Restoration of Joint and Spall Failures on PCC Pavement

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•IN April 1961, the North Dakota State Highway Department let a contract for portland cement concrete pavement on highway US 83 through the city of Minot. This contract called for a 4-lane divided highway with both depressed and raised medians. The PCC pavement was 9 in. thick with standard 6-by 12-in. wire mesh reinforcement. Slab lengths were 61 ft 6 in. with doweled contraction joints. The contract was completed in the fall of 1961. Before the pavement had a chance to completely cure, and in less than 30 days after completion, freezing weather and icy conditions required that the city use a mixture of sand and salt on the pavement to reduce traffic hazards. The pavement was constructed of air-entrained concrete but we believe the curing period was so curtailed by the freezing temperatures that the pavement's susceptibility to resist salt action did not have a chance to really become effective.

In the spring of 1962, areas of the pavement began to scale. By midsummer joints began to spall as the pavement expansion stressed the edges of the joints. Spalled areas showed evidence of salt concentrations in the plane of the spall indicating that the early application of salt had had a damaging effect on the pavement.

During 1962 and 1963 the spalls became larger, deeper, and more numerous. Joint seals had failed entirely and were allowing incompressible material to enter the joints. This added to the stresses on the pavement joint edges as the slabs expanded in hot weather (Fig. 1). Two years after the pavement was constructed, some joints had spalled so deeply that the dowel bars were visible. Some spalled areas 1 to 2 ft wide extended the full width of the street and were becoming traffic hazards (Fig. 2).

COURSE OF ACTION

Our research department was enlisted to determine a course of action. After studying available literature and making a physical inventory, it was decided that all transverse joints on the project would be resawed and resealed. All spalled areas would be restored to their original condition insofar as possible.

The decision was made to resaw all joints to a width of $\frac{5}{8}$ in. and seal with $1\frac{1}{4}$-by $1\frac{3}{4}$-in. neoprene compression seal. (It was proved later that the joints had to be sawed to $\frac{21}{32}$ in.)

The physical inventory showed that the spalled areas varied in size from small chip-like areas to areas 2 ft wide, 4 to $4\frac{1}{2}$ in. deep with some areas extending the entire width of the pavement. It was decided to separate the spalled areas into two categories as to type of repair. Spalled areas up to 36 sq in. were to be patched with an epoxy mortar and all spalled areas over 36 sq in. were to be patched with a portland cement mortar (Fig. 3). It was estimated there would be 127 sq ft of epoxy patching and 3,429 sq ft of portland cement patching.

The epoxy patching material, Thiokol or equivalent was to be mixed and placed in accordance with the manufacturers, recommendations.

The portland cement patching material was to be 1: 2 mortar mix with no more than 4 gal of water per sack of cement.

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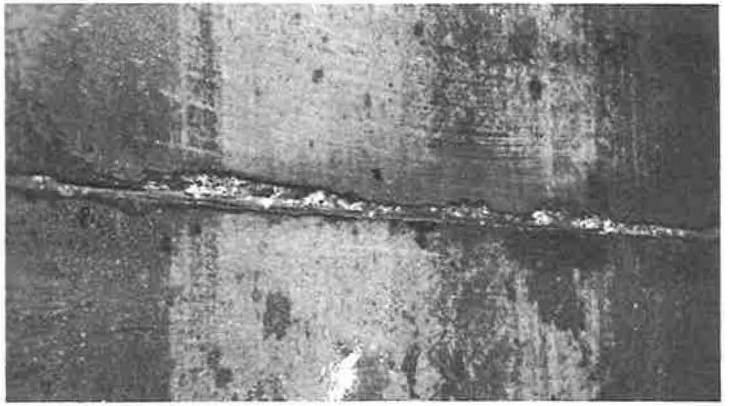

Figure 1. Slab expansion in hot weather.

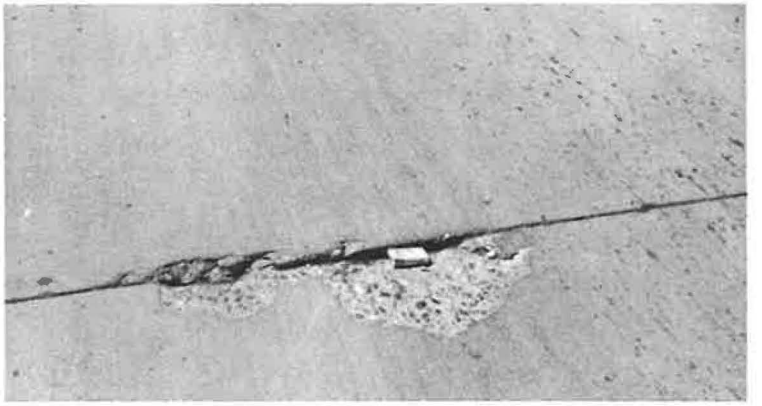

Figure 2. Spalled area at joint 2 years after construction; notice cigarette pack for reference.

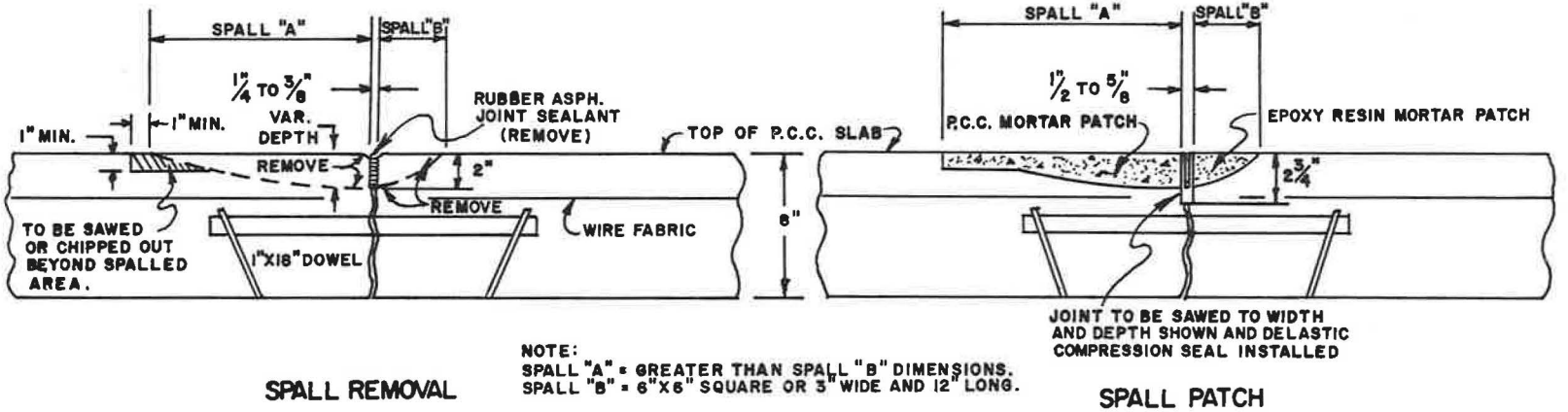

Figure 3. Spall and joint repair detail.

PROJECT AND CONSTRUCTION METHODS

In August 1964, a contract was let for this restoration work at a contract price of $41,700.00. The engineer's estimate of the cost of the work was $28,000.00. After awarding contract, the first step in the work was to locate and outline all unsound, or loose concrete in the area of each joint. The loose portions of concrete were easily detected by a hollow sound when rapped with a hammer. The outline of each area was then painted (Fig. 4) on the pavement. The joints were then sawed to the dimensions required for the preformed neoprene seal. A 1-in. deep saw cut was made following the painted outline of the spalled areas.

All unsound or loose concrete within each saw cut area was removed to a minimum depth of 1 in. Jack hammers were used to remove this concrete in the larger areas. A small chipping hammer was used in the small, shallow areas (Fig. 5). The resulting

Figure 4. Painting outline of unsound concrete.

Figure 5. Using a small chipping hammer in small, shallow areas.

areas to be patched had straight vertical sides, but the bottom of each was left very rough to aid in obtaining a good bond between the patch and the old concrete. Each area was then cleaned of all dust and loose particles of concrete by brooming and by a small vacuum cleaner. No attempt was made as yet to clean the joints. A 25 percent solution of muriatic acid etch was applied to each patch area with a stiff brush and allowed to remain until all acid action appeared to cease. This takes only a few moments. The acid was flushed out with water. A few of the patched areas have since shown evidence of a poor bond. When the poorly bonded material was later removed it was found that the acid residue had not been washed out well; therefore, if an acid etch is used, all traces of the acid must be thoroughly removed by washing, preferably under pressure. (The same contractor is now working on an air base just north of the city and is sand blasting after acid etch.) The areas to be patched were allowed to dry thoroughly before patching.

The epoxy patching mortar was composed of Presstite No. 1190 concrete adhesive in combination with Ottawa sand. One part epoxy to 3 to 5 parts sand was used as trial mixes. The mixture with 5 parts sand to 1 part epoxy was favored because it cured faster. The mortar was mixed in batches just large enough for a two-man crew to place and to finish the batch before it became unworkable.

A coat of epoxy adhesive was carefully brushed onto each face of the exposed area (Fig. 6). Then each depression was filled with mortar. The mortar was tamped into place. The surface was troweled and a light dusting of portland cement applied so that the surface color blended with the surrounding pavement. Before placing a patch, a wooden form was placed in the joint to form a wall of the joint (Fig. 7). The forms were not removed for 72 hours or more until the patches cured enough to allow traffic over them.

Several methods were used in an attempt to hasten the hardening or curing process but none was successful. In one, insulation was placed over the patches to retain heat. Various means of heating the patches were also tried including heated sand in the mortar. The 72-hr time for curing was found necessary.

The portland cement mortar consisted of 1 part Type III portland cement to 2 parts concrete sand with a water content of 3 gal per sack of cement. Air-entrainment was added to maintain an air content of from 8 to 10 percent. Calcium chloride at a rate of

Figure 6. Applying brush coat of epoxy adhesive.

Figure 7. Placing wooden form.

one percent of the cement was added to the mortar as an accelerator. Three-day compressive strengths of this mortar exceeded 3,000 psi. Prior to placing these patches, forms were placed in the line of the joint to form the joint wall. The patch area was painted with a portland cement grout, consisting of 1 part cement to 1 part sand. The grout was applied with a stiff brush to be sure it was scrubbed into every indentation of the area. The patching mortar was then tamped into the patch (Fig. 8), finished to blend in with the surrounding pavement surface, and sprayed with a white, liquid curing agent. All forms were removed in 72 hours after the patch was placed. The area was then opened to traffic.

Figure 8. Tamping mortar into patch.

Before installing the neoprene seal, all joints were re-sawn and cleaned of all dust and debris. Each joint was checked to be sure it was dry. The seal was installed according to the manufacturer's instructions.

CONCLUSION

There had been some doubt that the thinner, smaller epoxy patches would hold. As of this time only three very small epoxy patches have failed in bond. These failed due to the action of a steel-wheeled roller having been driven over them. The neoprene seals have functioned perfectly through the cold weather of the winter of 1964-1965 which had temperatures as low as -31 F. At this time we are highly optimistic that the project was completely successful and we believe time will support our optimism.

When the project was completed, there were 1,639 (232.7 sq ft) and 4,844.94 sq ft of mortar patches.