Full-Depth Concrete Pavement Repairs on the Ohio Turnpike

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Full-depth concrete patching is used to repair damaged sections of pavement on the Ohio Turnpike. Because of heavy traffic demands, methods have been developed to reduce the amount of time normally involved in accomplishing this type of repair.

One major time-saving results from sawing of the concrete to be replaced into 2- by 3-ft pieces which are removed intact; another from a rapid method for drilling holes in the vertical faces of the exposed concrete for placement of dowels. A program of rigid control of the concrete mix and the placing, finishing, and curing of the concrete results in high quality repairs that are expected to be permanent.

The work is scheduled so that all lanes are completely open to traffic during the week-end periods.

•THE OHIO Turnpike consists of 241 miles of four-lane roadway built in 62 contract sections by 27 different contractors during 1954 and 1955. The resultant variety of construction practices is reflected today in the extent and location of pavement repairs.

The maintenance department consists of two divisions, each headed by a superintendent and an assistant. Each division covers four maintenance sections. Each section is under a foreman and two crew chiefs directing from 16 to 20 workmen. A section clerk, mechanic and a building custodian are also employed. This work force is equipped and skilled in the performance of all maintenance activities necessary to maintain a modern controlled-access highway facility.

Except for a comparatively few spots, the pavement on the Ohio Turnpike is in relatively good condition. Where repairs to damaged and broken areas are necessary, full-depth concrete patches are used. Temporary measures, such as covering the broken areas with bituminous mixtures, do little toward restoring the pavement strength. When patching is needed, it is done at the earliest opportunity.

On heavily traveled highways, all lanes must be available to traffic as much of the time as possible. Full-depth repair work is carried out during the periods of least traffic. The actual repair work is scheduled for Monday, Tuesday, and Wednesday, thus leaving sufficient time for curing of the newly placed concrete before the reopening to traffic by 2:30 p.m. Friday. The method is simple and straightforward. Maintenance crews, once properly trained, do quality work economically without constant supervision.

The first experience of the Ohio Turnpike with full-depth patching was in 1957, using maintenance forces. A pavement breaker (drop hammer) was rented and maintenance equipment, on hand at that time, was used in the demolition work. A Gradall and an air compressor with pneumatic paving breaker were the only special equipment employed on this job. Considerable difficulty was experienced in removing this pavement because of the reinforcing steel. The job was started on a Monday with overtime that day, and continued for the full day of Tuesday when concrete was placed, finished by hand screeds, and the job completed by evening. As a result of this experience, con-

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siderable study was given to developing a better and more efficient means of doing this type work.

During 1960, it became apparent that an extensive patching program would have to be formulated. During that fall and the early spring of 1961, the necessary equipment was procured and during the spring a program was instituted to train crews to do this work. Through cooperation with the Portland Cement Association engineers, workmen were given careful preparatory training which helped correct misconceptions they might have had about concrete. The consultation provided at this critical time helped to get the work off to a good start.

DESIGN OF PATCH

The laying out of the patch involves consideration of the existing pavement conditions, the shape and dimensions of a patch, and its position in the pavement with respect to

Figure 1. Patch design and position in pavement with respect to joints and edges.

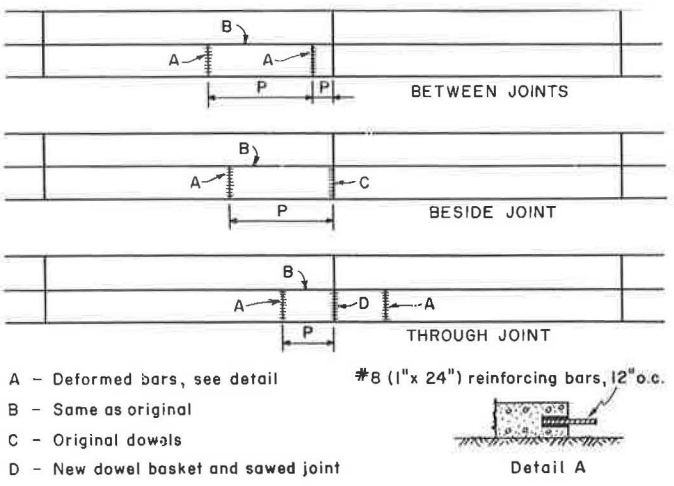

Figure 2. Ten-foot pavement repair.

joints and edges (Fig. 1). These items have a direct relation to the ability of the patch to stand up under traffic.

During the construction of the turnpike, it was decided that a minimum of 10 ft would be replaced when, because of some construction fault, it became necessary to replace a portion of the pavement. This policy was carried out in replacing defective pavement during the construction phase at several locations. An inspection of these patches showed no failures, and in fact, they were all in excellent condition. Following a study of these areas, we decided to continue using the minimum length of 10 ft for pavement repair (Fig. 2).

In constructing a full-depth patch it is necessary to determine the condition of the pavement on either side of the repair. To restore pavement smoothness, it is sometimes necessary to remove a considerable length of pavement. Adjacent settlements can be corrected by mudjacking before the pavement repair. It is generally a good practice to end a repair area no less than 10 ft from a joint or crack. If inspection of the crack indicates that it has not faulted, and the appearance is good, then the repair can end as close to it as necessary. Some repairs have ended approximately 6 ft from a crack. If the crack is open or faulted, the repair area is extended approximately 6 in. beyond the crack or the distance required to square the horizontal joint with existing pavement. In cases involving a failure at a joint, we have relocated a joint as much as 5 ft from its original location. Generally, these have been full-pavement width replacements.

REMOVING OLD PAVEMENT

Single Lane Width

After the size of the repair area has been determined, the pavement is sawed to a depth of approximately 6 in., to cut the reinforcing steel (Fig. 3). A cut is made on both ends of the repair area and approximately 2 in. in from, and parallel to, the centerline. A cut is made approximately 8 in. in from, and parallel to, one of the end cuts. The remaining cuts are made in such a manner as to result in pieces of approximately 2- by 3-ft.

Two- or More Lane Width

The sawing is the same as for a single lane width with the exception of the centerline cut. In this case, the centerline cut is made approximately 8 in. into the adjoining lane to provide space for setting forms.

Figure 3. Sawing of pavement to cut reinforcing steel.

Figure 4. Drilling of hole for lift pin which removes concrete piece.

Figure 5. Trench in shoulder beside slab to accommodate forms.

When sawing is completed, a hole $1\frac{1}{2}$ in. in diameter is drilled in the approximate center of each 2- by 3-ft piece for inserting the lift pin for removal of the piece (Fig. 4). A trench is excavated in the shoulder beside the slab to the depth of the slab and as long and wide as necessary to accommodate the forms (Fig. 5). For patches longer than 10 ft we have built short lengths of forms to add to the standard 10-ft forms. Pneumatic paving breakers are used to remove the 8-in. piece at one end of the repair area. After this piece is removed, the drop hammer is used to break out the first adjoining row of 2- by 3-ft pieces (Fig. 6.). Usually one hit of the hammer on the inside corner (where saw cuts cross) will break a piece loose. This is done one row at a time. Experience has shown a tendency to overbreak with the drop hammer. The more hits of the drop hammer the more spalls and chips to remove by hand. Sufficient material is blown out with an air blow pipe to provide room for inserting the lifting pin. The pin is inserted and the high-lift used to lift the piece of slab out (Fig. 7).

After the first row of pieces has been removed, the remaining spalls and chips are removed before removing the next

Figure 6. Drop hammer breaking out 2- by 3-ft concrete pieces.

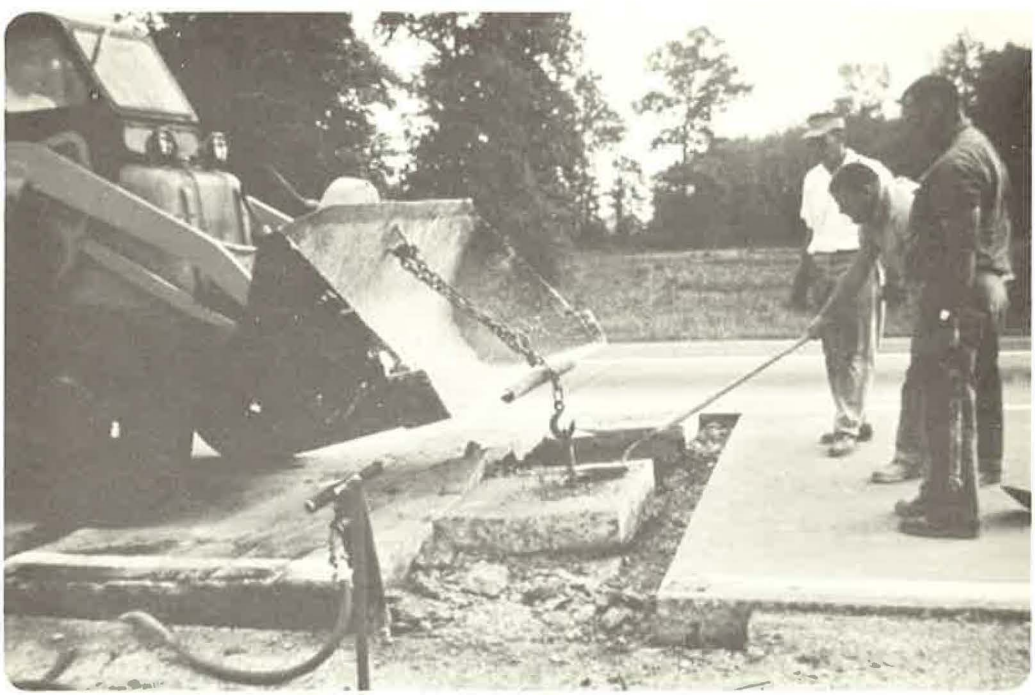

Figure 7. High-lift used to lift out piece of slab.

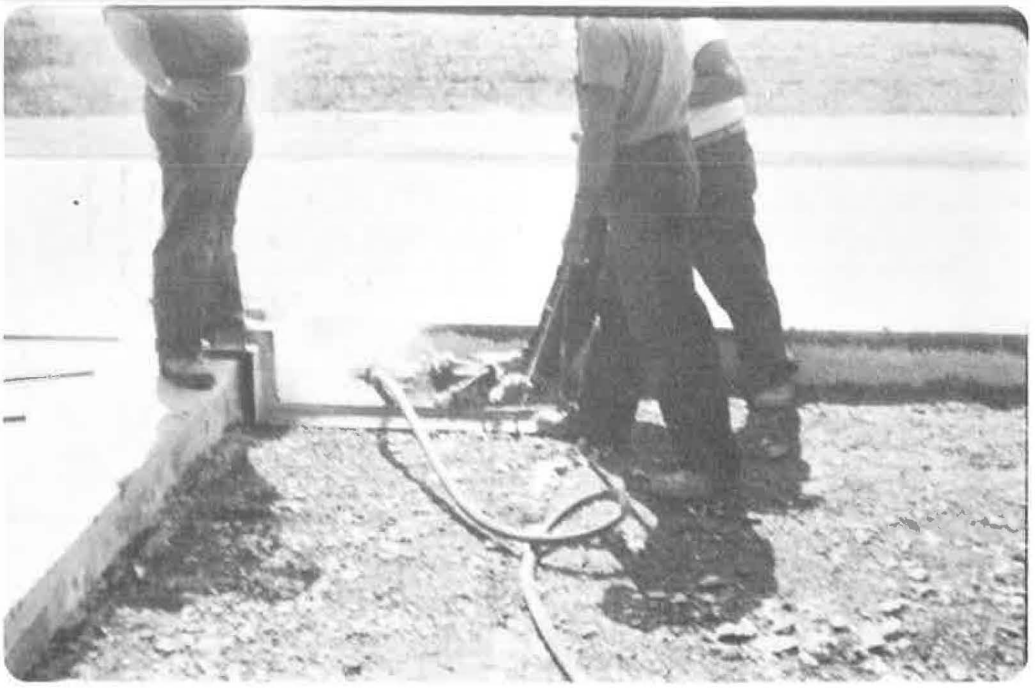

Figure 8. Removal of spalls and chips.

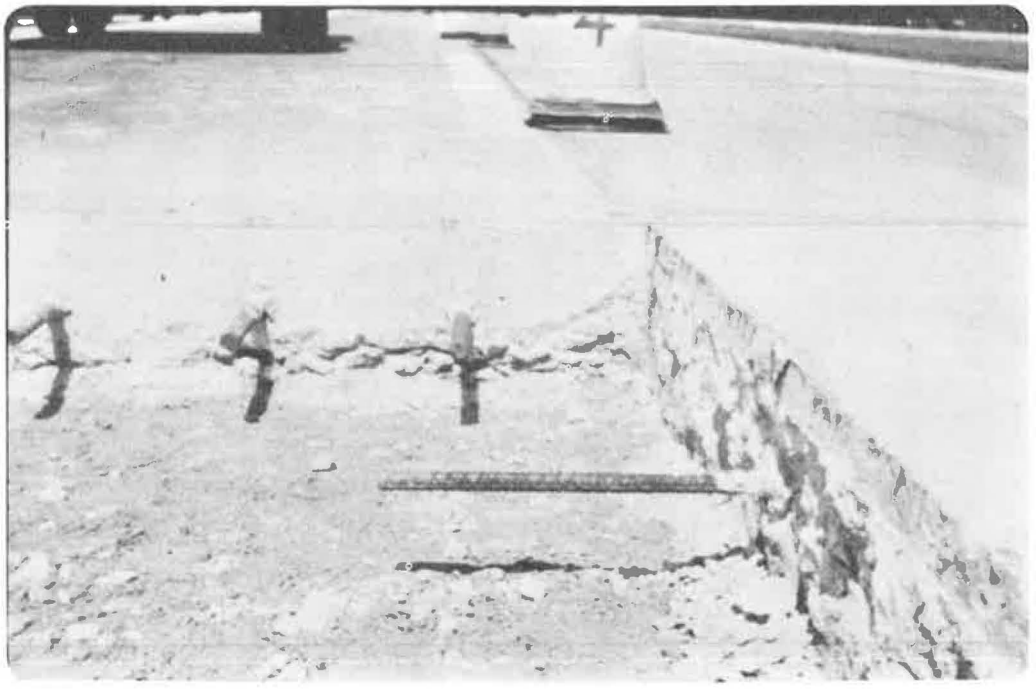

Figure 9. Replacement of joint, using steel bars to provide the working joint.

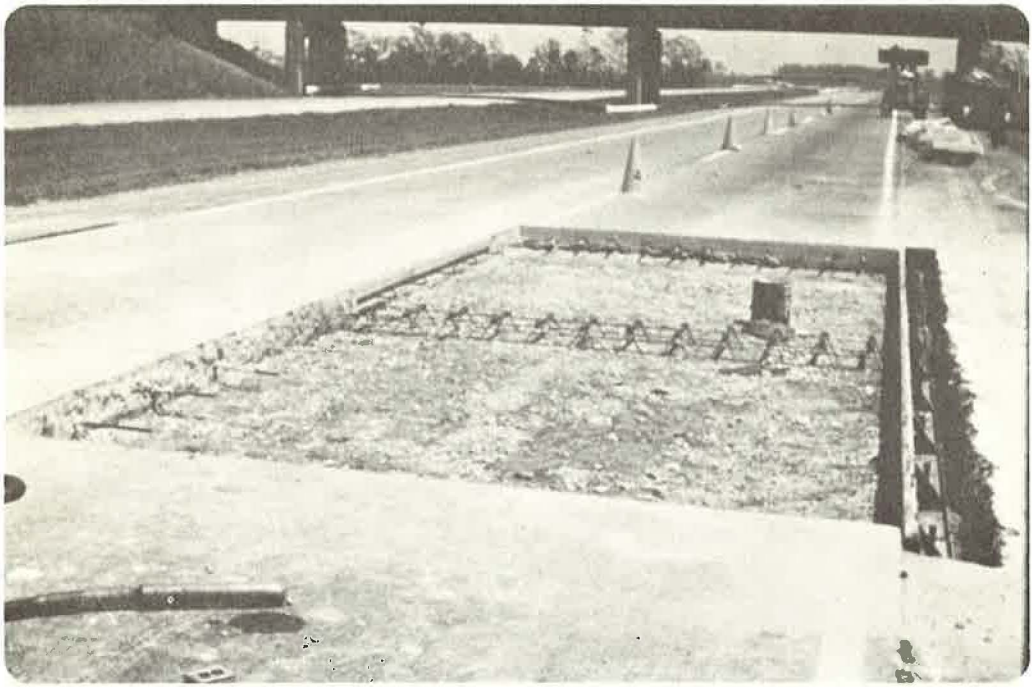

Figure 10. Standard hook bolt key joint.

row, to insure a minimum of subbase disturbance (Fig. 8). When all the old material is removed, $1\frac{1}{2}$-in. holes are drilled on 12-in. centers, 12 in. deep, into the vertical faces of the adjacent pavement at the transverse joints. In instances where the repair is an internal one (not at a contraction joint) No. 8 (1-in.) deformed bars are used for load transfer. Some locations involve the replacement of a joint where, for the most part, the full pavement width is replaced. The joint is replaced, using smooth, hot-rolled, steel bars $1\frac{1}{8}$ in. in diameter to provide the working joint (Fig. 9). One and one-half inch holes are drilled 12 in. deep on 30-in. centers on the longitudinal joint. Where the repair is full pavement width, a standard hook bolt key joint is used (Fig. 10).

A quick setting mortar is used to grout the bars into the slabs. When smooth bars are used, they are grouted into the old pavement and the exposed ends greased before the new concrete is placed in the repair area. All dowels are 24 in. in length. After placement of the dowels, the form is set and the subbase dressed, as required. Seldom, if ever, is any material added to the subbase.

PLACING OF CONCRETE

Ready-mixed concrete, containing 6.5 sk of cement per cubic yard, with between 5 and 6 percent entrained air and No. 4 and No. 5 coarse aggregate (AASHO M 43), is ordered from a local batch plant (Fig. 11). The material is delivered to the job site dry. Since most of the delivery trucks do not carry sufficient water, it is provided at the job site to complete mixing. The concrete is mixed long enough to insure thorough blending and full generation of entrained air. A dry low-slump concrete is used (Fig. 12). Concrete is tested for sufficient air before being placed in the repair area and test beams are cast. No admixture other than the air-entraining agent is added to the concrete.

When the concrete is mixed and the air test completed, the concrete is placed in the repair area to a depth of approximately 7 in. (Fig. 13). A vibrator is used for consoli-

Figure 11. Placement of ready-mix concrete.

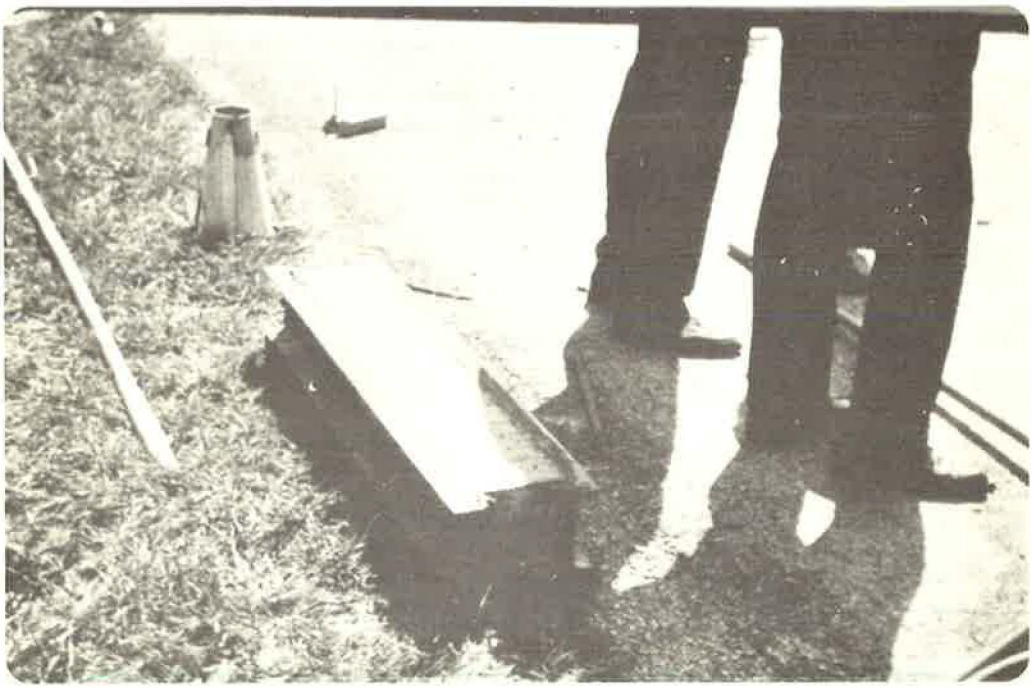

Figure 12. Dry, low-slump concrete.

Figure 13. Placing of concrete in repair area.

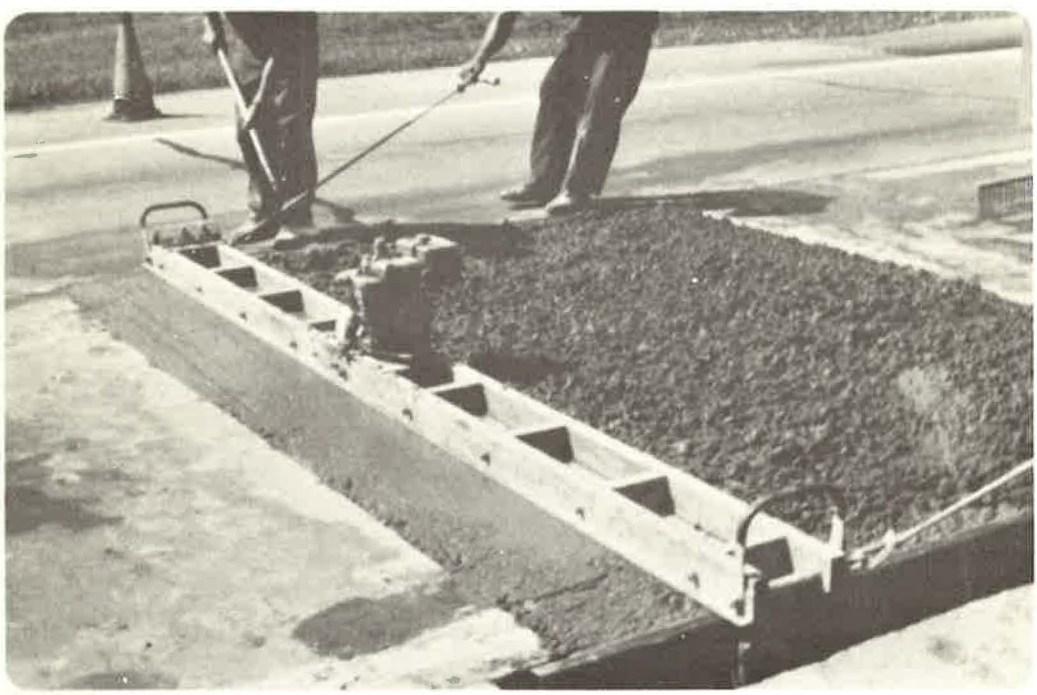

Figure 14. Addition of remaining concrete after placement of steel mesh.

Figure 15. Spraying of white-pigmented compound on concrete.

dation around the dowel bars. The steel mesh is placed and the remaining concrete added (Fig. 14). A vibrating screed is used to strike off the concrete, and several passes with the vibrator are usually sufficient. Hand work is kept to a minimum; generally, only a float and a straightedge are required to finish the surface. Burlap is used to texture the surface.

Immediately on completion of the finishing operation a white-pigmented compound is sprayed on (Fig. 15). The forms are usually removed after 24 hr. A trench drain is installed from the trench excavated for the forms to the adjacent shoulder and the form trench is back-filled and surfaced. Each maintenance division is equipped with a beam breaker. When the beams cast at the repair area indicate 500-lb flexural strength, the pavement is reopened to traffic.

COST AND TIME INVOLVED

Sawing is generally completed the day before the removal of the concrete to be repaired. Sawing time for the average size repair is 2 to 3 hr. Removing the old pavement and placing forms and dowels generally requires between 1½ to 2 hr with another hour required to place and finish the concrete.

The cost varies in relationship to the material cost and the size of the area being repaired. The average cost of labor and material, in place, is $12.00 per sq yd.

EQUIPMENT USED

The equipment used includes the following items:

Trucks, as needed, to remove material and equipment;
Front-end loader;
Concrete saw (Clipper Model 300);
Water tank, 900-gal capacity;
Drop hammer (Henry Model 810, mounted on an IHC Model 300 tractor);

Air compressor;
Jack hammer and rock drill;
Device to hold rock drill for drilling horizontal holes;
Lift pins;
Vibrating screed (Thor Model FS);
Concrete vibrator (Wyco square head No. 991-G 7); and
Miscellaneous small tools such as wheelbarrows, brooms, trowels, edgers.

CONCLUSIONS

Enough of these repairs have been made on the Ohio Turnpike to demonstrate that the principle is sound. Rigid controls are set up for the use of this repair method, and when followed carefully, the end results are good and the repairs are expected to be permanent.

NOTE: A color movie, shown at the 45th Annual Meeting of the Highway Research Board, has been developed by the Portland Cement Association to illustrate in detail the procedures developed.