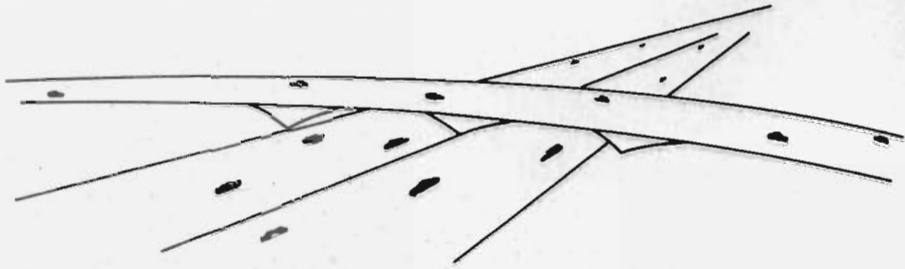

DEPARTMENTAL RESEARCH

Report Number SS 7.0

REPAIR OF CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

TEXAS HIGHWAY DEPARTMENT

REPAIR OF CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

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Special Study 7.0

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REPAIR OF CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

I. INTRODUCTION

Since the early 1950's many miles of continuously reinforced concrete pavement have been built in Texas. The new pavement type soon proved not to be a cure-all. It too has its problems which require maintenance and repair. In general, very excellent performance records are held by most all the continuously reinforced paving projects in this State; however, there are those problem projects which do require maintenance and are a constant problem for maintenance engineers. This report is based on observations in the field, together with design concepts to illustrate techniques to be used when making full depth repairs on continuously reinforced concrete pavement.

II. PROBLEM DIAGNOSIS

Many times the reason for a pavement failure can be determined by inspecting the existing crack pattern at the site, examining the surface conditions, and having a working knowledge of the rigid pavement design with experience in designing all layers including the subgrade, subbase and the concrete. Also necessary to diagnose these problems is an understanding of the behavior of continuously reinforced concrete pavement in response to temperature and moisture changes.

Having an idea of what might cause pavement problems which require full depth repair, helps greatly in diagnosing the problem. Usually the diagnosis can be confirmed by coring the pavement. Cores are an excellent, economical way of inspecting a pavement at the exact point of interest.

Transverse crack patterns, such as shown in Figure 1, which are identical to the detail of the transverse reinforcing steel usually are a sign of unconsolidated concrete beneath the steel mat. Usually pavements such as shown in Figure 1 tend to distress or fail rather rapidly when subjected to heavy traffic loading during very wet seasons. Longitudinal cracks begin to appear subsequently, as support is lost. Usually the loss of support comes from a degrading of the honeycombed or porous concrete in the bottom half of the slab and not the removal of subbase material from beneath the slab. In general it might be stated that whenever a longitudinal crack appears in continuously reinforced concrete pavement, a problem exists.

Cracking patterns such as that shown in Figure 2 are an indica-

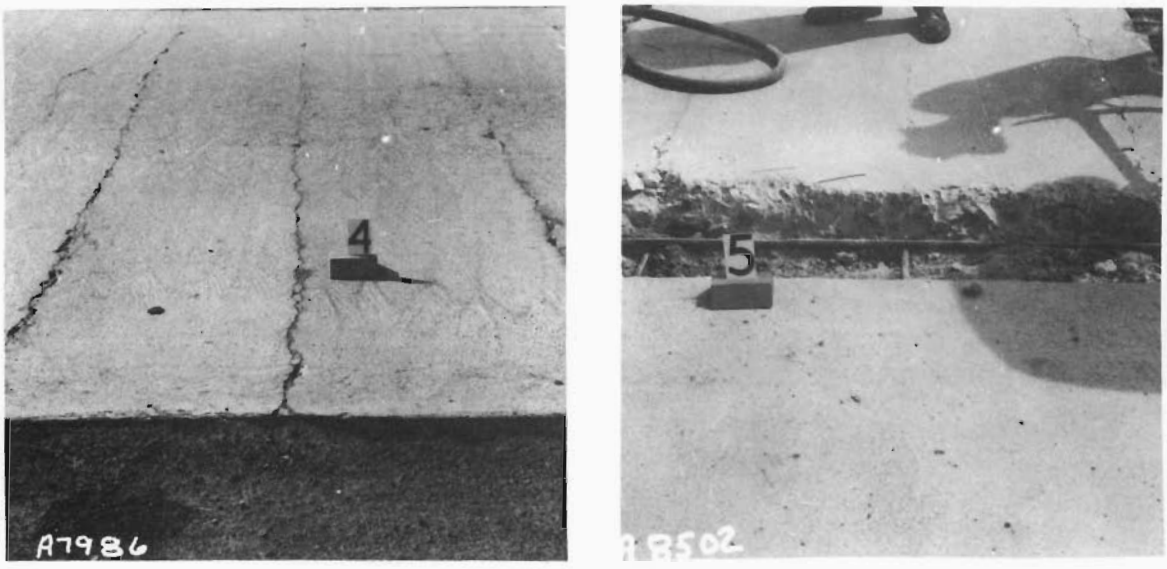

FIGURE 1a & 1B Transverse crack pattern identical to steel layout.

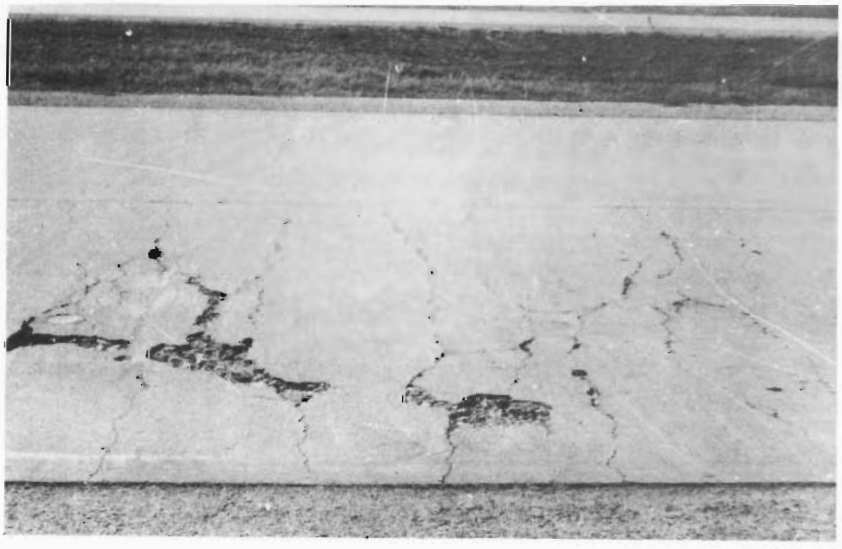

FIGURE 2. Closely spaced, web shaped crack pattern.

tion of something other than improper consolidation. In this pavement the problem was the concrete composition. Improper batching was the problem. Insufficient cement causes the spider web type crack pattern which continues to grow more severe with the number of load applications. These areas can be quite extensive. They might also be as small as one batch of concrete from the conventional dual drum paver.

The phenomenon of edge pumping, if present, may be an important factor in diagnosing the reason for a pavement failure. Pavement problem diagnosis and repair are usually unique on different paving jobs. A knowledge of the type of paving equipment used to build the pavement initially may be relevant when diagnosing a pavement failure.

III. PAVEMENT REMOVAL

After the decision to make repairs of a pavement failure has been made there are several items of importance which need attention. First, all repairs, i.e. full depth patches of CRC pavement should be made in stable weather conditions. A stable weather condition would be at such time when the range between the maximum an minimum temperatures in the daily cycle is minimal. Secondly, if the repair to be made covers more than one lane, e.g., both lanes of four-lane divided highway, the decision needs to be made as to which lane is replaced first.

Usually at the time when repair operations start, the cause of the failure has been determined either by previous repair on the same pavement or by coring operations on this pavement. Based on the crack pattern, usually a first estimate of the extent of the pavement failure is made and a saw cut is then made in the pavement to delineate edges of the repair patch. This is usually the technique used whether or not the patch is merely to keep the highway open to traffic or to truly repair the pavement and restore its continuity. The purposes of the saw cut are:

1. To make a clean edged joint on the patch.
2. To make finishing of the new concrete easier.
3. Avoid having a spalled edge at the surface where the two concretes will bond together.

These saw cuts usually determine the size of the patch. The size of the patch is usually dependent upon the purpose of the repair, i.e., whether or not the objective is to keep the road open to traffic, or whether the pavement is to be repaired and restored to its original

condition of continuity. In general, patches should not be less than half-lane width. Based on observations in the field, it is believed that the use of patches smaller than half-lane width and 6 foot in length are vain attempts. Observations indicate that two and even three or four patches have been placed adjacent to one another where entire areas of poorly consolidated concrete were not removed when the first patch was made. Thus, it is quite important to make sure that the patch or repair area is large enough to clean up all of the inferior concrete, which is a typical reason for repair.

If an entire lane width, that is, 12 feet is to be removed at one time, it may be desirable to skew the transverse saw cut 1 to 4 so that both wheels of a loaded vehicle will not cross the pavement-patch joint simultaneously, thus aiding load transfer and protecting the patched area. This would not be necessary on any patches that did not cover both wheel paths.

Figure 3 shows typical saw cuts made to bound a repair area. In small areas such as shown in Figure 3 the concrete is always removed from the steel, i.e., the steel is always left in place. Jackhammers are used to break away concrete in the repair area. Many failure areas are of the nature such that the concrete above the steel is sound and the concrete beneath the steel is loosely consolidated with little structural strength. Figures 4,5 and 6 show typical jackhammer operations in removal of the concrete from the reinforcing steel mat. Extreme caution should be exercised so that the longitudinal reinforcing steel is neither damaged nor cut while removing the concrete. Detail of reinforcing steel can be obtained from construction plans

FIGURE 3 Typical saw cuts

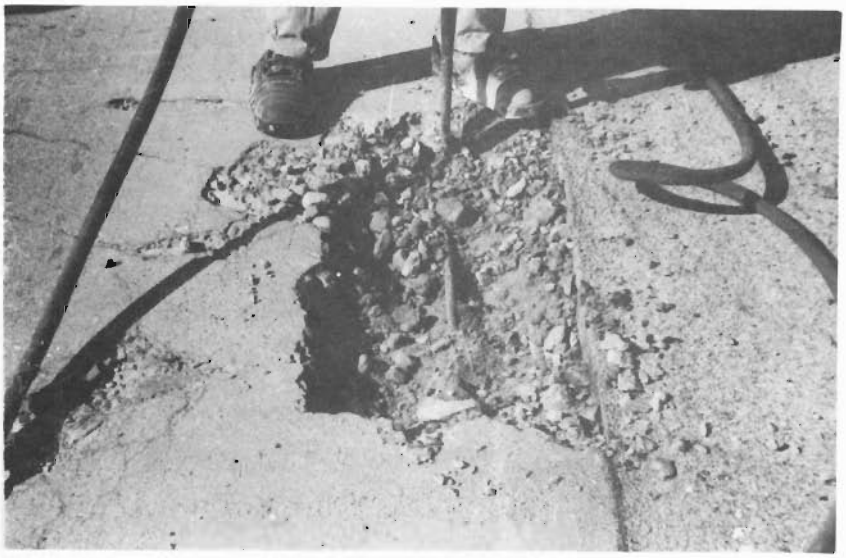

FIGURE 4 Jackhammer cracking concrete

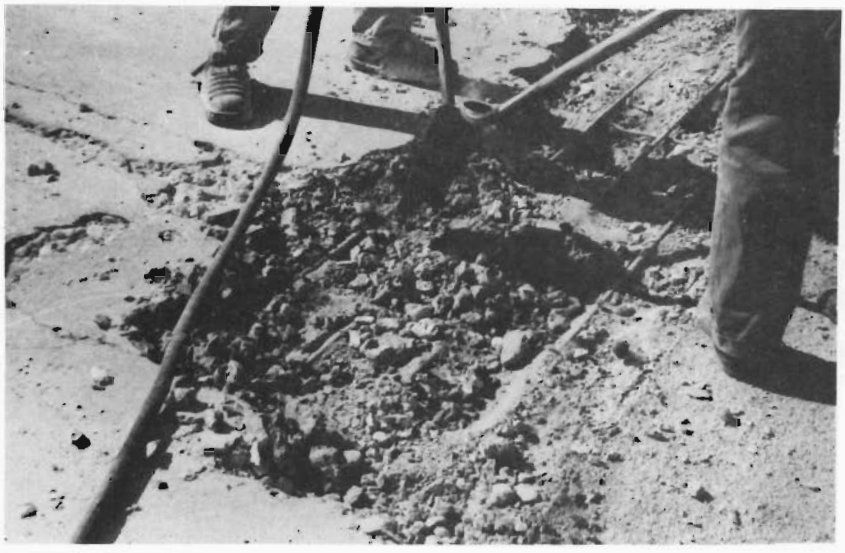

FIGURE 5 Jackhammer breaking concrete which is being removed by hand method.

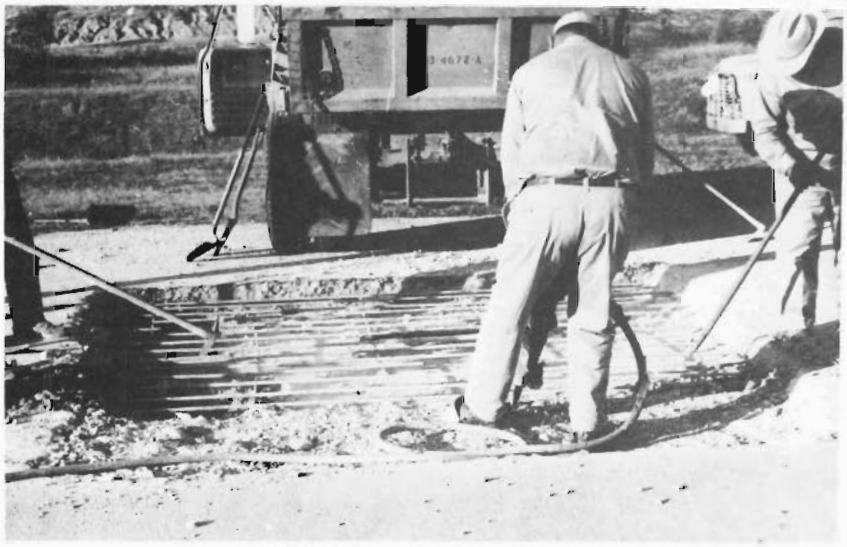

FIGURE 6 Rather extensive removal of concrete leaving steel in place.

which are available for all existing CRCP. It would be very poor practice to damage the longitudinal reinforcing steel in a small patch because not enough of the pavement is opened so that additional splice bars could be tied in with sufficient lap.

Figure 7 shows operations where concrete is being removed in an area where saw cuts were not used to bound the repair area. Note the special technique used to give a vertical face to the edge of the concrete slab.

Figure 8 shows this same area after all broken concrete had been removed and the area completely cleaned. Note the repair area is one lane wide, that is, 12 feet and is trapezoidal in shape, i.e., the longitudinal ends are not at right angles to the longitudinal edge of the pavement. They are skewed, however, not to the 1 to 4 as has been suggested. If a concrete saw is not available, a edge can be obtained simply by using the jackhammer as shown in Figure 9. This technique requires skill and good workmanship.

If a failure area is quite large, then it might be more economical to remove the entire pavement, i.e., concrete and steel rather than just the concrete.* Typical operations are shown in Figures 10, 11 and 12 where the concrete and the steel were both removed. Figure 10 shows that sufficient concrete has been removed from the area near the saw cut so that when the steel is to be cut there will be sufficient protrusion of the existing steel for sufficient lap.

Figure 11 shows the area to be removed. Note all the steel bars

* See Appendix A.

FIGURE 7

Preparing vertical face on slab where no saw cut was used.

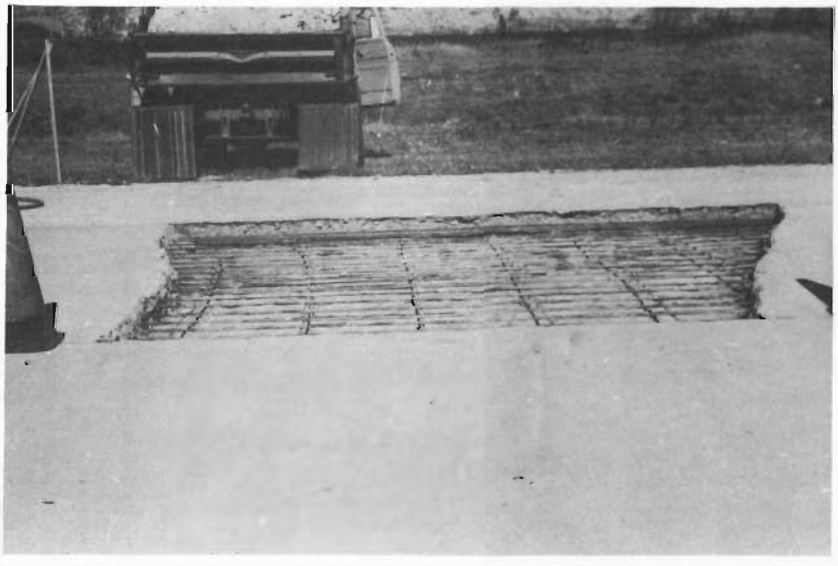

FIGURE 8 Failure area with all undesirable material removed.

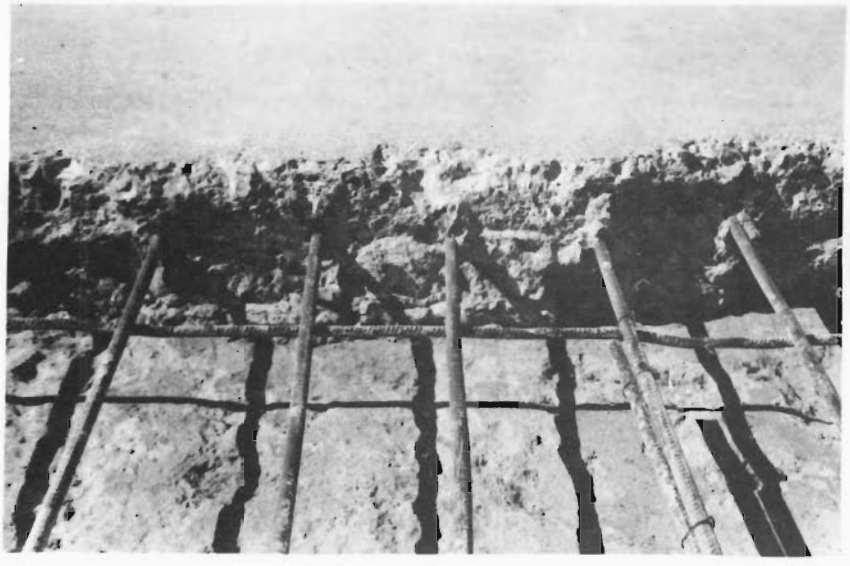

FIGURE 9 Vertical face made with jackhammer.

FIGURE 10 Concrete removed from steel to be left for lapping to new steel.

have been cut and a crane is being used for removal of the slab segments.

Figure 12 shows some of the slab being lifted off the subbase. Any damage done to the subbase should, of course, be repaired, i.e. restored to the initial grade. After all problem concrete has been removed, new reinforcing steel should be tied or welded in place in the area. This is shown in Figure 13. Experience has shown that when all of the steel is lapped in one transverse plane lap failures occur. In the repair shown in Figure 13, long laps were used to insure that no lap failure would occur at the ends of the repair area. Also to insure that the steel would remain continuous, the steel bars which were inserted were welded to the protruding bars in the existing slab.

After the entire area is clean and all steel in its proper place the area is ready to be paved or patched. However, just prior to placement of concrete in the repair area, it is good practice to paint the exposed faces of the slab with an epoxy bonding agent as has been done in Figure 14. The performance of the particular repair area shown in Figure 14 is quite good.

FIGURE 11

Concrete and steel to be removed from pavement.

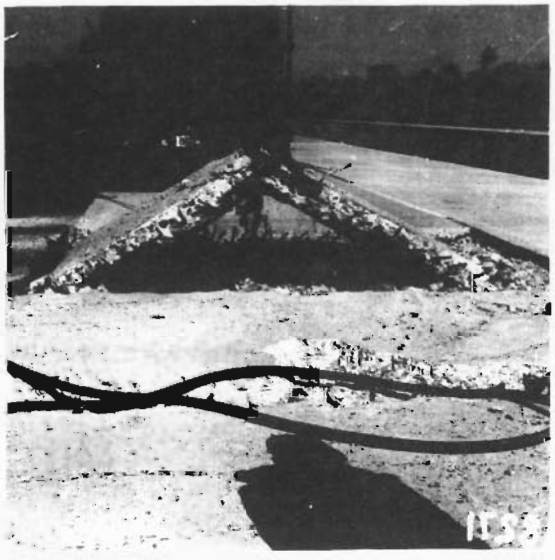

FIGURE 12

Removal of slab by mechanical device.

FIGURE 13 Steel being placed in repair area.

FIGURE 14 Exposed faces of pavement slab painted with epoxy bonding agent.

IV. PAVEMENT REPLACEMENT

After the area to be repaired has all concrete removed that is necessary and all loose material removed and all steel in proper place. the area is ready for paving. The concrete design mix used for the original pavement should be sufficient, depending upon the individual situation. It may be desirable to use a high early strength cement, i.e., Type III cement when the pavement needs to be opened very soon. This can also be achieved by using more than the regular 4.5 sacks of cement per cubic yard of concrete.

Figure 15 shows an area which is ready to have the concrete placed in it, the subbase has been dampened and the exposed faces of the slab have been painted with an epoxy bonding agent. In this particular case ready-mix concrete was used.

Figure 16 shows the concrete being placed into the repair area. Workmen are spreading the concrete by hand as well as with the dump from the agitating ready-mix truck.

Figure 17 shows all the concrete placed in the repair area. It is being compacted and vibrated by use of a hand-manipulated vibrator. Sufficient vibration in repair areas is very important to avoid any honeycombing or unconsolidation.

Usually repair areas are small enough so that they can be screeded by hand. Usually a homemade type screed is made from lumber which is a nominal 2 inches thick. The screed used to finish the area shown in Figure 15,16 and 17 can be seen at the rear in Figure 15 and at the right side in Figures 16 and 17.

Figure 18 shows the completed patch. All finishing was done

FIGURE 15 Ready for concrete placement.

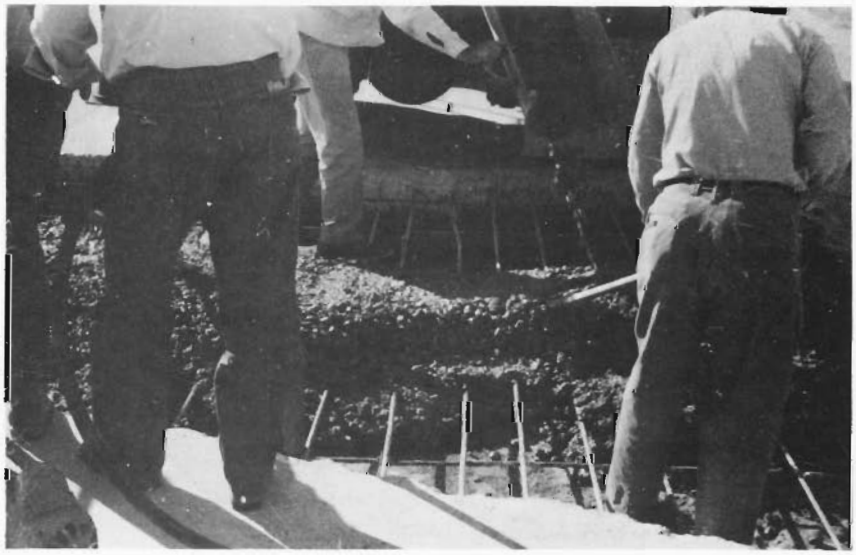

FIGURE 16 Concrete being replaced in repair area.

FIGURE 17 Vibrating concrete with hand manipulated vibrator.

FIGURE 18 Completed repair

by hand. Figure 19 shows another case where hand finishing was used. Note the 2" x 8" lumber used as a screed. Note also the hand manipulated vibrator which the workman is using to consolidate the plastic concrete. In most cases the wood float used to finish the concrete gives sufficient texture for adequate skid resistance; however, if this would not be sufficient, a burlap drag or a broom could be used to give the desired texture.

Of all the possible methods of curing, the membrane type curing is the most desirable. Curing membranes should be placed directly on the newly finished patch and should be used in ample quantity and should completely cover all of the exposed surface. The use of curing membranes avoids reapplication of water and is also a manpower saving. The curing should continue until the patch is ready to be opened to traffic, which is usually from one to three days or until the concrete reaches a flexural strength of 500 psi. A repair area may need to be opened to traffic thus risking possible damage to the repair areas. This may be the case where extensive repairs are being made just to keep the road open to traffic.

FIGURE 19 Hand finishing and vibration.

V. SUMMARY

If and when continuously reinforced concrete pavement needs full depth repairs, it is important that proper procedure and good technique be used to protect and maintain the public's investment. The following is a summarized procedure for repair:

1. Select stable weather condition if time and situation permit.
2. Use ample protection from high volume, high speed traffic.
3. Estimate extent of failure and prepare the areas with a saw cut about two inches deep.
4. The minimum patch width to restore pavement continuity should be six feet.
5. If steel is removed, the minimum length of patch should be 10 feet to maintain pavement continuity. *
6. A lane width patch should be placed on skew across the pavement. A 1 to 4 skew has been suggested.
7. If no steel is to be removed, extreme caution should be exercised not to damage or break any of the longitudinal steel.
8. If concrete and steel are removed, the longitudinal bars should be left exposed for lapping to new steel. Lap lengths of 36 inches have been suggested.
9. If the subbase is damaged in slab wrecking operations, it should be restored satisfactorily.
10. Placement of new concrete should be in such a manner so that the concrete is satisfactorily consolidated by mechanical vibration.

* See Appendix A.

11. Membrane curing is recommended. Also the repaired area should be allowed to cure from 24 to 72 hours to attain a flexural strength of 500 psi.

The foregoing comments and recommendations are for the case where the intent is to repair the pavement to an acceptable level of service. It is recognized that procedures and techniques such as summarized cannot always be utilized to keep a highway with many severe pavement problems open to traffic.

REFERENCES

1. "Maintenance Practices for Concrete Pavement", Portland Cement Association, Chicago, Illinois.

2. "Design & Construction, CRC Pavement", Continuously Reinforced Pavement Group, CRSI, Chicago, Illinois, 1968.

APPENDIX A

APPENDIX A

EXCERPTS FROM THE TEXAS HIGHWAY DEPARTMENT MAINTENANCE MANUAL

The following paragraphs are taken from the first edition of the subject Manual which was issued subsequent to the writing of this report, but prior to the distribution of this report. The instructions in the Manual are more explicit than those contained in the report. Whenever there is a conflicting statement it is suggested that the more recent publication be followed.

Major repairs to continuously reinforced concrete pavement should be made in such a manner that the continuity of the pavement structure is preserved. Repairs should be made on one lane at a time and if possible during stable weather conditions when the daily temperature cycle is small. The following suggested method of repair is recommended.

1. The minimum length of patch should be ten feet (10').
2. The patch should be placed on a one to four skew across the pavement to avoid both wheels of an axle crossing the construction joint simultaneously.
3. Cut a groove about one inch deep, taking care not to cut the reinforcing steel, at each boundary of the patch.
4. Saw a pair of cuts about six inches apart, parallel to and three feet inside of each of the cuts which define the patch boundaries.

5. Chip the concrete from between each pair of cuts down to the reinforcement and cut the steel with a torch, or bolt cutter.
6. Remove the concrete between the boundary cut and pair of cuts with an air hammer, leaving reinforcing steel exposed at each end. Where the length of the patch warrants the use of a pavement breaker this should be used only in the area bounded by the pairs of saw cuts. In this way the force of the hammer is not transmitted through the steel to the concrete beyond the patch boundaries which might injure the concrete and reduce the bond.
7. Restore the subbase to grade.
8. Splice-in deformed bars or deformed wire fabric with each member of reinforcement which extends into the patch area from the ends of the existing pavement. The reinforcement should be lapped approximately thirty-six inches (36"). The laps should be secured with wire ties. Welding is not recommended. If movement of the pavement ends causes the reinforcement to buckle this should be corrected just prior to placing concrete by removing and replacing the wire tie at laps. Add supplementary bars or wires to increase the area of longitudinal steel by fifty percent (50%). The splice bars or wires and the supplementary reinforce-

ment should run the full length of the patch. The reinforcement shall be firmly supported at the proper elevation above the subbase by approved metal high chairs.

9. Place concrete in the patch area, using extreme care to consolidate so as to avoid any honeycomb. This is particularly important because of the close spacing of the steel.

10. Finish the surface of the patch so it will provide a smooth ride. The patch should be properly cured and not opened to traffic until the concrete has attained a flexural strength of 600 pounds per square inch.

4-407 RIDING QUALITY:

The main principle involved with maintenance of concrete pavements is to keep it smooth. Variations in excess of one-fourth inch per ten feet (10') should receive immediate attention. Joints and cracks should be sealed to prevent the passage of water through the slab to the subgrade, to prevent trash and dirt from collecting in the joint and to preserve the original filler. New pavements should receive special attention during the spring following the first winter after its completion, as work performed at this time should reduce maintenance requirements in succeeding years.