Report No. FHWA-TS-78-215 FCP Category 7

Optimizing Maintenance Activities

Fourth Report

REPAIR OF CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

Combined State Studies Of Selected Maintenance Activities A Cooperative Analysis By Teams From Arkansas, Louisiana, Mississippi, Texas

U.S. DEPARTMENT OF TRANSPORTATION

Federal Highway Administration

Office of Development

Implementation Division

Washington, D.C. 20590

NOTICE

Report FHWA-TS-78-215

REPAIR OF CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

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ACKNOWLEDGMENT

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Sincere thanks are also extended to those persons who made arrangements for and conducted the meetings in the four States.

SUMMARY

This report details the results of an in-depth study of methods and costs of repairing failures in continuously reinforced concrete pavement. The study was conducted in 1977 by teams of Engineers from four States: Arkansas, Louisiana, Mississippi, and Texas. Similarities were revealed in the methods of repair used by maintenance personnel in the four States. Subtle differences were also discovered which can be considered for implementation by all of the participants and others to improve their maintenance techniques.

Although no startling breakthroughs were uncovered in either costs or superior methods of making patches, many small items were discovered which, in combination, could result in considerable savings of time and money and, at the same time, provide for greater safety to the traveling public as well as to the maintenance personnel.

In addition to the maintenance findings, this study also verified the existence of construction and design deficiencies in some of the pavements that have been built to date, and provided suggestions for possible preventive maintenance procedures to prolong the life of an existing underdesigned or improperly constructed CRC pavement.

Because of the extent of present rehabilitation problems and the impending future rehabilitation problems, it is suggested that additional studies be made to determine optimum rehabilitation techniques for CRC pavement.

RECOMMENDATIONS

The following recommendations are given as the repair methods developed by this study for the most typical conditions. The greatest difficulties arose in trying to make the recommendations broad enough to cover the many special conditions which arise in practice. Where a consensus was not obtained pertaining to a particular facet of the repair method, a description and discussion of an alternate acceptable method is provided. It was generally agreed that it is preferable to provide for permanent patching in the spring or fall when daily temperature extremes are at a minimum.

Recommended Methods of Patching CRCP

1. Provide for detouring traffic. Many suggestions for improving current practices were investigated but any procedure used will have to comply with State and Federal standards for controlling and handling traffic through construction or maintenance zones. Much additional consideration must be given to detouring procedures on projects where patching is an almost continuous or recurring operation. Figures 1 through 5 show typical detour signing.

2. Delineate the area to be patched, making sure that all fractured or deteriorated concrete to be removed is included in the area delineated. There was not complete agreement on how to delineate the area to be patched. The merit of having an experienced person mark off the area in some manner was acknowledged; however, an experienced breakout crew would be able to determine the extent of the area to be removed without being constrained by previously set markings.

   The minimum size of the area to be patched should depend on the extent of the deteriorated concrete although some of the States recommended that the width should be not less than full lane width. Other States reported that small patches have proven to be as durable as large patches if all

Figure 1. Advance warning sign (on both sides of the road).

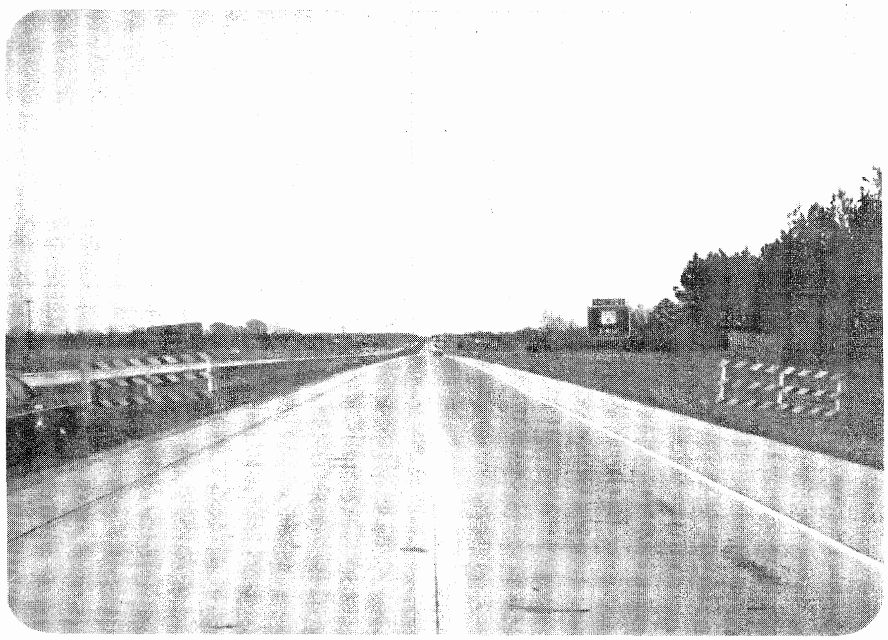


Figure 2. Road construction signs and barricades.

Figure 3. Right lane closed ahead (on both sides of the road).

Figure 4. Pavement width transition sign (on both sides of the road).

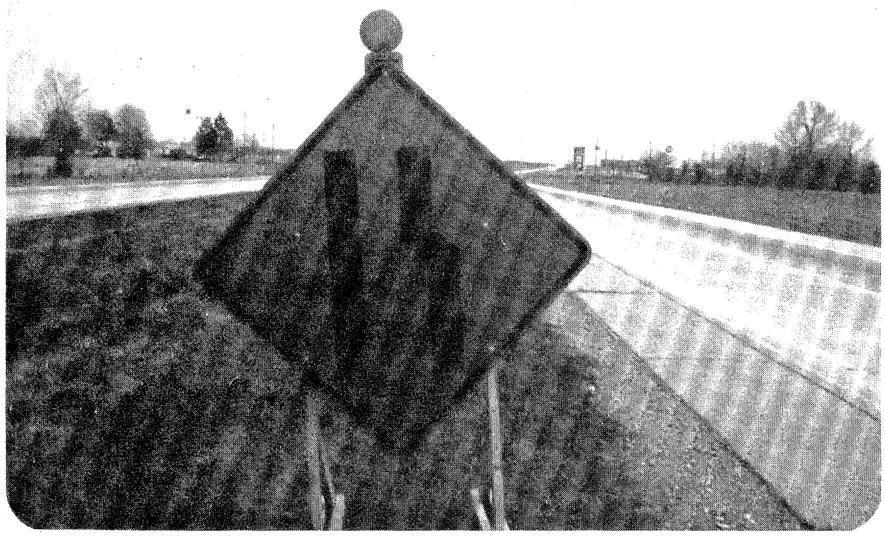
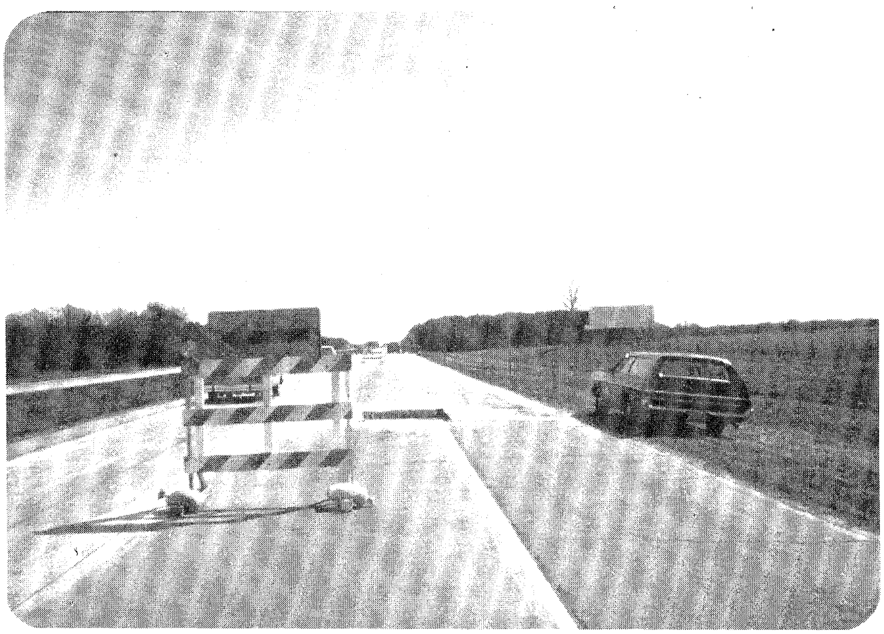


Figure 5. Detour arrow and barricade.



adjacent unsound concrete is removed and if the cause of the original failure is eliminated. It was the consensus of all the States that the patch area should be rectangular and not on a skew.

3. Break out and remove the failed area to sound concrete providing for a vertical face on the existing concrete. There was no agreement on whether a saw cut should be made. It was acknowledged that sawing hard aggregate is difficult and does not always provide a clean, unspalled face as intended. The advantages of eliminating the saw cut as practiced by some repair crews were not sufficient to change the minds of those who preferred the saw cut. Some of the economic analyses indicated that the sawing operation amounts to approximately 4 percent up to 10 percent or more of the total cost of a patch. On a typical 10-foot (3.0 metres) long, lane-width patch, the sawing operation could cost from $100 to $200.

There are several acceptable methods of breaking out and removing the concrete. The size and number of patches to be removed will have a bearing on the equipment and techniques to be used. For small patches, a jackhammer may be all that is needed. For numerous, larger patches, heavier mechanized pavement-breaking machines are desirable. In using heavier equipment, more care is needed to avoid damaging the adjacent concrete. For some situations it is more expedient to break the concrete into small pieces for removal by shovels or small loading equipment. In other cases, it is preferable to break out around the edges of the failed concrete, cut the steel, and remove most of the damaged area in one or more pieces with heavy lifting equipment. Figures 6 through 16 show typical examples of sawing and breaking out and removing the deteriorated concrete.

4. Cut steel to provide sufficient length for lap splicing or welding.

Some of the States preferred welding while others preferred tying. The

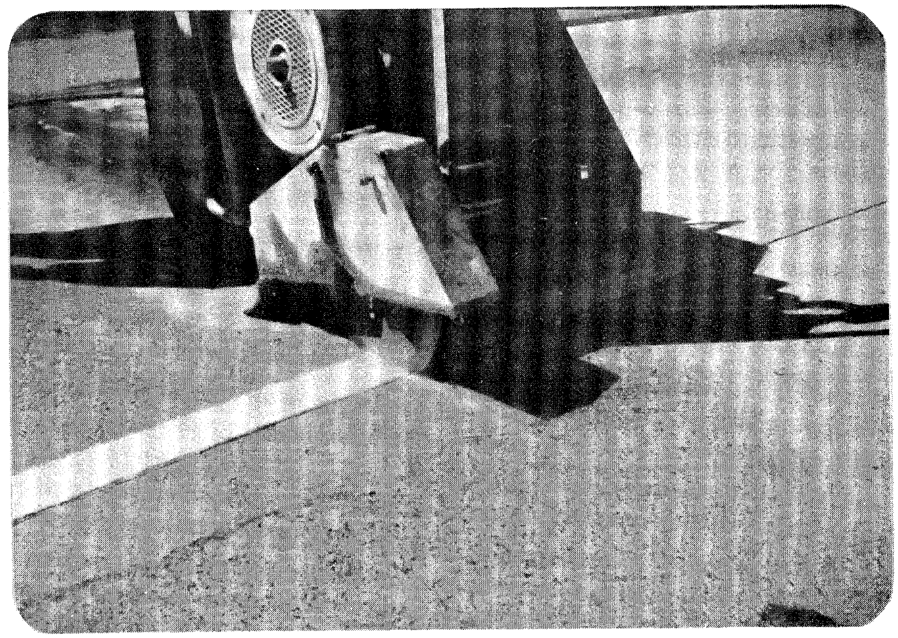


Figure 6. Sawing around the patch.

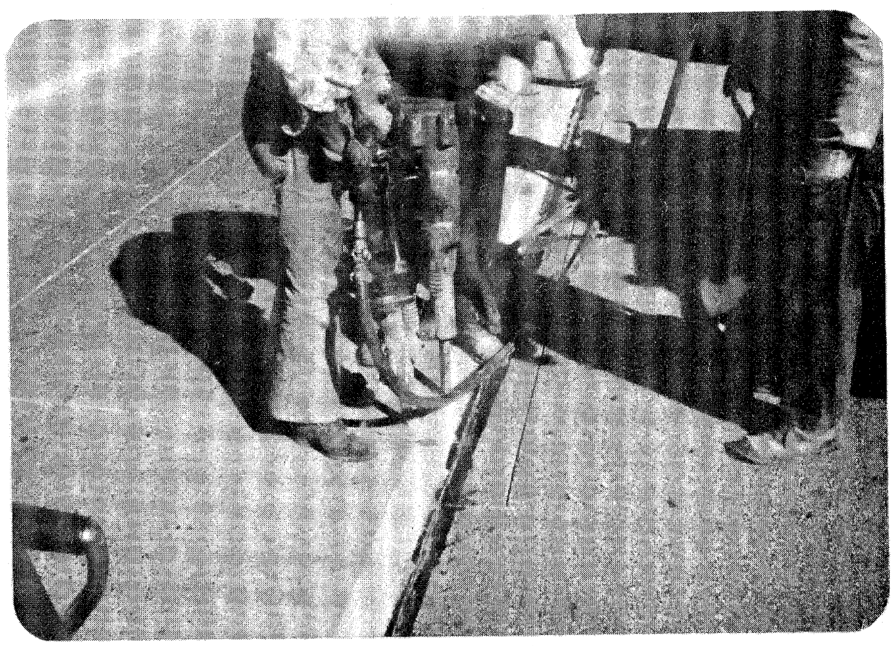


Figure 7. Breaking out around the patch with a jackhammer.

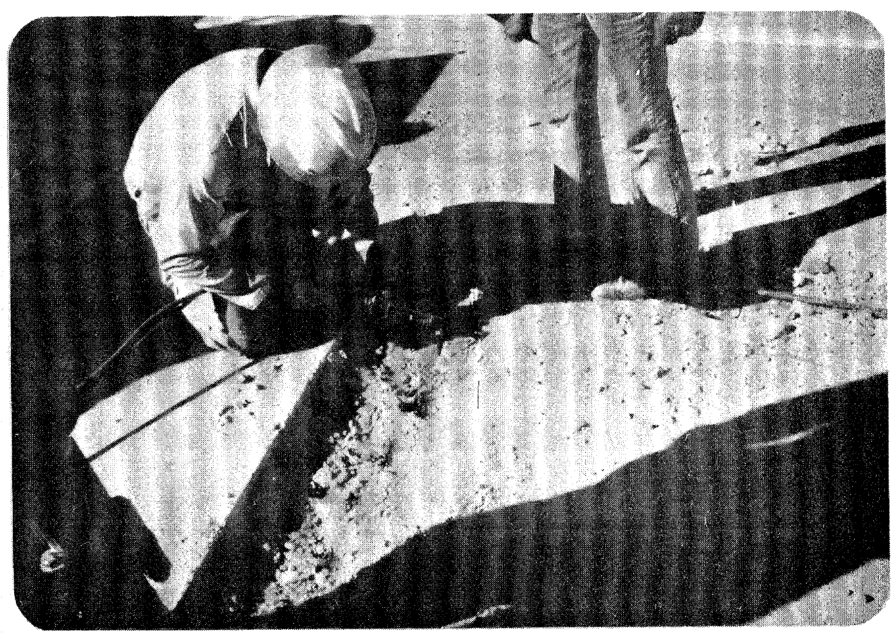


Figure 8. Cutting the steel.

Figure 9. Preparing to lift out the slab in one piece.

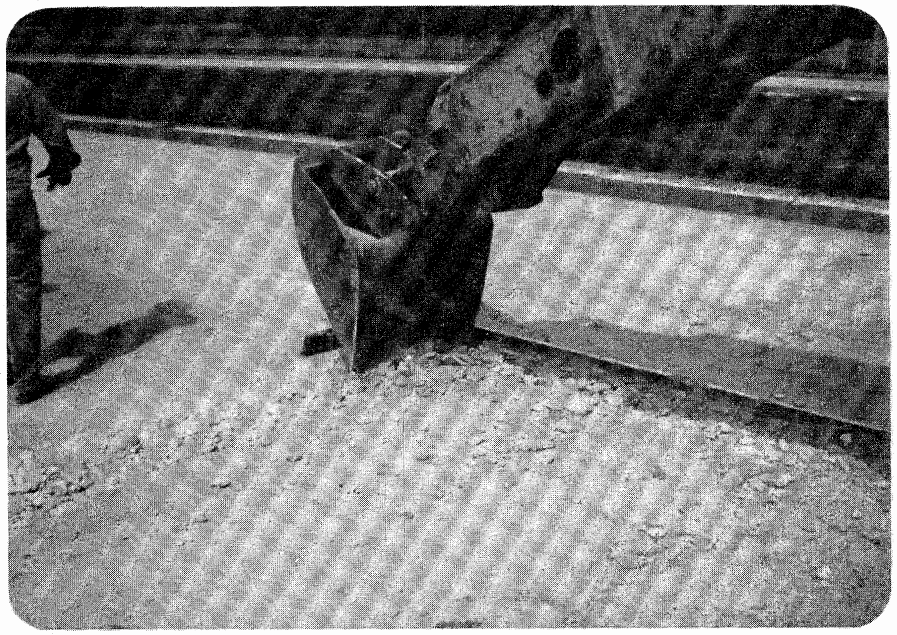


Figure 10. Raising the slab.

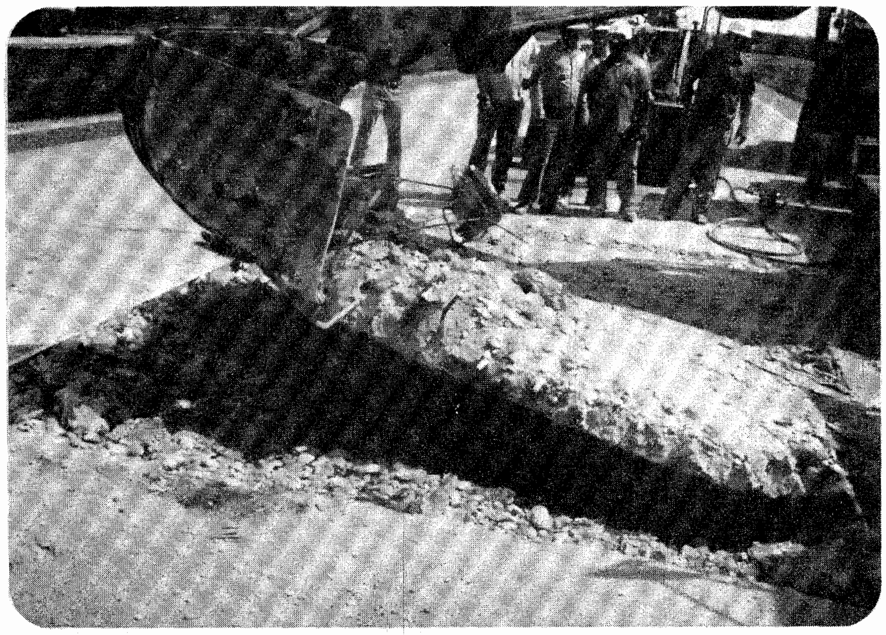
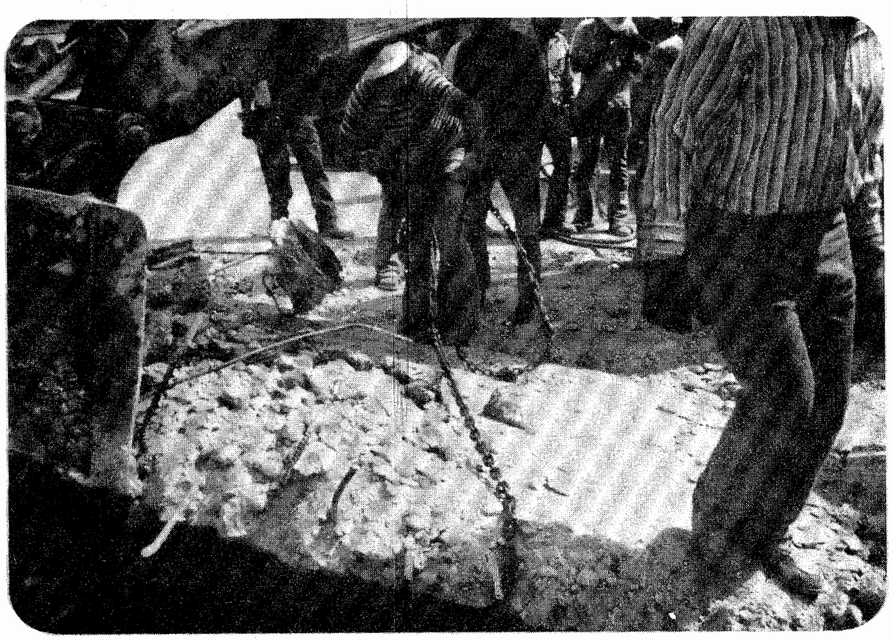


Figure 11. Putting a chain around the slab.



advantages of welding to maintain positive continuity of the steel were acknowledged. Tying the steel eliminates the need for a welder on the job thus reducing the cost of the patch. The existing steel could be left in place if the unsound concrete can be removed without breaking the steel. The practice of cutting the steel in the middle, bending it up to remove the concrete, then bending it back down for reuse is considered unsatisfactory. Figures 8 and 17 through 20 show examples of steel being cut and spliced by welding and tying.

5. Remove any unsound subbase. In most cases it was determined that it was better to replace the removed subbase (if any) with additional concrete rather than refinish the subbase with new subbase material. Where the amount of subbase to be removed is excessive, it may be more economical to replace it with new subbase rather than with additional concrete.

6. Replace the steel to match the existing bars and either splice in accordance with usual specifications or weld at least six inches. The need for placing any additional steel in the patch has not been demonstrated.

7. The use of a side form next to the shoulder is considered to be optional. Figures 21 and 22 show typical results of patches where forms are used and where not used.

8. The subbase, existing concrete faces and steel should be sprayed with water before the concrete is replaced. The use of grout, or epoxies, on the concrete faces was not considered to be cost effective by a majority of the States. Figure 23 shows the patch area being sprayed with water from a ready-mix truck. Note the side form in place.

9. Fill the excavated area with concrete using a design to provide for quick setting where needed. Figure 24 shows the concrete being placed from a ready-mix truck. In most cases, it is desirable to return the road to traffic service as soon as possible for the convenience and safety of

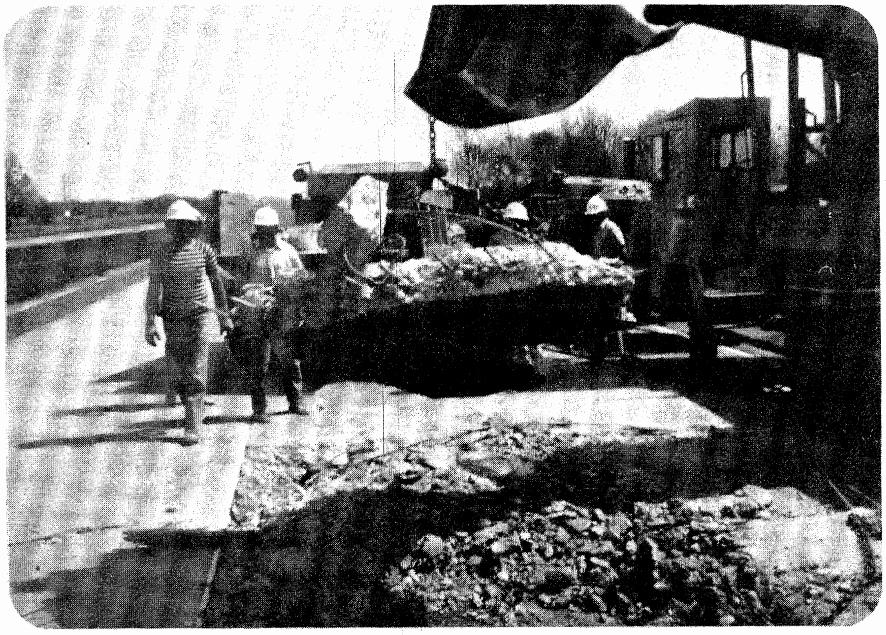


Figure 12. Lifting the slab.

Figure 13. Loading the slab for disposal.

Figure 14. Using a pavement breaker to break up the slab into small pieces.

Figure 15. Loading debris.

Figure 16. Final cleanup.

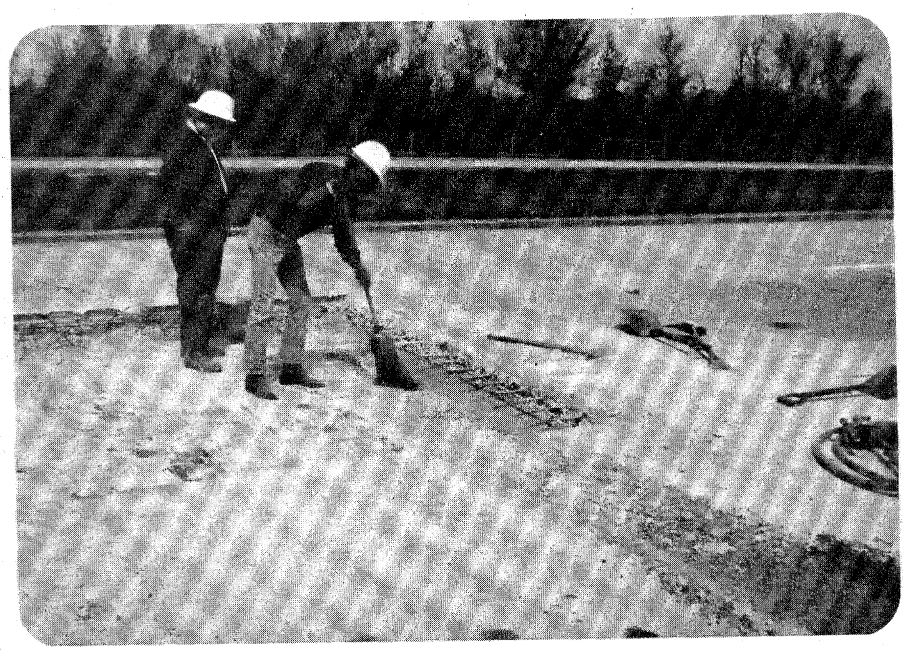


Figure 17. Tying steel for welding.

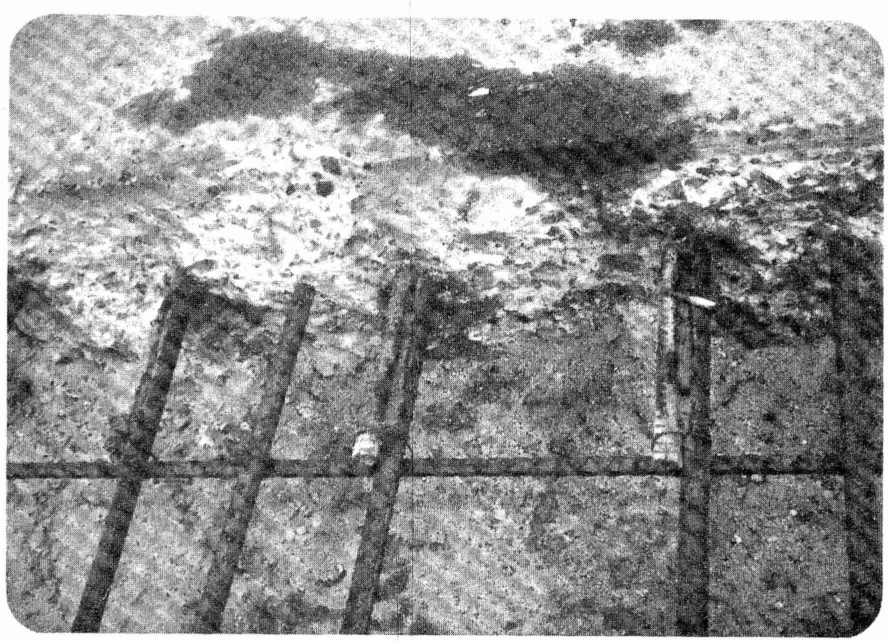


Figure 18. Typical welded steel splice.

Figure 19. Typical tied steel splice.

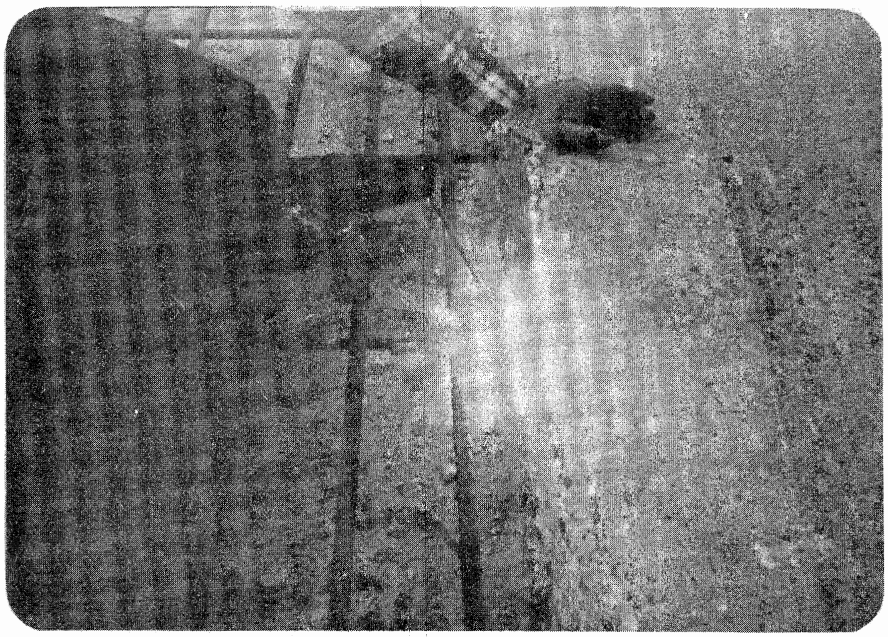


Figure 20. Welding the steel.

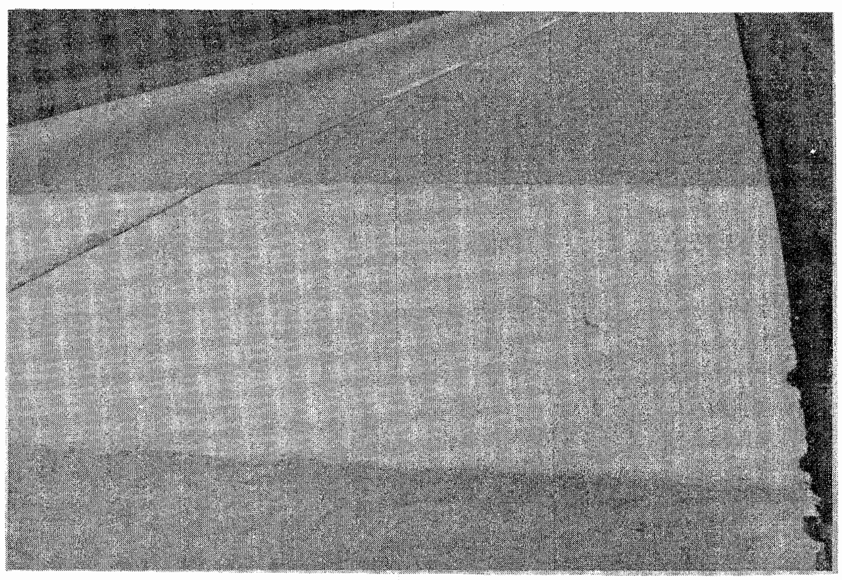


Figure 21. Typical patch where a side form was used.

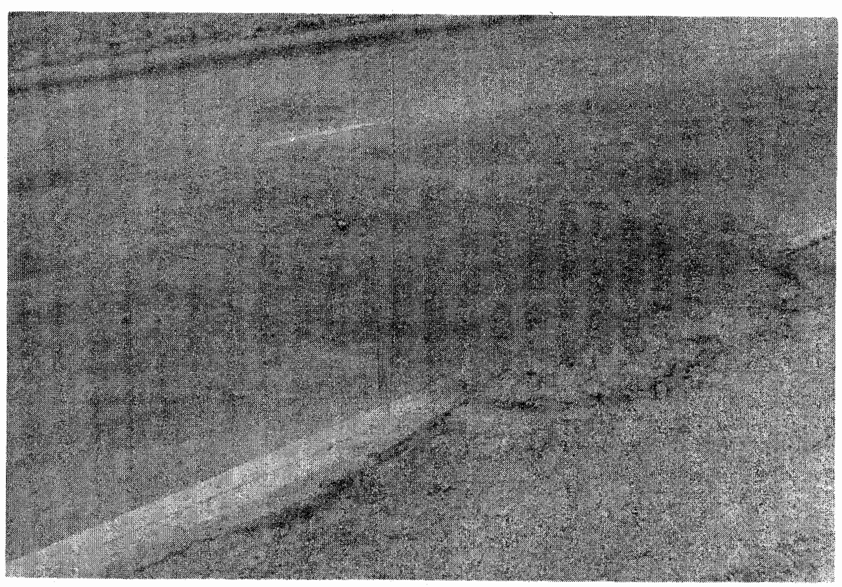


Figure 22. Typical patch where a side form was not used.

the public and maintenance personnel. Experience is needed to provide the proper additives or batch design which will develop early strength and still provide for satisfactory patch life. A material is needed which can be placed and returned to traffic in the same day. Several maintenance crews have developed special designs and techniques to accomplish this to their satisfaction. Other crews reported a lack of success with anything but a regular concrete mix with some minimum curing time before opening to traffic. The question of providing materials and mixing equipment or using commercially furnished concrete must be determined by the conditions. One State, using a mobile concrete mixer, reported that their costs for concrete were from 66 percent to 75 percent lower than the cost of using a commercial supplier, so long as the total yardage needed in one day was less than approximately 18 cubic yards (13.7 m^3).

10. Consolidate the concrete by mechanical vibration and screed the surface for riding quality. Adequate consolidation of the concrete is imperative and this can best be assured by mechanical vibration. Also, it is unnecessary to provide for a surface finish in excess of the condition of the existing concrete. Figures 25 through 27 show the concrete being spread, struck off and consolidated.

11. Use a sprayed membrane curing compound to cure the concrete patch. Other curing methods provide for a satisfactory patch but the use of a curing compound is the most practical. Figures 28 and 29 show the patch being finished and cured.

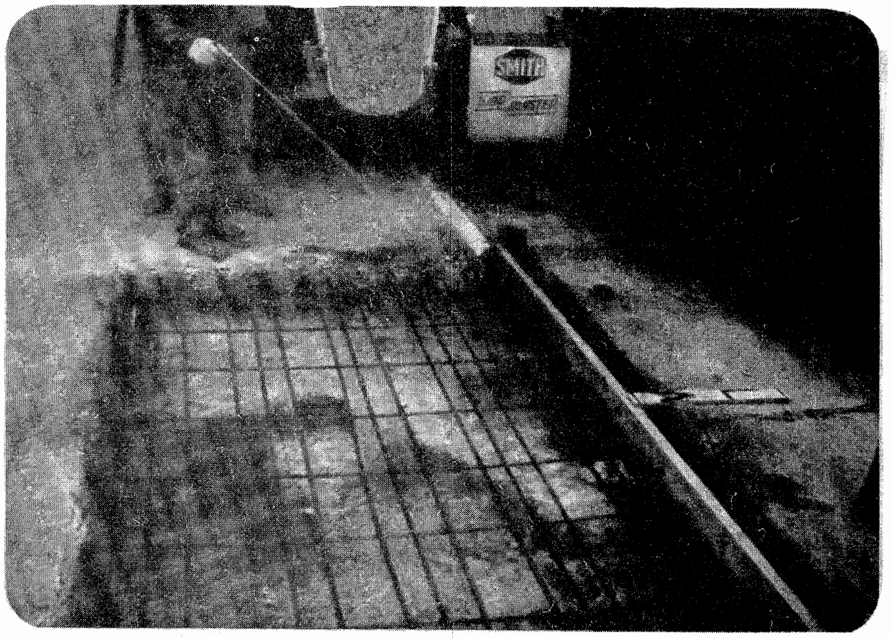


Figure 23. Spraying with water before placing concrete (note the side form being used).

Figure 24. Placing concrete from a ready-mix truck

Figure 25. Spreading concrete.

Figure 26. Striking off concrete.

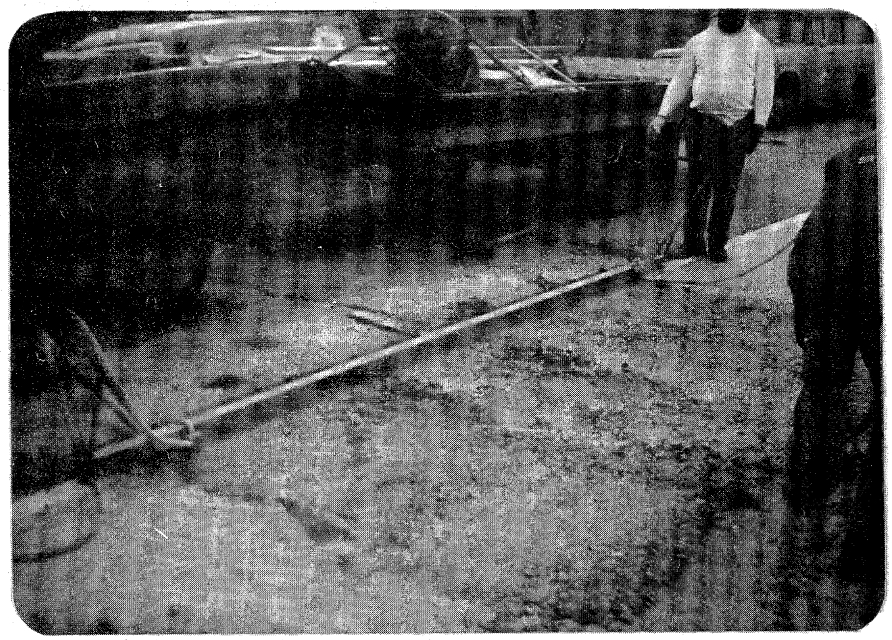
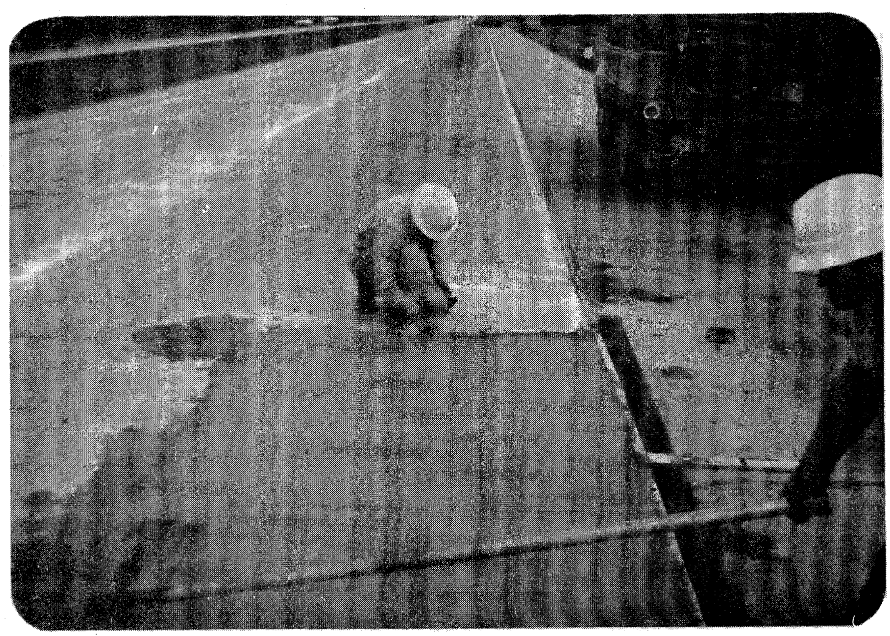


Figure 27. Vibrating the concrete.

Figure 28. Finishing the concrete patch.



BACKGROUND

A recent study by the Transportation Research Board identified a number of highway maintenance research needs. One topic recommended for study was optimizing the expenditure of maintenance resources. Value Engineering is a system of analysis which can be used for this purpose. The Federal Highway Administration is sponsoring a series of state-conducted maintenance research studies to promote the optimization of maintenance resources and to demonstrate Value Engineering techniques.

Value Engineering technique consists of an engineering approach in which all basic functions of a process are defined, analyzed, and assigned values according to their worth in obtaining the end product. The low value/high cost functions are further analyzed to see if they could feasibly be done less expensively by alternate means or in some cases completely eliminated.

The objective of this four-State joint research effort is to optimize expenditure of maintenance resources through in-depth study of continuously reinforced concrete pavement repair operations as one major activity of highway maintenance using Value Engineering techniques.

As continuously reinforced concrete pavement advances in age, the amount of required maintenance repairs is continually increasing. This project is, therefore, considered to be very timely to assist in filling a need which is becoming more pressing as time goes by.

The four States participating in this study have had similar problems and experiences in the design, construction and maintenance of continuously reinforced concrete pavement.

STUDY APPROACH

The study was conducted in cooperation with the highway agencies in the States of Arkansas, Louisiana, Mississippi, and Texas. The Federal Highway Administration sponsored and funded the study and the details and coordination were handled by a contract manager working out of the Region 6 office in Fort Worth, Texas. The field work was carried out over a period of seven months in 1977. This report was prepared upon completion of the field study, based on the developments in the four State meetings, and the final reports which were prepared by each of the participating States.

The study began with a two-day orientation session in Austin, Texas, on February 1 and 2, 1977. A capsule orientation course in Value Engineering was presented by Mr. E. D. Johnson, Value Engineering Coordinator, FHWA, Washington, D. C., and the States' representatives outlined their proposed study plans for the project. Interim meetings were scheduled in Jackson, Mississippi and Little Rock, Arkansas, to monitor the progress of the studies and to exchange information. The final meeting was scheduled for Baton Rouge, Louisiana. It was pointed out at the initial meeting that the primary objective was to provide cheaper or better ways to repair CRCP but that some consideration might be given to preventive maintenance or any other feature that was developed as a result of the study.

There were cogent discussions at all the meetings of present and proposed State practices pertaining to the repair of continuously reinforced concrete pavement. At the final meeting it became apparent that no spectacular discoveries had been made by the studies, but rather that a large number of small changes could be instituted by maintenance crews to provide for speedier, more efficient and possibly longer-lasting CRCP repair patches as enumerated in the "Findings" section of this report.

Perhaps the most significant finding was the fact that many CRC pavements are underdesigned for their traffic and environmental conditions. The studies suggested that the most effective treatment of these pavements might be preventive maintenance or rehabilitation rather than improved patch repair techniques.

FINDINGS

Existing Repair Practices

All the States inventoried their present repair practices. This inventory was reported at the interim meeting in Jackson, Mississippi, and revealed the similarities and differences in materials and methods as practiced in the several States, and by different maintenance crews in the same State. This exchange of information resulted in the possible immediate implementation of several different maintenance techniques. Some of these will be discussed later in this section.

The discussions and field trips in the States of Mississippi and Arkansas disclosed the similarities of problems being experienced with CRCP and led not only to consideration of repair but to questions concerning fundamental practices of design. The extent of the problems encountered confirmed the suspicion of deficiencies in design. From this it was concluded that the maintenance practices for an underdesigned pavement must necessarily be different from those of a properly designed pavement. This concept was further substantiated by numerous reports of failures occurring adjacent to repair patches. It was concluded that underdesigned pavements did not require premium patches which would last a great deal longer than the adjacent pavement. Thus, shortcuts and the use of less permanent patching materials such as asphaltic concrete may be considered when trying to maintain an underdesigned CRC pavement. One thing to keep in mind, however, is that when rehabilitation by overlay is performed, it will probably be necessary to rework any defective patches or any areas that would not serve as a satisfactory base.

Speculation

Several new concepts for pavement repair were suggested, but the constraint of time for completion of this project did not permit the accomplishment and evaluation of these new ideas. Some of the items considered are listed here.

1. Detouring Traffic. The use of more cones and less signing provides more positive delineation and better traffic operation. The cost savings are somewhat intangible -- being evidenced by a possible reduction in accidents, reduction in loss of signs, reduced user costs and greater safety to maintenance personnel and the traveling public. However, any changes in present practices would have to conform to the MUTCD.

2. Proper training and experience of the breakout crew can result in the elimination of the need for engineering personnel to survey and delineate the areas to be patched. The dollar savings may not be great. The most benefits are obtained where crews that would normally be constrained by previously set markings exercise judgment to enlarge or decrease the size of the patch based on what they find as the area is being broken out.

3. Some crews have found that they can successfully eliminate the use of a saw cut around the perimeter of the patch. As previously indicated, this results in a saving of $100 to $200 per typical patch repair plus a saving of time.

4. In the past, some policies had prohibited the practice of welding the reinforcing bars back in place. It has been shown that welding works satisfactorily and some crews prefer this method because it permits the existing steel to be cut closer to the existing concrete, which allows for faster removal of the deteriorated concrete. Welding also provides positive continuity of the reinforcing steel.

5. Replacing small amounts of deteriorated subbase with concrete rather than refinishing the subbase saves time and probably provides a longer-lasting patch. The saving is small and intangible, but eliminates a prior time-consuming requirement.

6. Eliminating the need for additional steel in the patch saves approximately 30 percent of the cost of the new longitudinal steel.

7. The elimination of the side form next to the shoulder saves the cost of installing and removing the form and a percentage of the material (depending on the number of times it can be re-used). The disadvantages of not using side forms is the uneven appearance of the patch and the interference of any subsequent blading or trenching operation in the shoulder along the pavement edge.

8. The time and material cost of using epoxy or grout to coat the faces of the existing concrete can be eliminated. However, some crews still consider the use of epoxy or grout to be a cost effective method of prolonging the life of a patch, especially on projects where relatively few patches are required.

9. The use of admixtures or special designs providing for rapid setting of the concrete have made it possible to reduce the required curing time to four hours or less and eliminates the need to keep the road closed overnight or longer. Such materials may be more expensive than conventional mixes, but the saving in user's costs and reducing the exposure to accidents is advantageous.

10. The development of satisfactory temporary patching materials permits the road to be maintained in a satisfactory condition until a later time when the number of permanent patches to be made can be handled in a more economical and expeditious manner. This mass production of permanent patching results in a considerable saving over making individual permanent patches each time a repair is needed.

11. Precast Patch. The use of precast concrete patches for the repair of jointed concrete pavement has been developed in other states. Such use

Figure 29. Curing the concrete patch.

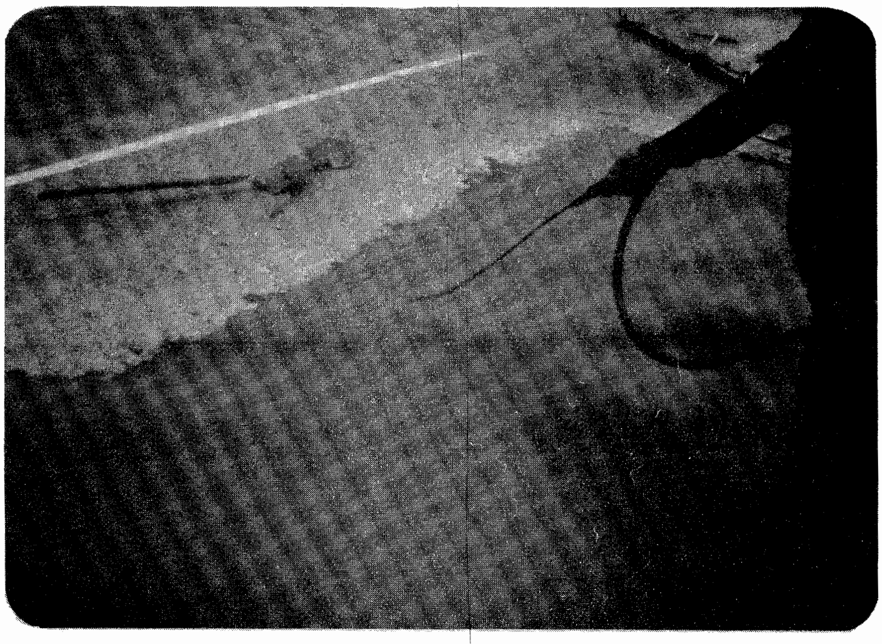


Figure 30. Preparing hole for precast patch.

with CRCP is more difficult due to the absence of joints and the need to retain continuity of the steel. However, the advantage of being able to complete a repair within one day makes precast patching an attractive possible alternative for CRCP repair. Such patches have been placed experimentally by the State of Mississippi. More time will be required to fully develop and evaluate this method of repair. The monetary saving for this type of patch is not expected to be great when compared with conventional patching methods. However, full development and utilization of this technique should permit much more rapid repairs. Figures 30 through 37 demonstrate some of the operations involved and the appearance of the finished patch. In this case, no attempt was made to maintain the continuity of the steel.

12. Polymer Concrete Patch. Polymer concrete offers the possibility of fast setting with higher strength and better bonding than normal concrete. Research in Texas has demonstrated the practicality of the use of polymer concrete for bridge deck repair. Experimental patches have also been made on CRCP. The high cost of this material combined with the specialized equipment and knowledge required for handling precludes it from being readily adopted for CRCP repair. Experimentation and further development and evaluation of this technique is being pursued in Texas. Figures 38 through 44 show the installation and results of polymer patching.

13. Steel Plate. Temporary repairs have been made to bridge decks by bolting a steel plate over the failed area. A steel plate has also been used as a cover for freshly placed concrete to carry traffic while the concrete is curing. It is speculated that a similar procedure could be used for patching CRC pavements by attaching the steel plate to the pavement with

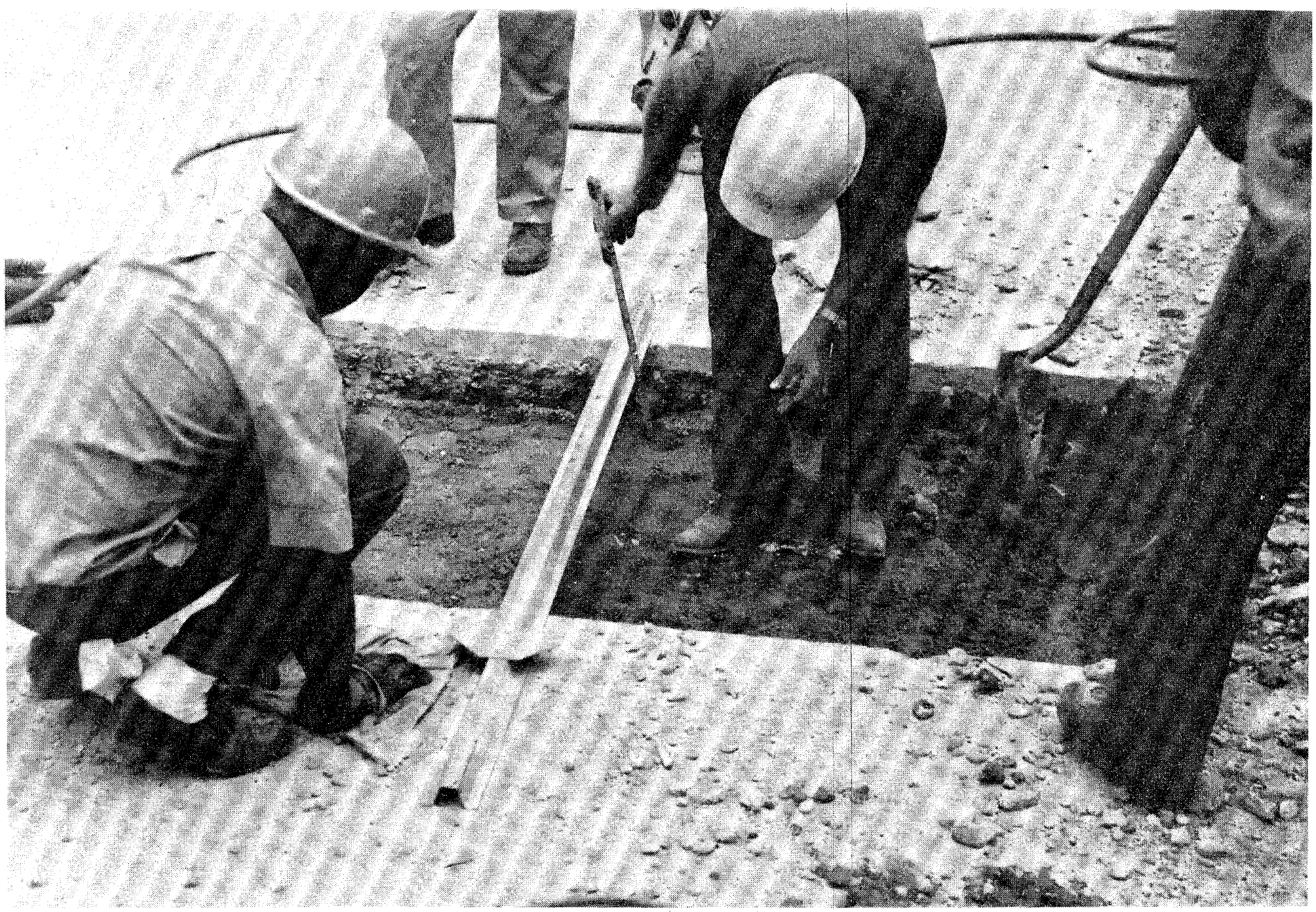


Figure 31. Checking for proper depth.

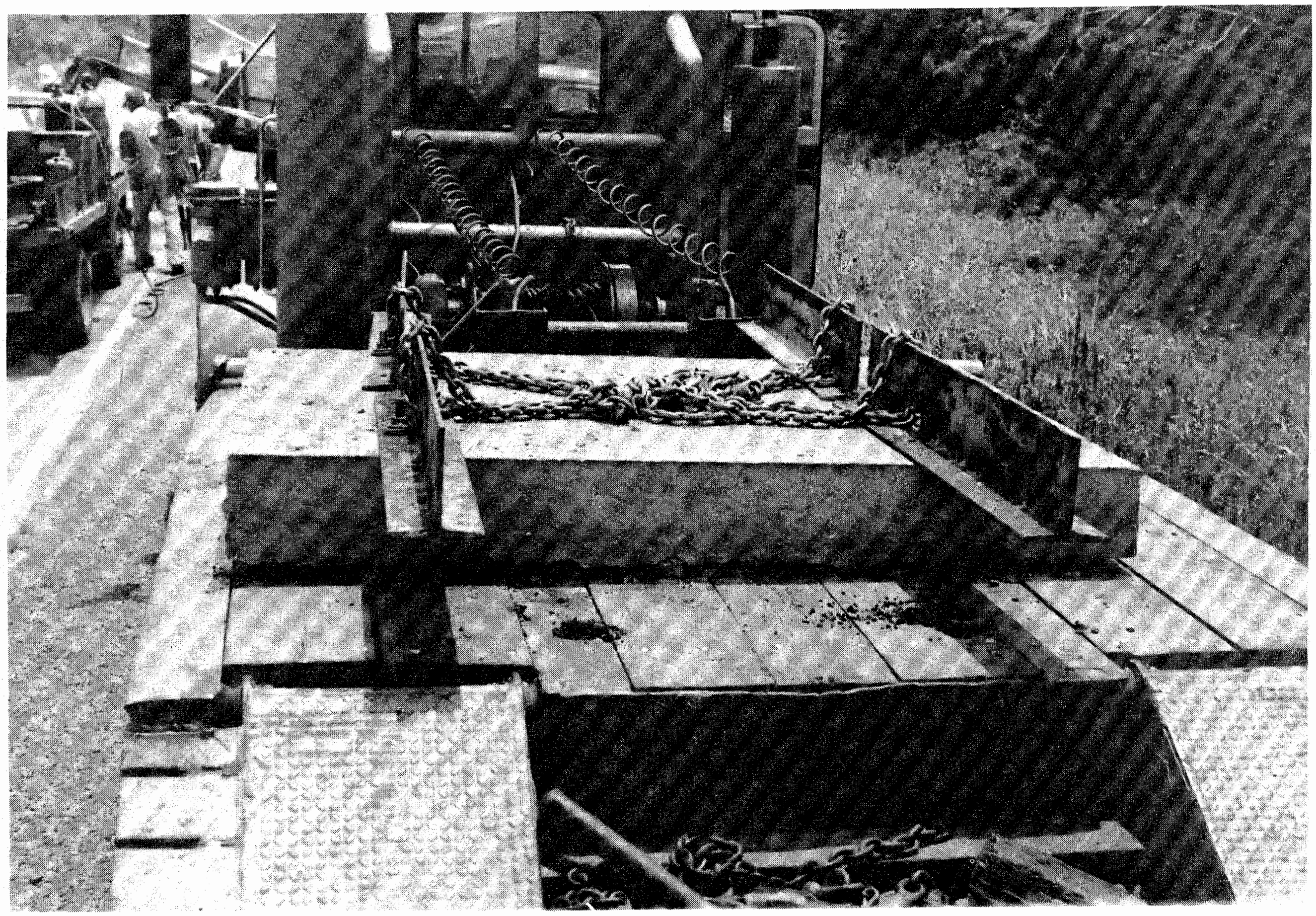


Figure 32. Transporting precast slab.

Figure 33. Taking the precast slab from truck to the hole.

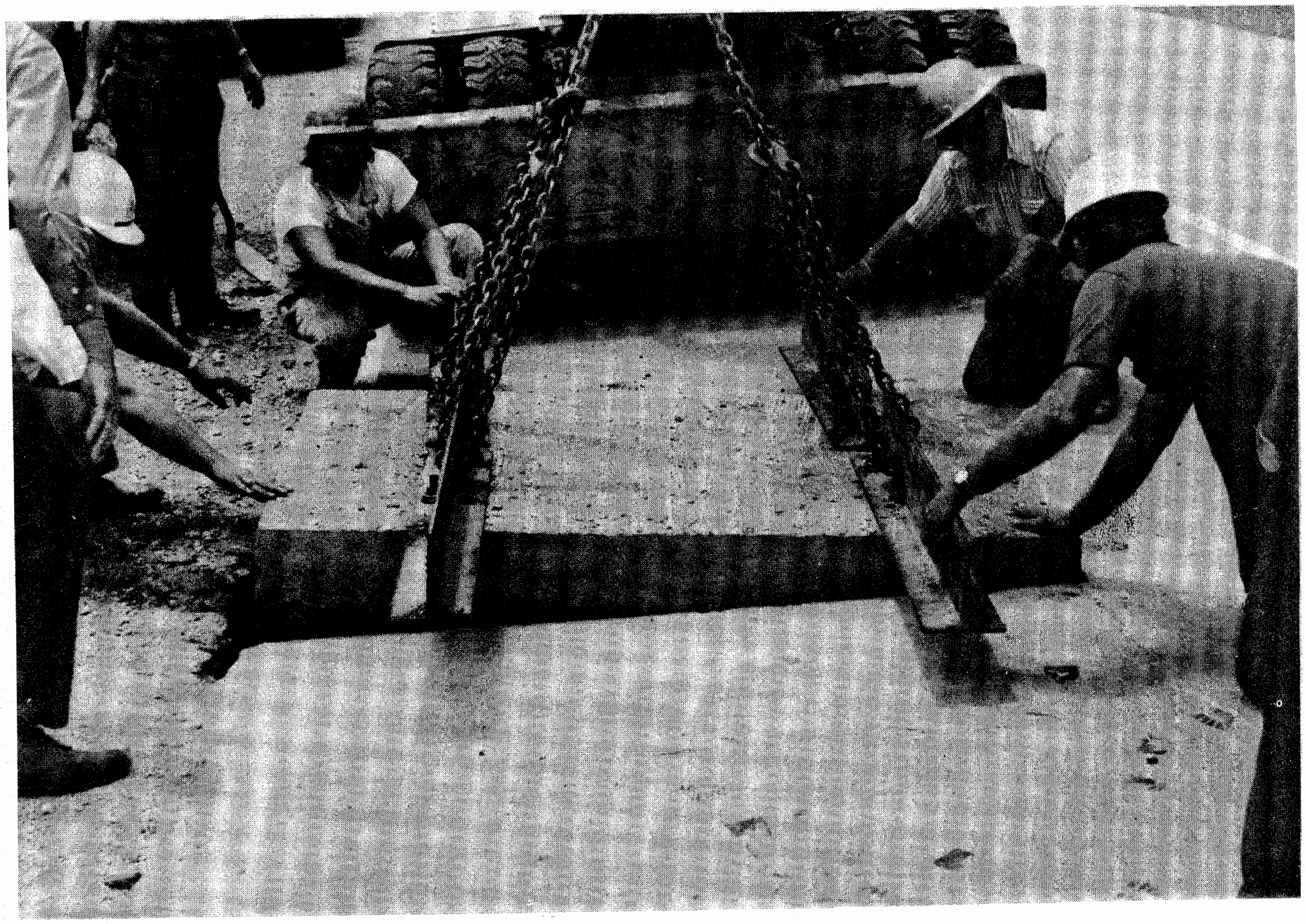


Figure 34. Lowering the slab into the hole.

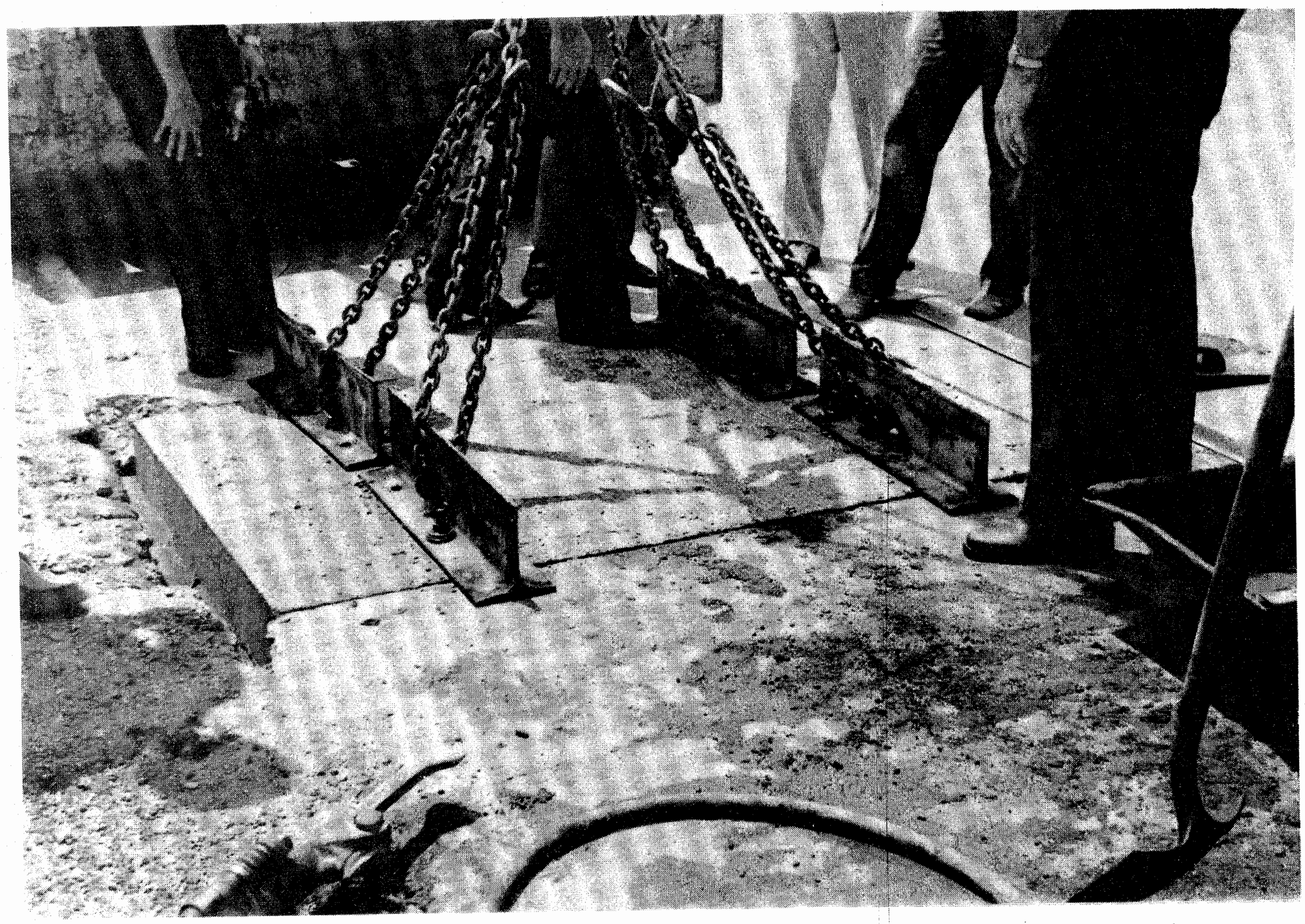


Figure 35. The slab in place.

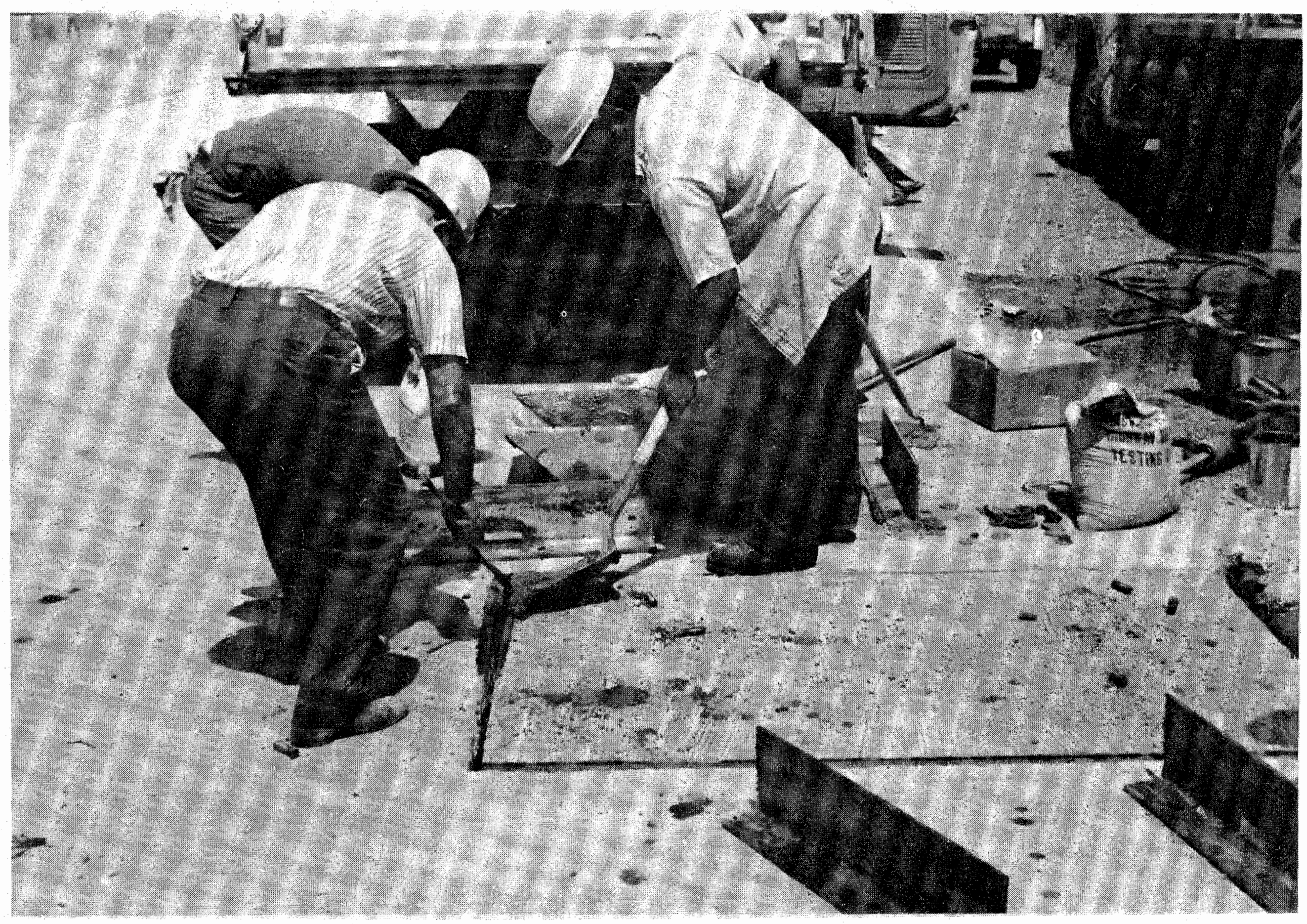


Figure 36. Placing grout around the precast slab.

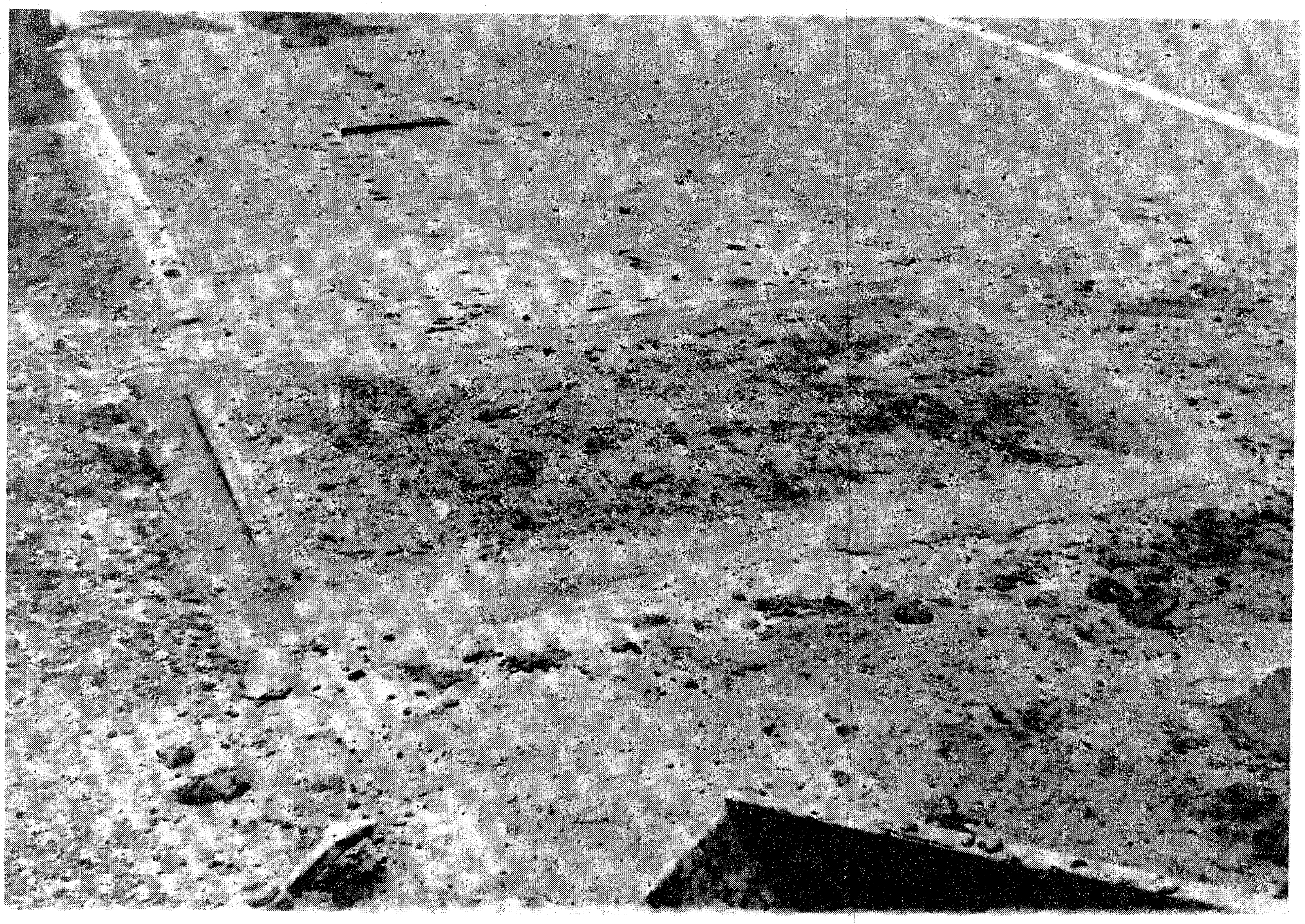


Figure 37. The finished precast slab.

Figure 38. Hole prepared for polymer patch.

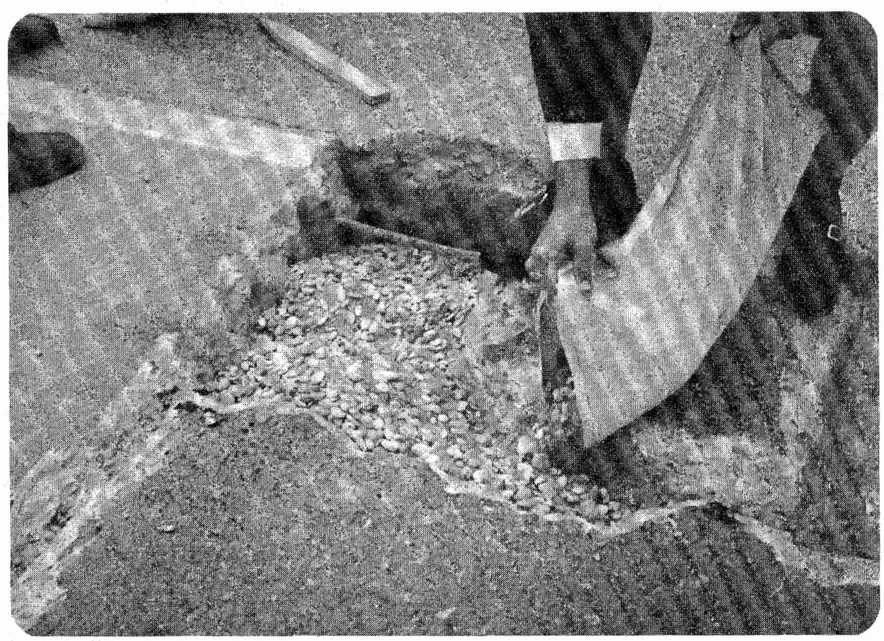


Figure 39. Placing coarse aggregate in the hole.

Figure 40. Placing fine aggregate.

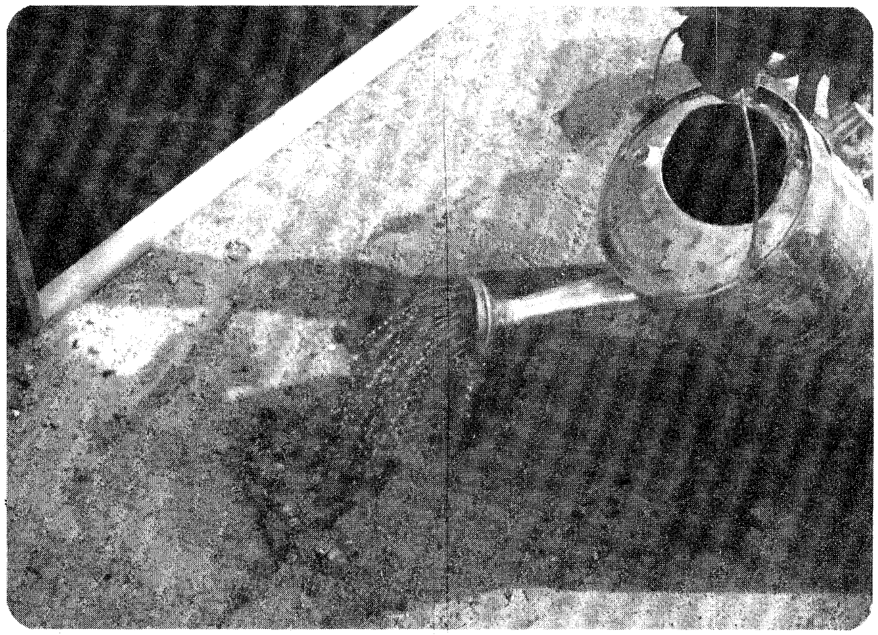


Figure 41. Pouring monomer on the aggregate.


Figure 42. Vibrating a typical polymer patch.

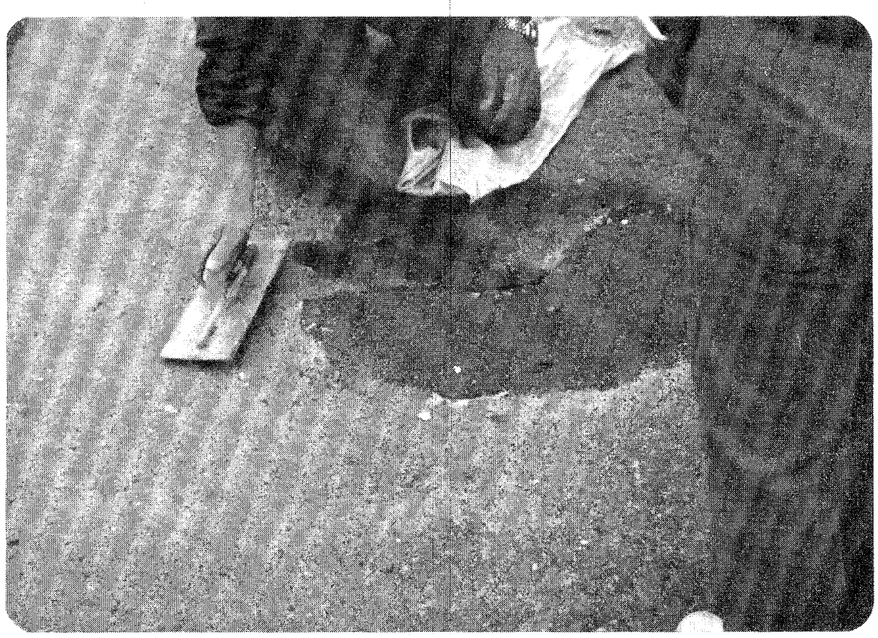
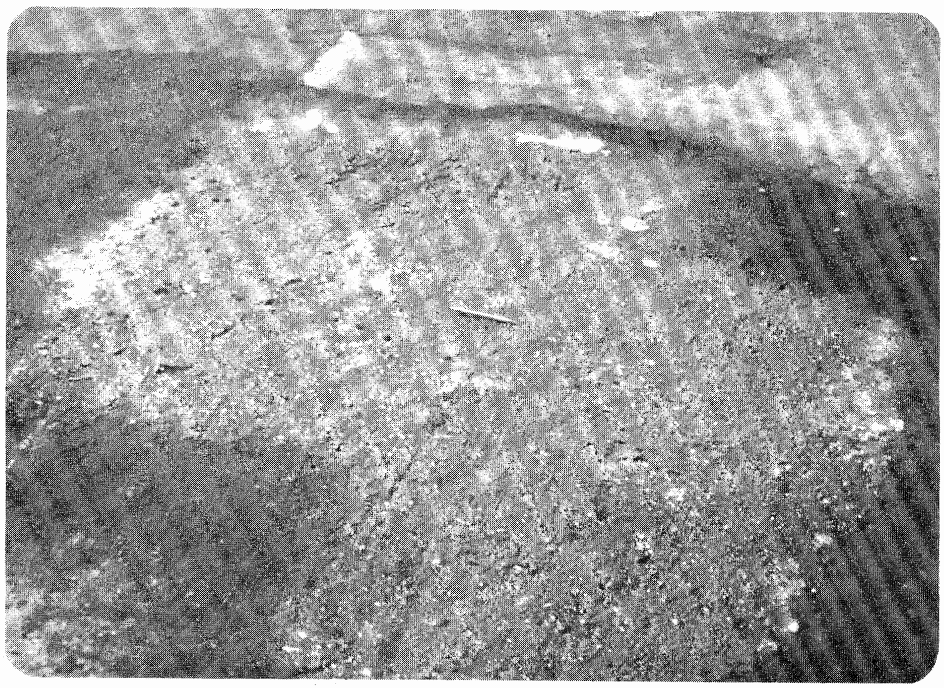


Figure 43. Finishing a polymer patch.

Figure 44. Typical finished polymer patch.



expansive concrete bolts. The plate could be removed after the concrete had hardened or it could be left in place permanently.

14. The State of Louisiana has experimented with the use of the dynaflect to evaluate the effectiveness of repairs being made. Further development of this procedure should help to provide an earlier determination of various repair techniques rather than having to wait for an evaluation of field performance.

ECONOMIC CONSIDERATIONS

A major emphasis of Value Engineering is to develop a more cost effective operation or to improve the performance at the same cost. Detailed studies were made by the State teams of all components in the repair process. As an example, one State submitted the following breakdown of the items involved.

	Item	Cost Per Unit (CY)*	% of Total
I	Engineering	$ 7.37	3.8
	A. Design Patch B. Prepare Specifications C. Make Estimates D. Order Materials E. Select Specific Areas F. Testing G. Record-Keeping		
II	Traffic Control	29.60	15.4
	A. Install Devices B. Provide Flagging C. Maintain Devices D. Remove Devices		
III	Perform Sawing	11.32	5.9
IV	Remove Pavement	67.41	35.2
	A. Break Up Concrete B. Cut Steel C. Remove Broken Concrete D. Prepare Patch Area		
V	Repour Patch	76.20	39.7
	A. Replace Steel B. Set Forms C. Wet Surfaces D. Pour Concrete E. Strike Off Concrete F. Vibrate Concrete G. Screed Surface H. Finish Surface I. Curing		
	Totals	$191.90	100.0

* 1 cy = 0.76 m^3

Comparative Repair Costs by State

Comparative costs for each work item listed in the previous table was not possible with the variations in records kept by the individual States. The following table comparing the range in costs per cubic yard and range of costs per square yard was developed from the available information to indicate how the different methods of repair influenced the costs.

State	Cost Per Cu. Yd.	Cost Per Sq. Yd.
1	\$ 81 - \$116	\$18 - \$26
2	130 - 230	30 - 51
3	131 - 308	29 - 69
4	192 - 250	43 - 56
	1 cy = .76 m^3	1 sy = .84 m^2

Several parameters other than the methods employed are involved in the above costs which stem primarily from material costs, patch size and number of patches. Bid prices received in contracts let on R-R-R projects in one of the four States in recent months provide a good comparison of estimated repair costs as submitted by contractors. These bid prices ranged from \$38.10 to \$70 per square yard (\$32.00 to \$58.80 per m^2). The contractor doing the work on one project at the lower price indicated that the actual cost exceeded the price as bid.

The items listed in the first paragraph of this section are typical of the repair methods practiced by each of the participating States. Each major function was studied to see if it could be eliminated or improved. Of the major items listed, it was determined that only Item III, Sawing, could be entirely eliminated, and there was not complete agreement that it should be. Many individuals considered that it was worth its cost. Also, it was concluded that very little could be done to improve present methods of performing Items I and II. Another cost item which is common to any repair method and that cannot be eliminated is travel time.

A detailed study was made of Item IV. Different methods and techniques for each of the sub-items were suggested and investigated. Several different types of pavement-breaking machines were considered which resulted in alternate methods of cutting out or breaking up the pavement. Different methods of cutting or handling the existing steel were investigated along with the removal of the concrete, which is usually accomplished by removal in small pieces or by removal in one or more large pieces. Complete removal of all debris and dust presents a tedious and time-consuming hand operation. The possibility of using a huge vacuum cleaner to expedite this process was suggested. In preparing the patch area, consideration was given to replacing any defective subbase with additional concrete rather than repairing the subbase. It might be cost effective to not remove all the debris if that which is left could be incorporated into the concrete without detriment to the patch.

There was also a great deal of speculation on how to more economically or quickly replace the material for the patch. In the replacement of the steel, there were proponents for splicing by both tying and by welding. There was not a consensus on whether forms should be used along the shoulder. It was generally agreed that the surfaces should be wet with water but that the use of epoxy to coat the surfaces of the existing concrete can be eliminated. Experience has not proved that the use of "additional" steel in the patch was necessary.

A great deal of consideration was given to the design of the batch, but authentic experimental evidence was lacking to verify or refute the claims that certain admixtures or designs would or would not set quicker and/or last longer or less than standard mixes. The use of admixtures, epoxies, polymers, etc., is considered to be still an experimental feature which shows promise for improvement over standard methods.

There was general agreement on the importance of consolidating the concrete in the patch and that this could best be done by mechanical vibration. More economical alternatives were not uncovered.

It was also concluded that the concrete has to be struck off and worked sufficiently to provide a smooth riding surface. The States were in agreement that finishing operations could be reduced (manhours for finishing) to provide a surface equivalent to the existing concrete surface for skid resistance.

Considerable study and discussion were given to a minimum size of patch. The only consensus reached was that all unsound concrete should be removed and that the cause of the distress should be eliminated. One study by the State of Arkansas reported very little difference between the cost of a partial width patch and a full width (1 lane) patch. The cost of a typical full-width patch was approximately $665.00, while the cost of a partial width patch was about $648.00 or a reduction of about 2.5 percent for the partial width patch.

The use of a concrete curing compound was determined to be the most economical and practical method of curing the patch.

In considering the economics of the various methods of repair, preventive maintenace or rehabilitation, the cost and safety of the traveling public should not be overlooked. In the metropolitan and other areas where traffic forms queues at construction sites, the value of time per vehicle must be a major contributing factor in determining which repair procedure should be employed.

The cost per vehicle hour for a passenger car is estimated to be in excess of $4 and for a truck semi-trailer combination the estimated cost is $10 per hour or more.

Where traffic volumes are heavy, the cost of a single CRCP patch is insignificant when compared with the user's cost. The major expense is the cost not apparent to the repair crew -- the cost of delay to the traveling public. Therefore, traffic differences must be considered in the field when repairing, maintaining or rehabilitating CRCP.

OBSERVATIONS

The most significant results of this value engineering study could be considered to be negative. There is no easy way to repair and maintain a rigid pavement, especially CRCP. Besides focusing on the difficulty of CRCP repairs, three other factors pertaining to CRCP were disclosed which may be of considerably more importance than simply the repair of CRCP.

1. The extent of repairs being experienced in the four States that conducted this study, plus the difficulties being reported by other states with CRCP, indicate a design deficiency in this pavement type. Based on observations of performance, discussions with those knowledgeable in this field, and theoretical considerations, the consensus of this study was that in most applications CRCP should be at least as thick as conventional jointed pavement for the same conditions.

   Also, it was concluded that CRCP should not be placed in areas where considerable subgrade or subbase movement can be expected. Although CRCP can bridge small voids without faulting, larger voids resulting from swell, settlement, pumping or other types of movement of the pavement support, result in punchouts of the relatively thin CRCP. The design recommendations from this study consist of additional thickness, non-erosive subbase, proper drainage, stable subgrade and the possibility of placing the steel in the top and bottom rather than in the middle of the slab. The use of a widened section to prevent the occurrence of edge loads is also recommended.

2. This project concentrated on the repair of punchouts of CRCP which is the most prevalent form of distress. Most of this experience has been associated with the older pavements which contained not only the design deficiency of being too thin, but also involved construction and material

deficiencies. Many of these pavements have reached or will soon reach the point where rehabilitation is necessary. The best rehabilitation strategy and the optimum time of its application is yet to be developed. This is, however, a very urgent need and should be pursued with sufficient resources and determination to provide a solution. It is doubted that the usual procedure of leveling up and overlaying with asphaltic concrete is the optimum answer. As indicated, an immediate rehabilitation strategy is needed for those pavements that are presently experiencing distress. Even more important from the long range point of view is being ready with proper rehabilitation techniques when the thousands of miles of CRCP that are now performing satisfactorily begin to wear out. The time to plan and prepare for that eventuality is now.

3. The immediate repair of a punchout is essential so that traffic may continue to use the facility. However, it appears that some form of preventive maintenance to postpone or prevent the occurrence of punchouts may be more cost effective. The main problem is how to deal with an underdesigned rigid pavement. This should also be exhaustively studied to determine if there are any solutions that would be more cost effective than making repairs.

The types of preventive maintenance suggested for consideration by this study included the installation of underdrains; the addition of concrete shoulders; more effective edge sealing; undersealing as well as strengthening by overlaying. Some of these have already been tried with varying degrees of success and failure. A much more detailed study should be made which will require not only a great deal of money but a rather long period of time to evaluate. The future problems are so great that the study should not be delayed.

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A NOTE ON THIS PUBLICATION

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Bituminous Patching

Sign Maintenance

Pavement Marking

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