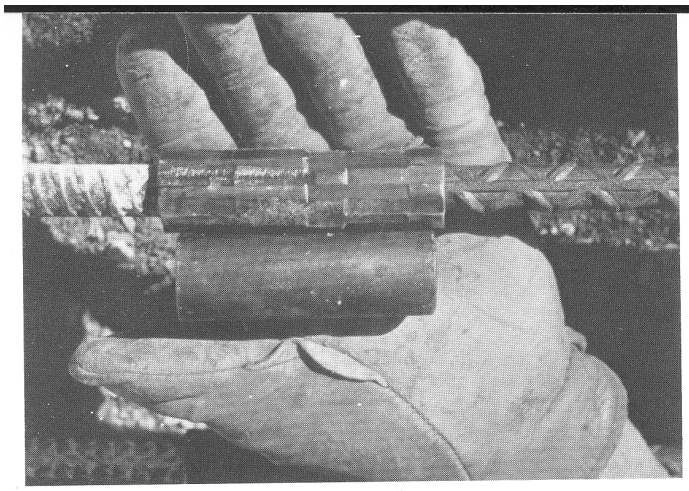


Figure 2 Mechanical couplers.

RESEARCH PAYS OFF

Illinois Improves Patching Procedures for Continuously Reinforced Concrete Pavements

Since 1962, the state of Illinois has constructed more than 2,700 equivalent two-lane miles of continuously reinforced concrete pavements (CRCPs). CRCP incorporates continuous longitudinal reinforcement in the pavement slab to eliminate the need for transverse contraction joints. Contraction joints control the pattern of inevitable cracks caused by shrinkage of the pavement slab after placement. Because CRCP has no contraction joints, an uncontrolled cracking pattern develops; however, the cracks are held to negligible widths because of the continuous reinforcement.

A majority of the Illinois CRCP was built as part of the Interstate highway system. As various sections of pavement neared the end of their service lives, it became apparent that improved repair procedures were needed. To meet that need, a research study was initiated in 1976. The study was sponsored by the Illinois Department of Transportation with the cooperation of FHWA and was conducted by the University of Illinois.

Problem

The most common form of CRCP distress has been cracking or deterioration of the pavement surface. Distress manifested in the surface of pavements occurs for a variety of reasons; for example, the accumulated effect of traffic loads, environmentally induced damage, and problems with component materials of concrete. Other forms of distresses include ruptured steel (wide cracks), pumping of foundation and subbase, longitudinal joint faulting, construction joint failure, blowups, and breakup of existing patches and the surrounding slab.

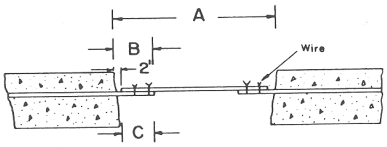
Before this study, the patching techniques used were those originally developed in 1967 for repairs on new construction by contractors. The procedures called for a patch to be not less than 10 feet long and not less than a full-lane width with a thickness equal to that of the existing slab.

The 10-foot standard patch consisted of one 4-foot center section and two 3-foot end sections. To prepare the area for the patch, two sets of saw cuts transverse to the reinforcing bars were made. One set of saw cuts located at each end of the patch was sawed across the pavement to a depth just above the reinforcing bars. A second pair of saw cuts was made full depth at a distance of 3 feet inside each of the patch edges. The 4-foot center section of the patch between the two full-depth saw cuts was then removed to provide a working area. The concrete in the remaining two 3-foot end sections was removed carefully with hand tools to avoid damaging the existing reinforcing bars. Continuity of the reinforcing steel was restored by lapping and tying new steel onto the exposed 3 feet of existing steel at each end.

The standard patch was applied to all types of distress regardless of the cause. Many times the patch exceeded the area of deterioration. The Illinois DOT recognized that a more cost-effective repair technique could be developed in which large patches were not required.

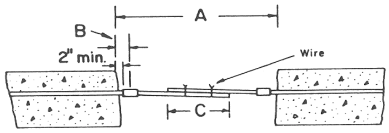
Solution

Researchers at the University of Illinois reviewed existing literature and practice, performed some laboratory testing, and conducted field evaluations of CRCP patching. This study resulted in the development of two distinct patching techniques: the first technique incorporated a shorter-tied overlap of existing steel and new steel and provided a shorter working area in the center of the patch; the second technique shortened the overlap of steel even more by welding the existing steel to the new steel and using a tied-lap splice in the center of the patch to avoid potential



	A (minimum)	B	C
No. 5 Bars	4 ft 6 in.	18 in.	16 in.
No. 6 Bars	4 ft 6 in.	22 in.	20 in.

TIED REINFORCEMENT



	A (minimum)	B	C
No. 5 Bars	4 ft 6 in.	6 in.	16 in.
No. 6 Bars	4 ft 6 in.	6 in.	20 in.

MECHANICALLY COUPLED REINFORCEMENT

Figure 1 Details of patching techniques.

Illinois Department of Transportation

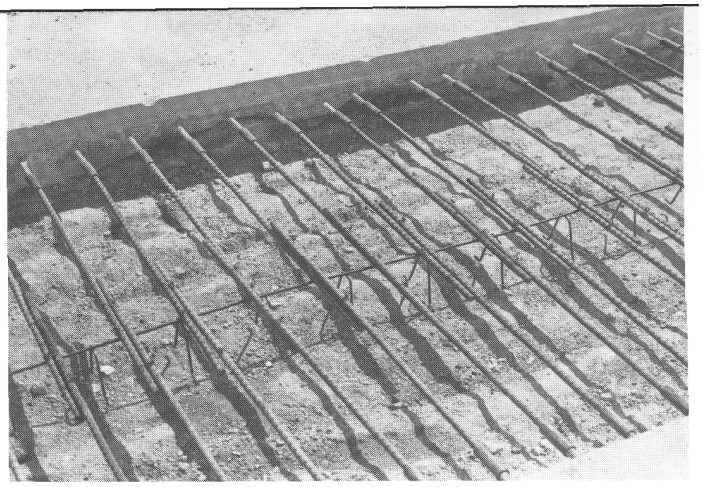


Figure 3 Mechanically coupled reinforcement patches.

buckling of the reinforcement.

However, field experience with the welded patch indicated that the quality of the welds was difficult to determine. For this reason, the use of welds was discontinued and replaced with mechanically coupled reinforcement. Details of the tied-splice and the mechanically coupled techniques are shown in Figure 1, which gives patch and splice dimensions for both No. 5 and No. 6 bars. The older pavements now being patched contain No. 5 reinforcement bars. The newer pavements are being designed and constructed with No. 6 bars.

For the tied-splice technique, the researchers evaluated several lengths of exposed reinforcing steel bars for the overlap with new reinforcing bars in the completed patch. Sufficient length must exist to effectively reestablish the continuity of the tensile strength of the reinforcing steel. The minimum satisfactory embedment length proved to be 18 inches for No. 5 bars and 22 inches for No. 6 bars. A minimum 2-inch clearance should be provided between the ends of the new reinforcing bar and the existing slab face to allow for possible expansion. This provides for a minimum 16-inch lap with No. 5 reinforcement bars and a 20-inch lap with No. 6 bars. The Illinois DOT has decided to maintain a minimum overall patch length of 4 1/2 feet to allow an ample working area in the center section of all patches.

Tests have indicated that mechanically coupling the new reinforcement to the exposed reinforcement at the ends of the patch is a satisfactory alternative to tying the rebars. To join bars, a side press with a removable die is used. The press fits around the coupler and bar and hydraulically presses the coupler down and around the deformations and core of the bar. Figure 2 shows the condition of a coupler before installation (bottom) and after installation (top). Using the coupler and allowing a 2-inch clearance between the new steel and the CRCP slab face requires that 6 inches of existing steel be exposed. To avoid potential buckling of the coupled bars, the new reinforcement should be lapped and tied at the center of the patch. The minimum lap length should be 16 inches for a No. 5 bar and 20 inches for a No. 6 bar. With coupled reinforcement, a minimum patch length of 4 1/2 feet is adequate. Figure 3 shows a mechanically coupled reinforcement patch before the placement of concrete.

Application

Since 1976 numerous experimental patches have been placed on CRCPs throughout Illinois. On the basis of the successful performance of these patches, the standard patch with a minimum length of 10 feet, used since 1967, was eliminated.

The Illinois Special Provisions for CRC Pavement Patching have been revised twice. The first revision, which became effective in September 1983, allowed the contractor the option of using either the short-tied reinforcement patch or the welded-reinforcement patch. The current revision, which became effective in April 1985, allows the contractor the option of using either the short-tied reinforcement patch or the mechanically coupled reinforcement patch.

Benefits

The splicing techniques save time in construction by significantly reducing the amount of pavement to be removed by hand in order to expose the ends of existing reinforcement. Combined with the overall reduced patch length, these techniques have resulted in substantial cost savings.

The use of the short-tied splice patch and the formerly used welded-splice patch on a 3-mile rehabilitation project completed in 1978 on Interstate Route 57 resulted in an average savings of $583 per patch for 83 patches. The savings were calculated using a cost of $1,400 for a 10- by 12-foot patch compared with an average cost of $817 for the smaller patches actually placed. The total cost savings of $48,000 on this small project demonstrated that substantial savings can be realized by using the shorter patches statewide.

It is estimated that 1,730 patches were placed in 1984 by using the new techniques. With an average savings of $500 per patch, the total cost savings amount to $865,000. It is expected that comparable savings were realized in 1985 and will be realized each year thereafter when the tied or mechanically coupled reinforcement patches are used.

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