.7	8823.8	57.1	5758.0	495921.0	
04/22/1999	8:30	12:30	4:00	8823.8	8866.9	43.1	4346.2	500267.2	

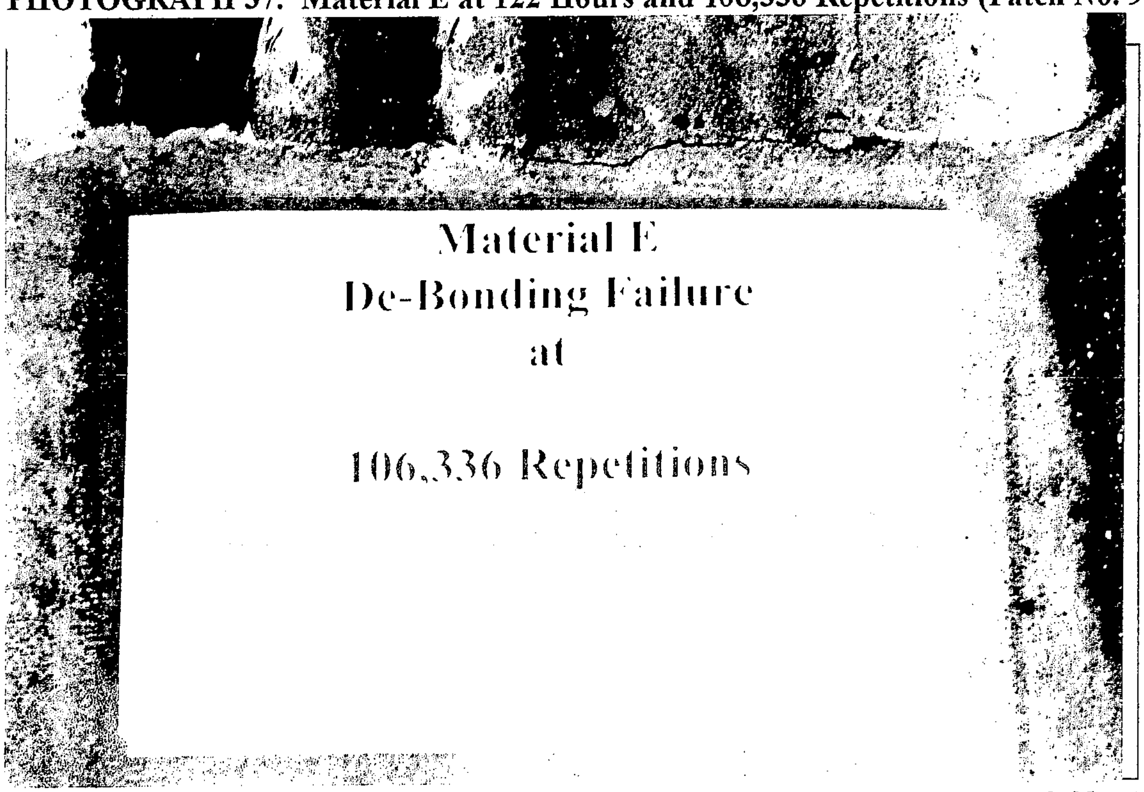
shrinkage/expansion cracks along Material B's surface is present. This was due to excessive addition of water while mixing the cementitious material. This factor is evident, because the other pothole with Material B present has no cracks or other failures associated with bad mixing procedures (Photograph 40).



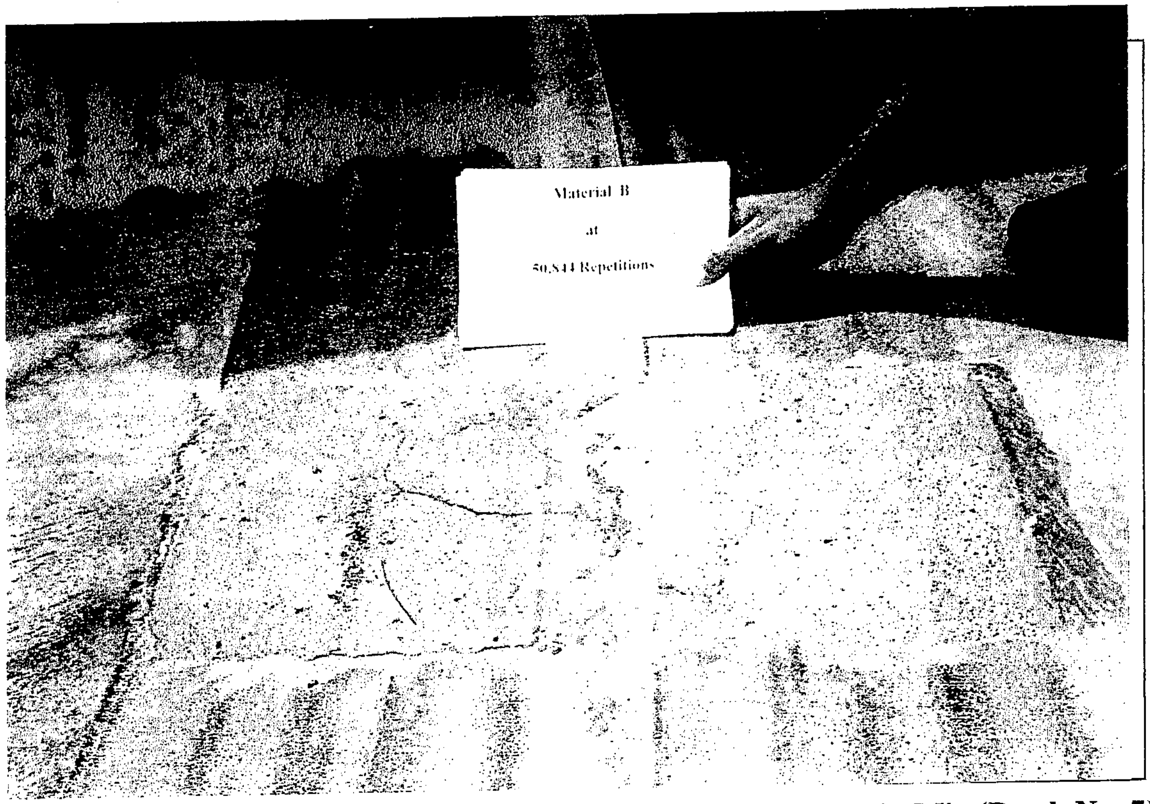
PHOTOGRAPH 36. Cracks along Interface Due to Shrinkage (Patch No. 5)



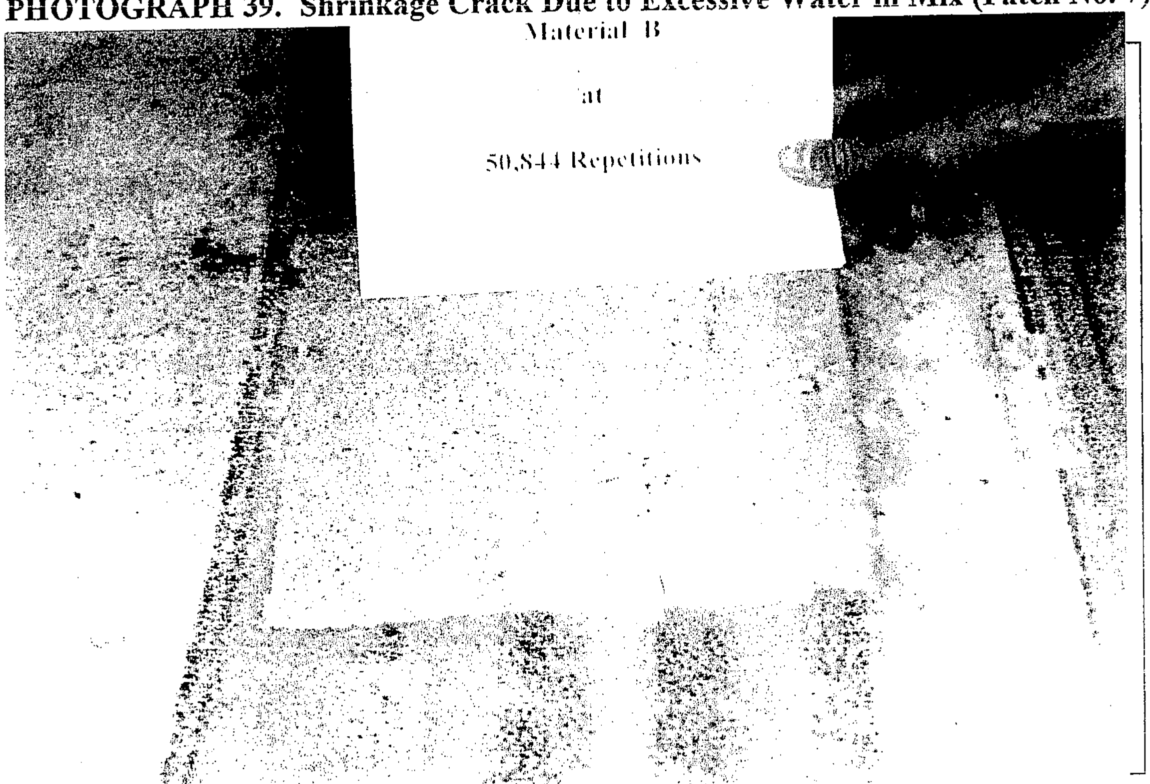
PHOTOGRAPH 37. Material E at 122 Hours and 106,336 Repetitions (Patch No. 9)



PHOTOGRAPH 38. Material E at 122 Hours and 106,336 Repetitions (Patch No. 1)

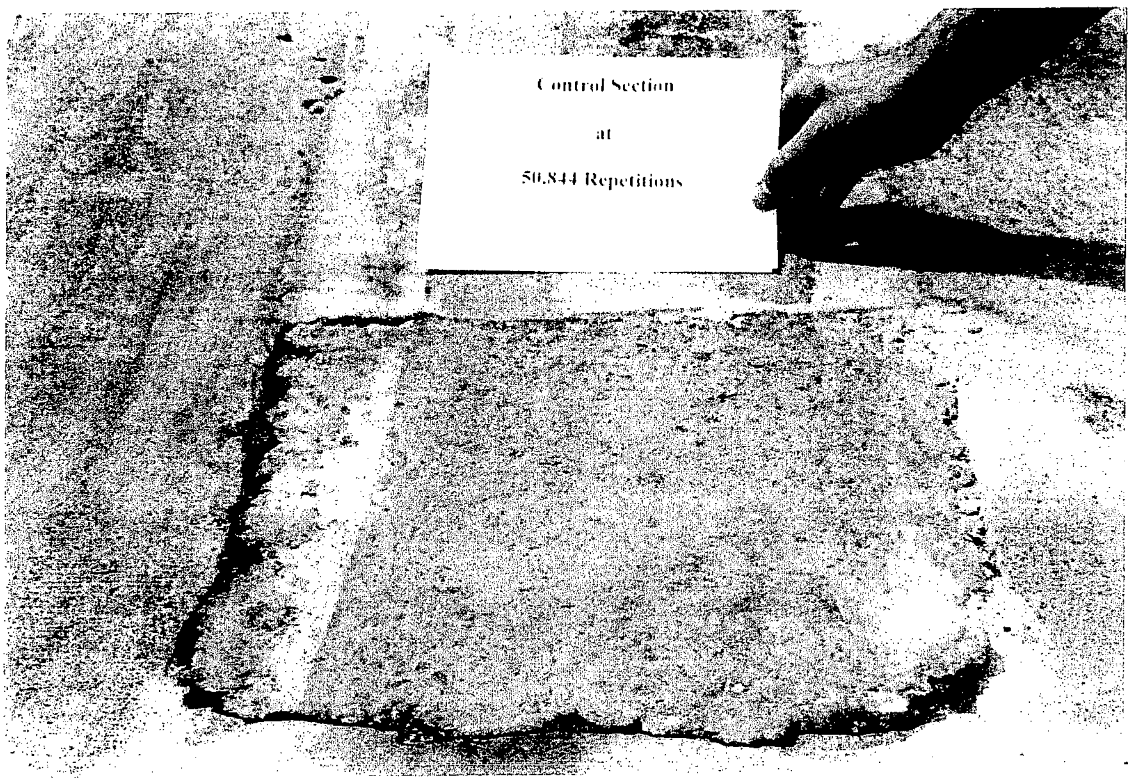


PHOTOGRAPH 39. Shrinkage Crack Due to Excessive Water in Mix (Patch No. 7)



PHOTOGRAPH 40. Material B at 71 Hours and 50,844 Repetitions (Patch No. 8)

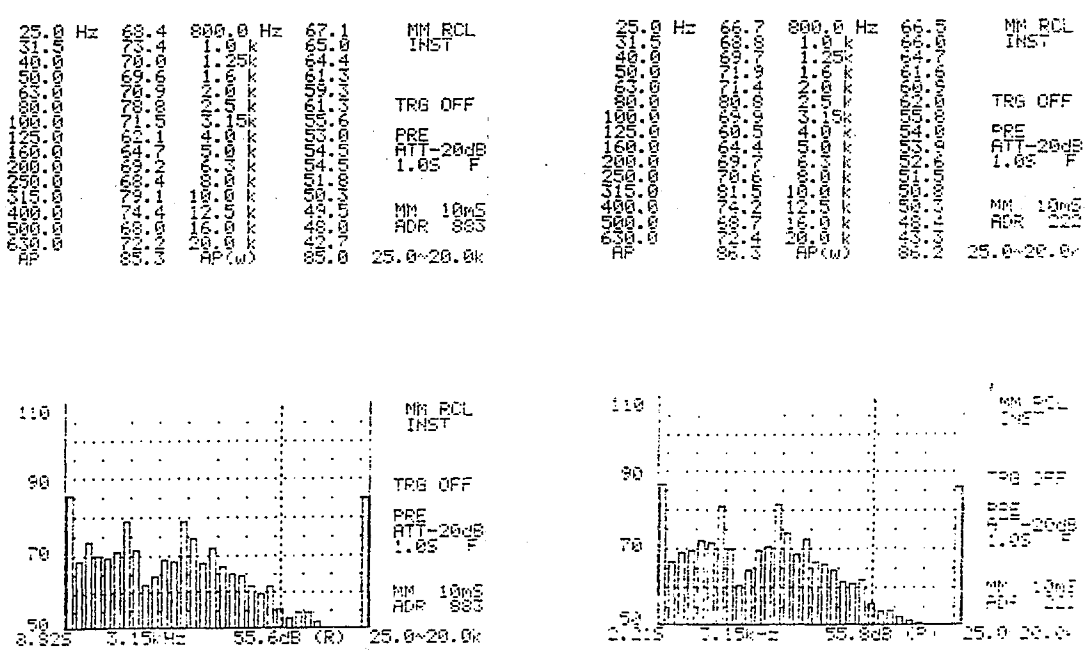
As discussed in Chapter IV, leveling of some of the patching materials was difficult. The control section was especially challenging due to the size of aggregate in the mix. Photograph 41 displays the unevenness of the material with the concrete pavement. Due to this problem, de-bonding of material may likely occur and propagate faster.



PHOTOGRAPH 41. Unevenness of Type II Due to Large Aggregate (Patch No. 4)

Noise Reduction Analysis

The Rion Analyzer took readings while the wheels passed at a speed of 19.3 km/hr (12 mph). The data were collected with and without the filler material in the joint. Figure 9 shows the decibel levels for both experiments. The data showed no significant difference for both measurements after several wheel passes. The poor results may have been contributed by the noise of the test track powered engine and the relatively slow speed of the wheel passes. In order to obtain variable data, the engine noise must be isolated by an insulated structure as recommended by a transportation noise research professor. The design and construction of this insulated structure may require some funding and period of time. A small project of this research can be done in the near future.



Without Joint Filler

With Joint Filler

FIGURE 9. Joint Noise Decibel Recordings

At this stage in testing, all patching materials have been closely monitored for any signs of de-bonding and excessive wear. Except for material D and E showing de-bonding, no displacements along the wheel path have been observed. The other patching materials were performing well up to the 106,336 load repetitions.

In December 1998, a new diesel engine was purchased and installed. The testing was resumed on December 4, 1998. By April 30, 1999, a total of 500,000 load repetitions has been accomplished. The testing for the project was ended. Photographs taken at the end of the testing are presented in Appendix C. Figure 10 shows the schematics of the distresses of each patching material. Also, a visual description is given for each patch at the end of the testing in Table 9. From Table 9 it appears that material C performed the best and material H is next as compared to the other materials.

The unit price of each patching material should be identified and considered in this study. To this point none of the manufacturers submitted the cost for materials for life-cycle cost analysis. In addition to the cost of materials the analysis will also include the cost of initial rehabilitation construction and the maintenance extension of service life to the pavement due to the application of the patching material.

TABLE 9. Patch Distress Descriptions After 500,000 Load Repetitions

Patch Distress Descriptions at End of Testing	
Rectangular Patch (0.5 ft^2)	
Material	**Distress Description After 500,000 Repetitions**
A (polymer)	Little wear Little debonding
B (cementitious)	Shrinkage cracks Little exposure of coarse aggregate
C (cementitious)	Little wear Little debonding Little exposure of coarse aggregate at edges
D (elastomeric)	Debonding Exposure of fiber reinforcing
E (elastomeric)	Debonding Some exposure of coarse aggregate
H (cementitious)	Debonding Little chipping at edges Little exposure of coarse aggregate at edges
Control Section (Type II PCC)	Little wear Chipping at edges Some exposure of coarse aggregate at edges
Square Patch (0.25 ft^2)	
Material	**Distress Description After 500,000 Repetitions**
A	Little wear Little debonding
B	Some exposure of voids and coarse aggregate
C	Little wear Little debonding Little exposure of coarse aggregate at edges
D	Debonding Exposure of fiber reinforcement
E	Debonding Some exposure of voids and coarse aggregate
H	Little debonding Little exposure of voids and coarse aggregate
Control Section	Little wear Chipping at edges Some exposure of coarse aggregate at edges
Spalls	
Spall #1	**Distress Description After 420,000 Repetitions**
Material G	Little Wear Little chipping at edge
Spall #2	**Distress Description After 400,000 Repetitions**
Material B	Some exposure of fine aggregate

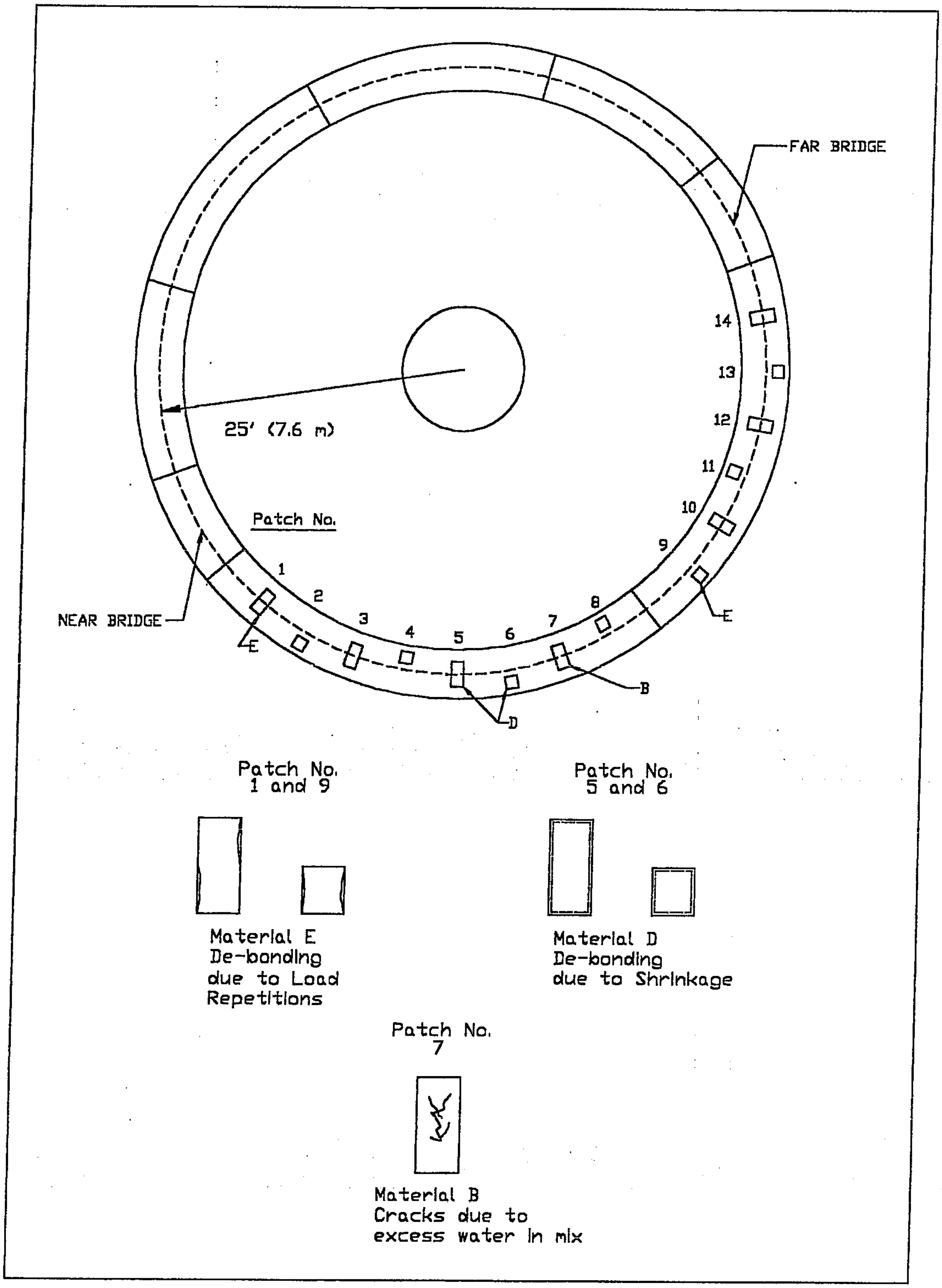


FIGURE 10. Distress Location of Patching Materials

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

The advancement of new fast-setting patching materials for repair of partial-depth potholes can make traveling motorists happier and safer. The hazards faced by motorists increase with damaged pavement distresses particularly potholes and spalls. These pavement distresses suffer from poor maintenance and weak materials. The use of advanced fast setting materials and high strength materials can save agencies time and money by not having to repair the same potholes over and over.

This project has focused on the performance of several types of patching materials for the repair of partial-depth patches. In order to accomplish the objectives of this study, three goals were established. First, the investigation of advanced patching materials available in the market that can be tested. Second, laboratory tests were conducted with various composite specimens at various patching configurations. The laboratory test results were used to select patching materials for the accelerated performance testing. A total of sixteen composite specimens made with 152.4 mm x 304.8 mm (6 in x 12 in) cylinders were tested in uniaxial compression. The crushing feature and compressive strength of each composite specimen was carefully analyzed as compared to the control section. Seven materials were selected for the accelerated performance test. Fourteen artificial potholes were created on the UCF-CATT. The patching materials were then mixed and placed according to manufacturer's guidelines and specifications. Visual inspection, physical measurements, and photographs documented the performance of the accelerated testing. A total of 500,000 load repetitions have been applied to the patched specimens. The condition of each patching material was described in Table 9.

Conclusions

Laboratory Testing

The composite specimens were to simulate the cross section of partial depth patches. It should be noted that the methods and procedures for testing the composite specimens in this project were experimental. The Florida Department of Transportation (FDOT) has interests in setting guidelines for patching materials, and may use the procedures in casting composite cylinders when testing for durable materials. The results of the compressive strength tests indicated the configurations used to cast the composite specimens might be reliable in choosing the most dependable materials. All of the samples tested in the laboratory showed unique fracture planes and bonding characteristics with the concrete. Failures occurred between 7.32 MPa (1,061 psi) and 42.7 MPa (6,189 psi) depending upon the material, the patching configuration and the aspect ratio (L/D). The type of material used; either polymer, elastomeric, or cementitious had no effect on the results, as seen in Table 6 (Chapter III). The results of the fracture patterns and compressive strength data have been evaluated and conceptually analyzed. Many types of quality materials exist in today's market, and to select the most appropriate specifications and guidelines must be made for all manufacturers' to follow.

Accelerated Testing Using the UCF-CATT

After a total of 500,000 load repetitions of 44.5 kN (10,000 lbs) wheel load applied at this test facility, some signs of patching distress have been found. The patches were observed and inspected daily, thus knowing the time any damage had incurred. At the end of the testing schedule, the 500,000 repetition represented a simulated life expectancy of 17.7 years, assuming an ADT of 10,000 with an average percent of heavy trucks of 6%.

As discussed in Chapter V, some de-bonding failures have occurred. These failures occurred because of shrinkage due to weather changes, and de-lamination of the patching material from the concrete interface. Elastomeric and polymer materials particularly had shrinkage problems. Cracking also occurred in a cementitious mix due to excessive water in the mix design. However, failure from severe wearing, cracking, and spalling has not been observed of any of the patch materials.

The two feather-edged potholes, which are simulating realistic pothole conditions on the highway, have performed well to this point. This has proven to be valuable, because if crews do not have to square-cut partial-depth patches, placing the material directly into the distress can save time and money. Appendix C provides the manufacturer's specifications for the materials used in the accelerated performance testing. However, in determining the pavement life extension, both the life of the individual repair and the life of the pavement as a whole shall be accounted for. The life-cycle cost analysis will be based upon application of the patching material on an actual state highway requiring maintenance, or one with available maintenance data. The costs of each material will be determined and evaluated with its service life. This evaluation will then be compared to the present materials used in the rehabilitation of concrete pavements. The life-cycle cost analysis for each method can then be studied to determine the best alternative for partial-depth patching. This investigation is an important step in convincing engineers and agencies that there are many reliable materials for the use in today's overly traveled interstate and highway systems.

Recommendations for Guidelines of Patching Materials

I. Preliminary Survey

A. First, it must be determined whether a full-depth repair or partial-depth repair is required of the damaged pavement area.

1) For potholes, spalling, or cracking of pavement one-third depth to full-depth, full-depth repair is recommended.

2) For potholes, spalling, or cracking of pavement for upper one-third depth, partial-depth repair is recommended.

B. Second, repair boundaries must be designated.

II. Damaged Pavement Removal

A. First, sawcuts should be made at repair boundaries. Note that it is better that irregular shape potholes be sawcut to a more desired shape like a square or rectangle.

B. Second, removal of the damaged pavement should be performed using the necessary chipping tools.

1) Note that too heavy chipping equipment can actually worsen the damaged area beyond the capacity of partial-depth repair. Therefore, caution is to be used in this regard.

2) Small, shallow potholes or spalls should be reduced down to a minimum depth of $1\frac{1}{2}$ inches to allow for adequate placement of the patching material.

C. Third, sandblasting of the inside walls of the pothole or spall should be performed regardless of manufacturer's specifications.

D. Last, all loose chips of concrete and any other foreign objects should be removed using air pressure to allow for a clean bonding face for the patching material.

III. Mixing of Patching Materials

A. First, the manufacturer's instructions for mixing the patching material should be read carefully, noting all necessary materials and equipment to be used.

B. Second, mixing should be done onsite because of fast setting time of the patching materials.

C. Third, proper equipment for mixing should be used as designated by the manufacturer and the patch material should be uniform in consistency before being placed.

D. Last, make sure to mix for designated mixing times and include aggregate in deeper patches as described by the manufacturer.

IV. Placement of Patching Materials

A. First, the manufacturer's instructions for placing the patching material should be read carefully, noting all necessary materials and equipment to be used.

B. Second, be sure to apply bonding agent to inside of pothole or spall if required by the manufacturer. Otherwise, a bonding agent may not be used.

C. Third, if the patch is to be placed along a joint, be sure to block off the designated pour area so that the patching material will not fill up the joint. The material should thus have a flush finish with the vertical edge of pavement at the joint.

C. Fourth, the patching material should be placed immediately after mixing and it is preferable that the whole patch be placed at once instead of in stages.

D. Fifth, the patch should be finished flush with the top of the surrounding pavement. The patch should always be finished from the center of the patch out to the edges so to maximize bonding capacity between the patch and the existing pavement, especially near the top of the patch.

E. Sixth, fill sawcut runouts with extra mortar from the mixed patch material to prevent water from penetrating and harming the bond with the existing pavement.

F. Seventh, allow for ample curing time for the patch to gain the necessary strength to be effective according to the manufacturer's specifications.

G. Eighth, inspect the patch for any signs of early shrinkage cracking and any other early signs of bad placement. If this happens, a high-quality epoxy material may be used to fill in the gaps.

H. Last, reopen the section of road containing the patch to normal traffic.

APPENDIX A

SAMPLES OF MATERIAL TECHNICAL DATA SHEETS

MATERIAL A

RESURF POLYMER CONCRETE AGGREGATE BLEND USE GUIDE

See direction labels on Aggregate blend, Resin and Catalyst. All Aggregates use the same Resin and Catalyst (and Resin Catalyst Ratio)

Catalyzed Resin is used as Primer and as Binder for Aggregates (as Mortars or Broadcast)

RESURF II AGGREGATE BLEND

(General Purpose)

High compressive strength, featheredges easily, broadcasts well; best on fair to good concrete with little or no movement. Especially recommended for small spalls, shallow or narrow nosings, & rail applications.

RESURF IV AGGREGATE BLEND

(General Purpose)

Moderate compressive strength, featheredges almost as well as RESURF II; mixes and finishes easier; flexible, impact and wear resistant; for repairing fair to low quality concrete where moderate compressive strength is needed.

RESURF CR AGGREGATE BLEND

(Crack Repair)

For hairline to 3/4 " cracks and very shallow spalls (warehouse floors); for rebonding breaking, broken, or previously patched concrete. All cracks, unless rebonded are working cracks.

All Portland Cement Concrete to be repaired should be <u>as clean and dry as practical</u>

GOOD DESIGN GOOD PRODUCTS, GOOD INSTALLATION

DIRECTIONS RESURF II RESURF IV

SOUND, CLEAN AND DRY CONCRETE IS REQUIRED

PRIME

1.To prime the concrete surface, catalyze and mix the required amounts of RESIN (note: the color change from reddish purple to greenish brown). Brush on

MEASURE

2.Anytime within two hours (whether primer coat is gelled or not). MEASURE:

a) 7.5 # RESIN (one mark on scribed one or five gallon pail supplied).
b) One mark on pint catalyst bottle. MIX
c) Add to one bag RESURF aggregate blend (Yield = 1/2 cu. ft.)

MIX

Mix (quickly and well) until Aggregate Blend is evenly wetted This should require one minute.

1 : 1 : 1

1 mark : 1 mark : 1 bag

FINISH

3. Fill hole (OVERFULL), tamp, trowel, screed. Finishing is aided by sprinkling dry RESURF aggregate on top while tamping, troweling and screeding.

4.Low or rough areas may be mended by painting (or puddling) with catalyzed resin and broadcasting to dryness with RESURF Aggregate Blend.
High areas can be shaved off to grade while polymer concrete is "cheezy (20-30 minutes after placement). Use a square end shovel or hoe.
Return traffic within two hours or when repair can not be penetrated with a thumbnail or pencil point. For detailed information see "Tips for Installation" Training Video and MSDS or call (334) 682-4296 Fax: (334) 682-4549

DIRECTIONS RESURF CR

SOUND, CLEAN AND DRY CONCRETE IS REQUIRED

1. Clean and dry crack to be repaired as well as practical. For cracks ranging from hairline up to approximately 3/4 " wide, catalyzed resin can be used as a clear varnish- gray paint- runny mortar- thicker (grainy) mortar-paste.

2.Catalyze and mix a small amount of resin in a gallon or 5 gallon pail- generally about 1/4 to 1/3 pail (catalyst to resin ratio- 1 mark on catalyst bottle to one gallon resin)

3.With vigorous stirring, *QUICKLY* add heaping double hands full of Aggregate Blend.

4.IMMEDIATLY pour desired consistency of mortar into crack- work mortar as dry as practical, but still pourable.

5.Repeat until crack is full- thin cracks and the bottom of wider cracks can be filled first with the wetter mix then finish filling wider part with higher aggregate mix.

6.When bottom and thinner cracks have been filled , wider areas and spalls should be filled and grouted to grade with RESURF II or RESURF IV.

RESURF CR, RESURF II, and RESURF IV use the same resin and catalyst, but different aggregate blends.

RESURF II/ RESURF IV

TIPS AND HINTS TO IMPROVE QUALITY AND EFFICIENCY

1) Read Directions on Aggregate Blend and RESURF IV/II manual (if available)
2) Store and keep all RESURF components and mixing tools as cool and shaded as practical (extends work time and improves workability)
3) Have all materials and tools grouped and ready (bags opened, etc)
4) The first batch can be worked about 5% wetter since some of the resin wets the wheelbarrow.
5) MIX QUICKLY AND AGGRESSIVELY; MIX TO THE BOTTOM ON EACH STROKE WITH A HOE; GOOD, QUICK MIXING CANNOT BE OVER EMPHASIZED: THIS MAKES FINISHING MUCH, MUCH EASIER! A Batch can and should be mixed in about 1 minute.
6) Keep batch sizes matched to the size of repairs and always maintain correct ratios (small, shallow, or narrow repairs can be worked wetter, especially when featheredging; work mix as wet as necessary.
7) Keep tools (hoe, wheelbarrow, screeds, trowels) scraped clean. This is especially important for the hoe; It makes #5 easier.
8) Always fill hole above grade and tamp/screed forward to get good compaction; *never, never* drag loosely forward with hoe or rake.
9) If a batch of Resurf II/IV only partially fills hole, tamp and consolidate to bottom of hole before putting next batch on top.
10) Broadcasting some dry RESURF II/IV Aggregate Blend or blasting sand on top aids finishing.
11) Edges can be easily pulled and smeared with the toe of a shoe or boot (when featheredging or even to tighten up at a saw cut edge.)
12) After looking at materials, measuring containers, direction label and these tips, give us a call to discuss any questions, fine points, or special needs.

PROBLEM IDENTIFICATION AND SOLVING (CONT'D)

SPECIAL NOTE: **All cracks are working cracks (just a matter of degree). Thick repairs bridging cracks are very difficult. The tensile strength of Porland Cement Concrete is approximately 1/10 its compressive strength. Working cracks (cracks) generally put tensile stresses on the repair and its bond. Thick polymer concrete repairs bridging cracks will probably initially fail at the PCC interface to relieve excess stress. Thin repairs over cracks will probably reflective crack to relieve excess stresses.**

SURFACE EVALUATION AND PREPARATION

Since the condition of the PCC area to be repaired may well determine the success of any repair, practical methods of evaluation and then concrete removal, cleaning, profiling,

SURFACE EVALUATION AND PREP CONT'D

and possibly drying must be available to the repair crew.

Visual examination by experienced personnel is probably the most important evaluation of the scope of the surface preparation needs.

Sounding by tapping with a hammer or dragging with a folded piece of large logging chain is valuable, especially on bridge decks. This may need to be repeated after some concrete has been removed.

Chipping should be done with as small as practical jack hammer and <u>no more concrete than necessary removed</u>. Unless solving an expansion or movement problem <u>NEVER</u> remove sound concrete.

Sand blasting is a very valuable tool for cleaning, profiling, selectively removing weak or crippled concrete, drying, and making the concrete surface easier to evaluate for cracks, etc.

SURFACE EVALUATION AND PREP CONT'D

Since carbon dioxide and water vapor combine to yield carbonic acid, which reacts with the concrete surface to yield carbonated concrete, it is recommended that the film be removed no more than 24 hours prior to the repair.

MATERIALS AND TOOLS

RESURF IV is packaged like RESURF II. The aggregate blend is in 0.5 cu. ft. poly-lined paper bags. RESURF RESIN comes in 5 or 55 gallon drums. Catalyst (which is included with the resin) comes in scribed pint or gallon bottles. All components must be stored and transported in a <u>sheltered area</u>. Wet or damp aggregate blend or resin will have a detrimental effect on reactivity. <u>Sunlight (UV) will destroy</u> RESURF catalyst over extended periods.

RESURF II and RESURF IV are very user friendly, general purpose polymer concretes.

MATERIALS AND TOOLS CONT'D

All materials or tools, that may not be readily available to a repair crew, are included in each shipment. (for a detailed list, see the concrete repair checklist)

Tools:

- **Measuring pails, faucets, scribed catalyst bottles (supplied by PCI)**
- **Stir sticks, paint brushes, wire brushes, lumber crayon.**
- **Small hammer, logging chain, chipping hammer, mason's hammer, pick.**
- **Sand blaster, air lance.**
- **Wheel barrow, hoes, shovels.**
- **Tamps, trowels, screeds (1x4 & 2x4)**
- **Forming materials which are covered next**

CLEAN UP AND DISPOSAL

When using RESURF II or RESURF IV, it is very easy to keep wheel barrows, hoes, tamps, trowels, and screeds scraped clean. This will vastly improve the efficiency of the tools. Any polymer concrete scale can be beaten off with a hammer the next morning when cool.

Cured RESURF II, RESURF IV, or RESURF CR polymer concrete, or cured RESURF RESIN are non-hazardous and can be treated like PCC.

PROBLEM SOLVING AND TRAINING SERVICES OFFERED BY POLYMER CONCRETE, INC.

RESURF II, RESURF IV, and RESURF CR are well designed, user-friendly concrete repair systems. The guidelines and specifics given here may need to be modified in the field.

PROBLEM SOLVING AND TRAINING CONT'D

If a procedure makes good engineering sense, it should work. All modifications of bag directions should be guided by: "Never make a hole any bigger than necessary, and never work the mortar any wetter than necessary." (remember good design, good products, good installation)

A video of repairs using RESURF II, RESURF IV, and RESURF CR, is available upon request. We are always available by phone at (334) 682-4296 (Day or Night) or Fax (334) 682-4549 to answer specific questions or offer emergency support or deliveries

CONCRETE REPAIR CHECKLIST

__ AGGREGATE BLEND(S)	__ WIRE BRUSH
__ RESIN	__ KNIFE
__ CATALYST	__ JUMPER CABLES
__ CATALYST BOTTLES	__ LUMBER CRAYON
__ RESIN FAUCET(S)	__ PERM MARKER
__ RESIN MEASURING PAILS	__ NOTE PAD/PENS
__ PAINT BRUSHES	__ CAMERA /ACCESSORIES
__ STIR STICKS	__ BROOMS
__ 1x4 / 2x4 TAMPS/ SCREEDS	__ PROPANE TORCH
__ WHEEL BARROW	__ ACETYLENE TORCH
__ HOE/PICK	__ TOOLS/PARTS
__ SHOVELS (SQUARE/ROUND)	__ GOGGLES
__ WORK PAILS/LIDS	__ STRIKER
__ TROWELS	__ TIP CLEANERS
__ LOGGING CHAIN	__ TARPS/POLYETHYLENE
__ BRICK HAMMER/SLEDGE	__ ROPE
__ HATCHET/AXE	__ PRY BAR
__ SANDBLASTER	__ CONCRETE SAW
__ SAND	__ SKIL SAW
__ NOZZLES/SPARE PARTS	__ EXTENSION CORD
__ HOSES/GASKETS	__ GENERATOR/GAS
__ WIRE/TAPE	__ HAND SAW
__ WRENCHES/PLIERS/TOOLS	__ HACK SAW
__ AIR LANCE	__ HAMMER/NAILS
__ CHIPPING HAMMER	__ CARPENTRY TOOLS
__ AIR HAMMER BITS	__ DRILL/BITS
__ AUTO TRANSMISSION FLUID	__ JACK/C-CLAMPS
__ EYE PROTECTION/ IRRIGATION	__ HEAT GUN/DRYER
__ DUST MASKS	__ TAPE MEASURE
__ VESTS	__ HARD HAT
__ GLOVES	__ SCISSORS
__ FORMING MATERIALS	__ DUST PAN
__ BOND BREAKERS	__ CAULK/CAULK GUN
__ COMPRESSOR	__ FLASH LIGHT
__ OIL, DIESEL, STARTING FLUID	__ 110 V LIGHT
__ BUSH AXE	__ CHALK LINE
__ EAR PLUGS	__ OTHER

All these tools may not be needed, but we have allowed for most contingencies.

MATERIAL B

BONSAL SINCE 1895

Rapid Patch - VR

BONSAL® Rapid Patch - VR is a quick setting, high early strength concrete repair material.

FEATURES AND BENEFITS:

- Open to Traffic in Two Hours
- Exceeds the Requirements of ASTM C 928 for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs
- Reduces Downtime Due to Rapid Repairs
- DOT Approved

USES:

Repair of Concrete

- Highways and Bridges
- Airport Runways
- Garage Parking Decks
- Warehouse Floors

PREPARATION:

Clean area and remove all unsound concrete, grease, oil, paint, and any other foreign materials that will inhibit performance. Slick or sealed surfaces must be thoroughly roughened.
Refer to:

- ASTM D 4258 Surface Cleaning Concrete for Coating
- ASTM D 4259 Abrading Concrete
- ASTM D 4260 Acid Etching Concrete
- ASTM D 4580 Measuring Delaminations in Concrete Bridge Decks by Sounding
- ACI 201.1R Guide for Making a Condition Survey of Concrete in Service
- ACI 201.3R Guide for Making a Condition Survey of Concrete Pavements
- ICRI Surface Preparation Guidelines for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Oxidation

The area should be back cut or have a vertical edge by sawing or other suitable means that will not cause damage to surrounding concrete.
If the product is being used on a questionable substrate, make a small test area. Examine the patch after several days to determine if a good bond has been obtained. Before making repairs, thoroughly saturate the area with water (this may require several applications of water). Remove excess surface water and puddles prior to use.

MIXING:

Mix Rapid Patch - VR in a concrete or mortar mixer, in a bucket by hand mixing or with a slow speed drill and mixing blade. Measure approximately 3 quarts of water and add to the mixer, then add the Rapid Patch - VR. Mix at a medium speed (450 rpm) for 3 minutes.

MIXING (Cont):

Rapid Patch - VR may be used for repairs from 1/2 inch to 8 inches in thickness. For repairing areas greater than 1 1/2 inches deep, Rapid Patch - VR may be extended with up to 50% by weight of stone meeting AASHTO M 43, Size No. 7 requirements.

PLACEMENT:

The working time of Rapid Patch - VR is approximately 10 minutes. Working time is shortened as the temperature increases. Materials and the substrate to be repaired, must be above 40°F during placement. The surfaces may be broomed or textured approximately 20 minutes after placement.

Fill the area to full depth and consolidate by rodding during the placement. The surface may be broomed or textured approximately 20 minutes after placement.

Placement Temperature

-	Minimum	Maximum
Substrate	40°F	90°F
Mix	50°F	80°F
Air	40°F	90°F

CURING:

Forms may be removed as soon as the product is firm and cannot be penetrated by a pointed masonry trowel. Prevent evaporation by keeping the exposed surfaces wet for several hours.

Rapid Patch - VR can be exposed under normal conditions. For installations where acids and sulfates are present, a protective coating is required.

Cure per Portland Cement Association publication Design and Control of Concrete Mixes (EB001.12T) and/or American Concrete Institute 308 publication Recommended Practice for Curing Concrete.

TECHNICAL DATA:

Set Time
ASTM C 266

Initial Set	20 minutes
Final Set	30 minutes

Compressive Strength
ASTM C 109

3 hours air cured	3000 psi
24 hours air cured	6000 psi
28 days air cured	7000 psi

TECHNICAL DATA (Cont.):

Flexural Strength
ASTM C 580
28 days air cured 800 psi

Length Change Percent
ASTM C 157
Air Cured -0.06
Moist Cured +0.06

Resistance to Deicing Salts
ASTM C 672
(10% Calcium-Chloride Solution) 25 Cycles
2 Rating

Absorption
ASTM C 642
9.8%

Freeze-Thaw Resistance
ASTM C 666 A
300 cycles 88% Dynamic Modulus

Flow
ASTM C 109
5 minutes

LIMITATIONS:

- DO NOT add excessive amounts of water.
- DO NOT apply when air or substrate temperature is below 40°F or above 90°F within 24 hours of application.
- DO NOT use for vertical or overhead repairs.
- DO NOT mix more than can be placed in 10 minutes.
- DO NOT retemper.
- DO NOT add anything other than water and recommended aggregate.

Technical Assistance

Charlotte, NC
(800) 334-0784

WARNING: Cracks in the material may reappear due to structural faults in the construction itself. The effectiveness of any repair depends on sound structures, proper preparation and application.

COLORS:

Grey

COVERAGE:

50 lbs. yields .42 cu. ft. (.60 cu. ft. with 20 lbs. of aggregate.)

PACKAGING:

50 lbs./22.7 kg multiply bag

SHELF LIFE:

One year from date of manufacture.

CAUTION: Contains Silicon Dioxide, Portland Cement and Calcium Hydroxide. Your skin may be sensitive to cement. Wearing rubber gloves is recommended. Avoid contact with eyes or prolonged contact with skin. In case of contact, flush thoroughly with water. For eyes, flush with clean water for at least 15 minutes and get prompt medical attention.

KEEP OUT OF REACH OF CHILDREN

Home Office

Charlotte, NC
Telephone#: (704) 525-1621
Toll Free #: (800) 738-1621
Fax#: (704) 529-5261

LIMITED WARRANTY: W.R. Bonsal Company ("Bonsal") warrants that this product and the materials used therein meet or exceed the applicable standards listed and enforced at the time of manufacture. Bonsal will replace any product or part which proves defective due to quality of ingredients used or due to the manufacturing process itself. This Warranty shall apply only if the product is used in strict accordance with applicable specifications and instructions provided by Bonsal for its use, and Bonsal shall not be liable otherwise. Replacement of any defective product, or, at Bonsal's option, refund of the purchase of any defective product shall be the buyer's sole remedy under this Warranty, and Bonsal shall in no event be liable for any damages in excess of the purchase price of the defective product. BONSAL SHALL IN NO EVENT BE LIABLE FOR ANY CONSEQUENTIAL, INCIDENTAL OR SPECIAL DAMAGES.

This Warranty constitutes the sole warranty given by Bonsal in connection with this product, and Bonsal has authorized no person to make or give any other warranties or representation, oral or written on its behalf. IN PARTICULAR, THERE ARE NOT IMPLIED WARRANTIES, INCLUDING WITHOUT EXCEPTION WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. No modification of this Warranty in favor of any buyer shall be valid unless given in writing and signed by an officer of Bonsal.

BONSAL SINCE 1895

REV 8/96

Rapid Patch - VR

MATERIAL C

BONSAL
SINCE 1895

Fast Set Cement Mix

BONSAL® Fast Set Cement Mix is a polymer modified, rapid setting Portland Cement repair product.

FEATURES AND BENEFITS:

- Ideal for Overhead Repairs
- Featheredges
- Can be Used for Horizontal or Vertical Repairs
- Freeze-Thaw Resistant
- Meets ASTM C 928 Packaged, Dry, Rapid-Hardening Cementitious Material for Concrete Repair
- Complies with DOT Requirements
- High Early Strength
- No Forming Needed
- Can be Extended with Coarse Aggregate
- Bonds to Existing Concrete and Masonry
- Does Not Shrink
- Sets in 20 Minutes
- Ready for Light Use in 4 Hours, Heavy Use in 24 Hours
- Non-Corrosive-Contains No Calcium Chloride
- Rapid Buildup

USES:

Repair of Concrete

- Poured in place, precast, tilt-up and prestressed
- Concrete Beams and Columns

• Walkways	• Driveways	• Curbs
• Tunnels	• Ramps	• Loading Docks
• Bridges	• Decks	• Concrete Pipes
• Cavities	• Median Barriers	
• Honeycombs	• Core Holes	

Repair of Concrete Masonry

- Resetting or Pointing of Brick, Block or Stone
- Stucco •Cement Tile Roofs

PREPARATION:

Clean area and remove all unsound concrete, grease, oil, paint, and any other foreign materials that will inhibit performance. Slick or sealed surfaces must be thoroughly roughened. Refer to:

- ASTM D 4258 Surface Cleaning Concrete for Coating
- ASTM D 4259 Abrading Concrete
- ASTM D 4260 Acid Etching Concrete
- ASTM D 4261 Surface Cleaning Concrete Unit Masonry for Coating
- ICRI Surface Preparation Guidelines for Repair of Deteriorated Concrete Resulting From Reinforcing Steel Oxidation

PREPARATION (Cont.):

- ASTM D 4580 Measuring Delaminations in Concrete Bridge Decks by Sounding
- ACI 201.1R Guide for Making a Condition Survey of Concrete in Service
- ACI 201.3R Guide for Making a Condition Survey of Concrete Pavements

Use of BONSAL Acrylic Additive
When using BONSAL Acrylic Additive in BONSAL Fast Set Cement Mix, saturate the substrate with water. Remove excess water prior to application and consult BONSAL Acrylic Additive product literature.

Note: BONSAL Acrylic Additive cannot be used as a roll, brush or spray applied substrate primer.

Use of BONSAL 118 Primer/Admixture
When using BONSAL 118 Primer/Admixture as a primer over sound substrates, dilute 1:1 with water. Consult BONSAL 118 Primer/Admixture product literature for coverage rates.

Make a small test area and examine after several days. Under conditions of excessive temperatures or high absorption, dampen substrate with water prior to applying BONSAL 118 Primer/Admixture.

MIXING:

Combine Admixture per table below before adding to Fast Set Cement Mix.
Discard any material that sets up.

Horizontal	Acrylic Additive or 118 Primer/Admixture		Water
9 lb. Pail	8 oz.	+	24 oz.
50 lb. Bag	1 quart	+	3 quarts

Overhead & Vertical	Acrylic Additive or 118 Primer/Admixture		Water
9 lb. Pail	6 oz.	+	12 oz.
50 lb. Bag	1 quart	+	2 quarts

For repair areas more than 2" deep, preblend 20 lbs. 3/8" coarse aggregate (AASHTO M43 size #7) per 50 lb. bag, 3 1/2 lbs. per 9 lb. pail, then add mixing liquid. For repair areas more than 12" deep or DOT requirements, consult the *W.R. Bonsal Company.*

PLACEMENT:

Placement Temperature

	Minimum	Maximum
Substrate	50°F	90°F
Mix	60°F	80°F
Air	50°F	90°F

Place the Fast Set Cement Mix on the substrate to be repaired. Force the mix into the original concrete. Lightly trowel to the desired finish.

For overhead repairs, thickness should not exceed 1" per application.

Finishing
To obtain a nonskid surface, use a damp sponge, rubber float or a damp broom.

CURING:

Protect from heat and direct sun for 12 hours. Do not wet the surface after the material has set. Maintain at least 40°F for 24 hours after application.

Materials modified with BONSAL Acrylic Additive or BONSAL 118 Primer/Admixture should be air cured, unless hot/or drying winds or low humidity are present. Under such conditions, cure per Portland Cement Association - Design and Control of Concrete Mixes (EB001.12T) and/or American Concrete Institute 308 - Standard Practice for Curing Concrete.

Actual moisture content testing is recommended prior to final floor covering installation. Consult the Floor Covering Manufacturer for substrate recommendations.

TECHNICAL DATA:

Set Time
ASTM C 191
Initial Set — 20 minutes
Final Set — 30 minutes

Compressive Strength
ASTM C 109
4 hours air cured — 3500 psi
24 hours air cured — 6000 psi
7 days air cured — 6500 psi
28 days air cured — 8500 psi

Shear Bond Strength
ASTM C 882
28 days air cured — 1200 psi

Shrinkage
ANSI 118.4, F-5
28 days air cured — None

TECHNICAL DATA (Cont.):

Length Change Percent
ASTM C 157
Air Cured — -.04
Moist Cured — +.08

Tensile Strength
ASTM C 190
7 days air cured — 380 psi

Alkalinity
12.8 pH

Flexural Strength
ASTM C 580
7 days air cured — 900 psi
28 days air cured — 1400 psi

Freeze Thaw Durability
ASTM C 666 A
300 cycles — 98%

LIMITATIONS:

- DO NOT apply when air or substrate temperature is below 50°F or above 90°F within 12 hours of application.
- DO NOT coat with materials that will trap water in the substrate.
- DO NOT use dirty water or tools.
- DO NOT retemper after 5 minutes of mixing.
- DO NOT over trowel.
- DO NOT apply over substrates that are frozen or contain frost.
- DO NOT add or mix any materials with this product, unless approved by the *W.R. Bonsal Company.*
- DO NOT add excessive amounts of water.
- DO NOT apply over Light Weight concrete.
- DO NOT apply over concrete cured less than 7 days.
- DO NOT reuse empty container. Recycle or dispose of properly.

WARNING: Cracks in the material may reappear due to structural faults in the construction itself. The effectiveness of any repair depends on sound structures, proper preparation, and application.

MATERIAL D

DelPatch Mixing Instructions

1494 Part A	9.33 Lbs.
1494 Part B	4.67 Lbs,
Fiberglass	4.4 Lbs.
Sand	18.0 lbs.

1. *Mix Part A & B* **First, approximately 15** seconds.
2. Add Fiberglass, mix well until gray in color; approximately 45 seconds.
3. Add sand last, mix approximately 30 seconds.
4. Pour into molds.

If concrete is used, allow concrete primer to dry at lease 1/2 hour but no More than 8 hours. The concrete primer can also enhance bond strength to steel. Grit blast all surfaces to be bonded.

CONSTRUCTION METHODS

607-3.1 -WEATHER LIMITATIONS. Spall repair shall be performed only when the ambient air temperature is 45°F (7°) and rising. Temperature of the concrete to be repaired shall be 45°F (7°C) or above.

607-2.2 Properties material shall meet the following properties:

PROPERTIES REQUIREMENT	TEST	METHOD
Tensile		
Strength	600 psi	
Elongation	25	
Hardness, Durometer D	50	ASTM 2240
Compressive		
Stress psi 5% Deflection	800 min/ 1400 max	ASTM D 695
Resilience, %		
5% Deflection	95 min	
Impact		
Ball Drop @ -20°F (No Cracking)	>10 ft	
Adhesion to Concrete (Psi)		
Dry Bond	400 min	
Wet Bond	250 min	
Fluid Immersion		
% Wt. Change after 70 hrs in Room Temp, Jet Fuel	8% max	ASTM D 471

MATERIAL E

E-poxy Industries, Inc.

"Tech Data"

EVA-POX® ELASTO-CRETE No. 74

PRODUCT PRESENTATION:

EVA-POX® ELASTO-CRETE is a colored three component, modified elastomeric compound. It was developed for use where a colored, flexible, non-shrink, non-vulcanized, energy absorbing and watertight expansion joint nosing or grout is required. Ideal for use with or without armor nosings in high stress areas. For application at a minimum of 45°F (7°C) ambient and surface temperatures.

USES:

- The energy absorbing nosing material in the "Ceva®" Expansion Joint Systems
- Parking garages and pedestrian walkways with or without the armor nosings
- Color matching pothole / chuckhole repair on bridges, highways, parking decks, etc.
- As a grout in a visible, aesthetically appealing area.

ADVANTAGES:

- Comes in various colors to conceal or accent expansion joint nosings.
- Excellent weathering resistance
- Excellent abrasion resistance
- Rapid setting elastomeric concrete
- Ideal for stage construction
- Non-vulcanized
- May be used with various armor nosings
- Excellent bond strength to steel, concrete and asphalt
- Excellent thermal shock resistance
- Traffic may be resumed in three hours
- Waterproof

SURFACE PREPARATION:

Concrete: All oils, grease, dirt, waxes, existing coatings, curing compounds, heavy laitance and sharp edges or protrusions must be removed. New concrete should cure 80% of the design strength. Sandblasting is highly recommended.

Steel: Surfaces must be clean, sound, and sandblasted to a near white metal (SSPC-10) finish immediately before the installation.

MIXING PROCEDURE:

Separately mix components A and B thoroughly. Pour entire contents of Component B and Component A into a metal 5 gallon pail. Mix the resins together thoroughly for 3 minutes or until there is no marbling present. After thoroughly mixing the resins add 24 lbs. (entire contents of pail) of the supplied Ceva® Aggregate and continue mixing until no dry material appears.

NOTE: Ceva® Aggregate is a special blend of graded, oven-dried aggregates. DO NOT use if the bag has become wet or aggregate is moist. Eva-Pox® Elasto-Crete Kits contain 24 lbs of the Ceva® Aggregate plus one can each of components A and B in a steel five gallon mixing pail.

For additional instructions see the "Installation Instructions For Elastomeric Concrete" data sheet.

AVAILABILITY:

Packaging: #74 Kit (.30 c[illegible] 8,496cu.cm.):
1 gal. can component A
1 qt. can component B
24 lbs. (10.9kg) Ceva® Aggregate

Colors: Gray, Beige*, Green*, Red*

* Minimum order required with all custom colors.

CLEAN UP:

Use EVA-POX® SOLVENT NO. 31

STORAGE:

DO NOT ALLOW PRODUCT TO FREEZE. Store in a dry area at temperatures between 50°F and 95°F (10°C - 35°C) in the original unopened containers. Material should be preconditioned to a temperature of at least 70°F (21°C) for ease of mixing. Lower temperatures have a thickening effect on the resins and slow the cure times; the opposite is true for higher temperatures.

TECHNICAL DATA

Properties (uncured):

	Part A	*Part B*	*Mixed*
Color	White*	Black*	Gray*
Shelf Life	1 Year	1 Year	
Density, (lbs./gal.)	9.3 ±0.2	8.8 ±0.2	9.2 ±0.2
Viscosity @77°F (25°C), (cps.)	30,000 - 40,000	6,000 - 7,000	20,000 - 40,000
Mixing Ratio (by vol.)	4 vols.	1 vol.	1 gal. : 24 lbs. Aggregate

*** Colors available with minimum order**

Pot Life @77°F (25°C)	20 - 30 min.
Initial Set @77°F (25°C)	1 1/2 - 2 hrs.
Initial Cure @77°F (25°C)	3 hrs.
Full Chemical Cure	7 days

Properties After Cure:

Compressive Strength	ASTM D695 (modified B)	2600 psi±400
Tensile Strength	ASTM D638	600 psi (min.)
Bond Strength	ASTM C882	420 psi (min.)
Elongation	ASTM D638	120% (min.)
Tear Resistance	ASTM D638	90 ppi (min.)
Water Absorption	ASTM D570	0.35% (max.)
Yield/Batch		0.30 cu.ft.

WARRANTY

Manufacturer WARRANTS that the product conforms to its chemical description and is reasonably fit for the purpose stated on its Technical Bulletin when used in accordance with its directions. Manufacturer makes NO OTHER WARRANTY either expressed or implied. Buyer assumes all risk in handling.

For further Technical or Application Information, contact E-Poxy Industries, Inc.

E-POXY INDUSTRIES, INC.
460 South Pearl Street
Albany, N.Y. 12202-1152

518-465-7850
1-800-833-3400
Fax#: 518-465-7802

http://www.e-poxy.com

Rev: 3/98

MATERIAL G

SILSPEC® 900 POLYMER NOSING SYSTEM

NATURE OF PRODUCT

Silspec 900 Polymer Nosing System is a two-component rapid curing liquid polymer that cures to a dense, semi-flexible, weather, abrasion and impact resistant polymer mortar for the construction or repair of expansion and construction joints on bridge and parking decks The combined polymer is mixed with Silspec 900 Blended Aggregate to form a polymer based mortar for nosing or joint repair It can also be cured in the "neat" form as a combination sealant primer and protective coating for steel

Silspec 900 PNS is 100% non-volatile Due to its relatively low viscosity, Silspec 900 is easy to mix and place. Silspec 900 is one of the more versatile and economical polymer systems available.

TYPICAL PHYSICAL PROPERTIES

*Combined Liquid Components**		
Mixing Ratio	1 : 1 By Volume	
Viscosity	9-20 Poises (Spindle No 2, 30 RPM9 250 C -L2'0)	ASTM D 2393
Color	Black	
Gel Time, minutes	25-50	AASHTO M-200-73
Elongation, percent	45-55	ASTM D 638#
Tensile Strength, Min, PSI	900	ASTM D 635#
Shore D hardness @ 25° C. (77° F.)	45-75	ASTM D 2240

#Test Method Type 1, Molded Specimens, 6.4 mm (.25 in) Thickness

Cured Mortar			
Compressive Strength	PSI @ 24 hrs. (Method B)	2500 Min	ASTM C 579
Bond Shear Strength	PSI	700 Min	ASTM C 882
Abrasion Resistance	Wear Index (Taber H-22)	1.0 Max	ASTM C 501
Compressive Stress	PSI	350 Min	OK/OHD L-6
Resilience	Percent	70 Min	OK/OHD L-6

Aggregate -- Well graded flint, supplied by manufacturer

*Type A Certification on Liquid Components furnished on each lot

(X.J.S., US Pat #5190395 and Foreign Patent Pending)

SUGGESTED USES

A) Silspec 900 PNS, upon curing, develops a tough, chemical wear, and impact resistant surface for use in areas exposed to foot or vehicular traffic. *(Contact SSI for procedures for obtaining skid resistance.)*

B) It is ideally suited for use as binder for mortar preparations.

C) When combined with Silspec Aggregate, it can be used to repair damaged expansion and construction joints in bridges, roadway pavements, and parking structures. It can also be used for small repairs.

D) Due to its low water absorption, it provides excellent protection during freeze-thaw cycles.

E) When used in conjunction with Dow Corning 902 RCS Silicone Sealant (The X.J.S Expansion Joint System, U.S. Pat #5190395), it provides an alternative for strip seals, compression seals, and elastomeric devices in new bridge deck expansion joints: and results in substantially improved performance at lower cost.

STANDARD TYPE

Will permit cure to a minimum of 70 C. (450 F) Silspec 900/950 Accelerator can be added to speed curing at low temperatures Contact SSI for recommendations.

Modification in viscosity to decrease problems of sag or "running" on steep inclines or ramps can be made by adding additional aggregate.

No modification of the material should be attempted without consulting SSI.

Shelf Life is two (2) years from date of shipment if stored below 32°C (90°F).

GENERAL USE PROCEDURES

SURFACE PREPARATION

Regardless of substrate, Silspec 900 PNS must be applied to dean, dry and sound surfaces for effective bond.

All unsound material must be removed from structurally sound substrate by jack-hammering, sandblasting or similar mechanical methods,

All loose material must be removed by brushing, vacuuming or blowing, Old paint, rust or other coating must be removed by the proper methods.

Asphalt/Bituminous Substrates --- Observe above methods carefully Do not use solvents. NOTE: While Silspec 900 adheres to asphalt the asphalt itself has poor tensil strength. Consequently, we recommend whenever possible, that Silspec 900 be bonded to concrete or sound steel substrate,

Steel Substrates -- Surface shall be sandblasted to near white condition.

Mixing of Liquid Components

Silspec 900 PNS is a two-component product (Base and Reactor); these must be *thoroughly* combined prior to use in a separate container, in the proper ratio of one volume Base to one volume Reactor. **We strongly recommend that the cans be wiped out with a spatula (if this is not done, 10% or more of the material can be left in the container).** Therefore, it is critical that the material be scraped out of the cans in order to assure adequate liquid/aggregate ratio, In small batches only, Base and Reactor can be hand-mixed. However, mechanical mixing, using a heavy duty, low speed drill motor with paint-type paddle stirrers or a mortar mixer, is strongly recommended- Mixing time should not be less than three minutes. Care should be taken to ensure thorough mixing from top to bottom as well as the sides of the container

The blended batch must be applied to the surface in 10-15 minutes. Once spread out, working time will be approximately 1/2 hour depending upon temperature. Clean equipment immediately with Toluol, Xylol, Lacquer Thinner, or a mixture of clean aggregate with water .

> *CAUTION --- Water retards the cure of Silspec 900 PNS, therefore if a mixture of clean aggregate and water is used to clean the mixer, extreme care should be taken to ensure that the mixer is thoroughly dry and any uncured material is removed prior to mixing new material*

> *NOTE --- Do not mix more material than can be used at one time*

MIXING AND PLACING OF MORTAR

Patching and Repairs --- The mixed Silspec 900 PNS is made into a mortar by combining one (1) volume of mixed polymer with three and one-quarter (3 25) volumes of Silspec Blended Aggregate. *Priming the surface with neat polymer is required before application of the mortar,* After combining the Base and Reactor for a minimum of 3 minutes, it is then placed in a suitable mixer, then add the Silspec Aggregate is added to produce a mortar- When mixing mortar in a bucket with a drill motor, never mix more than 112 kit at a time. Mixing is a two-step process; Step 1: Always measure the materials to insure the proper ratios **Extreme care** should be taken to insure that the aggregate is mixed uniformly kori top to bottom in the bucket. Step 2: After the first mixing. the mortar should be poured into a second bucket and mixed an additional 2 minutes to insure that the liquid-aggregate mix is uniform it is extremely important that the material be thoroughly compacted into the **wet** prime coat. Care should be taken to assure good compaction on the vertical face of the joint and along the side of the Styrofoam form. Simply smoothing the top with a steel float is **not** compacting the mix. A small margin trowel, or other means, should be used for compaction. If the material is more than 5 *cm* (2 in.) thick, it should be laid in lifts and compacted after each lift. Successive lifts should be placed immediately, while the previous lift is still fresh. One large kit, 7.6 Liters (2 Gallons) of mixed Silspec 900 PNS, when combined with one (1) bag of Silspec Blended Aggregate, will yield approximately 19,800 cu cm (.7 cu ft.) of mortar.

Cleaning --- All tools, other application or mixing equipment must be cleaned at frequent intervals and while Silspec 900 PNS remains soft and uncured.

For cleaning hand tools, solvents such as Xylol, Toluol or Lacquer Thinner are most effective, or cleaning can be accomplished using waterless hand cleaner.

> *NOTE ---* These *solvents are FLAMMABLE and all safety codes and regulations governing their use must be observed.*

Cure --- At 21° C. (70°F.) *(surface & air temperature)*, the mortar will cure sufficiently to accept traffic in four hours. Higher temperatures will shorten the cure while lower temperatures will lengthen the cure time For temperatures in excess of 38'C. (100'F.), or lower than 150C. (609F.), contact S.S.I. for recommended procedures and cure time

In cold weather, we recommend that liquid and aggregate be stored in a heated area until just prior to use.

GENERAL

During all operations, established safety codes and workman protection must be observed.

Observe Good Housekeeping Rules and Regulations during all phases of use and handling of either unmixed or mixed product,

Use of protective creams, clothing, goggles, and rubber gloves are recommended during all phases of handling and use, Read and follow all handling precautions on labels Use common sense in handling Silspec 900 and all other chemicals.

Ample ventilation should be provided during all periods of sandblasting, mixing and application procedures

In accordance with ICC Regulation #49, Item 173,4: Containers containing less than one (1) fluid ounce of liquid are considered non-hazardous material Empty containers may be crushed and

should be disposed of in accordance with state and local regulations

MATERIAL H

Technical Bulletin No. 21-R

ROADPATCH II

Cement-base, fiber reinforced, fast-setting repair material for concrete bridge decks, expressways.

DESCRIPTION

A cement-base, fast-setting patching material that develops high compressive strengths and will allow traffic bearing repairs to be put back in service in 2 hours from time of placement. ROADPATCH II is fortified with special alkali resistant glass fibers that improve appreciably the impact, flexural and tensile strengths. The use of these special fibers contributes substantially to the ability of the product to resist cracking and abrasion. These improved properties, the high compression strength, and the overall capabilities make ROADPATCH II a superior repair material for highway departments, municipalities, and industry throughout the world.

USES

To repair bridge decks, curbs, expressways and other areas where partial depth patching and quick turnaround are required.

ADVANTAGES

- Excellent impact resistance.
- High compression strength.
- Very resistant to cracking.
- Excellent flexural and tensile strengths.
- Freeze-thaw resistant.
- Fast-setting.
- Traffic bearing in 2 hours.
- Can be applied to a damp surface.
- Longer working time.
- Contains no calcium chloride.
- Resistant to Chloride Ion (CL-) intrusion.
- Will not burn itself out.

SURFACE PREPARATION

Area to be repaired must be clean, structurally sound and free of all loose, dirty, oily and scaly material before applying ROADPATCH II. Do not feather edge patches; either cut or chip to a depth of approximately 9.5 mm to 12 mm (3/8" to 1/2") around edge of patch.

MIXING

Thoroughly mix 22.7 kg (50 lbs.) of ROADPATCH II with approximately 3.5 qts. of water. For improved bonding and increased strength, use a mixing liquid consisting of 1 part ACRYL® 60 and 2 parts of water.

Mix for approximately 1 minute with mechanical mixer or 2 minutes by hand.

When mixing in rotary mixer, rubber tip blades are desirable. Add dry material to mixing liquid for better blending. Note: 6.8 kg (15 lbs.) of 6.3-9.5 mm (1/4" to 3/8") or less of dry, clean aggregate, stone or pea gravel may be added to 22.7 kg (50 lbs.) of ROADPATCH II for patches in excess of 2.5 cm (1"). The extended mix may be placed to a maximum depth of 15.24 cm (6") and a maximum volume of 0.155 m^3 (5.5 $ft.^3$) which equates to approximately 10, 22.7 kg (50 lb.) sacks.

Small amount of ROADPATCH II may be mixed by hand; just maintain same consistency as described above. When mixing by hand, add mixing liquid to dry material.

APPLICATION

Before applying ROADPATCH II, dampen area with water. Leave no standing water. Then apply ROADPATCH II, forcing the material against the sides and bottom of the patch area. Trowel material level, allow to take initial set. ROADPATCH II can be troweled or broom finished. Cure at ambient conditions.

PROPERTIES

- Set — approximately 10-15 minutes at normal temperatures.
- Heat of hydration — Minimum heat of hydration. Percentage of calcium chloride — NONE.
- Bondability — Bonds to all clean and sound concrete, masonry and stone.

LIMITATIONS

Do not re-temper.

Do not apply on frozen or frost-filled surfaces or if the temperature is below 4° C (40° F).

Do not feather edge repairs.

YIELD

22.7 kg (50 lbs.) will yield approximately 1.1 m^2 (12 sq. ft.) at 12 mm (1/2") thick.

PACKAGING

ROADPATCH II is available in 22.7 kg (50 lb.) sack.

COMMITMENT TO QUALITY

Harris Specialty Chemicals, Inc. is dedicated to providing quality, value-added products and services which consistently satisfy our customer's needs. As a group and as individuals, we are striving to improve the quality of our activities and to do them correctly the first time. We welcome input from our customers and suppliers.

TEST DATA

All tests conducted by Pittsburgh Testing Laboratory following ASTM procedures.

Compressive Strength (psi kg/m³) — ASTM C 109-85			
2 Hours	1 Day	7 Days	28 Days @ 70° F - 50% R.H.
2450	4583	5942	6317

Flexural Strength (psi kg/m³) — ASTM C 348-85		
1 Hour	1 Day	7 Days
366	615	1070

Tensile Strength (psi kg/m³) — ASTM C 190-84	
1 Day	7 Days
220	560

Shrinkage (psi kg/m³) — ASTM C 490-77/C 596-84
28 Days @ 70° F - 50% R.H.
-0.10%

LIMITED WARRANTY

Harris Specialty Chemicals, Inc. warrants that this product conforms to its current applicable specifications. Harris Specialty Chemicals, Inc. makes no other warranty, express or implied, including any WARRANTY OF MERCHANTABILITY OR WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE. The sole and exclusive remedy of Purchaser for any claim concerning this product, including, but not limited to, claims alleging breach of warranty, negligence, strict liability or otherwise, is the replacement of product or refund of the purchase price, at the sole option of Harris Specialty Chemicals, Inc. Any claims concerning this product shall be submitted in writing within one year of the date of delivery of this product to Purchaser and any claims not presented within that period are waived by Purchaser. In no event shall Harris Specialty Chemicals, Inc. be liable for any special, incidental, consequential (including loss of profits) or punitive damages.

SAFETY, HEALTH AND ENVIRONMENTAL RECOMMENDATIONS

Use appropriate personal protective equipment including eyewear, meeting the most current ANSI Z 87.1 standard. WARNING: This product contains a chemical suspected by the State of California to cause cancer. For specific health, safety, and environmental information consult the label and Material Safety Data Sheet available from Harris Specialty Chemicals, Inc.

TECHNICAL SERVICE

Harris Specialty Chemicals, Inc. sales and technical staff are available worldwide to assist in project evaluations, equipment recommendations, specification consultation, contractor training, job follow-ups and warranty issuance. Contact a local distributor or the Customer Service Department of Harris Specialty Chemicals, Inc. for any additional information or assistance.

Harris Specialty Chemicals, Inc. Headquarters:

World Headquarters
Jacksonville, FL
Phone: (904) 828-4900
Customer Service: (800) 327-1570
FAX: (904) 828-4992

European Headquarters
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B-2400 Mol, Belgium
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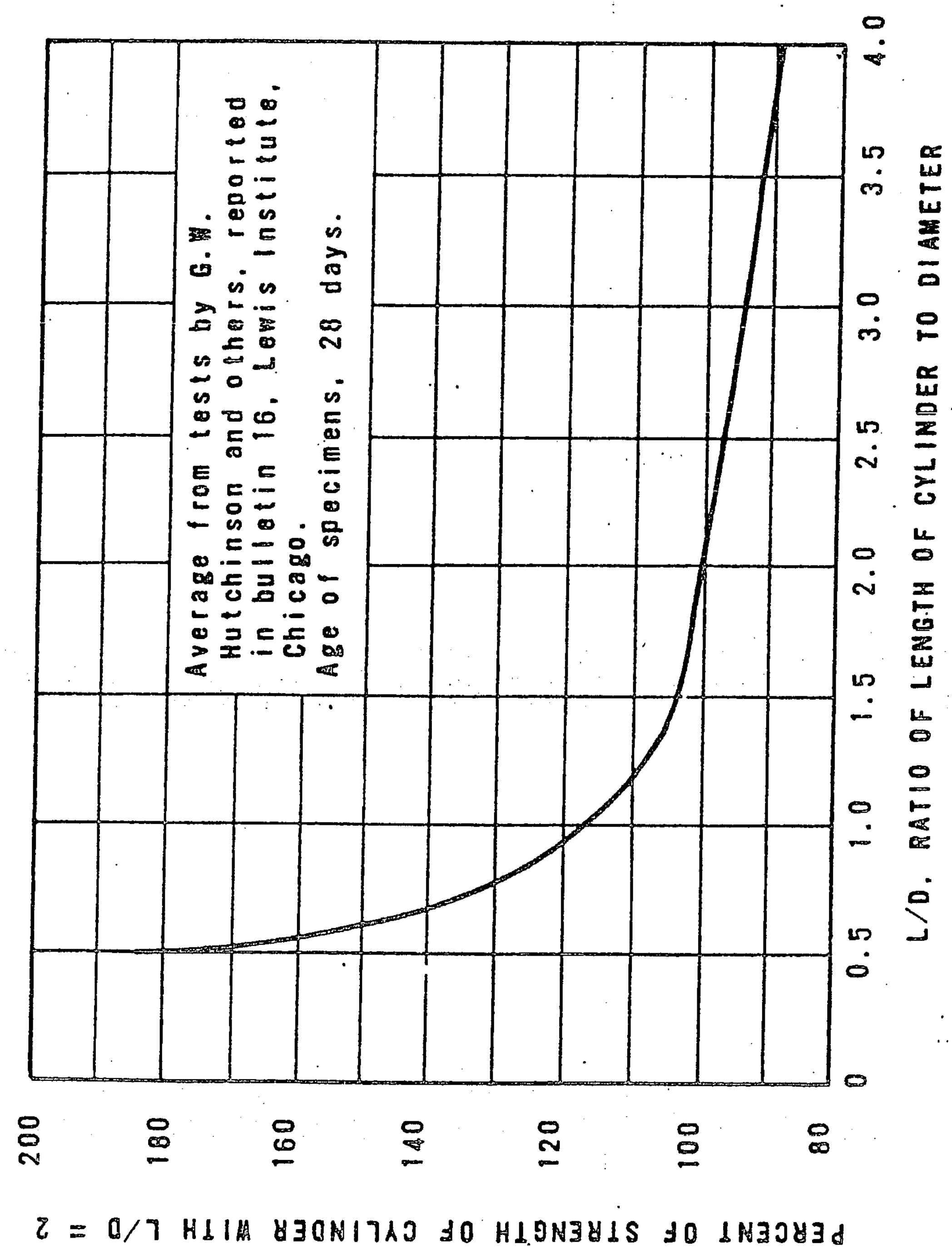
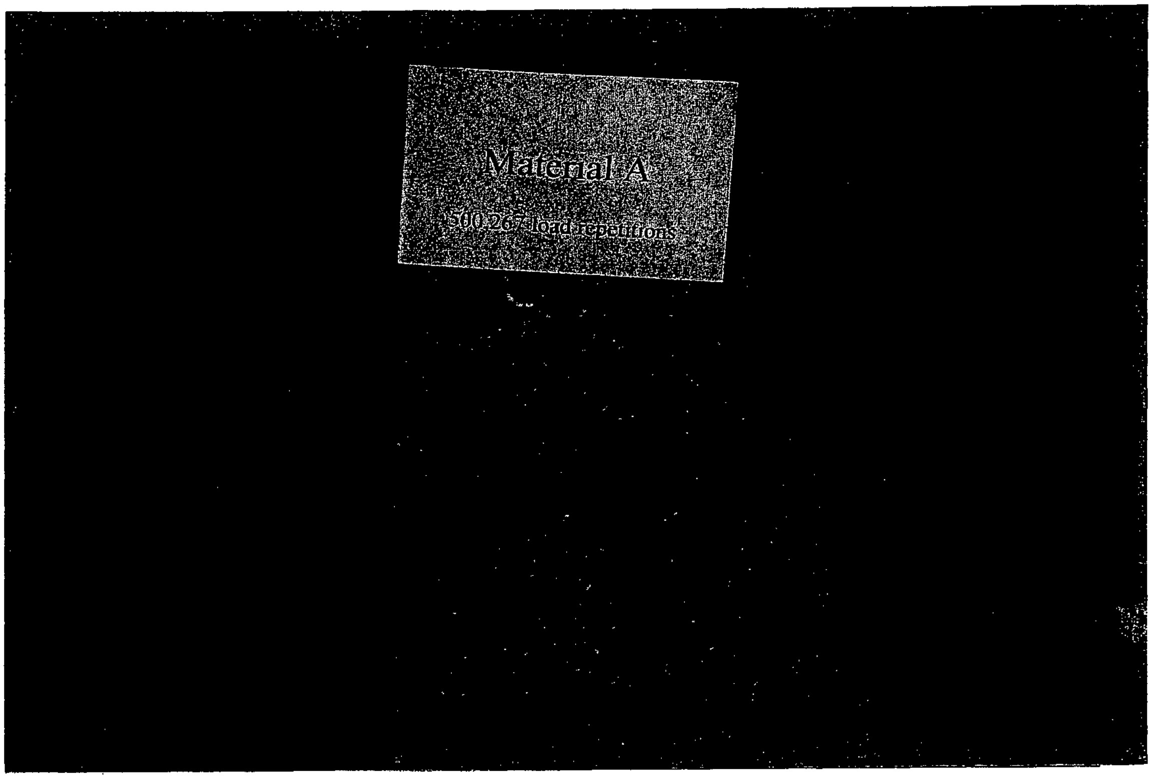
APPENDIX B

COMPRESSIVE STRENGTH vs. ASPECT RATIO (L/D)

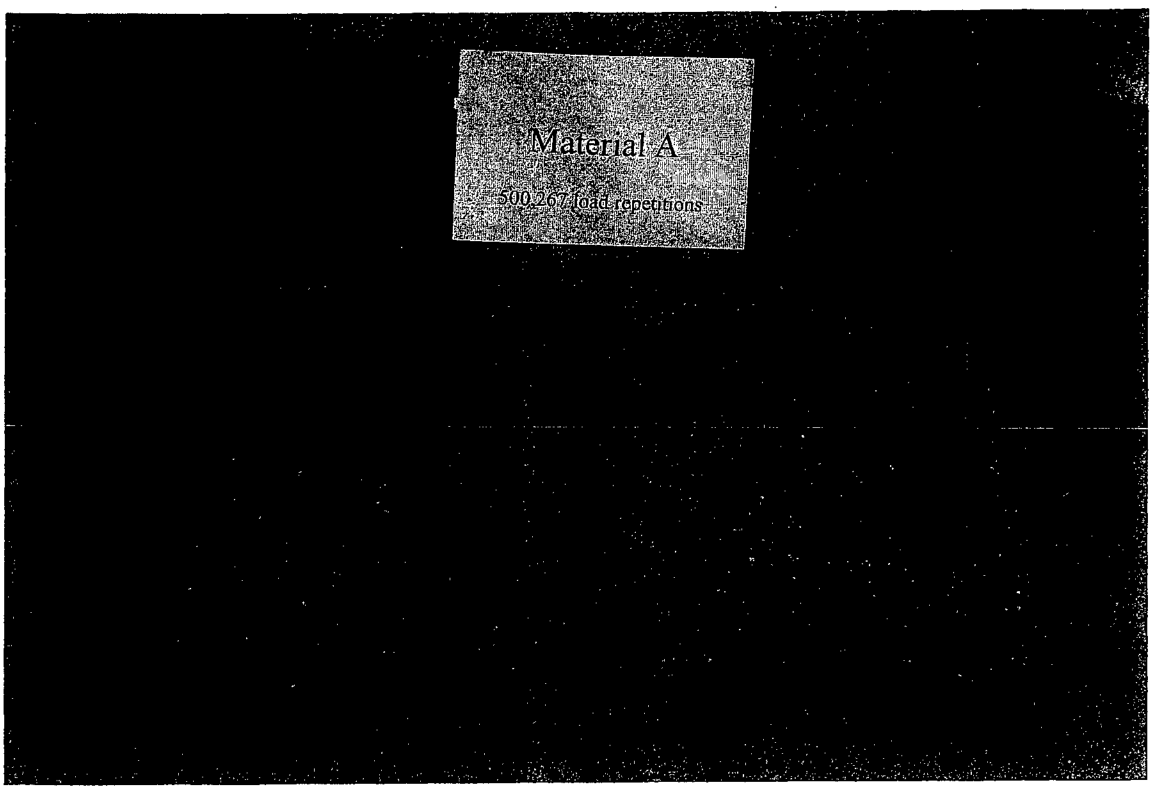

Average from tests by G.W. Hutchinson and others, reported in bulletin 16, Lewis Institute, Chicago.
Age of specimens, 28 days.
L/D, RATIO OF LENGTH OF CYLINDER TO DIAMETER
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
PERCENT OF STRENGTH OF CYLINDER WITH L/D = 2
80
100
120
140
160
180
200

APPENDIX C

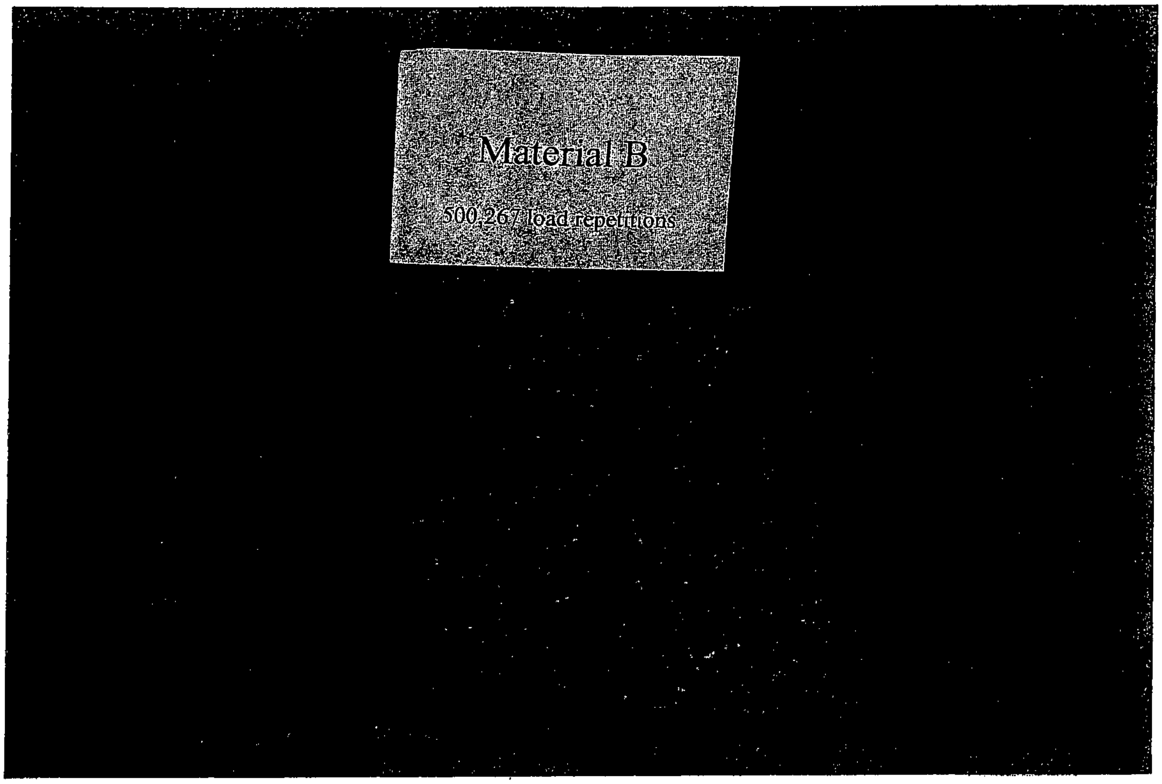
ACCELERATED PERFORMANCE TEST



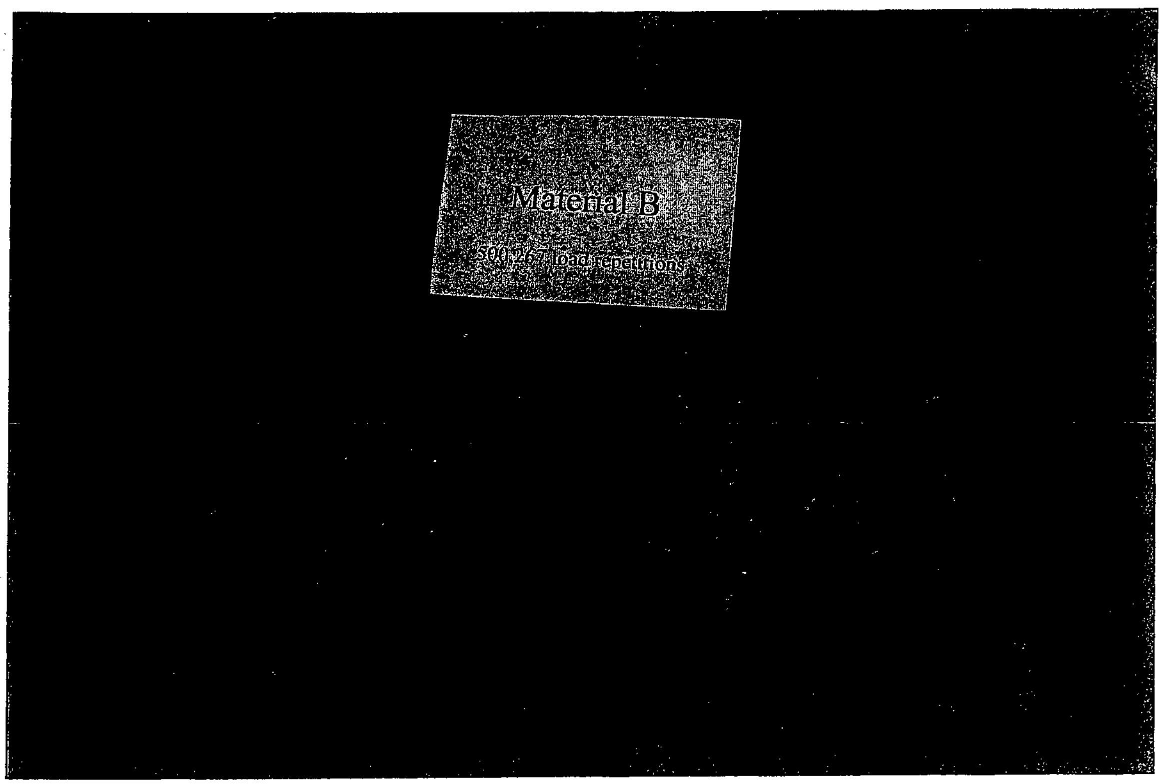
PHOTOGRAPH 42. Material A at 500,267 Load Repetitions (Patch No. 2)



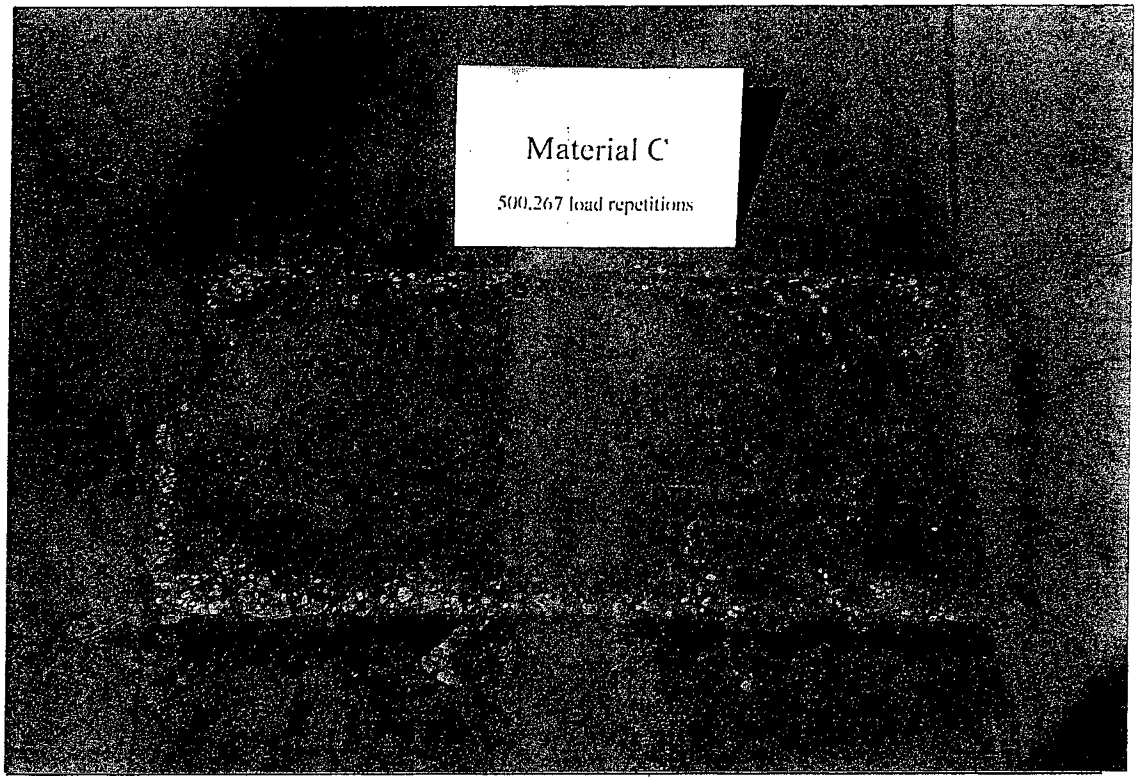
PHOTOGRAPH 43. Material A at 500,267 Repetitions (Patch No. 3)



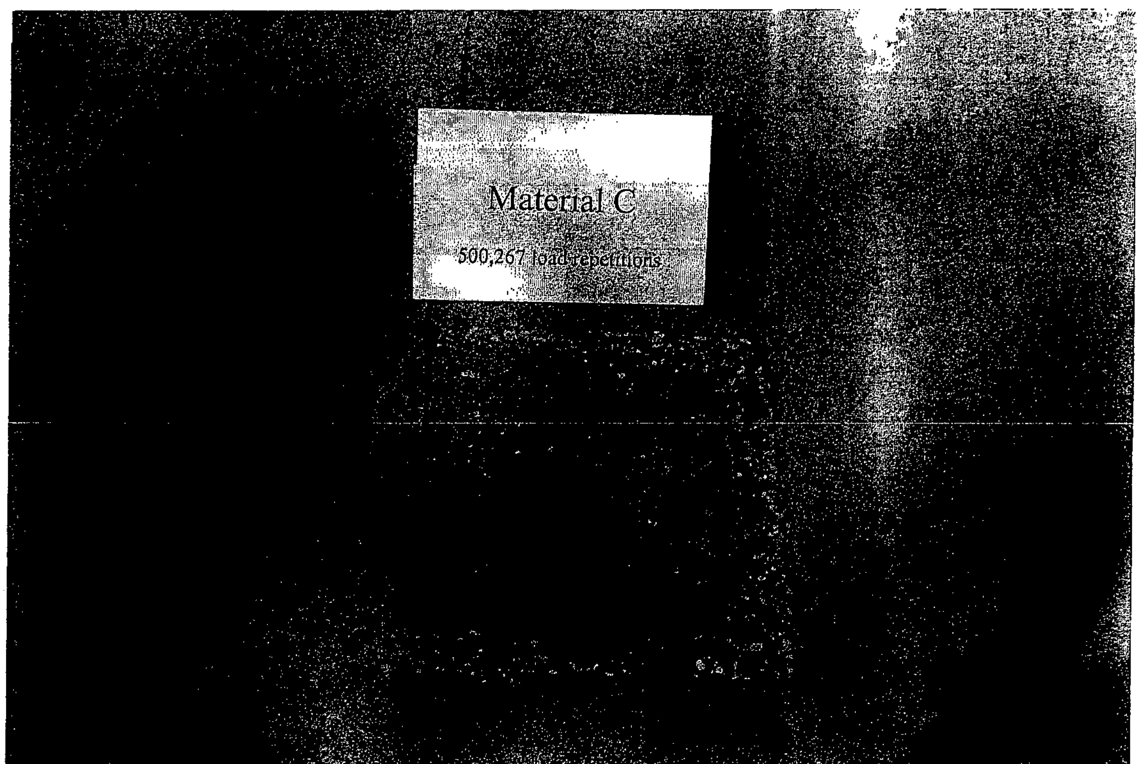
PHOTOGRAPH 44. Material B at 500,267 Repetitions (Patch No. 8)



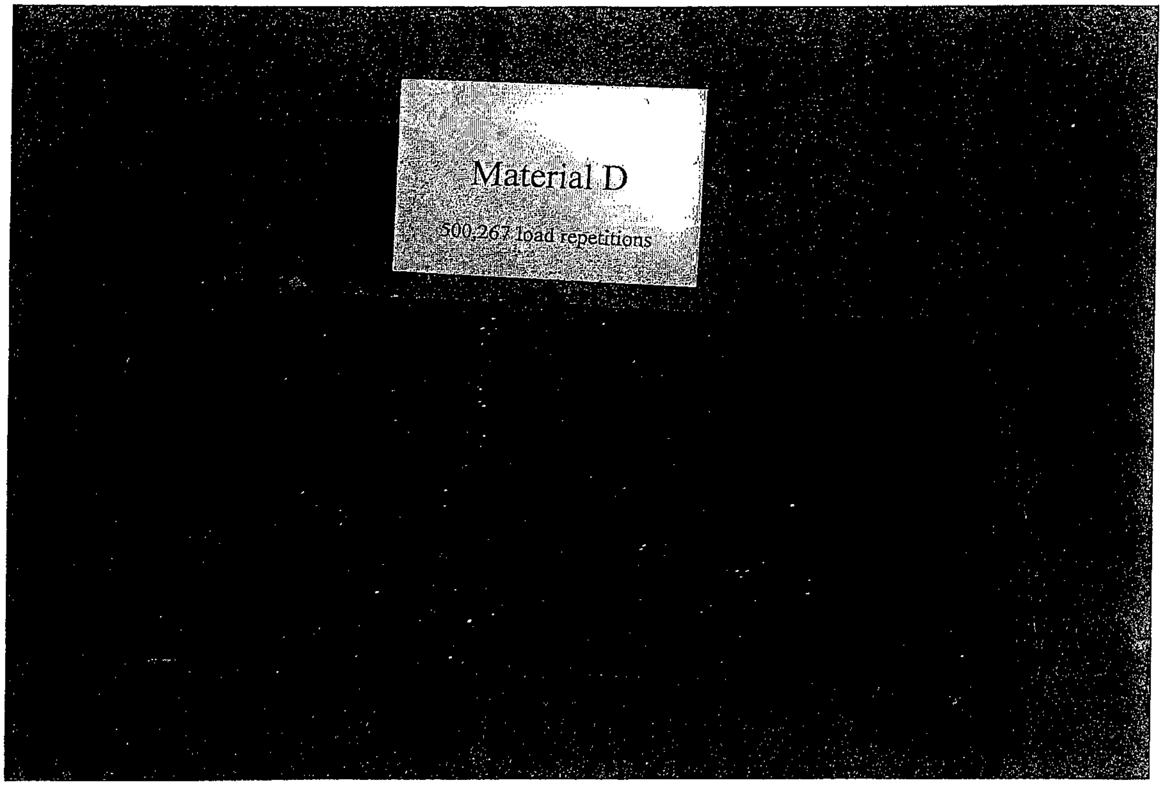
PHOTOGRAPH 45. Material B at 500,267 Repetitions (Patch No. 7)



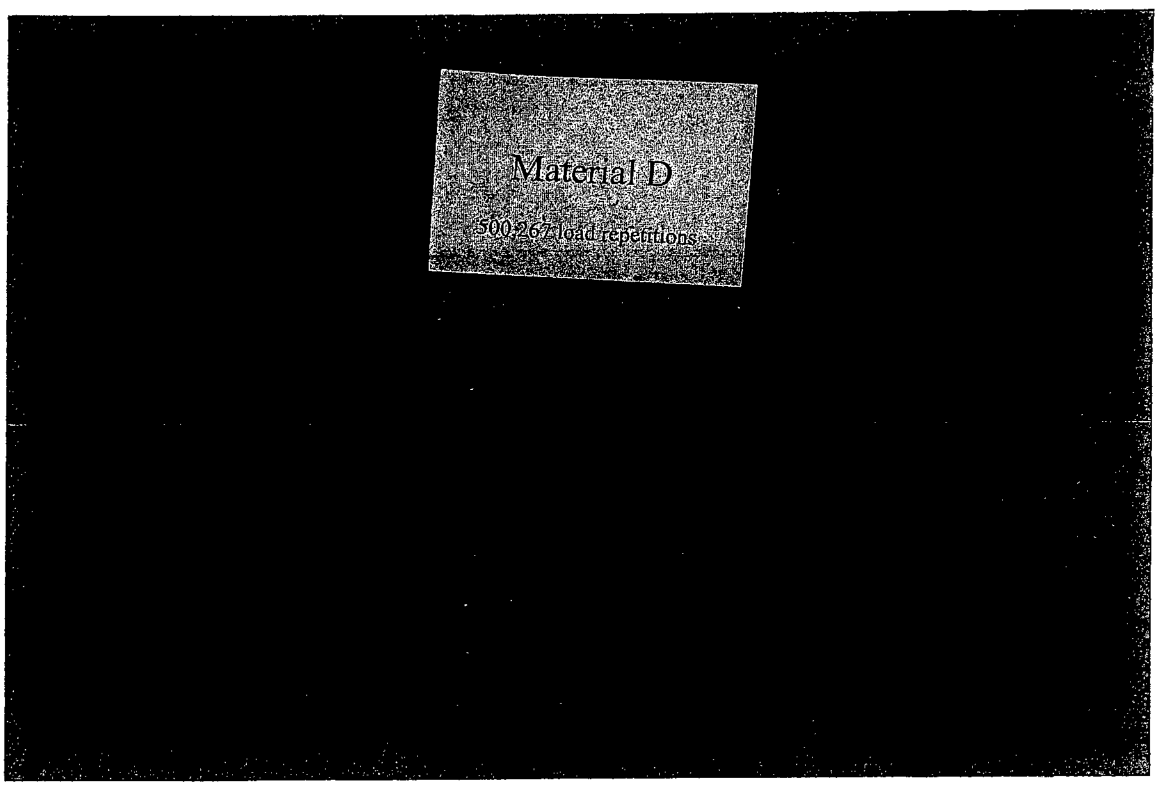
PHOTOGRAPH 46. Material C at 500,267 Repetitions (Patch No. 14)



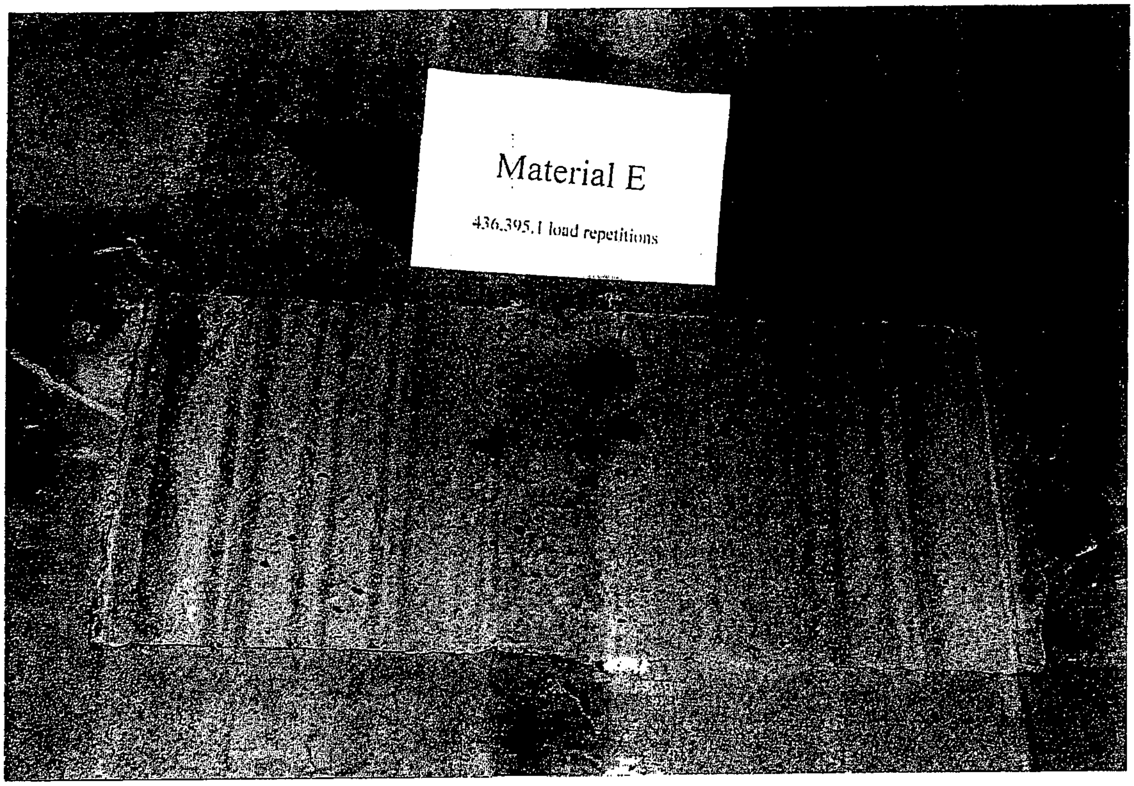
PHOTOGRAPH 47. Material C at 500,267 Repetitions (Patch No. 13)



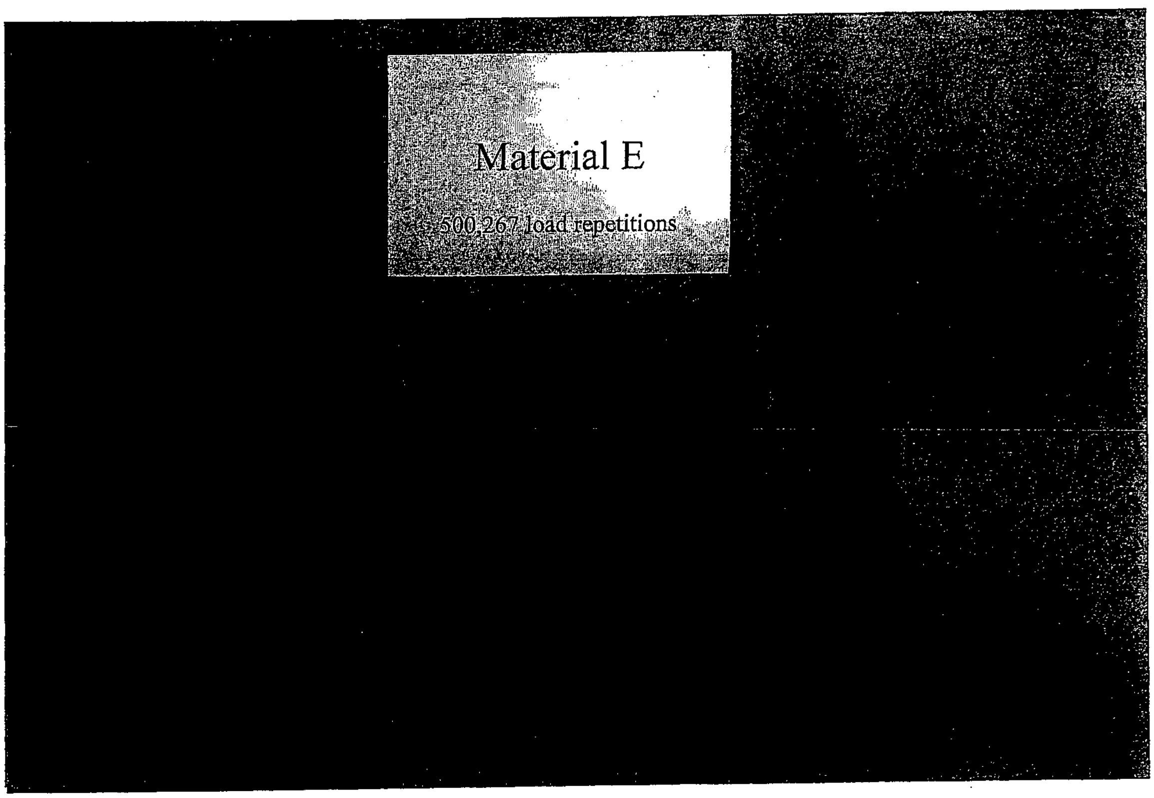
PHOTOGRAPH 48. Material D at 500,267 Repetitions (Patch No. 5)



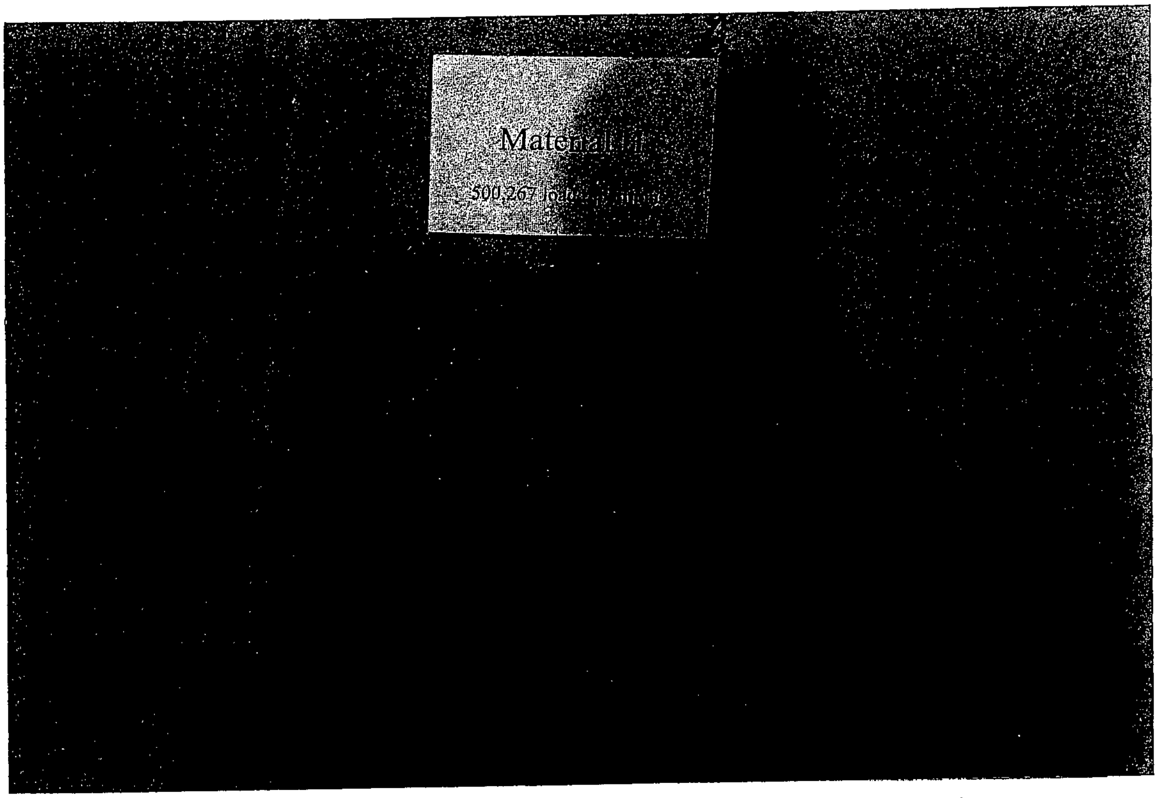
PHOTOGRAPH 49. Material D at 500,267 Repetitions (Patch No. 6)



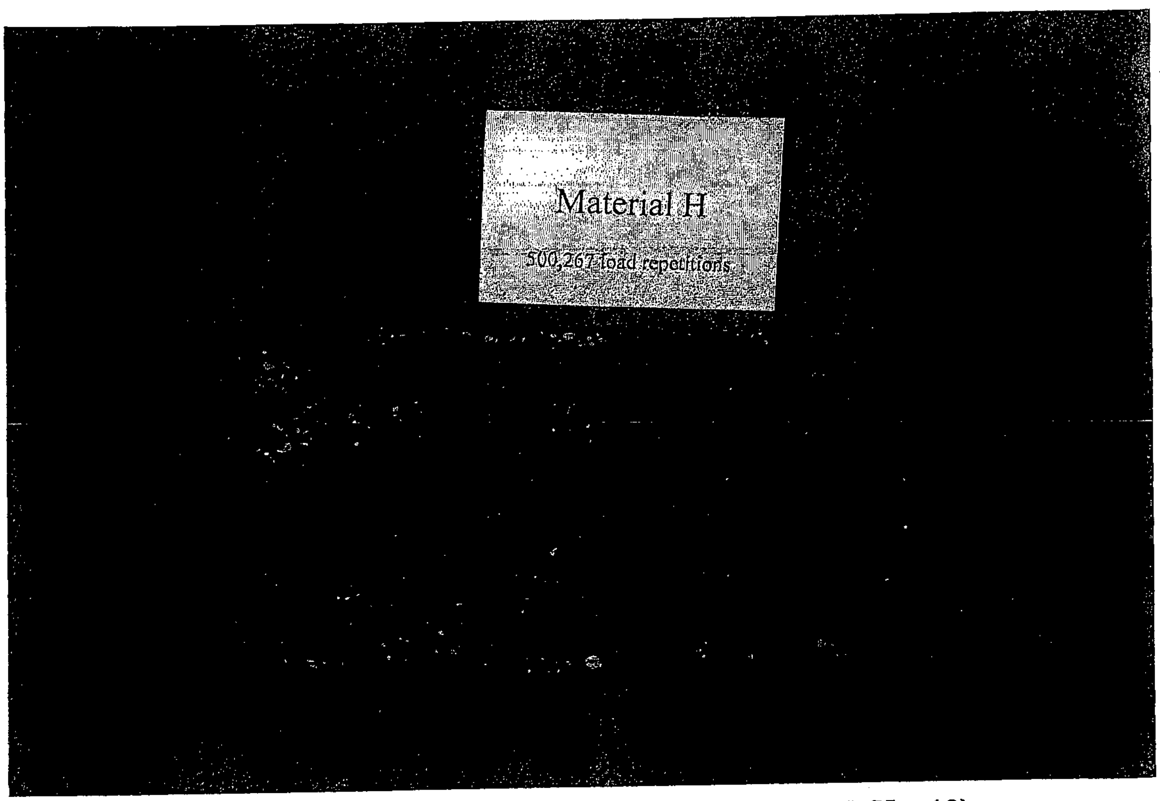
PHOTOGRAPH 50. Material E at 436,395 Repetitions (Patch No. 1)



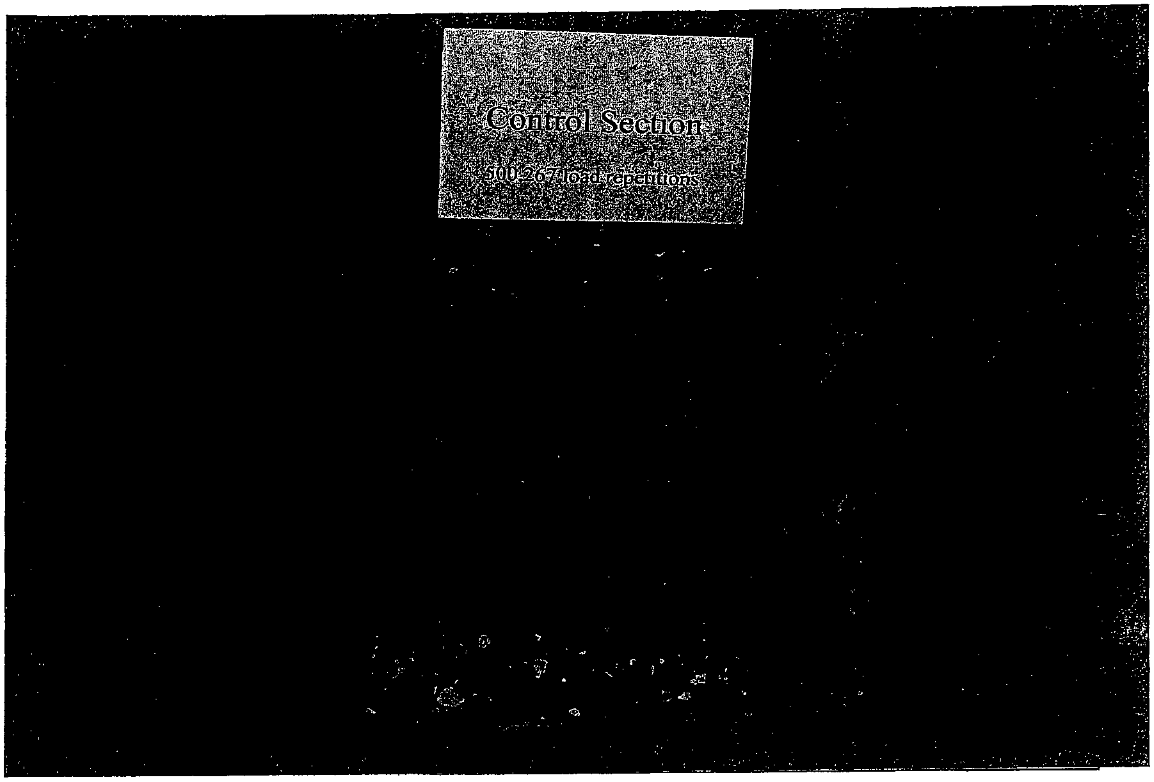
PHOTOGRAPH 51. Material E at 500,267 Repetitions (Patch No. 9)



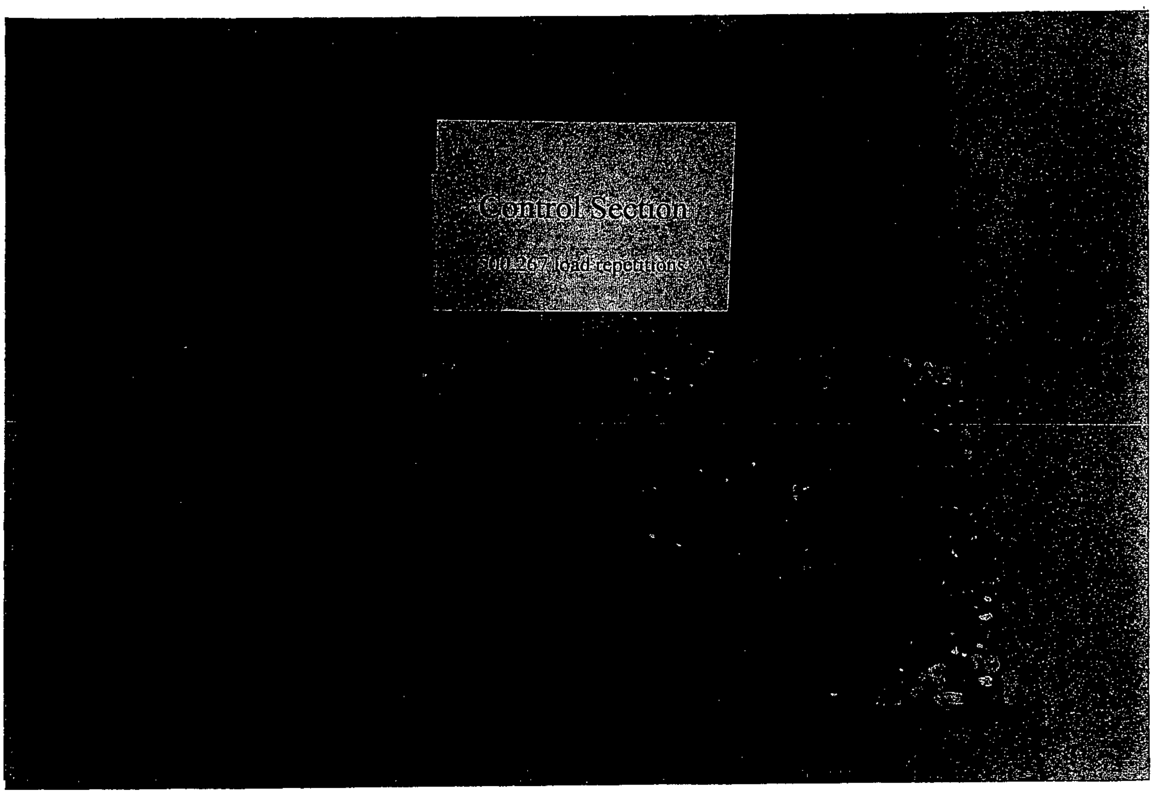
PHOTOGRAPH 52. Material H at 500,267 Repetitions (Patch No. 11)



PHOTOGRAPH 53. Material H at 500,267 Repetitions (Patch No. 12)

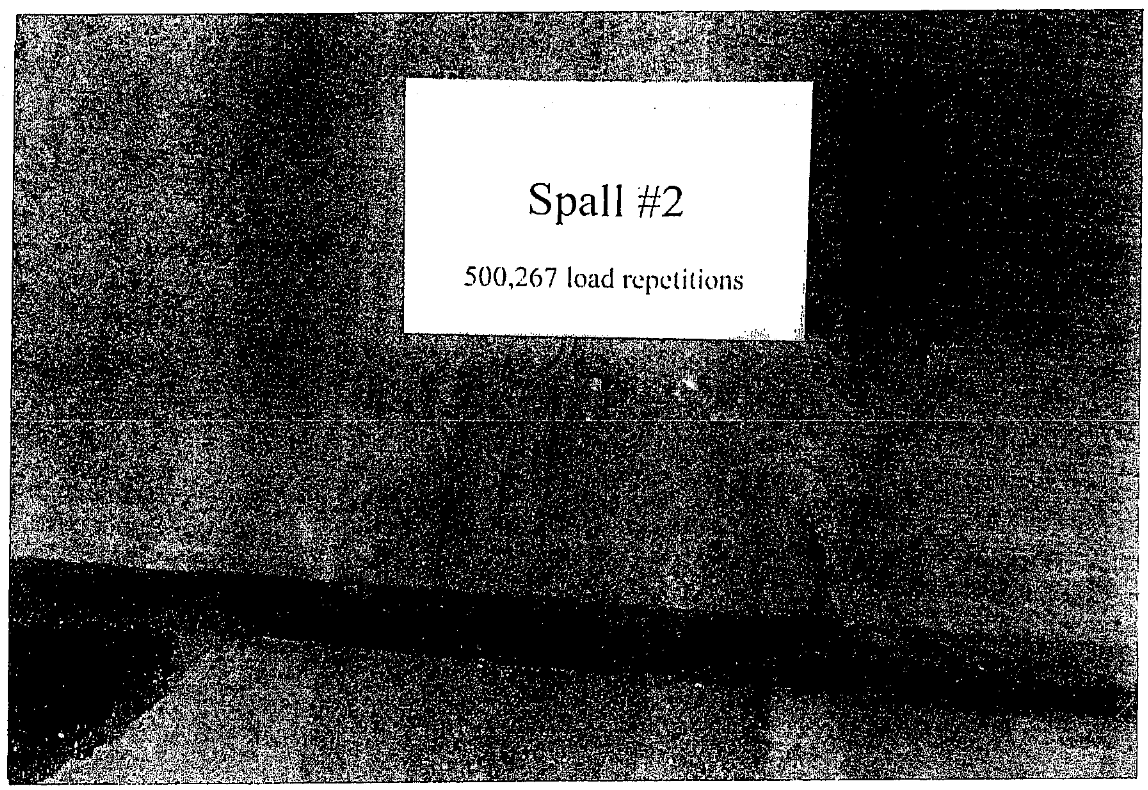


PHOTOGRAPH 54. Control Section at 500,267 Repetitions (Patch No. 4)



PHOTOGRAPH 55. Control Section at 500,267 Repetitions (Patch No. 10)

PHOTOGRAPH 56. Spall #1 at 500,267 Repetitions



PHOTOGRAPH 57. Spall #2 at 500,267 Repetitions

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