CONTINUOUSLY REINFORCED CONCRETE PAVEMENTS IN MISSISSIPPI

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This report covers a 5-year observation study of continuously reinforced concrete pavement construction in Mississippi. The current design and construction practice for CRCP is reviewed, and special items such as splices, transverse reinforcement, terminal treatments, end construction arrangement, vibration of concrete, curing of concrete, and longitudinal center joint are discussed. Field measurements on present serviceability index, crack spacing, and deflection are included and evaluated. Also included is a proposed maintenance procedure for CRC pavements.

•MISSISSIPPI ranks third in the nation in mileage of continuously reinforced concrete pavement (CRCP). Almost 900 miles (1448 km) of 2-lane pavement are in use in the state. On a nationwide basis, more than 10,000 miles (16 000 km) of 2-lane pavement were in use or under contract at the end of 1971. Thirty-three states currently have some CRCP (7); 19 have 100 miles (160 km) or more including 2 states that have more than 1,000 miles (1600 km). The use of CRCP is increasing rapidly. Therefore, it is important that highway engineers have a complete knowledge of the design, construction, performance, and maintenance of this type of pavement.

This report summarizes the experience with CRCP in Mississippi. It covers the results of a 5-year observation study that included the design, construction, testing and maintenance of CRCP.

CURRENT DESIGN AND CONSTRUCTION PRACTICES

Current Practices in the Design of CRCP

Unlike that of most other states, the standard CRCP design procedure in Mississippi was primarily based on the research findings of the state's early experimental projects constructed in Desoto and Jones Counties (10, 17, 18). A report by the American Concrete Institute (1) and the Minimum Criteria for Federal-Aid Roads established by the then Bureau of Public Roads also played an important role in these standard design procedures.

Stabilized base and subbase are used in Mississippi under all CRC pavement. Design is based on the CBR value and the anticipated traffic load; usually the design of 6-in. (152-mm) soil-cement-treated base and 6-in. (152-mm) lime-treated subbase (may vary as required by soil condition) is used (12). Beginning in 1971, designs of 4-in. (102-mm) asphalt concrete base and 6-in. (152-mm) granular subbase or 6-in. (152-mm) lime-treated subbase (as required by soil condition) have been tried on several projects.

The standard thickness for CRCP in Mississippi is 8 in. (203 mm). Strength for the concrete is not specified. However, general practice in the field is that the concrete should provide a modulus of rupture of 525 to 550 $lb/in.^2$ (3.6 to 3.8 MPa) at 7 days and 700 psi (4.8 MPa) or more at 28 days when tested by the third-point method.

The amount of longitudinal steel is 0.6 percent. Only deformed bars (with 60,000

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lb/in.^{2} or 414 MPa yield strength) are allowed. Smooth wire fabric was tried on 2 projects during the early 1960s and has since been discontinued as one of the CRCP design alternates. The current design uses No. 5 bars at 6½-in. (165-mm) spacing and has 0.037 in.^{2} of bond area per 1 in.^{3} of concrete (146 cm^2/m^3). No. 4 bars at 36-in. (914-mm) spacing are used as transverse reinforcement. Like most other states, Mississippi specifies the longitudinal reinforcement slightly above middepth. It is the intent of the Mississippi design that the specified value for longitudinal bars shall be 3¾ in. (95 mm) from center of the bar to top surface of the concrete. The unit of deviation shall be ±⅛ in. (3 mm). The lot size for conformance determination shall be 1000 ft (305 m) of pavement. Chair spacings shall not be greater than 36 in. (914 mm) c. to c. longitudinal and 27 in. (686 mm) transverse. Additional chairs shall be used if necessary to meet the steel placement requirements. The minimum length for laps is 20 in. (508 mm), and usually the laps are skewed (60 deg from center line).

At construction joints, longitudinal bars are required to extend a minimum length of 5 ft (1.74 m). No additional steel was installed at the construction joints on 5 projects built during 1962-1963. Since then No. 5 deformed bars, 5 ft (1.74 m) long and placed at 6½ in. (165 mm), have been used as additional steel.

For the first 5 years of practice, 5-lug anchors were used for bridge ends and 4-lug anchors for pavement ends. Since 1967, 4-lug anchors have been used for both bridge and pavement ends because the continuing measurements from the Jones County experimental project do not indicate any difference in pavement movement between the 4- and 5-lug anchor installations.

Current Practices in the Construction of CRCP

Base and subbase construction are the same for CRCP as for jointed pavement. The support of reinforcement on high chairs was the original installation method and has been an accepted standard for many years. In Mississippi, this method is the only one permitted with slip-form paving. Forms were used only on a few projects during the early 1960s.

Generally, materials, mixing, handling, and placing of concrete are no different for CRCP than for jointed pavement. Concrete usually has a cement factor of 1.40 (about 5.6 bags/yd^3 or 7 bags/m^3), which is the same as for jointed pavement, but only slip-form paving for CRCP uses air-entrained concrete. Air-entrained concrete contains no less than 3 percent and no more than 6 percent air. The limit for the concrete slump is between 1.5 and 2 in. (38 and 51 mm).

Proper vibration of the concrete is very important. The internal vibrations should be done in such a manner as not to dislocate the steel. The present Mississippi specification for consolidation of portland cement concrete pavements was written from the AASHO specification. For curing, both the white pigmented impervious membrane and white polyethylene sheeting have been used successfully. No more than 0.2 in. (5 mm) is allowed as tolerance for concrete thickness.

CURRENT DESIGN AND CONSTRUCTION PRACTICES

Splices

Splicing of reinforcing steel is a problem in CRCP. In the Mississippi design, minimum length for laps is 20 in. (508 mm) and usually the laps are skewed 60 deg from the center line. This design works fine for most projects. However, at the beginning of 2 projects where the adjacent project was completed several months earlier in another construction season, fragmental distress was found on top of the first lapped splices (Fig. 1). A few cores taken at random within the distressed area showed an excellent quality of concrete, but they were broken at the middle where the steel is located.

A close observation, made during the repair operation, indicated that the distress was not caused by construction and that the concrete was in good condition. Presence of the failure, which coincided with the lapped splices, suggested that it may be due, at least in part, to the very high tensile stresses in the steel ahead of the construction joint, which caused a decrease in bond at the splice where the concrete was poured several months later in another construction season. It is possible that the serious slab separation at the distressed area was preceded or accompanied by progressive reduction in bond between the closely spaced cracks.

It is recommended that, if a new project is to be added to an existing project that was constructed several months earlier in another construction season, the length of the first lapped splice should be more than the regular design of 20 in. (508 mm). The exact length of such lap is directly related to the local environment and is pending further study and experiments. An effort will be made to refer this special problem to the researchers at the University of Texas who are conducting a study on the design of CRCP. Before the new criteria become available, however, 30 in. (762 mm) is recommended for use at these locations. Consideration should also be given to adding extra cement to the first few batches of concrete at the beginning of the new project construction. This will allow mortar to coat the drums and truck and also give additional strength to the concrete immediately beyond the construction joint.

Transverse Reinforcement

Recent improvements in construction methods have decreased or eliminated the need to use transverse reinforcement to maintain spacing and depth of longitudinal steel (6). However, in Mississippi, the use of transverse reinforcement is still necessary. Experience has shown that the transverse reinforcement not only holds the longitudinal crack tightly closed but also keeps the cracked pavement from "sliding" due to the crown height of the pavement. This is especially true when expansive soils are present.

Terminal Treatments

The free end of a CRCP, regardless of its length, may undergo longitudinal movement and growth of as much as 2 in. (51 mm). Therefore, the free ends at the bridge and at the beginning or end of each individual project must have proper terminal treatments. Such terminals must be designed to restrain or to accommodate the movement.

In Mississippi, the only type of terminal treatment is the anchors for the purpose of restraining movement. Studies (20) have shown that these lug anchors will restrict approximately half the movement that would occur if no lugs were used. Therefore, the lugs are frequently used in conjunction with a few short reinforced concrete slabs connected by doweled expansion joints to absorb the additional movement. This lug-anchor system performed well in Mississippi.

The wide flange beam joint has been used successfully in many states (6). However, in Mississippi, no plan has been made to adopt this design because it is felt that the highly expansive subgrade soil in Mississippi may create other problems when the wide flange beam joint is used and thereby negate the original purpose of this type of design, i.e., to minimize maintenance costs and provide load transfer across the gap in the pavement under the flange.

End Construction Arrangement

Usually the plans specify that the pavement (except the splicing steel), base, subbase, and subgrade all end at the termination station of the project. For continuously reinforced concrete pavement, this created a problem for the construction of the adjacent project that would be constructed later. As shown in Figure 2, the contractor for the adjacent project has to bend the splicing steel in order to construct the base, subbase, and subgrade. Under this condition, the construction joint for the sublayers cannot be properly constructed to provide continuity and very often provides a weak plane when high stresses develop.

It is recommended that, when a continuously reinforced concrete pavement project is to be continued with another project, special end construction arrangement be made to allow continuity of all base structure layers. This can be accomplished by requiring the first contractor to extend the base layers 30 to 50 ft (9 to 15 m) beyond the termination station of the project.

Vibration of Concrete

Proper vibration of the concrete is very important, and both surface and internal vibration are used, sometimes in combination. The internal vibrations should be done in such a manner as not to dislocate the steel. Consideration should be given to adding extra cement to the first few batches of concrete each day. This will allow mortar to coat the drums and truck and also give additional strength to the concrete immediately beyond the construction joint. At the construction joint, additional hand vibrators should be used to ensure proper vibration (6).

A field test was conducted in Mississippi during the construction of a CRCP to study the effect of vibration on concrete (19). Research parameters included 3 vibrator frequencies (7,000, 9,000, and 11,000 impulses per minute in air), 1 eccentric weight (2.25 lb or 1.02 kg), and 5 paver speeds (10, 12, 14, 16, and 20 ft/min or 0.05, 0.06, 0.07, 0.08, and 0.10 m/s).

For each experimental section, 2 samples of fresh concrete, 1 behind and 1 between the vibrators, were taken for air content, unit weight, and gradation analysis. So that the lower half of the pavement (under the reinforcing steel) at the preselected location could be sampled, a portion of 2 longitudinal bars was omitted for a distance of 60 in. (1524 mm) (Fig. 3). This allowed the delineating sample device to take 4 increments of the sample above and 4 increments of the sample below the steel (Fig. 4). These samples were taken right behind the final finishing screed machine and rushed to the field laboratory for testing.

Random samples were taken from the aggregate stockpile (near the bin feeder belt) for gradation analysis.

A Rex slip-form paving machine was used on this project. There were 6 vibrators across a 12-ft (3.7-m) lane, and the diameter of eccentric in the vibrator was 1⅞ in. (48 mm). Walking bridges were furnished by the contractor for use by technicians in sampling and testing. A FRAHM tachometer was used to measure and set the frequency of the vibrator (Fig. 5).

The fresh concrete was tested at the field laboratory for air content (AASHO T 152) and unit weight (AASHO T 121), and then the sample was washed over a No. 4 sieve and dried. Sieve analyses for the plus No. 4 aggregates were conducted at the central laboratory of the Testing Division. On-the-spot slump tests were conducted by the project office personnel. Nuclear density gauges were used at 4 different spots around the sample location to measure the density immediately behind the vibrator and between 2 vibrators. At each spot, readings were also taken at 2-in. (51-mm) depths and 6-in. (152-mm) depths to determine the density above and below the reinforcing steel (Fig. 6).

The nuclear gauge was prevented from sinking into the concrete and also protected from possible damage caused by the cement paste by a 2 × 2 ft (0.6 × 0.6 m) plywood board at each test spot. A ¾-in. hole was drilled in the plywood board to allow the nuclear gauge to take the direct transmission measurements at 2 in. (51 mm) and 6 in. (152 mm). The nuclear gauges, with the plywood board, were calibrated in the laboratory, and a special calibration curve was developed for this measurement.

On the finished pavement, cores were taken around the area of the sample location. These cores were completely submerged in water for 3 days, and impact tests were conducted. A model N Schmidt concrete test hammer was used for the impact tests.

Preliminary analysis indicated that the range of paver speeds studied had no noticeable effect on the densities. No significant effect of vibration on the strength of concrete was found. However, for the paving machine used on this project [1⅞-in. (48-mm) eccentrics at 24-in. (610-mm) spacing], vibration frequency of 9,000 impulses per minute (IPM) in air produced the highest density.

The degree of vibration had no significant effect on the entrained air content. The slump values above the 1-in. (25-mm) range (not to exceed 2 in. or 51 mm) allowed the vibrators to develop densities higher than would be developed were the slump below the 1-in. (25-mm) range.

The vibration effort studied on this project produced no evidence of segregation. The sieve analysis also indicated a very close conformity among the field samples (plastic concrete), stockpile samples, and original laboratory samples.

Figure 1. Fragmental distress at lapped splices on US-82 in Leflore County.

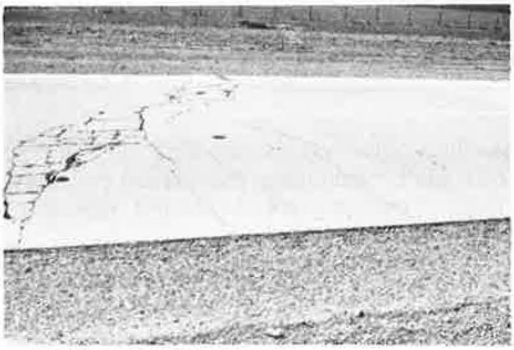


Figure 2. End arrangement of CRCP.

Figure 3. Location of samples for vibration study.

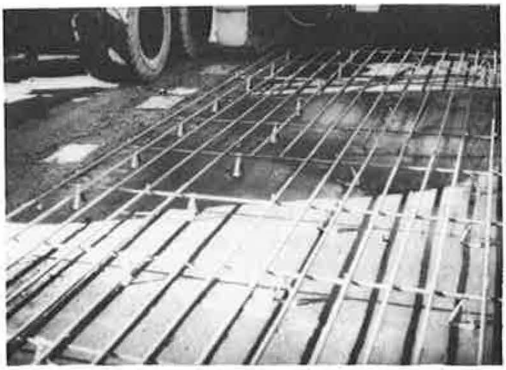


Figure 4. Field sampling for vibration study.

Figure 5. Using tachometer to set vibrator frequency.

Figure 6. Taking nuclear density measurements on plastic concrete.

The nuclear device is a very good tool for consolidation control for CRCP construction. Compared with the density obtained by the conventional method (AASHO T 121), the mean of the 4 nuclear density measurements was within ±2.5 lb/ft^3 (±40 kg/m^3) range accuracy. The standard deviation for all the nuclear density measurements was 1.13 lb/ft^3 (18 kg/m^3).

Curing of Concrete

White pigmented impervious membrane and white polyethylene sheeting have both been used successfully for the curing of concrete for continuously reinforced concrete pavement. Field surveys also indicated that these 2 curing methods did not appear to affect the pavement cracking pattern.

Longitudinal Center Joint

Before 1968, longitudinal sawed joints were used on all projects. Since that time, the polyethylene strip has been used for longitudinal center joints. When first adopted, the 4-mil (0.1-mm) strip was used. In 1969 the thickness of the strip was increased to 8 mils (0.2 mm). Some states have reported (3) that random longitudinal cracking has developed on projects having polyethylene strips at center joints. In Mississippi no such cracking has been found.

ANALYSIS OF FIELD MEASUREMENTS

Present Serviceability Index

Present serviceability index (PSI) was obtained on each of the 46 projects during the field surveys of 1970 and 1972. A PCA road meter was used to conduct the survey. The PSI and its relation to the accumulated equivalent annual 18-kip (8165-kg) single-axle loads is shown in Figure 7. As expected, the 18-kip (8015-kN) axle loads have significant influence on the PSI. In places where extremely high traffic counts or heavy traffic load is anticipated, it may be necessary to consider increasing the thickness of pavement.

The present equivalent annual 18-kip (80-kN) single-axle load applications (EALA) used in this report are not field measurements. They are calculated based on the following equation in the National Highway Functional Classification and Needs Study Manual of the Federal Highway Administration.

EALA = ADT × (percentage of total trucks and combinations) × (critical lane factor) × [18-kip (80-kN) single-axle equivalent constant] × 365

Another factor that is believed to have a very strong influence on the PSI is the differential movement of the very highly expansive subgrade soils. Pavements have been badly distorted and sometimes destroyed by the behavior of these active clay soils, which cover about 75 percent of the surface of the state. Seasonal wetting and drying have contributed to the roughness of the pavement surfaces through differential settlement and heaving of these active clay formations. Table 1 gives the Atterberg limits and specific gravities of major Mississippi clay formations.

Differential movement and distortion of pavement are often reported in the area of Delta Gumbo, Yazoo, and Zilpha Clay formations where the lowest PSI is recorded (Fig. 8). CRC pavements constructed on expansive soils have caused considerable maintenance problems. It is recommended that, unless specially designed, CRCP not be placed in areas of highly expansive soils.

Since only 2 measurements were made on each of the projects during the field survey, no attempt was made to make a detailed analysis of the annual change in the present serviceability indexes. However, on the average, the 1971 PSI readings were slightly lower than those of 1970.

Figure 7. PSI and accumulated equivalent annual 18-kip single-axle load (1 lb = 0.4536 kg).

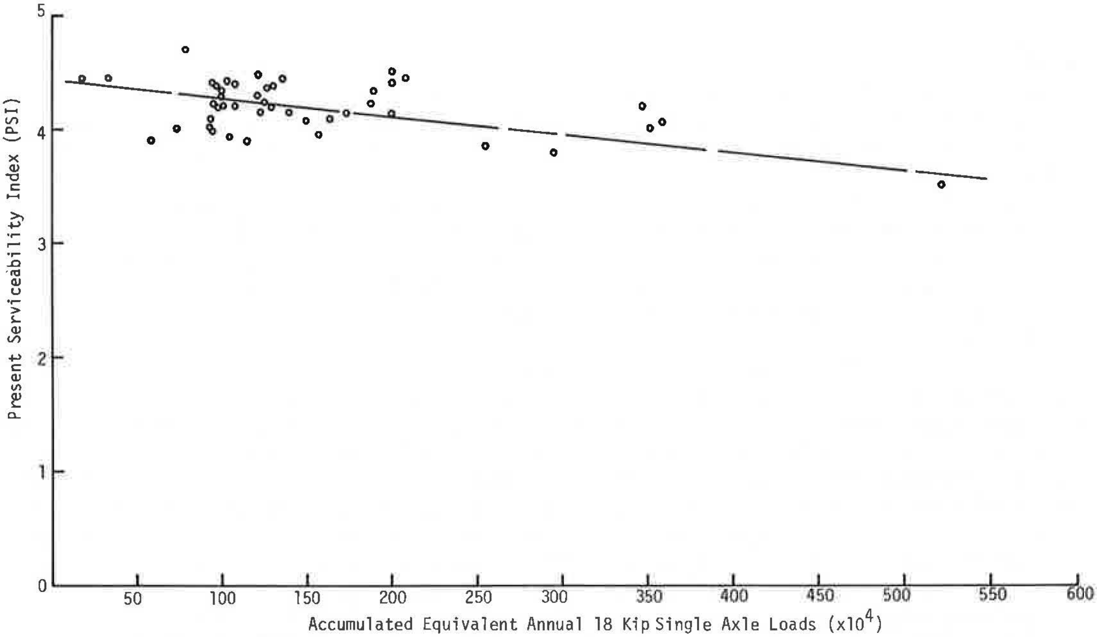
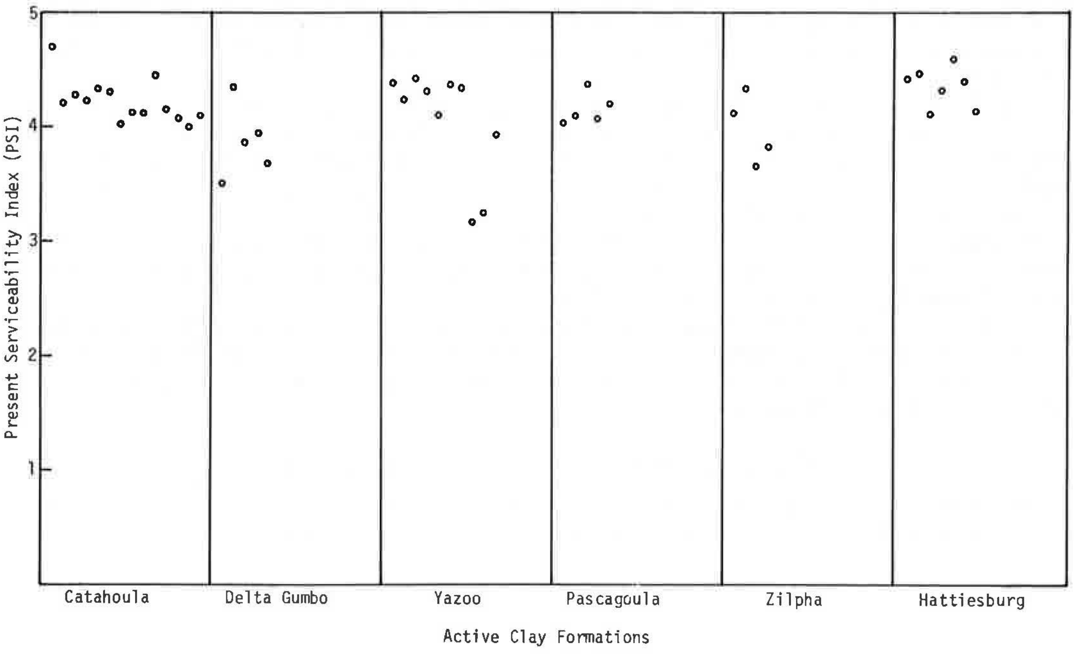


Table 1. Atterberg limits and specific gravity of major Mississippi clay formations.

Clay Formation	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit	Specific Gravity
Catahouls	58	29	29	19	2.71
Delta Gumbo	94	31	63	20	2.77
Demopolis	56	27	29	19	2.77
Hattiesburg	40	18	22	17	2.72
Mooreville	52	24	28	16	2.73
Pascagoula	50	25	25	21	2.78
Porters Creek	86	44	42	18	2.74
Yazoo	112	33	79	24	2.82
Zilpha	100	42	58	30	2.75

Figure 8. Present serviceability index of Mississippi clay formations.



Cracking

By definition a continuously reinforced concrete pavement is a jointless pavement sufficiently reinforced with steel to develop a large number of transverse, hairline cracks that will not impair the structural integrity of the pavement but will reduce the maintenance costs.

The spacing of these hairline cracks has been found to be inversely proportional to the percentage of steel in the pavement. A spacing of about 3 to 10 ft (1 to 3 m) is desirable to produce acceptably small crack widths (6). Factors influencing the spacing and width of cracks are numerous (16). In this study an effort was made to determine whether any relation exists between crack spacing, pouring temperatures, and traffic data.

The crack survey is also a statewide effort. Ten percent of the total length from each project was picked at random for this purpose, but none of the random sections was near construction ends. Readings were taken from the edge of the roadway by visual observation. Any visible crack, large or small, was counted and recorded. Figures 9 and 10 show that the pouring temperatures and the traffic loads do not appear to dominate the crack spacing. Data in these 2 figures have a wide scatter, and any attempt to correlate them would be meaningless. Figure 11 shows present crack spacing versus the year of completion. The age of the pavement, after a few years of service, is not an important factor influencing the crack spacing. All projects, despite their year of completion, have a crack-spacing range from 2.5 to 4.5 ft (0.8 m to 1.4 m).

In Figures 9 through 11, crack spacing from Desoto and Jones Counties experimental projects were not used because of different methods used in counting the cracks. In the 2 experimental projects only the cracks extending all the way across the pavement were counted. On the other projects, any visible cracks, large or small, were counted.

During the course of the field survey, a project engineer conducted some informal research that indicated that the crack pattern of CRCP conformed very closely with the crack pattern of the cement-treated base. To verify this information, we selected two 400-ft (122-m) sections of roadway and made cracking patterns on the soil-cement-treated base and the CRCP. Figure 12 shows that the results are negative.

Deflection

Very limited information on the deflection of CRCP was obtained during the field survey by using the Dynaflect. The Dynaflect measures pavement deflection induced by an applied load. It is an electromechanical system consisting of a dynamic force generator, a motion measuring system that is mounted in a towed trailer, and 5 motion-sensing geophones suspended from the towing arm of the trailer. Dynaflect-measured deflections have good correlation with the Benkleman-beam measured deflections. It has been found that a Benkleman-beam deflection equals about 20 times the Dynaflect deflections (unit in mils).

Dynaflect deflection readings were conducted in 1972 on a few CRCP projects at an interval of every 0.1 mile (0.16 km). On the Desoto County experimental project that was built in 1971, the average deflection is 0.46 mil (0.012 mm); standard deviation = 0.098 mil or 0.0025 mm. In another CRCP project constructed in 1971, the average deflection is 0.45 mil (0.011 mm); standard deviation = 0.085 mil or 0.0022 mm.

On another selected CRCP project that was constructed in 1964 and that has since shown extra wide cracks and bad spalling, the average deflection is 0.75 mil (0.02 mm); standard deviation = 0.138 mil or 0.0035 mm.

Dynaflect readings were also obtained on 20 conventional portland cement concrete pavements that were constructed during the 1940s and 1950s. Average deflections are from 0.85 to 1.5 mil (0.022 to 0.038 mm); standard deviation ranged from 0.14 to 0.48 mil or (0.0036 to 0.012 mm).

MAINTENANCE OF CRCP—SLABJACKING

Generally, slabjacking is used for filling voids, raising the pavement where depressions occur, and stabilizing the distressed pavement area. However, this operation is

Figure 9. Crack spacing and average pouring temperature.

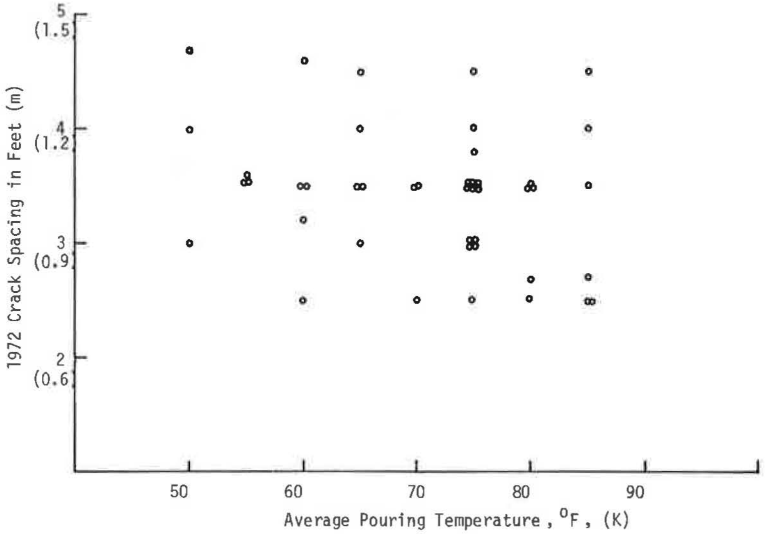


Figure 10. Crack spacing and accumulated equivalent annual 18-kip single-axle load (1 lb = 0.4536 kg).

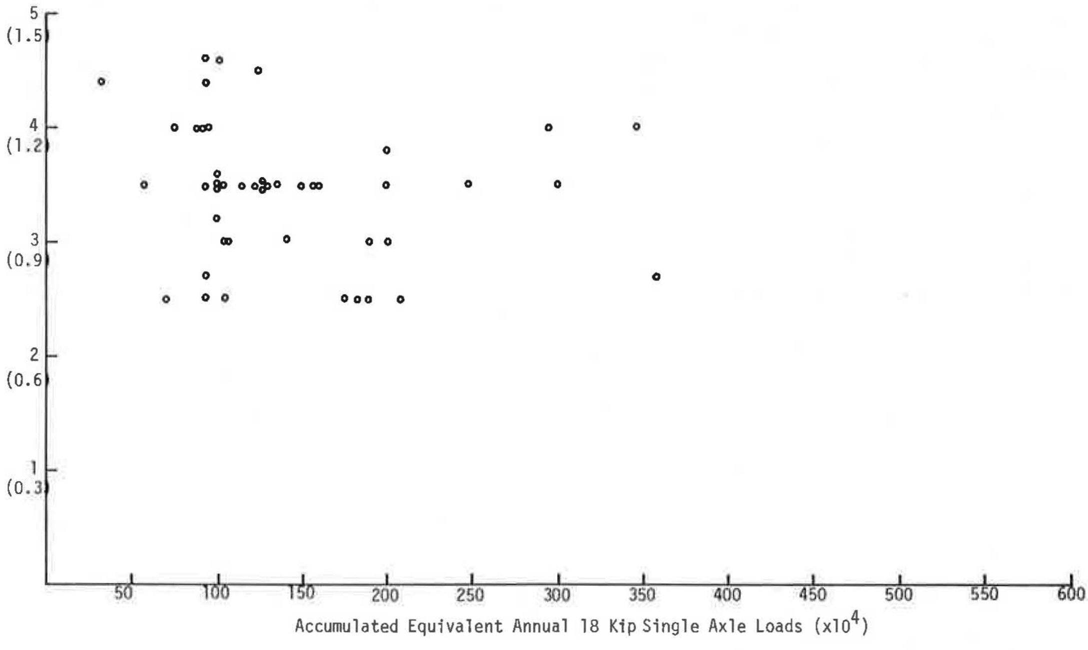


Figure 11. Crack spacing and year of project completion.

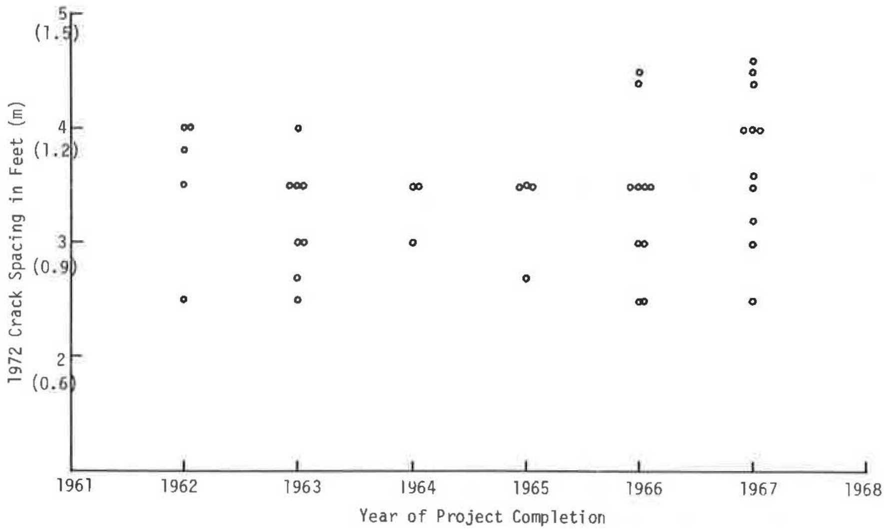
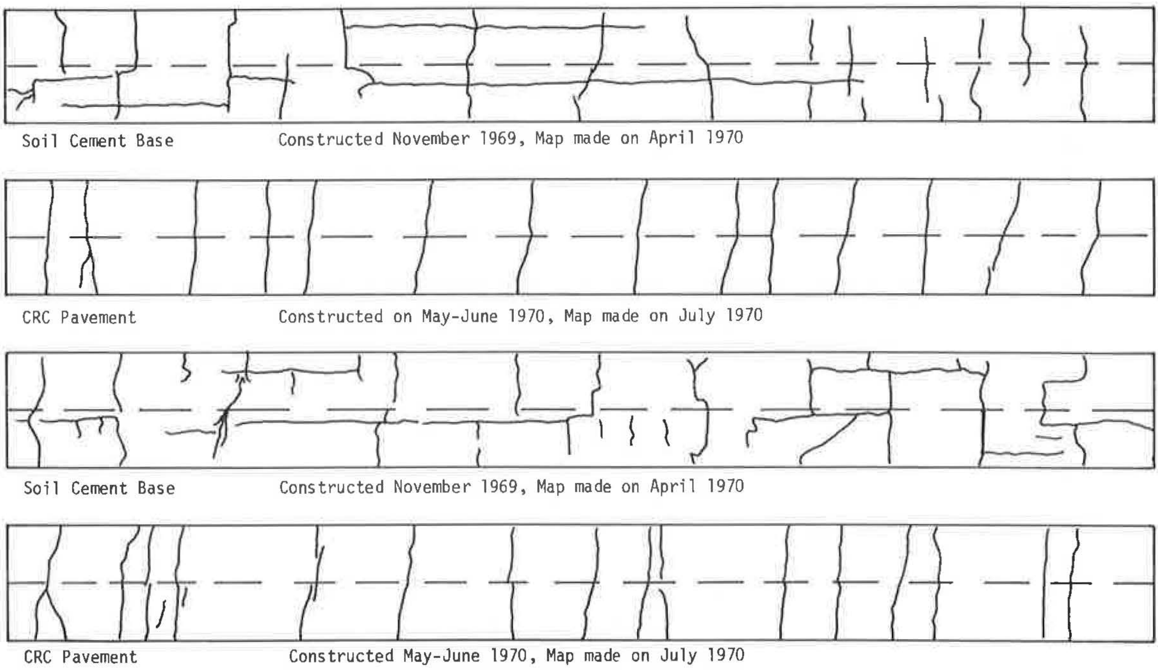


Figure 12. Cracking pattern of soil-cement base and superimposed continuously reinforced concrete pavement.



necessary for the maintenance of CRCP in Mississippi because of large areas of very active clay soils in the state. Seasonal wetting and drying have contributed to the roughness of the pavement surface through differential settlement and heaving of these active clay formations. The slabjacking operation can be used to feather out the grade on either side of the heaved or settled areas and thus maintain the riding quality of the pavement (22).

The slurry used in the slabjacking operation should be a mixture of high early strength portland cement (type 3), a minimum of 20 percent by volume; calcium chloride, a maximum of 5 percent by weight of cement; native silt soil or fine sand, a maximum of 75 percent by volume; and water. Type 1 portland cement can be used if type 3 is not available. However, when the type 1 is used, 28 percent cement should be added to the total mixture (13). Calcium chloride is to be added to the mixture in a premixed solution with water (21). Water should be added to produce the proper consistency.

On CRCP it is very important to drill the hole through base, subbase, and subgrade layer and to jack under the subgrade layer (4, 5, 9, 11, 14, 15, 22, 24). No more holes shall be drilled during a day's operations than can be jacked during the same day (5, 9). The best time for slabjacking is in cool weather (spring or fall) while the slabs are not at maximum expansion (14).

MAINTENANCE OF CRCP—TEMPORARY PATCH

Because of time required for the curing of portland cement concrete and interference with traffic, small areas of broken concrete resulting from CRCP distresses such as spalling, localized punch-out, construction joint, and localized radial are most often temporarily patched with bituminous mixture. When such patches are made, it is best to remove the loose concrete blocks before bituminous mixtures are applied. Usually this can be done by using a wrecking bar. Care should be exercised to avoid applying an excessive quantity of priming material; otherwise, rolling or shoving of the patch may occur (14).

On most locations, an initial temporary patch with bituminous mixture will provide good performance under traffic for a length of time. However, on some other locations this patch may need leveling or additional work annually or semiannually. It is a good practice to check these patches constantly to maintain the riding quality of the pavement.

MAINTENANCE OF CRCP—PERMANENT PATCH

For Small Distress Areas

On small distress areas where the failed material can be removed with a wrecking bar or other small tools, the fast-setting cement mix is a suitable solution for the permanent patch. The fast-setting cement can be mixed with pea gravel or used as a mortar. It also holds well when used as a skin patch. These patches will withstand traffic 30 to 40 min after completion.

For patches having firm bases or where the base is not damaged and the patches are from 4 to 8 in. (102 to 203 mm) deep, use 4 gal (0.015 m^3) of pea gravel per 50-lb (22.7-kg) bag of cement. For patches that are 2 to 4 in. (51 to 102 mm) deep, use 2 gals (0.0076 m^3) of pea gravel per bag of cement. For patches that are 1 to 2 in. deep (25 to 51 mm), just use the mortar and do not add any pea gravel. When this concrete mix is made, a water content not greater than 1.5 gal (0.0057 m^3) per bag of cement should be used. However, if the mixing temperature is higher than 80 F (300 K), this water content may have to be increased slightly to produce a workable mix. The initial water content has considerable effect on the 2-hour and the 7-day strengths but does not affect the long-term strength substantially. Therefore, the mix should always be placed and mixed with the least water possible to give a good working mixture (24).

This mixture hardens extremely fast, and it is very important that planning be done so that all the materials and equipment necessary to complete the patch are on hand when the first batch is mixed. This mixture will be hard enough to walk on in 15 min (24).

For Large Distress Areas

A standard maintenance procedure was established several years ago and has been used successfully by many districts and other highway departments. This procedure is applicable to large distress areas.

1. The existing pavement is sawed 1 in. (25 mm) deep normal to the centerline on both sides of the failure, and the failed concrete is broken out. The concrete must be removed for the full-lane width. To facilitate the removal of the broken concrete pavement, the reinforcing steel may be cut back to within 24 in. (610 mm) of the face of the remaining concrete.
2. The reinforcing steel replacing any bars that have been cut must have a minimum splice lap of 20 in. (508 mm), and the lapped steel is welded. The steel is not welded until the loose ends of the pavement in place have reached their maximum expanded movement. Usually this takes place around 3 to 4 o'clock in the afternoon.
3. Each end area of the patch is painted with epoxy resin.
4. High early strength cement should be used in the concrete placed in the patch. The concrete is normally placed as soon as possible after the reinforcing steel has been spliced. In no case should an area that has been opened for repairs be allowed to remain open overnight.
5. The concrete in the patch should be thoroughly cured.

When the outline of the patch is made, the edges of the proposed patched area (that will be sawed) should not cross or intersect existing cracks. Also, the saw cut should be no closer than 24 in. (610 mm) to the nearest crack.

When it is necessary to bend the steel at the 2 ends of the patch (to facilitate concrete removal), special precautions should be taken to make sure the steel is bent back to its original position. An S-shape resulting from such bending will sometimes create future problems.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The age of the CRC pavement, after a few years of service, is not an important factor influencing the crack spacing. All projects, despite the year of completion, have crack spacing ranging from 2.5 to 4.5 ft (0.76 to 1.37 m).
2. In Mississippi, the pouring temperatures and the traffic loads do not appear to dominate the crack spacing.
3. Cracking pattern on the stabilized base does not influence the cracking pattern on the CRC pavement.
4. During paving operation, the paver speed does not have noticeable effect on the densities of concrete.
5. Vibration during construction had no significant effect on the strength of concrete.
6. The degree of vibration during construction had no significant effect on the entrained air content of the concrete.
7. Vibration frequency of 9000 IPM (in air) produced the highest density in concrete.
8. The slump values above the 1-in. (25-mm) range (not to exceed 2 in. or 51 mm) allowed the vibrators to develop densities higher than would be developed were the slump below the 1-in. (25-mm) range.
9. The vibration effort studied in this report (7000, 9000, and 11,000 IPM, in air) produced no evidence of segregation.
10. The sieve analysis indicated a very close conformity on the aggregate gradation between the plastic concrete, stockpile, and original laboratory samples.
11. The nuclear device is a very good tool for consolidation control of CRCP construction.
12. In Mississippi, white pigmented impervious membrane and white polyethylene sheeting have both been used successfully for the curing of CRCP. These 2 curing methods do not appear to affect the pavement cracking pattern.

13. Polyethylene strip center joint has been used successfully in Mississippi. No longitudinal cracking can be related to this type of center joint.

14. The 18-kip (80-kN) axle loads have a significant influence on the present serviceability index.

15. CRC pavements constructed on expansive soils have caused considerable maintenance problems. Seasonal wetting and drying have contributed to the roughness of the CRC pavement surface through differential settlement and heaving of these active clay formations.

16. CRC pavement on stabilized base and treated subgrade should have Dynaflect deflection measurements of about 0.45 mil (0.011 mm) (multiplied by 20 to get Benkleman-beam deflection measurements). For conventional portland cement concrete pavements, the average deflections are from 0.85 mil (0.022 mm) to 1.5 mils (0.038 mm).

17. Most CRCP in Mississippi is performing perfectly with tight cracks, visible only on close inspection and usually at normal spacing.

Recommendations

1. If a new CRCP project is to be added to an existing CRCP project that was constructed several months earlier in another construction season, the length of the first lapped splice should be more than the regular design of 20 in. (508 mm). Consideration should also be given to adding extra cement to the first few batches of concrete at the beginning of the new project construction.

2. When a CRC pavement project is to be continued with another project, special end construction arrangements should be made to allow continuity of all base structure layers. This can be accomplished by requiring the first contractor to extend the base layers 30 to 50 ft (9 to 15 m) beyond the termination station of the project.

3. The present specification on vibration of portland cement concrete should be revised, and the use of a tachometer to check or set vibrator frequencies should be adopted.

4. The use of a nuclear device (density gauge) for consolidation control should adopted.

5. CRC pavements, unless specially designed, should not be placed on areas with highly expansive clay soils.

6. The proposed CRCP maintenance procedure should be incorporated into the state's maintenance manual.

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