Thin Bonded Concrete Repairs on the Ohio Turnpike

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•THIN BONDED concrete patches are used on the Ohio Turnpike to repair damage to bridge deck and roadway pavement largely resulting from scaling and/or spalling due to freezing and thawing.

The severity of such scaling or spalling may be related directly to snow and ice removal methods, concrete quality control during construction, amount of entrained air and adequacy of cover over steel. Highway signs warning that "Bridge Deck Freezes Before Roadway" are fairly common and indicate the destructive force of additional freeze and thaw cycles to which bridge deck concrete is subjected.

Bridges on the Ohio Turnpike are no exception to those of other systems. Some difficulty has been experienced on 99 of 314 structures. The Ohio Turnpike consists of 241 mi of four-lane roadway built in 62 contract sections by 27 different contractors.

Thin bonded concrete repairs, as compared with full-depth repairs, are particularly suited to turnpike maintenance operations. On heavily traveled highways, all lanes must be available to traffic as much of the time as possible. Thin bonded repair work with high early strength concrete makes possible the reopening of sections within 6 to 24 hr. Much of the work can be done at night during low-peak traffic hours. Because structural strength is already available in the existing structure or pavement, the repaired work can be opened as soon as it will not erode. It does not have to develop significant flexural strength.

This type of repair is less costly than removal and replacement of pavement, especially on bridges. The method is simple and straightforward. Maintenance crews, once properly trained, can do quality work economically without constant supervision.

Economic considerations resulted in a somewhat unusual type of thin bonded concrete overlay on the Ohio Turnpike to correct the uneven riding surface of twin bridge decks carrying east- and westbound traffic over Raccoon Creek. Both structures are of three-span continuous steel beam construction. Because the rolled-in camber in the beams was not taken into consideration when the concrete decks were placed, the finished grade line was not acceptable. The remedy appeared to be reconstruction of the decks. However, after much consultation, it was decided to correct the grade line by placing a thin bonded concrete overlay on the completed decks. The overlay varied in thickness from 3½ to 6½ in. This work was done in May 1955, and there was in 1963 no evidence of failure in the decks of either bridge.

Scaling, spalling and popouts are among the principal types of damage encountered in concrete surfaces. Scaling affects the finished surface and results in a rough ride, as well as being unsightly. The use of chemicals in snow and ice control increases the severity of damage when the concrete has insufficient air content. Some areas on a bridge deck may also show surface scaling because of improper concrete finishing techniques. Plastic shrinkage cracking may be caused by surface drying before the application of curing compound or other curing methods.

A common type of surface spalling on concrete bridge decks is preceded by hairline cracks above reinforcing bars. Rusting develops an expanding layer around the metal with the result that otherwise good quality concrete is spalled away in a line above the

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bar. A design criterion calling for more cover over reinforcing bars would lessen this type of spalling, as would closer attention to the placing of steel during construction. Popouts are attributable to the presence of unsound particles of coarse aggregate in the concrete. The Ohio Turnpike has experienced popouts in a 3-mi section of pavement but not on bridge decks. Normally, the testing of materials will prevent or minimize this type of difficulty.

Heretofore, a rather general practice for repairing scaling, spalls, or other surface failures in concrete pavement has been to use bituminous materials. Although such repairs are quick and easy, they are usually of a temporary nature and sometimes only hide the problem. Moreover, bituminous surfaces appear to absorb and hold ice control chemicals in contact with the concrete surface over a greater length of time, thus accelerating the destructive force already at work. The major reason for using concrete in the repair of concrete surfaces is that the material is compatible and, therefore, more durable. Color likenesses are retained and costs are reasonable.

With respect to bridge decks, it is important that repairs definitely arrest further deterioration. Cumulative layers of surface thickness are undesirable because of increased dead load. Due to the heavily reinforced design of concrete bridge decks and the forming required, the cost of construction is high compared to that of pavements. Complete replacement of a deck is an extremely expensive procedure, and also creates untenable traffic problems. Thin bonded concrete repairs are effective and overcome these problems.

The first experience of the Ohio Turnpike with thin bonded concrete repairs was in 1959 under contract. This work was performed on a bridge deck and on some areas of deeply scaled roadway pavement within an interchange. Methods used were those recommended by the Portland Cement Association. Most of the original repairs performed satisfactorily and the procedure is still considered basically sound. In 1960 additional work on a bridge deck was done by Ohio Turnpike maintenance forces.

In 1961 it was decided to train a crew in each of the eight turnpike maintenance sections to perform repair work in concrete. Through cooperation with Portland Cement Association engineers, workmen were given careful preparatory training which helped correct misconceptions they might have had about concrete, such as the notion that new concrete cannot be made to bond to old. PCA field representatives served as consultants when the crews did their first patching jobs. Discouragement that otherwise might have resulted from early mistakes was avoided and good morale was maintained. Every 2 yr, the repair techniques are reviewed.

METHOD OF REPAIR

The success or failure of a patch depends on the soundness of the underlying material to which the patch will be bonded. A concrete patch or a thin concrete overlay should not be attempted on any concrete slab that appears to be deteriorating throughout. Damage caused by minor scaling, popping, spalling, or mechanical, fire or chemical damage can generally be repaired with bonded patches.

Before repairs can be accomplished, all deteriorated or defective concrete must be removed. One of the most common errors in repair procedures is the failure to remove completely all unsound concrete.

The extent of the damaged area is determined by sounding and is outlined by sawing to a depth of about 1 in. with a concrete saw. The outlined area must include all adjacent unsound material. Parallel lines are sawed 1 in. deep and about 1 ft apart in each direction within the outlined area to aid in breaking out the deteriorated concrete. This concrete is removed by a jack hammer to a depth where sound material is encountered over the entire area. Care must be taken not to damage the reinforcing steel.

If the difficulty has resulted from reinforcing steel not having enough concrete cover, such as spalling on a bridge deck, the concrete must be excavated deep enough to permit forcing of the bars to a level where at least 1 ½ in. of the new patching concrete will cover all reinforcing bars. Careful use of a sledge hammer and wooden block is needed to prevent damage to the bars. It is sometimes necessary to tie the bars to lower reinforcing steel to hold them down while the concrete is being placed. In some cases, the elevation of the new concrete may be raised sufficiently to provide the necessary cover.

The excavated area is thoroughly cleaned with an air hose and by hand. The edges of the saw cut are wire brushed and all loose material is blown out. Water under pressure is directed into the areas and then blown out with air. The damp area shows up any remaining loose material, which is taken out with a hand pick. The surface is then treated with a solution of 20 percent muriatic acid. When the foaming action has stopped, the surface is washed repeatedly with clean water until all acid is removed and the surface shows neutral reaction to pH paper. All free water is then blown from the surface, which is now ready for patching.

For best bond, the concrete surface should be relatively dry at the time of patching. If the concrete has gone through an extended drying period, some moistening may be advisable, but the surface should be clear of any free water before applying the bonding agent.

Starting in 1962, a number of areas to be repaired were patched without prior acid etching. The grout bonding coat was applied directly over the previously washed and dried excavated area after it had been thoroughly cleaned. Figure 1 shows the results of a number of bond tests with different bonding techniques (1).

Before placing the new concrete, a bonding coat of grout (a cement and water mixture) about 1/16 to 1/8 in. thick is thoroughly broomed into the concrete surface to coat it uniformly and to remove air pockets. The grout is not spread so far ahead that it changes color by drying before the concrete is placed. In hot, dry weather the old concrete surface is dampened by light sprinkling just ahead of the grouting. However, care is taken to prevent accumulations of free water.

The cement used is Type IIIA air-entraining portland cement. The aggregate is a well-graded silica sand.

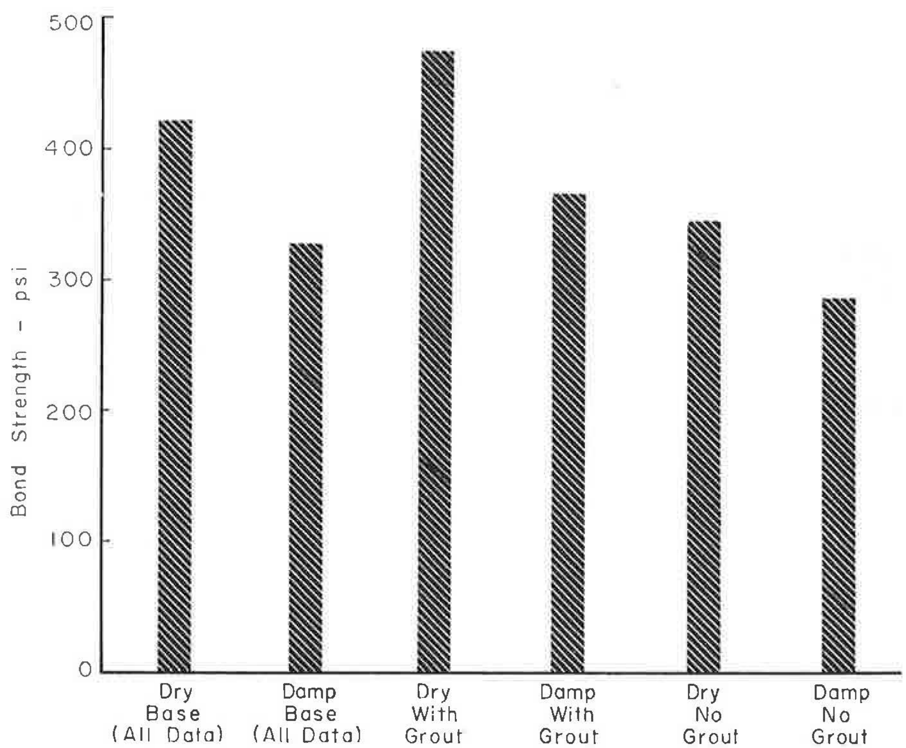


Figure 1. Effect on bond of grout and moisture condition of base.

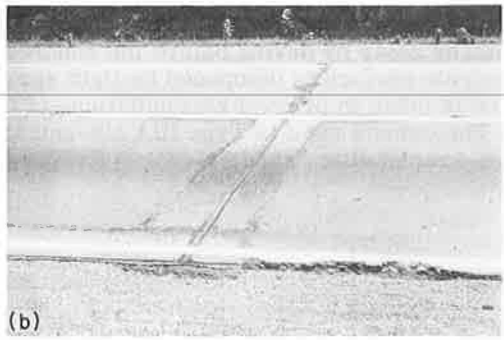
TABLE 1

AGGREGATE GRADATION OF CONCRETE FOR PATCHING

Sieve Size	Total Passing (%)
3/8 in.	100.0
No. 4	95.4
No. 8	72.3
No. 16	49.1
No. 30	36.4
No. 50	25.7
No. 100	7.1
No. 200	0.5
Decantation	1.4

The original aggregate gradation was modified in 1963 to provide a more workable mix by the addition of more fines. Present gradation is given in Table 1. The mix proportions are 3 cu ft of aggregate to each sack of air-entraining cement, with an air-entraining admixture added during mixing. About 8 to 11 percent air in the mortar is necessary for a durable patch. The concrete materials are batched directly from the truck bed into the charging hopper of the one-sack mixer. The concrete is mixed long enough to insure thorough blending and full generation of entrained air.

The slump of the mixed concrete is such that a handful of concrete, when squeezed into a ball in the palm of the hand, remains in the shape of a ball when the palm is opened, with only slight moistening of the hand. Concrete is tested for sufficient air



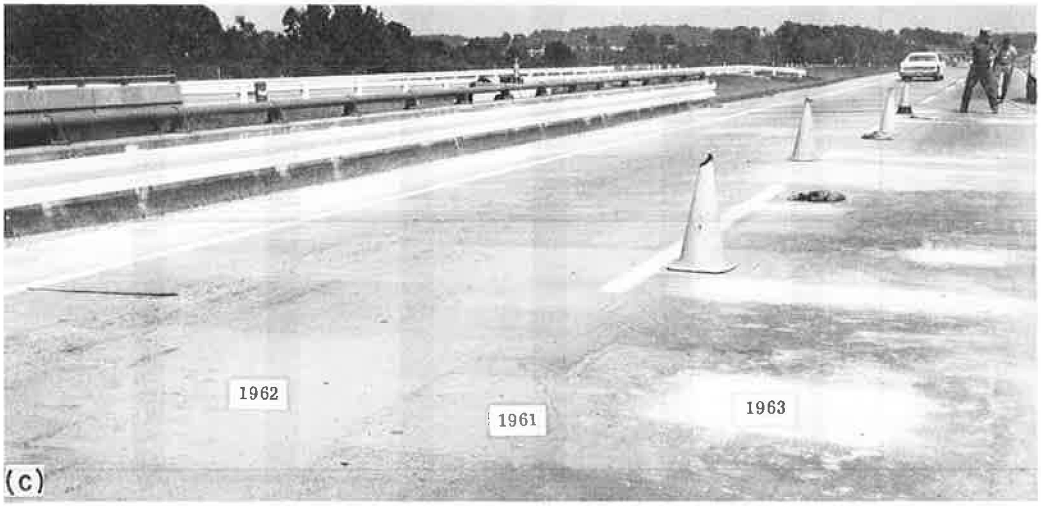


Figure 2. Various applications of thin bonded repair techniques: (a) popouts, existing and as repaired; (b) joint repair; and (c) bridge deck patches made at three different seasons.

before being placed in the patch. No admixture other than the air-entraining agent is added to the concrete.

The concrete is placed in the patch on the bonding coat as soon as possible and spread smoothly. Excess is removed with a vibratory strikeoff. The concrete after the passage of the strikeoff has a dense and firmly compacted surface. It is then darbied with wooden floats. A steel trowel need not be used in any such patching. The texture of a wood-floated patch will give good skid resistance and will match adjacent surfaces.

Immediately on completion of the finishing operations, curing is begun by spraying the patch with a white-pigmented compound. When it is not practical to apply this membrane immediately, the patched area is covered with damp burlap until it can be done.

In the repair of popouts, an air hammer is used to break out the soft material which caused the popout. This is blown out, the popout is acid etched, thoroughly washed, painted with mortar, and the patching concrete is placed. The method of repair is unique in that it is not desirable to remove more surrounding concrete materials. Therefore, a thorough cleaning-out of the area and the placement of concrete with feather edges are necessary. Because of this feather edge finish, the curing compound must be applied immediately on placement of the patch material. Very good results have been obtained in this type of popout repair. Repair work is stopped in the early afternoon, so that about 4-hr daytime curing may take place before traffic is permitted on the latest applied concrete repair material.

Various applications of thin bonded repair techniques, all of which are serving satisfactorily, are shown in Figure 2.

The experience of the Ohio Turnpike Commission in using thin bonded concrete repair methods since 1959 has been good. Enough of these repairs have been made on the Ohio Turnpike to demonstrate that the principle is sound. Very rigid controls are set up for use of this method of repair, and when followed carefully, the end results are good and the repairs are expected to be permanent.

REFERENCE

1. Felt, E. J., "Repair of Concrete Pavement." Portland Cement Assn., Devel. Dept. Bull. D44, p. 145.