State of Illinois
DEPARTMENT OF TRANSPORTATION
Bureau of Materials and Physical Research

# FINAL SUMMARY REPORT OF CRC PAVEMENTS IN ILLINOIS

By

Jagat Singh Dhamrait

Final Summary Report
IHR-36
Continuously Reinforced Concrete Pavement

A Research Study Conducted by
Illinois Department of Transportation
in cooperation with
U.S. Department of Transportation
Federal Highway Administration

The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policy of the U. S. Department of Transportation and the Illinois Department of Transportation. This report does not constitute a standard, specification, or regulation.

NOTICE

Neither the United States Government nor the State of Illinois endorses products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

May 1979

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.
FHWA/IL/PR-084

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle
Final Summary Report of CRC Pavements in Illinois

5. Report Date
May 1979

6. Performing Organization Code

7. Author(s)
Jagat Singh Dhamrait

8. Performing Organization Report No.
Physical Research No. 84

9. Performing Organization Name and Address
Illinois Department of Transportation
Bureau of Materials and Physical Research
Springfield, Illinois 62706

10. Work Unit No.

11. Contract or Grant No.
IHR-36

12. Sponsoring Agency Name and Address
Illinois Department of Transportation
Bureau of Materials and Physical Research
126 East Ash Street
Springfield, Illinois 62706

13. Type of Report and Period Covered
Final
October 1959 - December 1978

14. Sponsoring Agency Code

15. Supplementary Notes
Study Title: IHR-36 - Investigation of Continuously Reinforced Concrete Pavement. This study is conducted in cooperation with the U. S. Department of Transportation, Federal Highway Administration

16. Abstract
Determining the economic feasibility and the behavior of continuous reinforcement in portland cement concrete (PCC) pavement and developing essential design criteria are principal objectives of the research this report summarizes. Between 1963 and 1971, experimental continuously reinforced concrete (CRC) pavements were constructed in seven highway districts to gain construction experience and to observe service behavior. Even though contractors, during early projects, developed machines for placing reinforcement, a slipform paver that feeds the longitudinal bars through a series of tubes, eliminating the need for transverse bars, evolved as the common method of placing CRC pavement. Early failures revealed that CRC pavements require more careful construction procedures than conventional jointed pavements and, as the pavements aged, load failures attributed to poor drainage, greater than anticipated traffic loads, and concrete disintegration (D-cracking) became evident, particularly in the 7-inch slabs. A 1970 examination of reinforcement disclosed that no significant corrosion existed in the experimental pavements, even though water did penetrate each investigated crack. More recently, lug anchors, originally used to restrain pavement movement, have rotated, causing a rough-riding bump at each lug. Illinois' design policy currently provides for at least an 8-inch-thick slab (steel depth 3 inches below the surface) overlying a stabilized subbase. Wide-flange beam terminal joints accommodate end movements and, where needed, underdrains are located along the edge of the pavement subbase. CRC overlays (7-inch minimum) can satisfactorily upgrade structural capabilities, but they should not be considered solely for restoring pavement smoothness.

17. Key Words
CRC pavements, CRC overlays, construction, performance, cracking, deflection, steel corrosion, end anchorages, terminal joints, instruments, BAM, CAM, LSSM, shoulder drainage

18. Distribution Statement
No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)
Unclassified

20. Security Classif. (of this page)
Unclassified

21. No. of Pages
20

22. Price

Form DOT F 1700.7 (8-69)

# TABLE OF CONTENTS

Page

STATEMENT OF PROBLEM ---------------------------------- 1

OBJECTIVES -------------------------------------------- 2

Phase 1 - Continuously Reinforced Concrete Pavement ------------------------- 2
Phase 2 - Continuously Reinforced Overlay ---- 3
Phase 3 - Water-Reducing Admixture ----------- 3

SUMMARY OF FINDINGS ------------------------------ 3

Phase 1 - Continuously Reinforced Concrete Pavement ------------------------- 3
Phase 2 - Continuously Reinforced Overlay ---- 7
Phase 3 - Water-Reducing Admixture ----------- 8

IMPLEMENTATION ------------------------------------- 8

PUBLISHED REPORTS WITH ABSTRACTS ------------------ 10

# FINAL SUMMARY REPORT OF CRC PAVEMENTS IN ILLINOIS

## STATEMENT OF PROBLEM

Conventional portland cement concrete pavement used exclusively in Illinois for heavy-duty service generally has performed well. Structural weaknesses have not occurred with such frequency as to cause serious concern, but the defects that have occurred almost always have been associated with transverse joints. These defects are attributed to open joints that allow subsequent infiltration of water and debris during cooler periods of the year. Continuous longitudinal steel reinforcement of an amount sufficient to prevent appreciable opening of cracks appears to afford a method of eliminating contraction joints required for crack control.

Technical development in the use of continuously reinforced concrete (CRC) pavement has proceeded on an empirical basis due to the lack of sufficient background knowledge. The results of an experimental pavement, which was constructed in 1947-1948 on Route US 40 west of Vandalia, have provided the necessary information to extend the Illinois rigid pavement design procedure to include continuously reinforced pavement. The study also pointed out a need for longitudinal center joints in CRC pavement, a need for extra reinforcing steel at construction joints, a need for terminal anchorage at pavement ends, and a need for some way to control subbase pumping.

Yet, insufficient background knowledge warrants further study to determine feasible construction procedures as well as the most economical combination of pavement thickness, reinforcing steel type and depth, and subbase type necessary to provide adequate pavement serviceability.

## OBJECTIVES

The overall objective of the (Continuously Reinforced Portland Cement Concrete Pavement) study, as outlined in the research project prospectus dated October 1959, is to develop information that will permit refinement in the design of CRC pavement and to improve construction procedures that will place this type of pavement in a better position with respect to initial cost. Later, the study was expanded to include a CRC overlay of an existing concrete pavement and to evaluate the use of water-reducing admixtures in the portland cement concrete for CRC pavement. The study was separated into three phases, and the specific objectives of research for each phase are as follows:

### Phase 1 - Continuously Reinfoced Concrete Pavement

(a) To evaluate construction procedures and techniques and to develop mechanical means for placing continuous steel reinforcement.

(b) To determine the effects of slab thickness and the type and depth of reinforcement on transverse cracking and pavement deflection.

(c) To determine the behavior of longitudinal reinforcement relative to corrosion at transverse cracks.

(d) To evaluate the effect of various types of end anchorages and terminal joints on pavement behavior.

(e) To expand knowledge on stress levels and ranges in the steel and concrete of continuously reinforced pavement.

(f) To determine the effects of subbase types and shoulder drainage systems on the pavement and shoulder behavior.

Phase 2 - Continuously Reinforced Overlay

(a) To determine the effects of slab thickness and amount of longitudinal reinforcement on transverse cracking.

(b) To determine the effects of slab thickness and amount of steel on deflections.

Phase 3 - Water-Reducing Admixture

(a) To determine the effect of water-reducing admixtures on workability and physical properties of portland cement concrete for continuously reinforced pavements

(b) To determine the effect of water-reducing admixtures on durability and structural behavior of continuously reinforced concrete pavement under traffic

(c) To evaluate and report the benefits, if any, of using water-reducing admixtures in concrete pavement construction.

## SUMMARY OF FINDINGS

### Phase 1 - Continuously Reinforced Concrete Pavement

Seven experimental sections of CRC pavement were constructed between 1963 and 1966 for limited observation and to gain construction experience. One instrumented section in 1966 was constructed for intensive research along with another instrumented section, which contains variable subbase and shoulder drainage systems and which was completed in 1971. In addition to lug anchors used originally, wide-flange beam terminal joints were constructed in two additional projects.

Contractors who were awarded contracts for the construction of the experimental pavements were encouraged to develop mechanized procedures for placing CRC pavement. Although a bar assembly machine and several reinforcement depressors were developed for placing steel reinforcement in pavement placed with side forms, equipment manufacturers, at the same time, were developing a slipform paver which now has become the most popular and efficient method of placing rigid pavements in Illinois. The use of slipform pavers also has helped slow down rising paving costs in Illinois. In general, the performance of Illinois CRC pavement, since opened to traffic, has been quite satisfactory. A few localized failures have developed and were found to be caused by construction deficiencies.

Experience indicates that CRC pavement must be built more carefully than the conventional jointed pavement. Insufficient lap and gaps in reinforcement as well as unconsolidated concrete around the reinforcing steel, particularly at joints, will cause early failures. Patches in CRC pavements are sensitive to recurring failures, so special precautions need to be taken when making repairs.

Determining the relationship between pavement behavior and the design variables--pavement thickness, type and depth of steel reinforcement--was one main objective of the study. The pavement behavior, expressed in terms of deflection, transverse cracking, failures, and riding quality, was analyzed and was correlated with the design variables. The findings indicated that the 7-inch (178-mm) and 8-inch (203-mm) CRC slab as expected deflected more than the edge of the standard 10-inch (254-mm) PCC pavement. The CRC slab thickness and reinforcement type had no effect on transverse cracking, but the depth of steel reinforcement had a major effect on transverse cracking. A few localized failures have developed and were found to be caused by poor subbase drainage and a high level of load applications. Failures first appear in the vicinity of the outer wheelpath and gradually widen with time and with exposure to traffic. They occur as wide cracks, indicating steel rupture; as punchouts, implying a loss in support; and as disintegrated concrete, suggesting either poor consolidation or poor aggregate quality. As cracks widen, spalling and pumping develop rapidly. The amount of patching increased as the depth of reinforcement and cumulative axle loadings increased, but decreased as pavement thickness increased. Riding quality, as measured by Illinois BPR-type road roughness indicator, could not be associated with pavement type or any other variable investigated.

To expand the knowledge of stress levels and ranges in the steel and in the concrete of a CRC pavement, strain gages and concrete strainometers were installed in one project. At the time of transverse crack development, an abrupt increase in tension took place in the steel reinforcement. Only a few strain gages continued to function effectively after the first year. Those few gages that continued to function for several years indicated a trend for the steel reinforcement to shift more toward compression with time. However, it is uncertain how much of the shift was due to drift in the instrumentation. The concrete strainometers were showing about 100 micro-in./in. (300 psi) of tension when the nearby induced crack appeared. During the first winter, the tensile strain increased to about 160 micro-in./in. (480 psi).

The need for an unerodible subbase to maintain uniform support under CRC pavements, and to insure satisfactory performance, has long been recognized. Keeping this in mind, an evaluation was made of four types of subbases and three types of underdrain systems. It was found that a trenched granular subbase design has a very strong tendency to collect water and to create periods of weakened subgrade support. The water in the "daylighted" shoulder subbase drains slowly and remains in the subbase under the outer shoulder edge much of the time. The drainage system in which the perforated pipe is placed at the edge of the pavement subbase appears to be most efficient. The slab constructed on lime-stabilized soil mixture (LSSM) developed cracks more uniformly than the slab constructed on bituminous aggregate mix (BAM), on cement aggregate mix (CAM) and on granular subbase. No relationship between the average deflection and the type of stabilized subbase was apparent, but the average deflection for the slab on the granular subbase was slightly greater than the slab on stabilized subbase.

The Illinois Department of Transportation adopted a bare-pavement policy for ice- and snow-control conditions that has resulted in an extensive use of deicing chemicals. Many engineers are concerned that this increased use of deicing chemicals could accelerate steel reinforcement corrosion at transverse cracks, which would greatly reduce the service life of the CRC pavement. An analysis was made of 151 cores in early 1970, and the findings at that time indicated that even though water penetrated all cracks, the corrosion of the steel reinforcement in adequately designed CRC pavement was relatively minor. Of all the parameters investigated, crack width appeared to be the only significant factor influencing the progression of corrosion.

The end movement of CRC pavement can exert damaging forces against bridge structures and adjacent conventional pavement. To prevent this type of damage, some type of terminal treatment either to restrain or to accommodate the movement is needed. During the construction of experimental projects, lugs were used to restrain movement. The number and spacing of lugs were varied at different locations, and the behavior of the various lug arrangements was compared. All combinations of lug spacing and number of lugs appear to have been effective in partially restraining the pavement movement. At a few locations throughout the State, problems have developed with dips forming between lugs, creating a rough riding surface. These problems have been alleviated by cutting a 4-inch (102-mm) pressure-relief joint and some instances by mud-jacking or overlaying the undulated area. At two projects, ten wide-flange beam terminal joints were constructed. The wide-flange joint provides an effective method of accommodating the movement at the pavement ends at a lower cost than restraining the movement with anchor lugs.

## Phase 2 - Continuously Reinforced Concrete Overlay

This phase is concerned with the construction, observation, and evaluation of the behavior of experimental sections of CRC overlay over an existing resurfaced PCC pavement. Experimental sections were constructed in 1967, and the following design variables were investigated.

Overlay Thickness - 6-inch (152-mm), 7-inch (178-mm) and 8-inch (203-mm)

Amount of Longitudinal Reinforcement - 0.6, 0.7, and 1.0 percent of the cross section area of the overlay

Early in the construction phase, the need for a bituminous concrete leveling course to level the profile and true up the cross section so that the overlay could be placed without deviating from the design thickness more than 1 inch became evident.

After construction, observations and measurements were carried out over a 10-year period to evaluate the behavior of the experimental overlays under traffic. During that period, the overlays carried in excess of 7 million equivalent 18-kip (80 kN) single-axle load applications which produced little change in either riding quality or level of service and which required no structural maintenance. Transverse cracking followed the normal trend for regular CRC pavement, and edge deflections were very small for all test sections. Changes in transverse crack width from summer to winter were small for all sections and decreased with increasing slab thickness.

### Phase 3 - Water-Reducing Admixture

This phase of the study is concerned with an investigation of the use of water-reducing admixtures in the concrete of continuously reinforced pavement. Three types of water-reducing admixtures (WRDA, WRDA-79, and Pozzolith-Improved 8) were used in the portland cement concrete on five projects. The use of water-reducing admixtures effectively increased the slump of the concrete without increasing the amount of mixing water, and reduced the amount of air-entraining agent necessary to obtain the specified air-content range. Significantly higher compressive strengths, up through one-year tests, were obtained from the concrete containing admixtures, but no significant increase in flexural strength was obtained with the addition of the admixture. The use of the admixture has not adversely affected concrete durability or subsequent pavement behavior.

## IMPLEMENTATION

The knowledge gained in preparing the plans and construction specifications for the present experimental pavements, together with the experience gained from the pavement behavior, has provided the basis for development and refinement of the present CRC design standards and specifications being used by the Illinois Department of Transportation.

As findings emerged from this study, they were presented at meetings and at conferences. Information was compiled into interim reports and was distributed to Districts, Central Bureaus and other States as well as other interested persons. In addition, pertinent findings were documented in papers, which were submitted to the technical association for publication. In this manner, the research findings did receive widespread distribution.

On the basis of information gained from the five research pavements, Illinois specifications have been revised to permit the use of approved water-reducing admixtures in portland cement concrete of a CRC pavement.

Observation of the behavior of Illinois' experimental pavements has indicated that a 7-inch (178-mm) CRC pavement on granular subbase in a trench construction does not appear to have the structural integrity required to overcome the variety of construction imperfections or other deficiencies that sometimes contribute as a group to a premature failure of pavements carrying heavy truck loads. On the basis of these observations, the pavement design policies in Illinois have been revised to provide an 8-inch (203-mm) minimum thickness of CRC pavement with reinforcement placed 3 inches (76.2 mm) ± 1 inch (24.54 mm) below the surface, over a stabilized subbase having a positive underdrain system.

Since all combinations of the number of lugs and lug spacings appeared equally effective in restricting the movement of pavement ends, the standard design, in 1969, was changed from four lugs at 40 feet (12.2 m) to three lugs at 20 feet (6.1 m). This change resulted in a 25 percent cost savings with no apparent effect on performance. Since the wide-flange beam terminal joint has performed well over a 7-year period and has effectively accommodated movements of the ends of CRC pavements at a lower cost than restraining the movement with lugs, it was recommended that the wide-flange beam joint replace the anchor-lug system as the standard terminal treatment for CRC pavements. This recommendation was implemented in 1978.

From the information gained in the CRC overlay study, three main recommendations were made. The first recommendation was that a CRC overlay be considered primarily for the purpose of increasing the structural capability of the pavement and not for the purpose of leveling the existing pavement and restoring its riding quality. Prior to the construction of a CRC overlay, a bituminous concrete leveling course should be placed over the existing pavement to true up the cross-section, to level the profile, and to break the bond between the existing and the new CRC overlay. The second recommendation was that the specifications should include a control on the constructed thickness of the CRC overlay, requiring it to be not less than plan thickness, which assures adequate structural capability, and to not exceed plan thickness by more than 1 inch (25 mm), which prevents excessive reduction in the effective percent of longitudinal reinforcement. Longitudinal reinforcement that amounts to 0.6 percent of the cross-sectional area of the CRC overlay should be considered as a minimum. The third recommendation was that the minimum thickness for CRC overlay over an existing concrete pavement, in Illinois environment, should be 7 inches (178 mm). These recommendations will be implemented as soon as an opportunity for a CRC overlay alternative arises.

On the basis of the information gained from the underdrain study, Illinois design standards were revised in 1975 to locate the underdrains at the edge of the pavement subbase.

## PUBLISHED REPORTS WITH ABSTRACTS

(1) Burke, John E., and Dhamrait, Jagat S., "A Twenty-Year Report on the Illinois Continuously Reinforced Pavement," Highway Research Record No. 239, 1968.

Experimental sections of CRC pavement built in 1947-1948 were 7 inches (178 mm) and 8 inches (203 mm) thick on a fine-grained soil subgrade. Longitudinal reinforcement amounted to 0.3, 0.5, 0.7, and 1.0 percent of the slab cross-sectional area. Transverse reinforcement was spaced at 12-inch (305-mm) and 18-inch (457-mm) centers. A control section of the then-standard Illinois design of a 10-inch (254-mm) slab reinforced with welded wire fabric with doweled contract joint at 100-foot (30.48-m) centers and constructed over a 6-inch (152-mm) granular subbase was included.

After 20 years of service, the CRC pavements have shown the potential of overcoming the basic weakness that occurs at transverse joints and cracks of conventional pavement. Pavement performance increased with an increase in amount of longitudinal steel and with an increase in slab thickness. Steel contents from 0.5 to 0.7 percent appear to be the desired range. Findings indicated a need for a longitudinal center joint to control the longitudinal cracking and a need for a terminal anchor or terminal joint to control longitudinal movement of the slab. Also, the use of a subbase to control pumping was indicated.

(2) "An Interim Report on the Use of Water-Reducing Admixtures in CRCP on Southwest Expressway," Illinois Division of Highways, Research and Development Report No. 6A, June 1966.

(No Abstract)

(3) "Use of a Water-Reducing Admixture in CRC Pavement on Interstate Route 57," Illinois Division of Highways, Research and Development Report No. 16A, September 1967.

(No Abstract)

(4) Dhamrait, Jagat S., Jacobsen, Floyd K., and Schwartz, Donald R., "Condition of Longitudinal Steel in Illinois Continuously Reinforced Concrete Pavements," Department of Transportation, Physical Research Report No. 43, March 1973.

An investigation was made of several CRC pavements constructed within Illinois to determine the extent of corrosion occurring on the longitudinal reinforcement at transverse cracks. The effects of crack width, crack spacing, depth of reinforcement, slab thickness, and type of reinforcement were studied to determine their influence on the progression of corrosion. An analysis was made of 151 cores removed from 12 experimental pavements previously constructed throughout the State for an intensive study on the behavior of a variety of CRC pavement designs. The investigation also includes observations of 23 cores removed from the old Vandalia test pavement, which is of special interest because of its performance history and age.

Of the cores removed from the experimental pavements, 49 percent showed no evidence of active steel corrosion, 50 percent indicated slight pitting to moderate pitting, and less than one percent showed advanced rusting with a marked reduction in cross-sectional area of the reinforcing steel. The findings indicate that corrosion of the steel reinforcement in adequately designed CRC pavements is relatively minor, and that corrosion of the steel does not appear to be a potential problem with pavements designed in accordance with the present criteria.

Of the parameters investigated, crack width appeared to be the only significant factor influencing the progression of corrosion. The entrance or ejection of water through transverse cracks was evident in all cores. Some discoloration was noted at all cracks.

(5) Dhamrait, Jagat S., Jacobsen, Floyd K., and Dierstein, Philip G., "Construction Experience with CRC Pavements in Illinois," Department of Transportation, Physical Research Report No. 55, March 1977.

Developing mechanical means for economically setting steel reinforcing in a continuously reinforced concrete (CRC) pavement was one objective of a study Illinois started in 1960. While constructing six experimental pavements between 1963 and 1966, one bar assembly machine and several reinforcement depressors were developed; however, slipform pavers that feed the longitudinal bars through a series of tubes, eliminating the use of transverse bars, have replaced the use of side forms, and now is the most common way of placing CRC pavement in Illinois. Experience indicates that CRC pavement must be built more carefully than conventional pavement; otherwise, insufficient lap and gaps in reinforcement as well as unconsolidated concrete around the reinforcing steel, particularly at joints, will cause early failures. To repair a CRC pavement successfully, patches should be at least 10 feet (3.04 m) long by one lane wide, 18 inches (457.2 mm) from transverse cracks, and 10 feet (3.04 m) from construction joints; reinforcing steel exposed for lapping should not be bent above the pavement surface; new steel should be supported on chairs at the same level as the existing steel and should be securely tied; and damaged steel within the lap area, when less than 10 percent, may be repaired by welding; otherwise, welding is not permitted.

(6) Dhamrait, Jagat S., and Taylor, Richard K., "Terminal Treatments for Illinois Continuously Reinforced Concrete Pavements," Department of Transportation, Physical Research Report No. 72, June 1977.

As part of an extensive study conducted to determine the significant relationship between the behavior of CRC pavement and various design features, an evaluation was made of several types of anchor-lug systems and terminal joints. Movement of the ends of CRC pavements can exert damaging forces against bridge structures and adjacent conventional pavement. To prevent this type of damage, some type of terminal treatment is necessary at each free end. A terminal treatment can be designed either to restrain the movement (an anchor system) or to accommodate the movement (a terminal joint system).

Because the optimum number and spacing of anchor lugs for various soil conditions and subbase types were not known, the number and spacing of lugs were varied at different locations in the State and the behavior of the various lug arrangements was compared. All combinations of lug spacing and number of lugs appear to have been effective in partially restraining the pavement movement; however, distresses in the lug area have developed at some locations.

In an effort to find a less costly yet satisfactory method of alleviating the effect of end movements, ten wide-flange beam terminal joints were constructed at two locations. The data indicate that the terminal joint provides an effective method of accommodating the movements at the ends of pavements at a lower cost than restraining the movements with anchor lugs.

(7) "Dhamrait, Jagat S., and Schwartz, Donald R., "Continuously Reinforced Concrete Overlays on Existing Portland Cement Concrete Pavements," Illinois Department of Transportation, Physical Research Report No. 80, May 1978.

Five experimental sections of CRC overlay over an existing resurfaced PCC pavement on Route US 40 were constructed in 1967 as part of Interstate Route 70 construction near Pocahontas, Illinois. Three thicknesses of overlay and two separate amounts of longitudinal reinforcement were used in the experimental sections. Observations and measurements were carried out over a 10-year period to evaluate the behavior of the experimental overlays. During that period the pavements carried in excess of 7 million equivalent 18-kip single-axle load applications with very little change in riding quality or level of service, without requiring any structural maintenance. Transverse cracking followed the normal trend for regular CRC pavement, and edge deflections were very small for all test sections. Changes in transverse crack width from summer to winter were small for all sections and decreased with increasing slab thickness. Recommendations are included for design and construction of overlays relative to minimum overlay thickness, amount of longitudinal steel, use of a bituminous leveling course as a bond breaker, and tolerances for overlay thickness control during construction.

(8) Dhamrait, Jagat S., and Taylor, Richard K., "Behavior of Experimental CRC Pavement in Illinois," Illinois Department of Transportation, Physical Research Report No. 82, March 1979.

Determining the relationships between pavement behavior and the design variables (pavement thickness, type of steel reinforcement and depth of steel reinforcement) was one main objective of a study Illinois started in 1960. The pavement behavior, expressed in terms of deflection, transverse cracking, distress, and riding quality was analyzed and correlated with the design variables. The data were collected from six experimental projects constructed throughout the State during 1963-1966. The investigation also includes instruments and procedures used to expand the knowledge on stress levels and ranges in the steel and concrete of CRC pavement.

The findings indicate that the 7-inch (178-mm) and 8-inch (203-mm) CRC slab deflected greater than the edge of the standard 10-inch (254-mm) PCC pavement. The CRC slab thickness and the type of reinforcement have no effect on transverse cracking, but the depth of steel reinforcement has a major effect on transverse cracking. At the time of transverse crack development, an abrupt change from compression to tension took place in the steel reinforcement.

In general, the performance of Illinois CRC pavements since opened to traffic (11 to 14 years of service) has been quite satisfactory. A few localized failures have developed and were found to be caused by construction deficiencies, poor subbase drainage, and a higher level of load applications than anticipated.

(9) Dhamrait, Jagat S., and Schwartz, Donald R., "Effect of Subbase Type and Subsurface Drainage on Behavior of CRC Pavements," Illinois Department of Transportation, Physical Research Report No. 83, May 1979.

As part of an extensive study conducted to determine the significant relationship between the behavior of CRC pavement and various design features, an evaluation was made of four types of subbases and three types of subsurface drainage systems. Deformation of the subbase due to loading and/or subbase erosion under severe climate and moisture conditions can cause severe pavement distress. To prevent or delay these types of pavement distress from developing early in the service life of the pavement, some type of stable subbase and subsurface drainage system is necessary.

The pavement behavior, expressed in terms of transverse cracking and deflections, was analyzed and correlated with the type of subbase and type of subsurface drainage system. The investigation also includes the procedure used to evaluate the efficiency of the drainage system and to expand the knowledge of the stress levels in the steel.

The pavement sections containing the various subbases and subsurface drainage systems are performing excellently after 6½ years of service.

The lime-stabilized soil mixture as subbase offers the potential for reduced construction costs, and it is recommended that additional sections be built for further evaluation. The subsurface drainage system with longitudinal underdrains placed at the edge of the stabilized subbase was the most efficient in removing free water from beneath the pavement structure and has been adopted by Illinois as the standard treatment for Interstate highways.