

# A Study of Bond Strength of Portland Cement Concrete Patching Materials

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## ABSTRACT

Laboratory studies were conducted to evaluate bond strength between rapid-setting portland cement concrete (PCC) patching materials and PCC pavement. Slant shear and impact tests were used to evaluate bond strength development. Rapid-setting PCC, Roadpatch, and polymer concrete were evaluated. Manufacturer-recommended bonding agents were used with Roadpatch and polymer concrete. Portland cement grouts and epoxy were used with rapid-setting PCC. Nails installed along bond surfaces were evaluated as mechanical anchors. Testing was conducted after 6-hr curing for early-strength evaluation and after subjecting samples to cyclic temperature variations for durability evaluation. The slant shear test proved to be a valuable one for measuring bond strength development. Roadpatch and rapid-setting PCC provided desirable strength characteristics. Polymer concrete had superior early bond strength, but its long-term strength gain and durability were not as good as those of Roadpatch or rapid-setting PCC. Epoxy bonding agents were adversely affected by low temperatures and PCC grout was adversely affected by high temperatures. The inclusion of 1/8-in. diameter nail anchors along bond surfaces did not measurably improve bond strength.

The major focus of federal, state, and local highway agencies has shifted from construction of new facilities to maintenance, repair, and rehabilitation of existing facilities. The Interstate system is virtually completed, and older, more heavily traveled sections, which have experienced traffic that has often exceeded design weights and volumes, are requiring increased maintenance and often complete rehabilitation.

A large portion of heavily traveled urban Interstate pavements is composed of portland cement concrete (PCC). Before and during complete rehabilitation, patching of cracked and deteriorated areas, joint repair, and joint resealing are required. Heavy traffic conditions on urban freeways create difficult, hazardous, and costly maintenance operations. Speed of repair and strength and durability of the patch are at a premium. Patch strength and durability are directly related to the bond developed between the patch and the base concrete. The research reported here evaluated the relative bond strength developed between several rapid-setting patching materials and base concrete. The work also investigated sensitivity of strength development to the use of several bonding agents and anchors.

## IMPORTANT PATCH PROPERTIES

High early strength is a major requirement of a rapid-setting patching material. Although minimum acceptable early-strength values have not been definitely established, O'Connor (1) has suggested compressive strengths of 300 psi at 2 hr and 2,500 psi at 24 hr. Ross (2) has suggested 6 hr as the maximum time that a patch could be allowed to cure before the road is opened to traffic within an 8-hr work shift. This value was used for early-strength evaluation.

A patch must be durable to withstand environ-

mentally induced stresses without debonding. Bond strength durability was evaluated by comparing the strengths of specimens subjected to cyclic temperature variations with those of control specimens of the same age. One group was subjected to daily temperature variations of 80 to 120°F and a second group to variations of 15 to 50°F.

Patches are subjected to traffic-induced dynamic stresses, and therefore ductile behavior to provide energy absorption capacity and fracture resistance is desirable. Patch resistance to dynamic loading was evaluated by performing impact tests on overlays of patching materials bonded to base concrete. The energy absorbed during impact and failure of the test specimens was assumed to be indicative of the ductility of the composite specimens.

## MATERIALS EVALUATED

Three rapid-setting materials--Roadpatch, polymer concrete, and a rapid-setting PCC--were evaluated. Roadpatch is a proprietary patching material. The particular polymer cementing agent used in the tests was a proprietary two-component methyl methacrylate system.

Each proprietary patching product was mixed and placed according to the manufacturer's recommendations. Gradations of the fine and coarse aggregates used as fillers in the patching materials are given in Table 1. Both were commercial materials produced by washing and grading natural sand-gravel. The predominant mineral constituent was quartz.

## Roadpatch with Steel Fibers

Roadpatch is a fast-setting nonshrinking portland cement (PC)-base patching material. The manufacturer alleges 1-hr compressive strength of 1,500 psi with

TABLE 1 Aggregate Gradations

Sieve Size	Percent Fines by Weight	
	Coarse Aggregate	Fine Aggregate
3/4 in.	100	—
1/2 in.	97	—
3/8 in.	59	100
No. 4	2	96
No. 8	—	85
No. 16	—	68
No. 30	—	39
No. 50	—	19
No. 100	—	7

0.005 percent expansion on setting. Ingredients, including steel fibers, are proportioned and packaged by the manufacturer. Coarse aggregate was added to this mixture (50 percent by weight) to serve as a filler material. A slurry consisting of the cementitious ingredients was used as a prime coat to enhance bonding.

#### Polymer Concrete

Polymer concrete consisted of a rapid-setting low shrinkage two-component methyl methacrylate system and coarse aggregate. In addition to a monomer and hardener, the manufacturer-supplied cementing system contained fine aggregate. To this, coarse aggregate (50 percent by weight) was added. The manufacturer alleges cured (45 min to 2 hr) compressive strengths, for the mortar, of 8,000 psi with 0.012 percent linear shrinkage. A two-component methyl methacrylate-based primer was used to enhance bonding.

#### Rapid-Setting PCC

Type III PC and 2 percent (by weight of PC)  $\text{CaCl}_2$  were used to promote rapid strength development in the PCC. The mix had a water-cement ratio of 0.43, with the following ingredient proportions: water, 348 lb/yd<sup>3</sup>; cement, 810 lb/yd<sup>3</sup>; fine aggregate, 1,300 lb/yd<sup>3</sup>; coarse aggregate, 1,400 lb/yd<sup>3</sup>.

The problems associated with the use of  $\text{CaCl}_2$  in concrete that contained steel were recognized. However, it was used in the study rather than one of the available nonchloride accelerators because of its established set-accelerating properties. Its use precluded the introduction of an additional variable for consideration.

Patches were constructed with no bonding agent applied to bond surfaces, with a neat-cement (Type III) grout, or with an epoxy grout as a bonding agent.

#### TESTING PROGRAM

Patch materials, bonding agents, and anchors were evaluated with a series of laboratory tests on patch material specimens, base concrete specimens, and composite specimens of patch material and base concrete. Static and impact loading were employed to measure material strength and bond strength between patch materials and base concrete. Specimens of various ages were tested to assess rate of strength gain. Specimens subjected to cyclic temperature variations were tested to assess environmentally related strength deterioration.

#### Test Procedure

Three types of laboratory tests were performed. Compressive tests were employed to evaluate the strength of patching materials and base concrete. Slant shear tests were used to evaluate bond strength between patch materials and base concrete. Impact tests were performed to evaluate dynamic bond strength and energy-absorbing capacity of patches. Compressive strength tests were performed according to ASTM Method C 39-72 on 4 x 8-in. cylindrical specimens. Slant shear and impact tests are described in the following paragraphs.

#### Slant Shear Test

Bond strength was assessed by a composite cylinder test called the Arizona Slant Shear Test (3), which has been adopted by ASTM as Method C 882-78 (Bond Strength of Epoxy-Resin Systems Used with Concrete). The specimens consisted of 4 x 8-in. composite cylinders of base concrete and patching materials as shown in Figure 1. Patching materials were cast on hardened half-volumes of base concrete having bond planes inclined at 30 degrees from the longitudinal axis of the cylinder. The bond surface was prepared by sandblasting to remove laitance and expose aggregate.

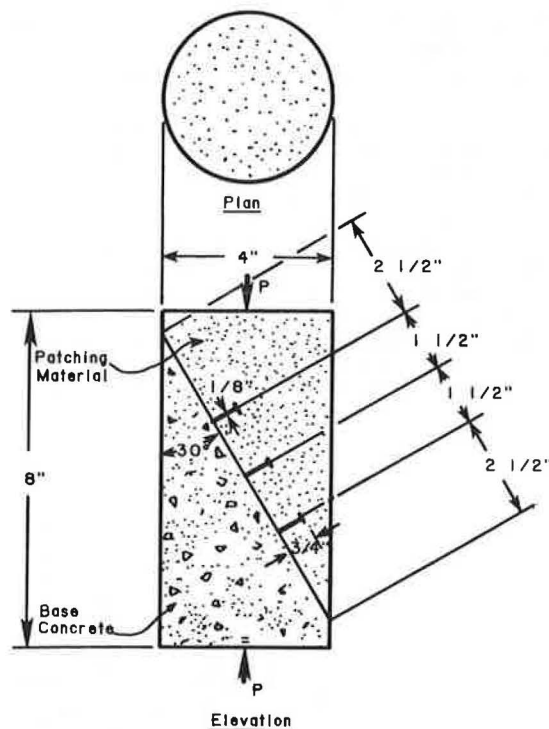


FIGURE 1 Slant shear specimen.

Three 1/8-in. diameter nails were grouted into the base concrete along the bond surface on part of the specimens to evaluate their effectiveness as anchors. The nails were centered in the bond area as shown in Figure 1.

The measure of strength from the slant shear specimens was computed by dividing the compressive axial load by the cross-sectional area measured perpendicular to the cylinder axis (12.57 in.<sup>2</sup>). This indicates the compressive strength and is different

from the bond strength that would be obtained by dividing the component of axial load parallel to the bond surface ( $P \cos 30$  degrees) by the bond area (25.13 in.<sup>2</sup>). Compressive strength was selected for comparative purposes and is reported here rather than pure bond strength because it permits direct comparison with compressive strength of patch materials and base concrete. It also permits utilization, for comparative purposes, of the results from approximately 20 percent of the specimens that did not experience pure bond failure. Bond strength can be obtained by multiplying the reported compressive strengths by 0.43.

#### Impact Test

The impact test was designed to measure the energy absorbed by a block-overlay specimen when struck by an impact load sufficient to cause fracture. The impact strength of the base concrete was determined by testing homogeneous specimens that were monolithically cast in a block-overlay configuration. The impact strength of patches was measured by using specimens composed of an overlay of patching material cast on a block of base concrete as shown in Figure 2. The bond surface was prepared by sandblasting.

Two 1/8-in. diameter nails were grouted into the base block along the bond surface on part of the specimens to measure their effectiveness in increasing energy absorption capacity. The nails were located as shown in Figure 2.

A frame-supported pendulum was used to perform the impact tests (4). The pendulum consisted of a steel rod (approximately 5 ft long) with an impact head (20.4 lb) bolted to one end and an axle welded to the other. The impact head was constructed of welded steel plates, which provided a smooth impact surface. The axle was mounted into roller bearings on either side of the frame, allowing the impact head to swing freely in an arc. A pointer attached to the axle registered the angle of inclination of the pendulum, and a following pointer attached to the frame measured the total angle that the pendulum swung through after being released.

After a test specimen was positioned and locked into the jig, the pendulum was raised to a horizontal position. The following pointer was adjusted to mea-

sure the angle that the pendulum would swing through from this horizontal position and the pendulum released. The pendulum rotated through an arc causing the leading plate of the impact head to strike off the overlay of the specimen. The impact occurred as the head swung through the lowest point of its arc. The specimen and impact head were aligned so that the leading plate of the impact head would strike the overlay flush across the face of contact.

It was found that the pendulum made a free-swing arc of 175.5 degrees. The 4.5 degree difference in angle was due to the inherent energy losses (caused by friction of the moving parts) of the machine. The energy dissipated by the fracture of the specimen could be determined from the difference in angle of the arc measured after impact and the free-swing arc of 175.5 degrees.

The relationship between the angle of pendulum rotation and the energy absorbed by the specimen during fracture is given by

$$E = 103.8 - 112.6[1.0 - \cos(A - 90^\circ)] \quad (1)$$

where E is the energy absorbed by the test specimen during fracture in foot pounds and A is the angle measured from the horizontal to the maximum height of the pendulum after impact in degrees.

#### Test Series

Four groups of tests were designed to accomplish program objectives. Group 1 tests evaluated rapid bond strength development. Composite slant shear cylinders were loaded in compression to determine static strengths, and composite impact specimens were impact loaded to determine dynamic strengths. Group 1 specimens were tested after 6 hr of moist curing.

Group 2 tests evaluated long-term bond development. Composite slant shear cylinders were loaded in compression to determine static strengths and composite impact specimens were impact loaded to determine dynamic strengths. Group 2 specimens were tested after 3 days' moist curing and 30 days' air curing. The results were used as the basis for evaluating bond strength loss with weathering.

Groups 3 and 4 tests evaluated the durability of

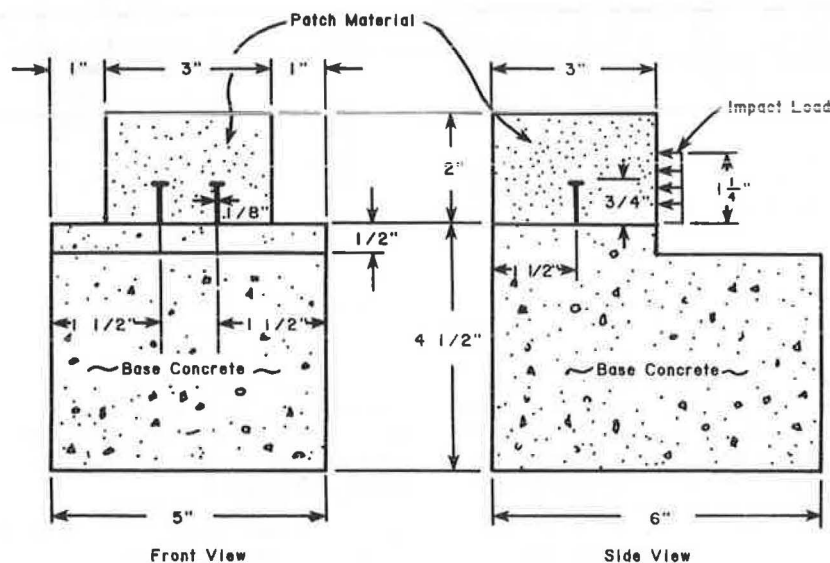


FIGURE 2 Composite impact specimen.

static and dynamic bond strength. Composite slant shear specimens were loaded in compression to determine static strength and composite impact specimens were impact loaded to determine dynamic strengths. Group 3 specimens were loaded after 3 days' moist curing followed by 30 days of exposure to cyclic high temperatures. Group 4 specimens were loaded after 3 days' moist curing followed by 30 days of cyclic freezing and thawing. Daily cyclic temperature variations for these groups are shown in Figure 3.

#### EXPERIMENTAL RESULTS AND DATA ANALYSIS

Data generated in the testing program are presented and analyzed in this section. Each reported compressive strength or energy absorption is the average from tests of two specimens. Comparisons between the strengths were made by using the F- and t-tests at a

5 percent level of significance. The F-test was used to compare standard deviations of the distributions. When the F-test permitted acceptance of the hypothesis of equal standard deviations, the t-test was used to compare mean strengths. When the F-test dictated rejection of the hypothesis of equal standard deviations, a modified t-test was used to compare mean strengths. The hypothesis of equal mean values was tested with the t- or modified t-test. Modes of failure, particularly for impact tests, had a significant effect on the test results and are considered along with quantitative static and impact strength data.

#### Strength of Base Concrete

Each test group contained control specimens that were cast from the same concrete batch used to form

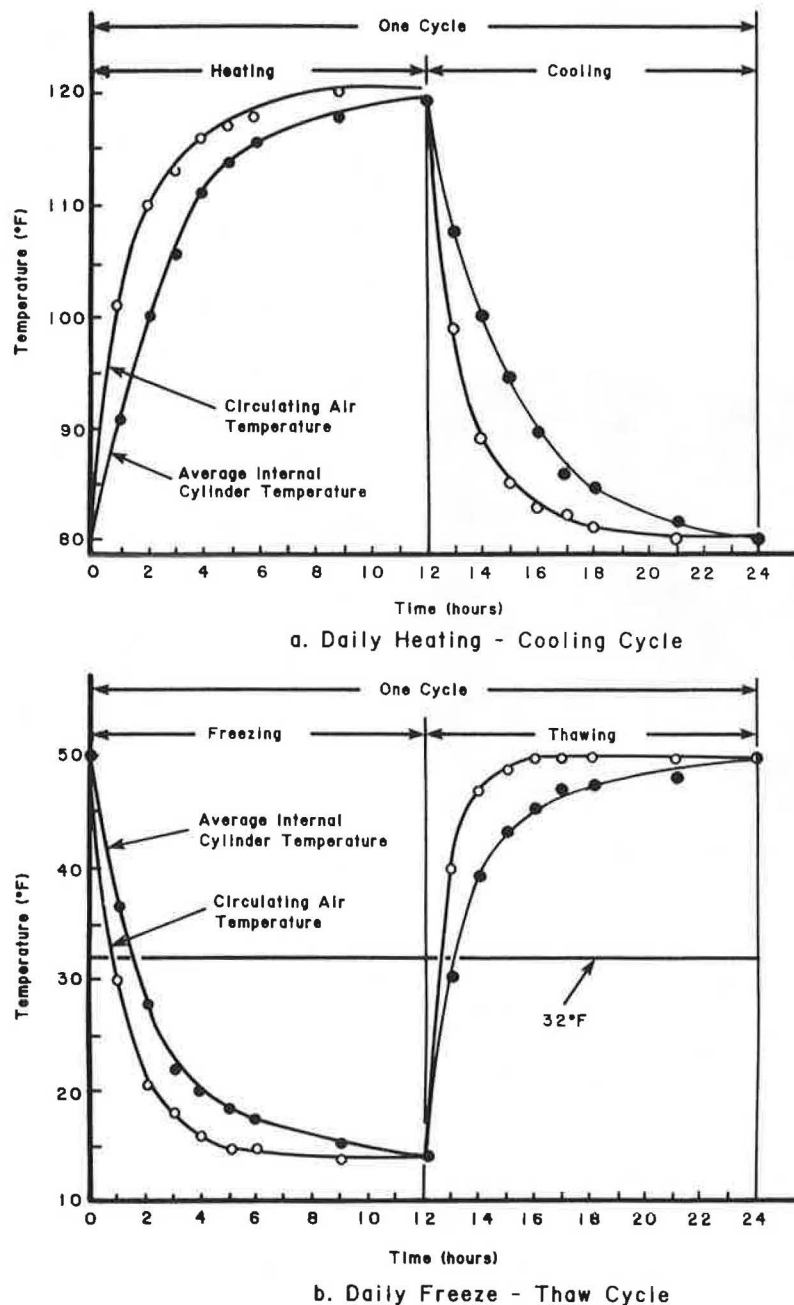


FIGURE 3 Simulated weathering process.

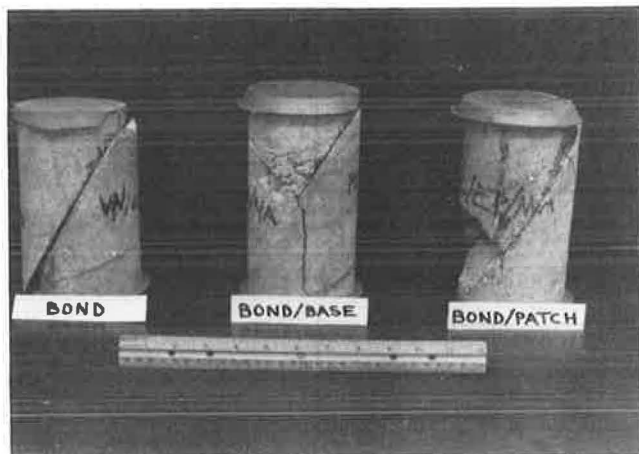
the half-cylinders and base blocks. These control specimens were moist cured for 28 days and then subjected to the same conditions as the composite specimens in the particular group. The intent was to provide bases for patching that would have strengths greater than those of the patch materials. Compressive strengths and energy absorption capacities of the homogeneous base concrete specimens are given in Table 2.

**TABLE 2 Compressive Strength and Energy Absorption Capacity of Base Concrete**

Test Series Designation	Average Compressive Strength (psi)	Average Energy Absorbed (ft-lb)
Group 1	6,088	51
Group 2	6,784	60
Group 3	6,545	65
Group 4	6,008	37

#### Failure Modes

Three modes of failure were observed in slant shear tests. These are shown in Figure 4 and were designated bond failures, bond or base failures, and bond or patch failures.



**FIGURE 4 Failure modes for slant shear specimens.**

Bond failures were the most common and were characterized by a sudden rupture along the bond surface at the maximum load. The bond or base and bond or patch failure modes occurred in one-third of the cured and weathered specimens. These were characterized by failure planes that deviated from the bonding plane into the base concrete or patching material.

The composite impact specimens exhibited four modes of failure. These are shown in Figure 5 and are designated bond failures, base failures, bond or base failures, and bond or patch failures. Bond failures occurred in only a portion of the 6-hr tests. Tests in Groups 2, 3, and 4 experienced one of the three latter failure modes. In these specimens the bond strength, or the residual strength provided by anchors, was sufficient to cause failure in the base or patch material.



**FIGURE 5 Failure modes for composite impact specimens.**

Variations in failure mode were undesirable because quantitative bond strength comparisons could only be made between specimens that had similar failures. Only 8 percent of the composite impact specimens exhibited pure bond failure; therefore, only qualitative comparisons of energy absorption capacities can be made. To provide quantitatively meaningful data the size of the base block would have to be increased to ensure failure along the bond surface.

Results from the slant shear test generally provided a sound basis for comparing relative bond strengths of patching materials and techniques. Approximately 80 percent of the composite cylindrical specimens exhibited bond failures.

#### Six-Hour Compressive Strengths of Patching Materials

Average 6-hr compressive strengths of the patching materials were rapid-setting PCC, 2,646 psi; Roadpatch, 1,930 psi; and polymer concrete, 4,357 psi. A graphic comparison of these strengths is shown in Figure 6. Comparisons with the t-test at the 5 percent level of significance indicated significant differences in mean strengths. The polymer concrete obviously developed the largest early strengths, but strengths of the PCC and the Roadpatch appear to be adequate for patching.

#### Six-Hour Strength

Results of Group 1 slant shear tests are presented in Figure 7. All specimens experienced bond failures. The anchored and unanchored polymer concrete specimens had strengths at least 56 percent greater than those of any of the other specimens. The unanchored PCC specimens with an epoxy prime had the lowest strength. This strength was significantly lower than that of the PCC specimens with no bonding agent. A general-purpose epoxy bonding system, with manufacturer-recommended Type II or III (ASTM C 881-78), was used for the prime coat. Specification pot life for the epoxy varied from 60 min at 50°F to 30 min at 90°F. A more rapid-setting epoxy formulation would likely have increased the rate of bond development.

A comparison of unanchored PCC specimens with no bonding agent and unanchored PCC specimens with a PC grout shows that the PC grout significantly increased the average strength. The strength increase was about 730 psi. A comparison of PCC with PC grout specimens



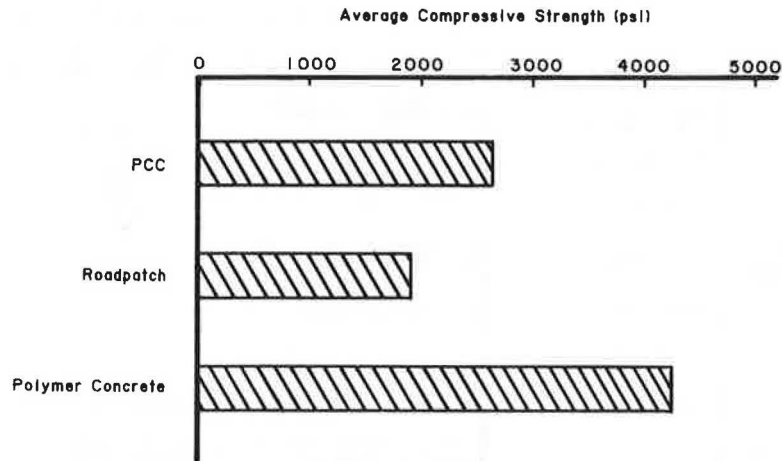


FIGURE 6 Average 6-hr compressive strengths of patching materials.

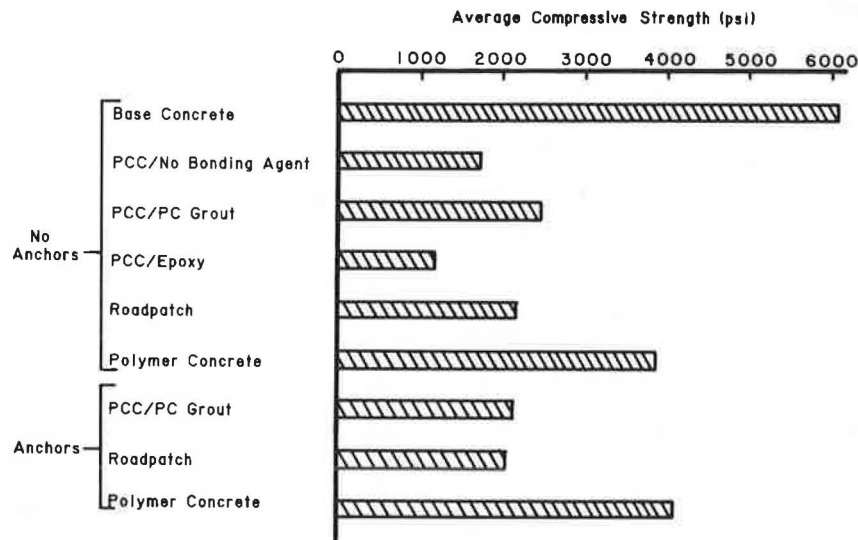


FIGURE 7 Average 6-hr compressive strengths: Group 1 tests.

and Roadpatch specimens reveals comparable strengths with no significant differences. Also, it appears that the presence of anchors did not appreciably increase slant shear strength. Comparison of anchored and unanchored strength for PCC with PC grout, Roadpatch, and polymer concrete revealed that there was no significant difference in the average strengths.

Results of Group 1 impact tests are presented in Figure 8. Only the unanchored PCC specimens with no prime or with PC grout experienced bond failures. Therefore, when energy absorption capacities are compared, the specimen's failure mode must be considered. Where failure modes were different, comparisons are by necessity qualitative.

From Figure 8 it can be noted that those specimens experiencing base or bond and base failures had energy absorption capacities between 42 and 61 ft-lb, which is similar to that measured for the base concrete (51 ft-lb). This is to be expected because these specimens failed through the base as did the homogeneous specimens of the base concrete. The bond strength in these specimens was sufficient to cause failure in the base and, thus, the similarities in energy absorption.

The unanchored PCC specimens with no bonding agent or with PC grout experienced bond failures and had

the lowest energy absorption capacities. Comparison can be made between the static and dynamic strength of the unanchored epoxy-bonded PCC specimens. The average slant shear strength for these specimens was the lowest of all the patching materials and techniques. However, the impact specimens exhibited base failures and their average energy absorption capacity was the highest of all the unanchored specimens. Although the magnitude of energy absorption capacity is not significant, these results suggest that the strength of the epoxy-bonded specimens was sensitive to the loading rate, resulting in effective energy dissipation during dynamic (i.e., impact) loading but poor static strength.

The high energy absorption capacities of the anchored PCC and Roadpatch specimens and the bondpatch failure mode provide an interesting comparison with the anchored polymer concrete specimens. On the basis of measured energy absorption, the anchored PCC and Roadpatch were superior. However, on the basis of failure mode the polymer concrete was superior because failure occurred through the base. The high measured energy absorption capacities of the anchored PCC and Roadpatch were primarily due to the testing mechanism and failure mode. On impact, bond failure occurred and the load was transferred

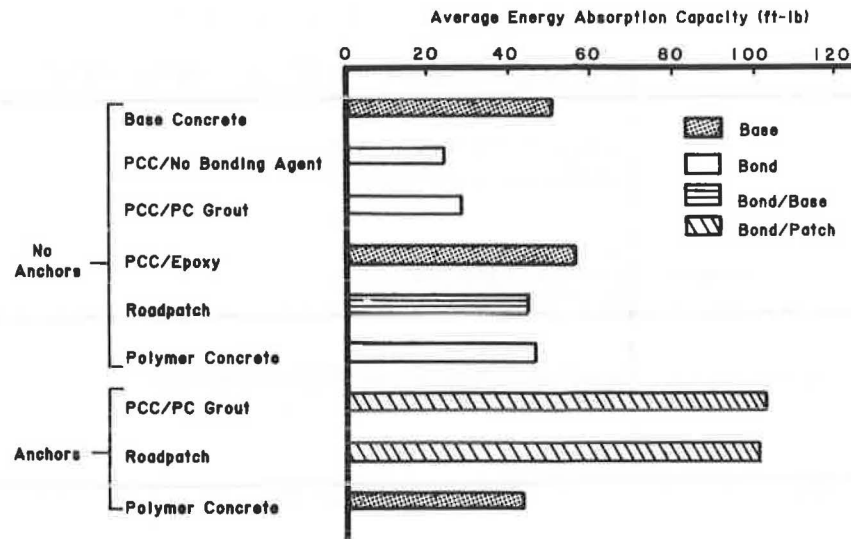


FIGURE 8 Average 6-hr energy absorption capacities.

to the ductile anchors. The anchors had sufficient strength to essentially stop the pendulum, thus giving an indication of high energy absorption. This behavior illustrates one of the benefits of anchors, which is that they hold the patch in place after bond failure occurs. This behavior also illustrates the improper application of the test for measuring bond strength of anchored specimens and suggests a remedial testing technique. A more appropriate procedure would be to increase the arc through which the pendulum rotated before striking the specimen until bond failure occurred. This loading procedure would provide comparable results for both anchored and unanchored specimens.

After the early-strength tests had been completed, several changes were made in the types of patching materials and techniques for Groups 2, 3, and 4. Testing of unanchored PCC specimens with no bonding agent was discontinued because of low strength and energy absorption capacity. Because the anchors had no measurable effect on strengths of polymer concrete and Roadpatch, anchored specimens of these materials were eliminated. The low strengths and large failure strains of unanchored epoxy-bonded PCC specimens indicated a need for anchors. The reasoning was that as strain occurred along this bond surface, a portion of the load would be transferred to the anchors,

thus increasing bond strength of epoxy-bonded PCC patches.

#### Cured Strength

Control specimens (Group 2) were tested to establish a basis for assessing bond strength loss due to weathering and to assess long-term bond strength gain. Curing conditions were 3 days' moist cure followed by 30 days' air cure at 70°F. Groups 1 and 2 slant shear tests are presented in Figure 9 to facilitate comparison. Most specimens failed in pure bond although three exhibited a bond-base failure, indicating sufficient bond strength to cause base concrete failure. All cured specimens except those with epoxy bonding agents had compressive strengths in excess of 5,000 psi. The unanchored epoxy-bonded specimens did, however, exhibit the largest (415 percent) percentage strength increase. The anchored epoxy-bonded specimens had the smallest cured strength. Comparable 6-hr tests were not performed for this case, and thus no assessment of strength gain was possible. The polymer concrete specimens achieved the smallest strength gain (67 percent). The Roadpatch specimens achieved the largest cured strength (6,187 psi). However, when compared with

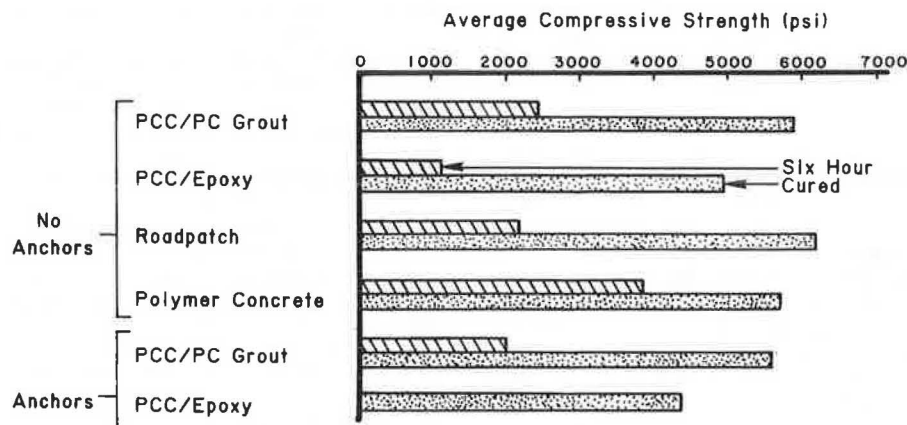


FIGURE 9 Comparison of 6-hr and cured strengths.

other cured strengths it was only significantly different (5 percent level) from that of the anchored epoxy-bonded PCC specimens.

All Group 2 impact specimens exhibited base failures, indicating sufficient bond strength to cause failure in the base block. Qualitatively, implications of impact results are that all materials and bonding techniques develop impact bond strengths capable of causing base failures; that is, they are the same as homogeneous specimens.

#### Weathered Strength

Results from slant shear specimens subjected to temperature variations are presented in Figure 10 along with control test data. Bond failure predominated and quantitative comparisons with control specimens provide valid indications of bond strength loss.

The PCC specimens (anchored and unanchored) with epoxy prime had the smallest strengths for Groups 2, 3, and 4. This is further evidence that the particular epoxy used was not beneficial for bond development and is particularly true for the cold weathered specimens, which have by far the least strength.

The unanchored and anchored PC-grout-bonded PCC specimens had lower (19 and 10 percent, respectively) strengths when subjected to the high temperatures. At a 5 percent level of significance, the strength of the unanchored specimens subjected to high temperatures was different from that of comparable cured specimens, but the strength of anchored high-temperature specimens was the same as that of comparable cured specimens. The fact that the 10 percent

strength difference for anchored specimens is not significant is attributable to the large (1,632 psi) range for the weathered strength. At a 5 percent level of significance, the strengths of anchored and unanchored specimens subjected to low temperatures were the same as comparable cured strengths. It was reasoned that the reduced hot-weathered strengths were possibly due to drying and shrinkage of the grout bonding layer.

The strength of the hot-weathered epoxy-bonded PCC specimens was lower, whereas the strength of the hot-weathered anchored epoxy-bonded PCC specimens was higher than that of control specimens. These differences were not significant at a 5 percent level and no definitive conclusions can be drawn about the effects of high temperatures on epoxy bonding. However, the low temperatures had a significant (5 percent level) adverse effect on the strengths of unanchored and anchored epoxy-bonded PCC specimens. These strengths were only 47 and 63 percent, respectively, of the control specimens. This result is a consequence of the temperature dependency of the epoxy curing and a degradation of bond.

The patching materials least affected by the cyclic temperatures were Roadpatch and polymer concrete. Both the hot- and cold-weathered Roadpatch specimens exhibited strengths that were over 94 percent of the strength of the control specimens. At a 5 percent level of significance the strengths were the same. The polymer concrete specimens showed excellent resistance to high temperatures (only 1 percent decrease), but experienced a loss of strength (13 percent) when subjected to low temperatures. At a 5 percent level of significance the high-tempera-

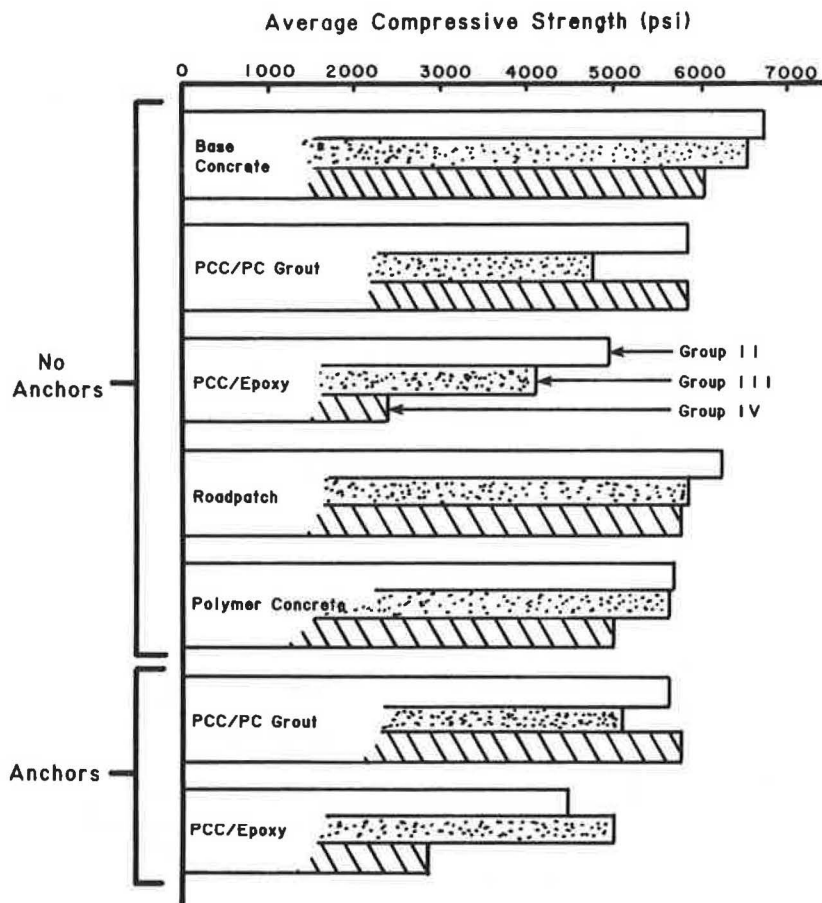


FIGURE 10 Comparison of cured and weathered strengths.



ture strength was the same but the low-temperature strength was different from the cured strength.

As in the 6-hr slant shear tests, the anchors had no discernible effect on the strengths. The anchors also failed to reduce strength loss due to variable temperature.

The modes of failure experienced by the slant shear specimens provided no indication that cyclic temperature variations caused a decrease in bond strength. In general, bond failures were observed for corresponding specimens in Groups 2, 3, and 4. The Group 4 anchored grout-bonded PCC specimens were an exception and exhibited bond-patch failure. No totally satisfactory explanation can be offered, but the retardation of strength gain of the PCC patch material appears plausible.

Control specimens and specimens subjected to high and low temperatures experienced base-block failures when impact loaded. As a consequence the measured energy absorption capacities are quantitatively inappropriate measures of bond strength.

Several qualitative comparisons may be made by examining the results from Groups 2, 3, and 4 impact tests. Epoxy-bonded specimens experienced base failures, indicating that the dynamic bond strength is sufficient to cause failure in the base blocks. This is considered further evidence that epoxy bonding is sensitive to rate of loading. With the slow rate of loading employed in the slant shear test the epoxy-bonded specimens experienced bond failures and gave lower strengths. Although there are inconsistencies and scatter (Figure 11), the energy absorption capacities of the epoxy-bonded specimens are comparable with strengths of other specimens in the same group.

The one instance where the measured energy absorption capacities were considered quantitatively significant was for the hot-weathered (Group 2) unanchored PC-grout-bonded PCC specimens. The weathered strength was only 53 percent of that of the control specimens (Figure 11), and these specimens experienced a bond-base failure rather than a base failure. The hot weathering process had an adverse effect on bond strength.

#### CONCLUSIONS

The objectives of this project were to evaluate rapid-setting PCC pavement patching materials, bonding agents, and anchor systems. The following conclusions summarize the major findings of the research:

1. Roadpatch and rapid-setting PCC provide desirable patch properties.
2. Polymer concrete had superior early bond strength but its long-term strength gain was not as good as that of the Roadpatch or rapid-setting PCC. Cold temperature weathering also caused a larger decrease in strength of polymer concrete.
3. Epoxy had a slow rate of strength gain and was adversely affected by low temperature; its bond strength was sensitive to rate of loading. Type III PC grouts improved bond strength but were susceptible to high-temperature weathering.
4. The inclusion of 1/8-in. diameter nails did not measurably improve bond strength, but it did increase the ductility and energy absorption capacity of the patches.

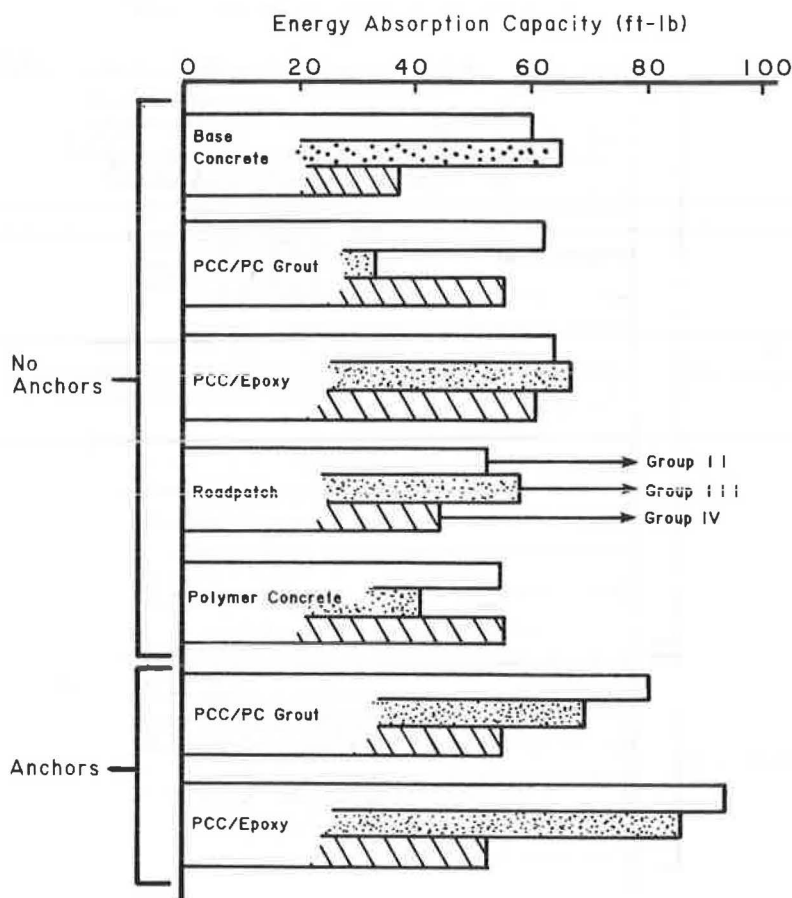


FIGURE 11 Comparison of cured and weathered energy absorption capacities.

5. The impact test, as used, was unsatisfactory for evaluating dynamic bond strength.

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## Laboratory Evaluation of Four Rapid-Setting Concrete Patching Materials

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#### ABSTRACT

Many proprietary patching products are available for the repair of portland cement concrete (PCC) pavement. These materials must cure rapidly to minimize delay and limit safety hazard exposure to both the traveling public and maintenance personnel. However, long-term strength and durability are equally important, although information concerning these properties and direct comparisons between patching alternatives is limited. Compressive strength, tensile strength, direct shear, and energy absorption tests were used to evaluate polymer concrete, magnesium phosphate cement, Roadpatch with steel fibers, and epoxy-bonded PCC. The split-cylinder tensile bond strengths of the patching materials were comparable to those of the base concrete. The shear bond strengths and energy absorption tests indicated that polymer concrete has good cured properties as a composite patch but may be susceptible to weathering or thermal deterioration. Roadpatch also had satisfactory cured strength properties but had better resistance to decreases in direct shear bond strength and tensile strength when exposed to simulated weathering. Roadpatch appeared to exhibit a good overall combination of characteristics that indicate satisfactory short-term and long-term durability. The epoxy-bonded PCC alternative demonstrated substantial strengths, but the slow rate of strength gain noted was a major disadvantage for potential field application. Magnesium phosphate concrete does not appear to be an attractive early cure material and it may be susceptible to damage from dynamic loading.

Portland cement concrete (PCC) pavement repair performed in urban areas requires rapid-setting patching materials to minimize the maintenance time. Heavy traffic conditions interacting with maintenance work create delay and safety hazards for both the maintenance crews and the traveling public.

Rapid-setting patching materials also make possible the scheduling of patching activities in early morning hours. Thus, a pavement patch can be installed and the pavement section reopened to traffic without causing daytime delays.

Many properly applied rapid-setting patching ma-