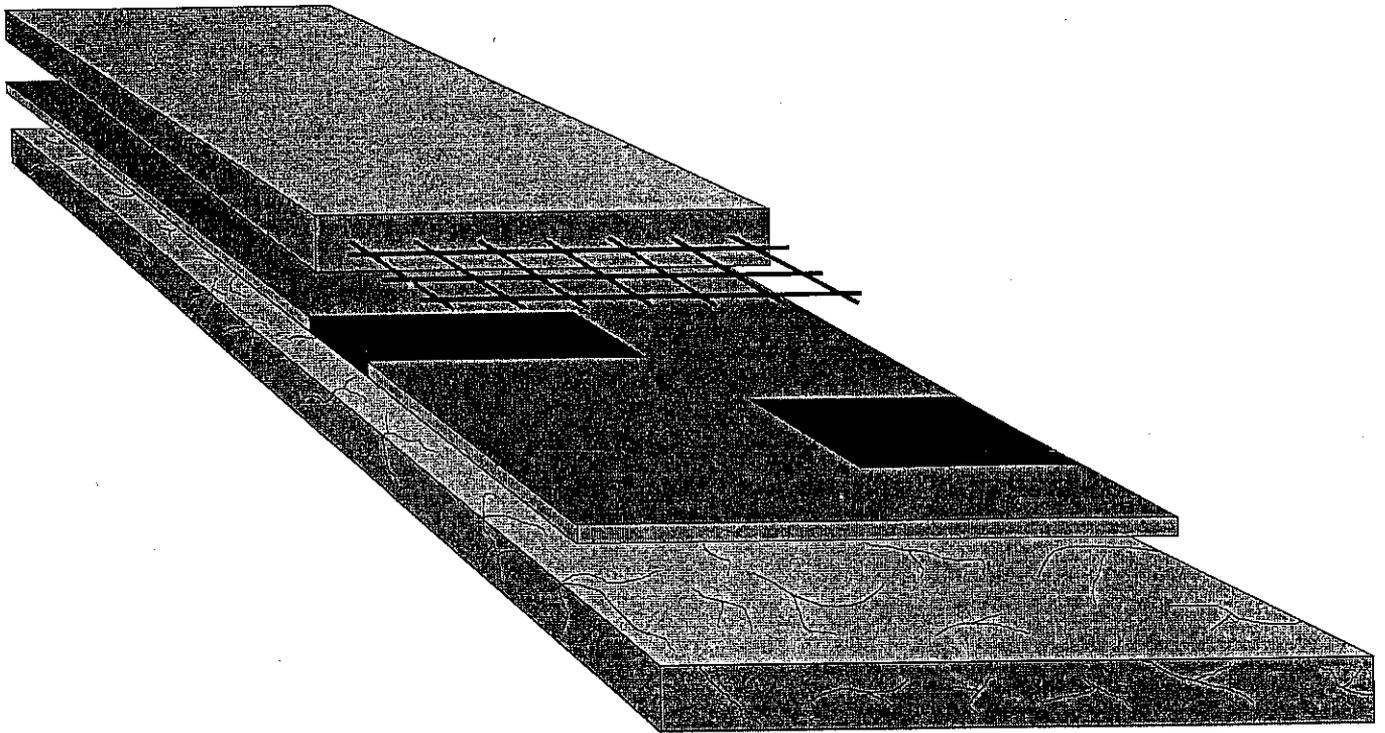


# Planning, Design and Construction of an Unbonded Concrete Overlay



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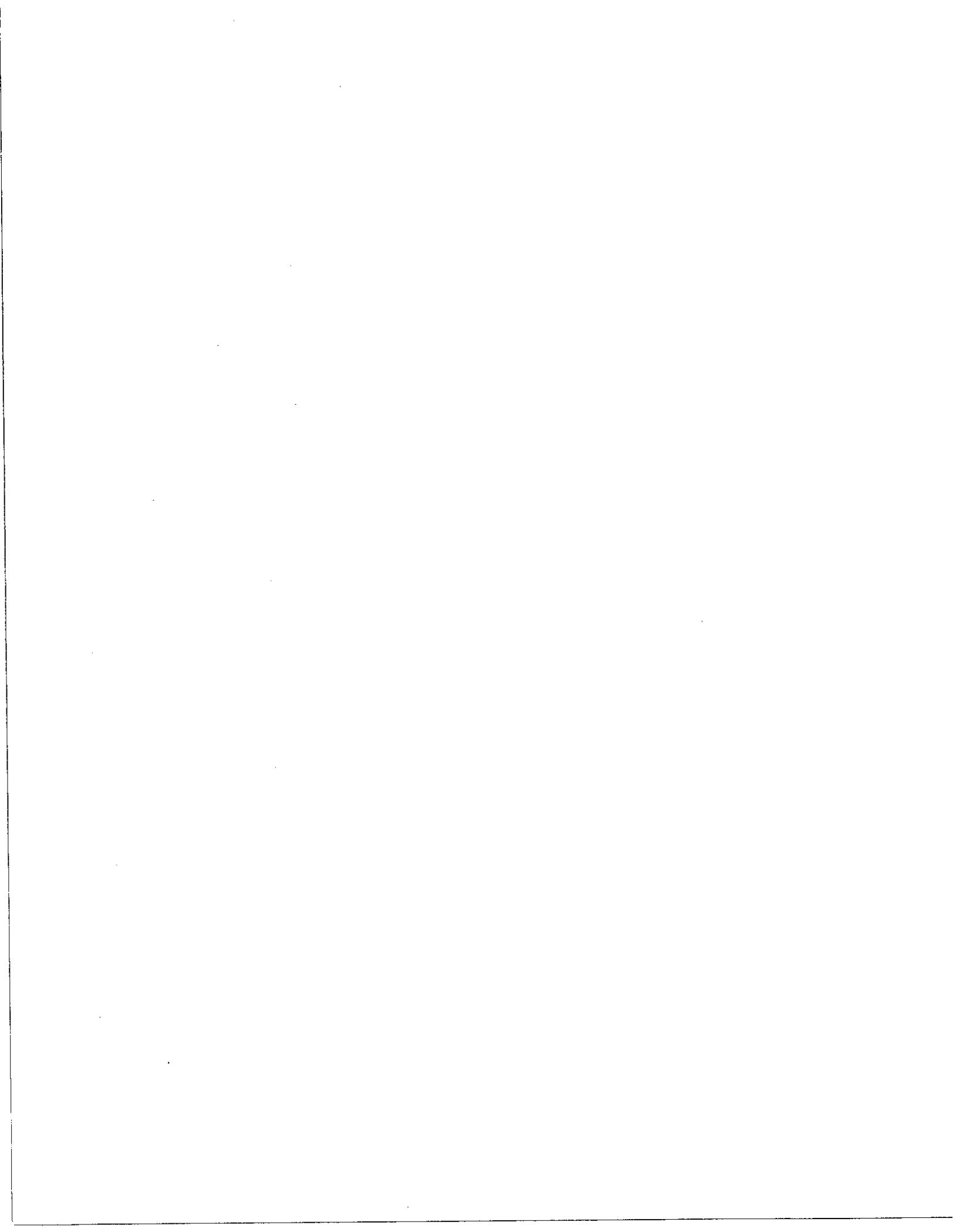
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16. Abstract Prior to 1980, Illinois had constructed three unbonded concrete overlays. These overlays were constructed to incorporate portions of the existing alignment and pavement in construction of the interstate system. This report details the planning, design, and construction of a fourth Illinois unbonded concrete overlay.  Three design approaches were used to determine the thickness of the overlay; the U.S. Army Corps of Engineers method published in NCHRP Synthesis 99, the AASHTO design method published in the AASHTO Guide of Pavement Structures, and an arbitrary thickness reduction from a new pavement thickness calculation based on the Illinois Department of Transportation (IDOT) Design Manual. IDOT built a 23-cm (9-in.) continuously reinforced unbonded overlay utilizing the existing bituminous overlay as the separation layer or interlayer.  The Falling Weight Deflectometer (FWD) data demonstrated an increase in the structural capacity of the pavement due to the addition of the unbonded overlay. Comparing FWD data from a new pavement to the unbonded concrete overlay indicated that a nominally designed 23-cm (9-in.) unbonded concrete overlay is structurally comparable to a nominally designed 25-cm (10-in.) new pavement. Initial costs indicate unbonded concrete overlays can provide a cost effective alternative to complete removal and replacement.			
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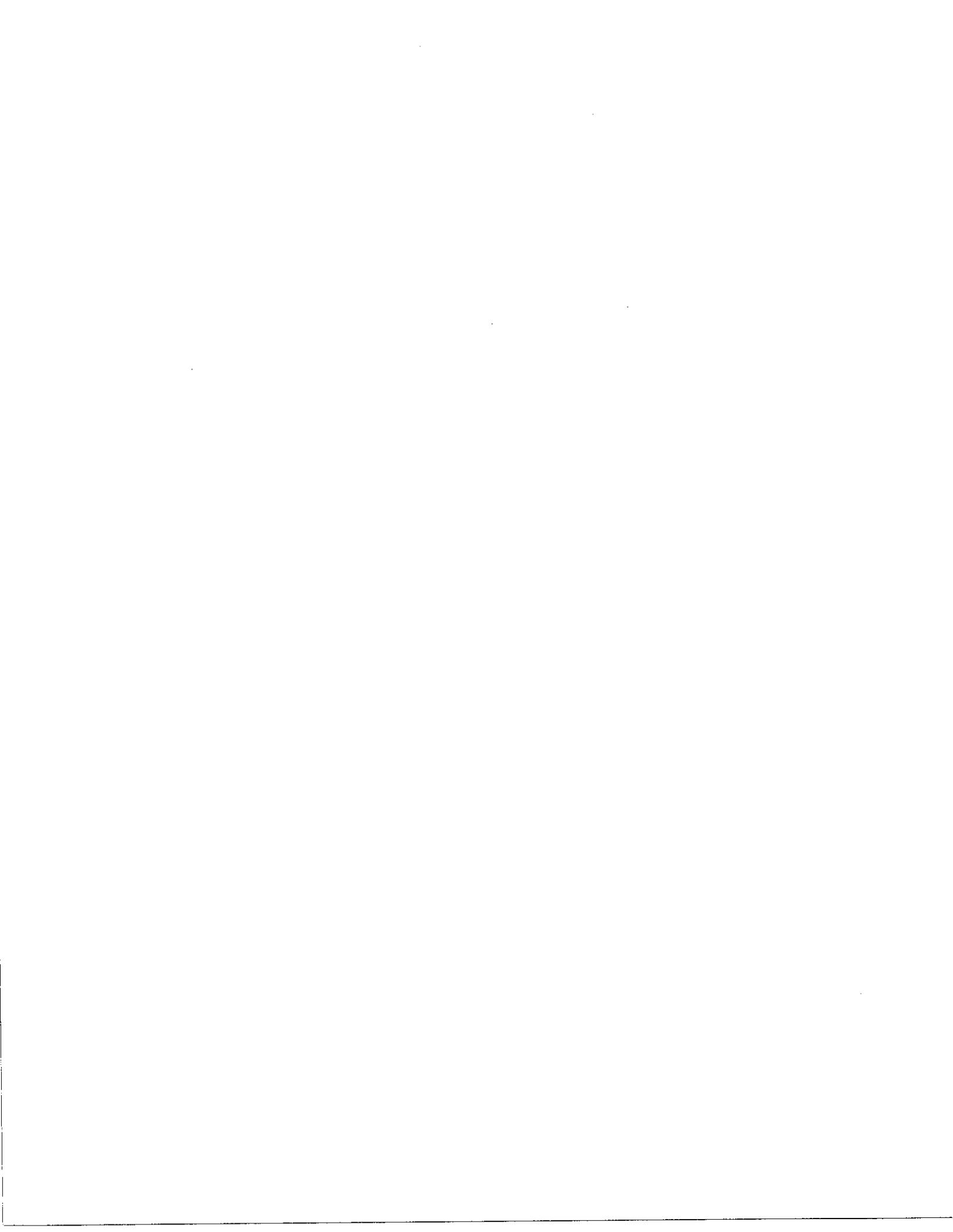
**PLANNING, DESIGN AND CONSTRUCTION OF  
AN UNBONDED CONCRETE OVERLAY**

Interim Report

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## EXECUTIVE SUMMARY

With increased loads and traffic many of portland cement concrete pavements in Illinois are reaching the end of their service lives. Forty percent of Illinois interstate concrete pavements are D-cracked and are difficult to repair permanently. Unbonded concrete overlays are being studied to determine if they can provide long term pavement rehabilitation.

Since 1967, Illinois has constructed three unbonded concrete overlays. These overlays were constructed to incorporate portions of the existing alignment and pavement in construction of the interstate system. This interim report details the planning, design, and construction of a fourth Illinois unbonded concrete overlay.

Three design approaches were used to determine the thickness of the overlay; the U.S. Army Corps of Engineers method published in NCHRP Synthesis 99, the AASHTO design method published in the AASHTO Guide of Pavement Structures, and an arbitrary thickness reduction from a new pavement thickness calculation based on the Illinois Department of Transportation (IDOT) Design Manual. IDOT built a 23-cm (9-in.) continuously reinforced concrete (CRC) unbonded overlay utilizing the existing 7.5 to 11-cm (3 to 4.5-in.) thick bituminous overlay as the separation layer or interlayer.

The Falling Weight Deflectometer (FWD) data demonstrated an increase in the structural capacity of the pavement due to the addition of the unbonded concrete overlay. Comparing FWD data from a new pavement to the unbonded concrete overlay indicated that a nominally designed 23-cm (9-in.) unbonded concrete overlay is structurally comparable to a nominally designed 25-cm (10-in.) new pavement. Initial costs indicate unbonded concrete overlays can provide a cost effective alternative to complete reconstruction.

This experimental project will continue the evaluation of unbonded CRC overlays by providing information on the suitability of unbonded concrete overlays as an alternative to reconstruction for D-cracked CRC pavements and determining if the existing bituminous overlay can function as the interlayer.

## **ACKNOWLEDGMENTS**

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## **DISCLAIMER**

The contents of this report reflect the views of the author, who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Illinois Department of Transportation nor the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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## **INTRODUCTION**

Construction of the interstate system in Illinois started in the late 1950's to early 1960's and is complete. Rehabilitation is now the main focus for most state transportation agencies, including the Illinois Department of Transportation (IDOT). The interstate system is aging. The steady increase of both truck volume and weight reduces pavement service life at a rate faster than anticipated. Timely repair or rehabilitation is limited by both widespread need and insufficient funds.

Illinois uses various types of preventive and corrective rehabilitation techniques. The most common rehabilitation technique is thin bituminous concrete overlays (8-cm (3.25-in.)) in conjunction with patching. However, approximately forty percent of the interstate portland cement concrete pavements in Illinois contain D-cracking susceptible coarse aggregate. Bituminous overlays on D-cracked pavements are prone to develop early distress and performance can be greatly reduced. Multiple bituminous overlays on D-cracked pavements may not be a cost effective solution.

To solve these problems, a rehabilitation technique which provides structural improvement of D-cracked pavements is needed to extend the service life. One method of providing structural improvement is an unbonded concrete overlay.

Since 1967, Illinois has constructed three unbonded concrete overlays. These overlays were built to incorporate portions of the existing pavement instead of removing them during construction of the interstate system. This report details the planning, design and construction of a fourth Illinois unbonded concrete overlay.

## **HISTORICAL PERSPECTIVE**

Although many believe the concrete overlay to be a new concept, it is not. Concrete overlays date back as early as 1913. At that time most pavements were comprised of 10 to 15-cm (4 to 6-in.) of concrete. As state transportation agencies are experiencing again today, engineers then were faced with the effects of increased traffic and truck weight. Pavements were deteriorating and a method for rehabilitation was needed. To increase the load carrying capacity and life of a pavement, a 10 to 15-cm (4 to 6-in.)

concrete overlay was added. A separation course was used to deter reflective cracking caused by the existing cracked pavements. The most common separation layer used was some form of bituminous material (1).

State transportation agencies are revisiting concrete overlays as a rehabilitation technique as concrete paving becomes more efficient. The concept has worked in many situations. With new materials and technologies, different variations of concrete overlays have been tried. Some were more successful than others.

Illinois has constructed three unbonded continuously reinforced concrete (CRC) overlays since 1967. The first project is east of East St. Louis on I-70. The experimental sections are located westbound between mileposts 31.38 and 35.19. The pavement overlaid was part of former US 40. The separation material consisted of 15-cm (6-in) of bituminous aggregate mixture (BAM) leveling binder. Three thicknesses, 15, 18 and 20-cm (6, 7 and 8-in.), and three different steel percentages, 0.6, 0.7 and 1.0, were used in the pavement cross section.

The second project, constructed in 1970, is south of Springfield on I-55. The experimental sections are located between mileposts 89.00 and 91.61. The pavement overlaid was part of former US 66. The separation material consisted of 20-cm (8-in.) of bituminous resurfacing plus a minimum of 10-cm (4-in.) of BAM. The unbonded CRC overlay is 20-cm (8-in.) thick.

The third project, constructed in 1974, is north of Springfield on I-55. The experimental sections are located northbound between mileposts 105.52 and 108.03. The pavement overlaid was part of former US 66. A minimum 10-cm (4-in.) BAM layer served as the separation material. The unbonded CRC overlay is 23-cm (9-in.) thick.

A performance evaluation of these projects was conducted in 1988 (2). It was concluded that:

- Unbonded concrete overlays on existing pavement have performed well for at least twenty years,

- The existing and proposed pavements should have the same width (Unequal widths caused a great deal of distress which shortened the service life and eventually required patching and overlay of one project.),
- Increased thickness provides increased performance.

## BACKGROUND

An unbonded concrete overlay consists of the existing concrete pavement, a separation material or interlayer, and the concrete overlay (Figure 1). The overlay relies on minimal structural contribution from the existing pavement. Essentially, the two layers function independently with the existing pavement treated as the subbase. The interlayer is used to separate the two pavements, help them act independently, and minimize reflective cracking from the existing pavement. The average recommended bituminous interlayer thickness is 2.5-cm (1-in.), according to AASHTO and the American Concrete Pavement Association (ACPA). Performance of unbonded concrete overlays would indicate thicker interlayers are needed (2).

There are three primary variables that affect the performance of the interlayer: temperature, viscoelastic properties, and thickness. Temperature and viscoelastic properties are not controllable variables. Therefore the thickness of the interlayer is important when designing the overlay.

The word "unbonded" can cause misconceptions about unbonded overlays. The general belief is that the asphalt and concrete do not bond and that the new pavement slides on the top of the interlayer. In fact, the concrete and asphalt do bond. The behavior resembles a large viscosity test of a liquid between two plates. The thinner the interlayer, the more friction and the more the pavements act like a monolithic slab. Therefore, to allow the pavements to act independently, the interlayer thickness must be adequate. By increasing the thickness, friction is reduced, shear strains are dissipated, and the interlayer deforms to accommodate the movement. The thicker the interlayer the more the pavements can act independently of each other.

## PLANNING

### Project Criteria

Several criteria were used to select an appropriate project site. The pavement must be:

- Overlaid, thin, D-cracked, continuously reinforced concrete pavement with a record of poor performance and accelerated deterioration. (Thin pavement refers to a thickness of 18 to 20-cm (7 to 8-in..))
- Programmed for rehabilitation between 1994 and 1997.

Once a project site was chosen an evaluation of the existing pavement was made. One of the most important considerations as noted by Barenberg is the condition of the existing pavement:

Evaluating the true condition of the existing pavement is one of the most critical factors in selecting the best overlay option. This evaluation should reflect how the existing pavement will affect the behavior and performance of the overlaid pavement. Such an evaluation should be based on structural or behavioral considerations rather than on serviceability considerations (3).

### Project Site History

The selected project site was located east of Galesburg, westbound on I-74 between milepost 53.79 and 61.73 (Figure 2). The existing pavement was constructed in 1969 and opened to traffic in 1970. The pavement cross section consisted of 10-cm (4-in.) of BAM stabilized subbase with a 18-cm (7-in.) CRCP (Figure 3). The existing bituminous overlay ranged from 7.5 to 11-cm (3 to 4.5-in.). The pavement was retrofitted with underdrains in 1981 and 1983. The 1992 Condition Rating Survey (CRS) value was 5.5. The CRS is comparable to the Present Serviceability Index (PSI) which was developed from the AASHO Road Test. Both are a subjective measurement of the condition of the pavement at a certain point in the service life. CRS is based on a scale of 1.0 to 9.0, with 9.0 being excellent condition. PSI is based on a scale of 0 to 5, with 5 representing the highest possible serviceability (4,5).

A distress survey of the existing bituminous overlay determined the following pavement distresses: transverse cracking, longitudinal cracking, reflective cracking and reflective D-cracking distress. Pavement conditions identified prior to the bituminous overlay were: punchouts, D-cracking and patching.

## DESIGN

There are two types of rehabilitation pavement design. A functional design improves friction and corrects surface irregularities. A structural design improves pavement structural capacity. A structural design will help eliminate the problems associated with D-cracking.

Three design approaches were used to determine the thickness of the overlay. All methods were based on a twenty-year design period with a 1992 ADT of 11,500. The ADT consisted of 72% PV, 4% SU and 24% MU. Growth rates of 1, 3 and 2.5 percent were used, respectively. Using these numbers in the rigid pavement traffic factor (TF) equations of Section 7 of the IDOT Design Manual, a TF of 24.12 or 24 million Equivalent Single Axle Loads (ESALs) was calculated.

### Method 1

The first approach used was developed by the U.S. Army Corps of Engineers and published in NCHRP Synthesis 99 (1). The overlay thickness is given by:

$$h_o = \sqrt{h_d^2 - Ch_b^2} \quad (1)$$

Where:

$h_o$  = required overlay thickness in centimeters (inches)

$h_d$  = new pavement thickness in centimeters (inches)

$h_b$  = existing pavement thickness in centimeters (inches)

C = coefficient based on the existing pavement condition

C = 1.0      Existing pavement is in good overall structural condition with little or no cracking.

C = 0.75      Existing pavement has initial joint and corner cracking due

to loading but no progressive structural distress or recent cracking.

C = 0.35 Existing pavement is badly cracked or shattered structurally.

The new pavement thickness ( $h_d$ ) was calculated using Section 7 of the IDOT Design Manual. The calculation was based on a pavement condition coefficient of 0.55, an Illinois Bearing Ratio (IBR) of 3 and an existing pavement thickness ( $h_b$ ) of 18-cm (7-in.). The calculated overlay thickness was 22-cm (8.75-in.).

## Method 2

The second design approach used was the AASHTO design method published in the AASHTO Guide for Design of Pavement Structures (4). The overlay thickness is given by:

$$D_{ol} = \sqrt{D_f^2 - D_{eff}^2} \quad (2)$$

Where:

$D_{ol}$  = Unbonded PCC overlay thickness in centimeters (inches)

$D_f$  = Slab thickness for future traffic in centimeters (inches)

$D_{eff}$  = Effective thickness of existing slab in centimeters (inches)

This method is based on the existing pavement design, traffic, condition of the existing pavement, support and drainage, serviceability loss, and reliability.

The slab thickness for future traffic ( $D_f$ ) refers to a new pavement design. The design is based on the effective modulus of the subgrade, concrete elastic modulus, mean concrete modulus of rupture, load transfer coefficient, drainage coefficient, design serviceability loss, reliability, overall standard deviation and traffic factor. These variables are used in the AASHTO rigid pavement design nomograph (AASHTO Figure 3.7, Design Chart for Rigid Pavement Based on Using Mean Values for Each Input Variable (Segment 1 and 2), ppg. II-45 - II-46).

The effective thickness of existing slab ( $D_{eff}$ ) refers to the effective thickness of an existing PCC or AC/PCC pavement. It is based on the results of the condition survey and is calculated with the following formula.

$$D_{eff} = F_{jcu} * D \quad (3)$$

Where:

$D$  = Existing PCC slab thickness in centimeters (inches) (maximum of 25-cm (10-in.))

$F_{jcu}$  = Joints and cracks adjustment factor for unbonded concrete overlays

$F_{jcu}$  adjusts for the loss in the PSI due to deteriorated reflection cracks and punchouts in the overlay caused by unrepaired cracks or other discontinuities in the existing slab prior to overlay. The number of deteriorated transverse joints and cracks per mile are entered on a graph to determine  $F_{jcu}$  (AASHTO Figure 5.13,  $F_{jcu}$  Adjustment Factor for Unbonded JPCP, JRCP and CRCP Overlays, pg. III-150).

The calculated overlay thickness was 24-cm (9.5-in.).

### Method 3

The third design approach used was an arbitrary thickness reduction from a new pavement thickness calculation based on the IDOT Design Manual. This approach calculates the pavement thickness for a new rigid pavement and subtracts 2.5-cm (1-in.) for the structural contribution of the existing concrete pavement. The overlay thickness is given by:

$$T_{ol} = T_{new} - 2.5 \quad (1) \quad (4)$$

Where:

$T_{ol}$  = Thickness of the unbonded overlay in centimeters (inches)

$T_{new}$  = Thickness of a new PCC pavement in centimeters(inches)

The new pavement thickness was calculated using Section 7 of the IDOT Design Manual. The calculated overlay thickness was 23.5-cm (9.25-in.).

The calculated thicknesses ranged from 22 to 24-cm (8.75 to 9.5-in.). A 23-cm (9-in.) unbonded concrete overlay was chosen.

The proposed cross section consisted of the existing pavement with the existing overlay serving as the interlayer and a 23-cm (9-in.) CRC overlay with tied PCC shoulders (Figure 4). IDOT requires percent steel in all CRCP. Underdrains were to be removed and replaced. Earthwork was to be completed on either side and an aggregate shoulder was to be placed adjacent to the PCC shoulder.

### **Overlay Tie In**

The existing pavement was to be removed and replaced on both ends of the project. At the bridge, the east end of the project, the existing lug system was to be removed and replaced. An experimental terminal treatment was to be installed with the new lug system (Figure 5). A lug system was to be used to tie back into the existing pavement on the west end of the project (Figure 6).

The experimental terminal treatment is called a piston dowel joint (Figure 7). The joint is designed as a normal expansion joint except special "pistons" are used in place of dowels. The joint is designed to push shut during pavement expansion. If more expansion is needed, the adjacent expansion joint can start to close. Upon pavement contraction, the piston dowel joint opens 5-cm (2-in.) and is held in this position by the piston head. If further contraction is needed, the adjacent expansion joint opens more. This unique design is installed to prevent the pavement slab between the expansion joint from pushing on the nearby bridge abutment. Six piston dowels were placed per 3.6-m (12-ft) lane (Figure 8).

### **Design Considerations**

A major consideration when designing an unbonded concrete overlay is the vertical clearance between the pavement and the overhead structure. AASHTO recommends a minimum clearance of 4.3-m (14-ft). IDOT policy is 5.0-m (16.25-ft) for new structures and 4.4-m (14.5-ft) for existing structures. To maintain this clearance the overhead structure must be raised or the pavement must be lowered. This is a common issue and

should be evaluated on a project to project basis. If there is an unbonded overlay in long term planning, it may be cost effective to raise the structures prior to letting of the overlay. The overhead structures were previously raised on this project. Therefore no vertical clearance problems were encountered.

## **CONSTRUCTION**

### **Surface Preparation**

Surface preparation for the overlay included partial depth patching and cold milling replaced with leveling binder. Since the existing bituminous overlay was serving as the interlayer, all existing concrete patches within the overlay (Figure 9) were milled off to the level of the existing PCC pavement and replaced with bituminous material. This provided a uniform bituminous interlayer cross section. The concrete patch was first milled down 7.5-cm (3-in.) (Figure 10). This was achieved in a couple passes of the milling machine. The area was cleaned and replaced with bituminous material (Figure 11).

The presence of rutting was perceived as a potential problem. Excessive rutting could cause a reduction in the percentage steel in isolated areas. A rut survey was performed and any areas where the rutting exceeding 1.3-cm (0.5-in.) were cold milled 2.5-cm (1-in.), cleaned, primed and covered with leveling binder. The leveling binder was placed to maintain the thickness of the interlayer.

The black surface of the bituminous material absorbs the heat of the sun. When the fresh concrete is placed on a hot surface, the speed of the hydration process is increased on the bottom of the new concrete slab causing thermal stresses to develop. Since the existing overlay was being used as the interlayer, it was felt that the surface was oxidized enough to reflect the heat of the sun. A pavement whitewash was recommended to be placed only on the areas where new bituminous material was placed if concrete paving occurred between June 15 and September 15.

## Paving Operations

Before the paving operation could begin, the reinforcing bars were placed on the existing pavement (Figure 12). On May 22, 1995, construction of the overlay commenced. A typical concrete pavement mixture was used for the overlay. An on-site concrete batch plant was used to supply concrete to the project.

The paving operation was the same as paving a new concrete pavement. Concrete trucks dumped into the spreader which was followed by the paver (Figures 13 and 14). As the concrete was fed through the paver, it was burlap dragged and finished by a mechanical float (Figure 15). The pavement was then hand finished (Figure 16). The tining machine was preceded by an artificial turf drag (Figure 17). After the water sheen disappeared from the pavement the curing machine dispensed curing compound onto the overlay (Figure 18). Centerline sawing commenced either late in the evening or the next day.

As paving approached June 15 the cold milled areas had not been overlaid. The reinforcing bars had already been placed making it difficult to apply any type of whitewash without affecting the reinforcing bars. Therefore, water trucks were used to reduce the temperature of the cold milled areas by spraying water on the bituminous material.

Although areas with significant rutting were addressed in the plans, the contractor was still concerned about overruns; therefore, some preliminary measurements of rut depths and existing and proposed cross slopes were made. A 1530-m<sup>3</sup> (2000-yd<sup>3</sup>) overrun was calculated. The contractor felt that this was a significant overrun and proposed to cold mill the surface to get a truer profile at IDOT's expense. Cold milling the surface would cause an unacceptable reduction in the thickness of the interlayer. As discussed earlier, this could adversely affect the performance of the overlay. Consequently, the contractor paved the overlay with no additional surface preparation.

## EARLY PERFORMANCE MONITORING

### Falling Weight Deflectometer

Structural testing of the pavement was made with a Dynatest 8002 Falling Weight Deflectometer (FWD) (Figure 19). The FWD is a non-destructive device which loads the pavement equivalently to a moving truck load. Drops were made every 152.5-m (500-ft) with loads ranging from 3178 to 4994-kg (7000 to 11,000-lb). Each drop was normalized to a standard 4086-kg (9000-lb) during analysis. The FWD data and statistics for before and after construction of the overlay are summarized in Table 1.

In April 1995, the FWD was used to determine the structural capacity of the existing pavement before construction of the overlay. The average deflection was 0.19-mm (7.46-mils). Area values are an indication of pavement rigidity and range from 30 to 90-cm (12 to 36-in.). These values are calculated by determining the 'area' of the deflection basin (Figure 20). The average area was 63-cm (25.24-in.).

In July 1995, the FWD was used to determine the structural capacity of the overlay. The average deflection was 0.05-mm (2.02-mils). The average deflection decreased by 73% with less variation. The average area was 78-cm (31.03-in.). The average area was increased by 23 percent with minimal variation. The structural capacity of the pavement was increased by the addition of the unbonded overlay.

The data shows that the overlay increased the structural capacity of the pavement cross section. The pavement should have structural properties equivalent to a new concrete pavement of similar thickness. To examine this, the post-construction FWD data was compared to FWD data of a new concrete pavement. The new concrete pavement used for comparison was a section of I-39. The section tested was a 25.40-cm (10-in.) CRCP constructed on a 10-cm (4-in.) stabilized subbase and 30 to 40-cm (12 to 16-in.) of lime-modified soil. Historical data shows the average deflection on the I-39 section is 0.06-mm (2.5-mils) and the average area is 77-cm (30.92-in.). Comparing this data to the average deflection of 0.05-mm (2.02-mils) and the average area of 78-cm (31.03-in.) of the unbonded overlay, the deflection is lower and the area is slightly higher. This

implies that a nominal 23-cm (9-in.) unbonded overlay design is structurally comparable to a nominal 25-cm (10-in.) new pavement design.

### **Thickness**

Cores were cut to determine pavement thickness. The average core thickness was 24-cm (9.7-in.) with a standard deviation of 1.3-cm (0.5-in.). Some factors contributed to the thick pavement: cross slopes greater than 2.2 cm/m (3/16 in./ft), dips in the original pavement, rutting, and penalties for thin pavement. Concrete pavement thicker than designed is fairly common in Illinois.

### **Smoothness**

All mainline pavement was tested with the California profilograph. Per Illinois specifications, the average profile index for the entire project length must not exceed 6.7 cm/km (4.25 in./mi). The measured profile index for the unbonded overlay was 2.3 cm/km (1.45 in./mi). The contractor received 103% of the unit bid price, for the overlay, which is given for any profile index under 3.6 cm/km (2.25 in./mi).

### **COST ANALYSIS**

A preliminary cost estimate was made to measure the cost effectiveness of unbonded concrete overlays compared to reconstruction. Bid prices from the unbonded concrete overlay were compared to bid prices of a CRCP reconstruction on I-80. The bid items were categorized as bridges, bituminous surfacing, crossovers, grading, miscellaneous, pavement, pavement removal, subbase items and traffic control. Total project costs were determined per 2-lane mile for comparable items. The analysis produced a \$807,476 cost for the unbonded concrete overlay and a \$1,456,533 cost for the CRCP reconstruction. A breakdown of these items can be found in Table 2. These costs indicate unbonded concrete overlays can provide a cost effective alternative to complete removal and replacement. However, each project is unique and should be evaluated on an individual basis.

## SUMMARY

With increased loads and traffic, many Illinois portland cement concrete pavements are reaching the end of their service lives. Forty percent of interstate portland cement concrete pavements in Illinois are D-cracked and are difficult to repair. Unbonded concrete overlays are being studied to determine whether they can provide long term pavement rehabilitation.

The selected project site was located east of Galesburg, westbound on I-74. The existing pavement consisted of 10-cm (4-in.) of BAM stabilized subbase with a 18-cm (7-in.) CRCP. The existing bituminous concrete overlay ranged from 7.5 to 11-cm (3 to 4.5-in.).

Three design approaches were used to determine the thickness of the overlay; the U.S. Army Corps of Engineers method published in NCHRP Synthesis 99, the AASHTO design method published in the AASHTO Guide of Pavement Structures, and an arbitrary thickness reduction from a new pavement thickness calculation based on the IDOT Design Manual. The calculated thicknesses ranged from 22 to 24-cm (8.75 to 9.5-in.). The proposed cross section consisted of the existing pavement with the existing overlay serving as the interlayer and a 23-cm (9-in.) CRC overlay with tied PCC shoulders.

FWD data demonstrated an increase in the structural capacity of the pavement due to the addition of the unbonded overlay. The pavement should have structural properties equivalent to a new concrete pavement of similar thickness. To examine this, the post-construction FWD data was compared to FWD data of a new concrete pavement. The comparison proved that a nominal 23-cm (9-in.) unbonded concrete overlay design is structurally comparable to a nominal 25-cm (10-in.) new pavement design.

A preliminary cost estimate was made to determine the cost effectiveness of unbonded concrete overlays compared to reconstruction. Bid prices from the unbonded concrete overlay were compared to bid prices of a CRCP reconstruction. The calculated numbers indicate unbonded overlays can provide a cost effective alternative to complete reconstruction. Each project is unique and should be evaluated on an individual basis.

To date, the constructability of an unbonded concrete overlay is proven. A two-year performance observation period will be complete in October 1997. The evaluation will be based upon observations of the existing pavement conditions, construction procedures and field performance. In addition, the evaluation will also be based on the analysis of deflection, roughness and skid measurements. This experimental project will continue the evaluation of unbonded CRC overlays by providing information on the suitability of unbonded concrete overlays as an alternative to reconstruction for D-cracked CRC pavements and if the existing bituminous overlay can function as the interlayer.

## **CONCLUSIONS AND RECOMMENDATIONS**

Several conclusions and recommendations are made concerning the planning, design and construction of the unbonded concrete overlay:

- The structural capacity of the pavement was increased by the addition of the unbonded concrete overlay.
- The unbonded concrete overlay is structurally comparable to a new concrete pavement.
- Unbonded concrete overlays can provide a cost effective alternative to complete reconstruction.
- Cross sections should be taken to determine the pavement trueness, so any irregularities can be addressed in the design phase.

## REFERENCES

1. Hutchinson, Ronald L. *Resurfacing with Portland Cement Concrete*. National Cooperative Highway Research Program Synthesis of Highway Practice 99. TRB, National Research Council, Washington, D.C., December 1982.
2. Lippert, David L. and DuBose, James B. *Performance Evaluation of Concrete Overlays*. Physical Research Report No. 101. Illinois Department of Transportation, Bureau of Materials and Physical Research, Springfield, Illinois, November 1988.
3. Barenberg, Ernest J. Rehabilitation of Concrete Pavements by Using Portland Cement Concrete Overlays. *Transportation Research Record 814*, TRB, National Research Council, Washington, D.C., 1981, pp. 29-34.
4. American Association of State Highway and Transportation Officials. *AASHTO Guide for Design of Pavement Structures 1993*. American Association of State Highway and Transportation Officials, Washington, D.C., 1993.
5. Illinois Department of Transportation. *Pavement Condition Rating Survey Distress Guide*. Illinois Department of Transportation, Office of Planning and Programming, Springfield, Illinois, 1992.
6. Tabatabaie, A. M. and Barenberg, E. J. Finite-Element Analysis of Jointed or Cracked Concrete Pavements. *Transportation Research Record 671*. TRB, National Research Council, Washington, D. C., 1978, pp. 11-17.

**TABLE 1**

FWD Statistics for Deflections

Test Date	# of Tests	D <sub>0</sub> (mils)			D <sub>1</sub> (mils)			D <sub>2</sub> (mils)		
		AVG	STD	CV(%)	AVG	STD	CV(%)	AVG	STD	CV(%)
4/95	61	7.46	2.25	30.12	5.42	1.10	20.35	4.38	0.77	17.65
7/95	76	2.02	0.28	13.64	1.83	0.26	14.23	1.66	0.25	14.99

Test Date	# of Tests	D <sub>3</sub> (mils)			AREA (in)			ERI (ksi)		
		AVG	STD	CV(%)	AVG	STD	CV(%)	AVG	STD	CV(%)
4/95	61	3.39	0.57	16.91	25.24	3.13	12.42	10.03	1.86	18.51
7/95	76	1.47	0.23	15.47	31.03	1.14	3.66	17.44	1.03	5.89

D<sub>0</sub>, D<sub>1</sub>, D<sub>2</sub> and D<sub>3</sub> are surface deflections at 0, 12, 24 and 36 inch offsets from the center of the loading plate.

$$\text{Area in inches} = 6 * (D_0 + 2*D_1 + 2*D_2 + D_3) / D_0$$

Reference 5

$$\text{ERI in ksi} = 24.7 - (5.41 * D_3) + (0.31 * D_3^2)$$

Reference 5

**TABLE 2**

**I-74 Unbonded PCC Overlay**  
Letting Date 10/7/94

Item	Project Cost	\$/2-Lane Mile
Bridges	\$994,091	N/A*
Bituminous Surfacing	\$385,486	N/A*
Crossovers	\$106,302	N/A*
Grading	\$353,425	44,178
Miscellaneous	\$119,178	14,897
Pavement	\$5,117,026	639,628
Traffic Control	\$870,184	108,773
<b>Total Project Cost</b>	<b>\$7,945,692</b>	<b>807,476</b>

**TABLE 3**

**I-80 CRCP Reconstruction**  
Letting Date 5/19/95

Item	Project Cost	\$/2-Lane Mile
Crossovers	\$544,798	N/A*
Grading	\$541,864	81,853
Miscellaneous	\$664,902	100,438
Pavement	\$6,276,655	948,137
Pavement Removal	\$510,893	77,174
Subbase Items	\$410,328	61,983
Traffic Control	\$1,237,593	186,948
<b>Total Project Cost</b>	<b>\$10,249,026</b>	<b>1,456,533</b>

\*This item was unique to this project and does not apply to the rehabilitation on a per 2-lane mile basis.

Description of Items

Bridges - All items that apply to bridge reconstruction.

Bituminous Surfacing - All items that apply to the placement of a bituminous surface.

Crossovers - Earthwork, drainage, pavement and pavement removal.

Grading - Regrading slopes, ditch reprofiling, seeding and erosion control.

Miscellaneous - Various items such as guardrail, attenuators, signs and other items not generally associated with the rehabilitation option.

Pavement - Pavement preparation, patching, mainline concrete, asphalt resurfacing, shoulders, shoulder aggregate and pavement marking.

Pavement Removal - Removal of bituminous surface and original concrete pavement.

Subbase Items - Lime modification, granular subbase and granular base items.

Traffic Control - Items associated with maintaining traffic.

# Unbonded Concrete Overlays

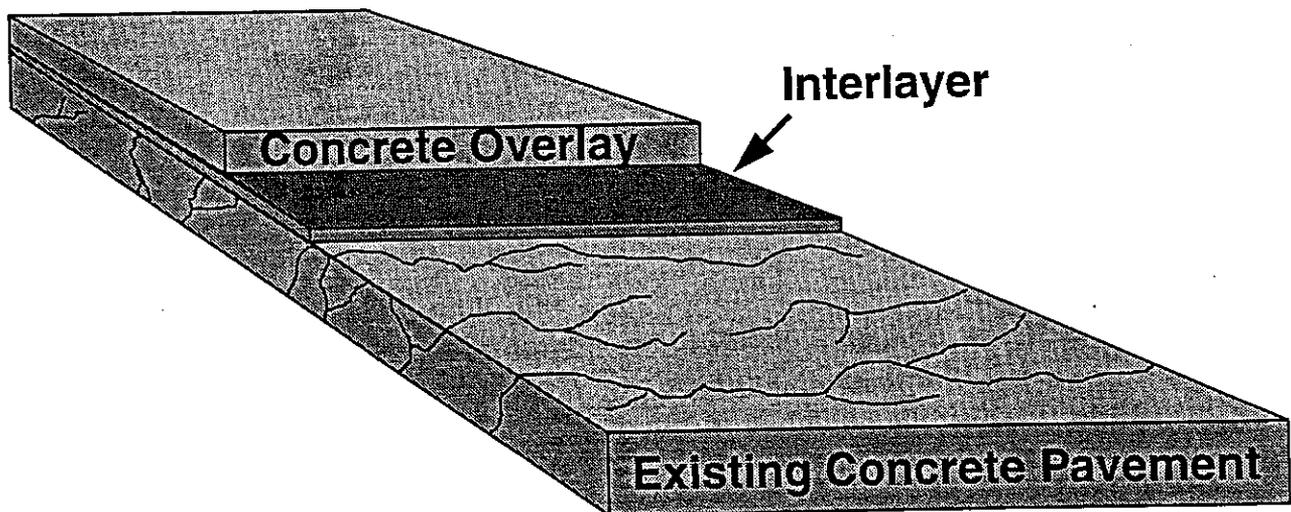


FIGURE 1. An unbonded concrete overlay consists of the existing concrete pavement, a separation material or interlayer, and the concrete overlay.

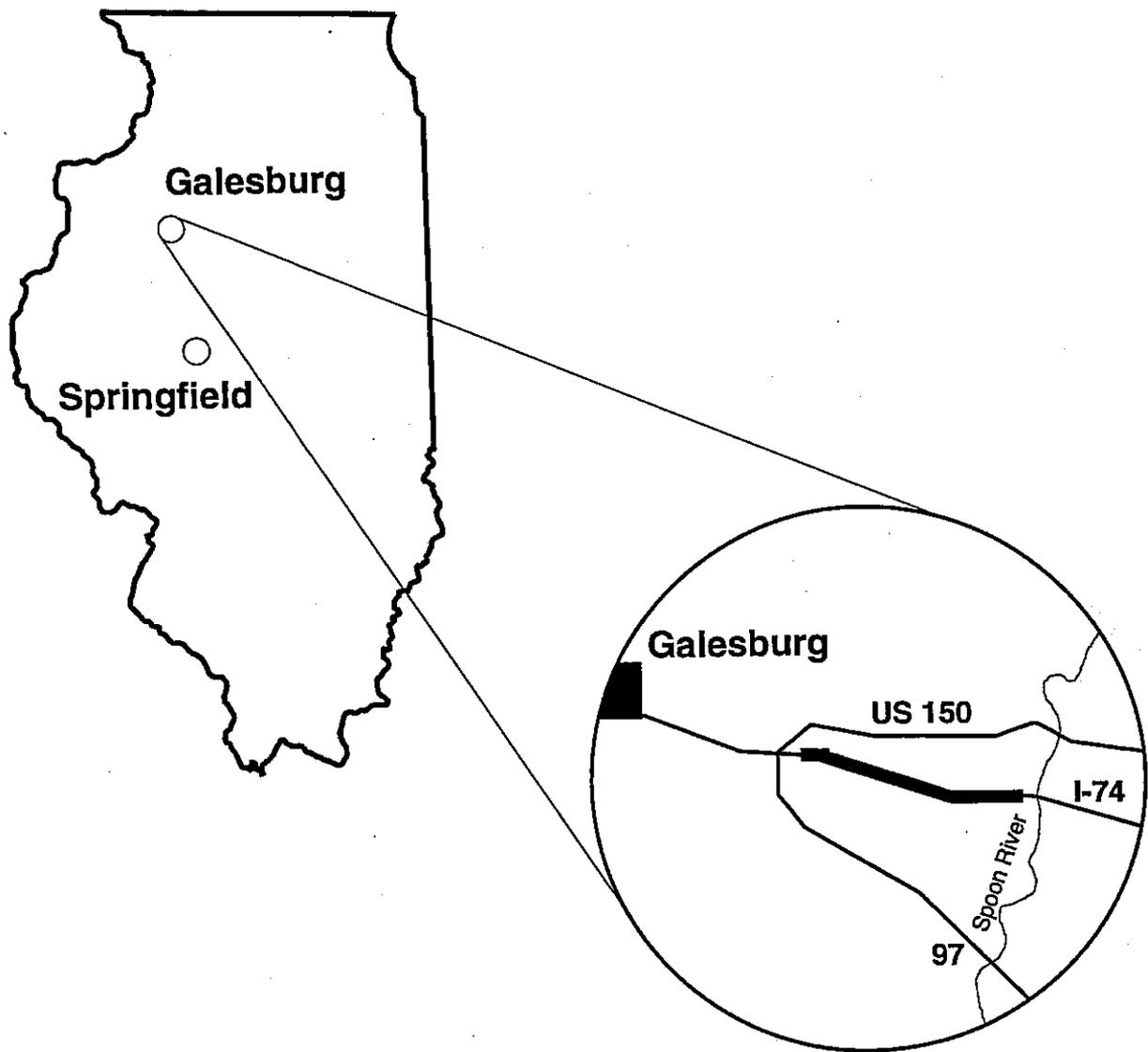


FIGURE 2. The selected project site was located east of Galesburg, westbound on I-74 between milepost 53.79 and 61.73.

# Existing Cross Section

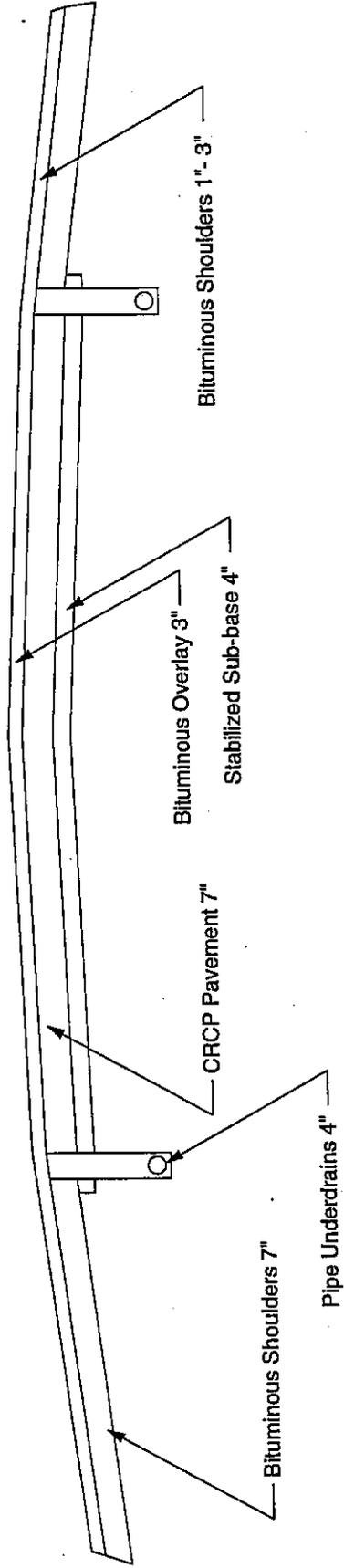


FIGURE 3. Existing cross section of westbound I-74 east of Galesburg.

# Proposed Cross Section

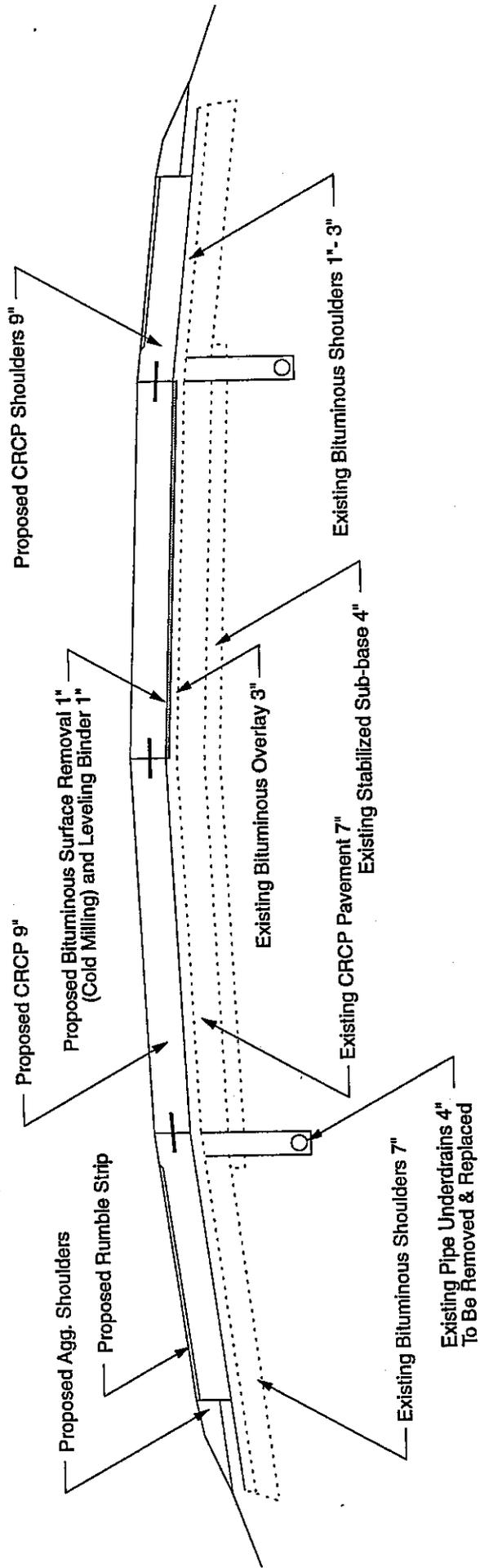


FIGURE 4. Proposed cross section of the I-74 unbonded concrete overlay.

# Spoon River Bridge Tie In

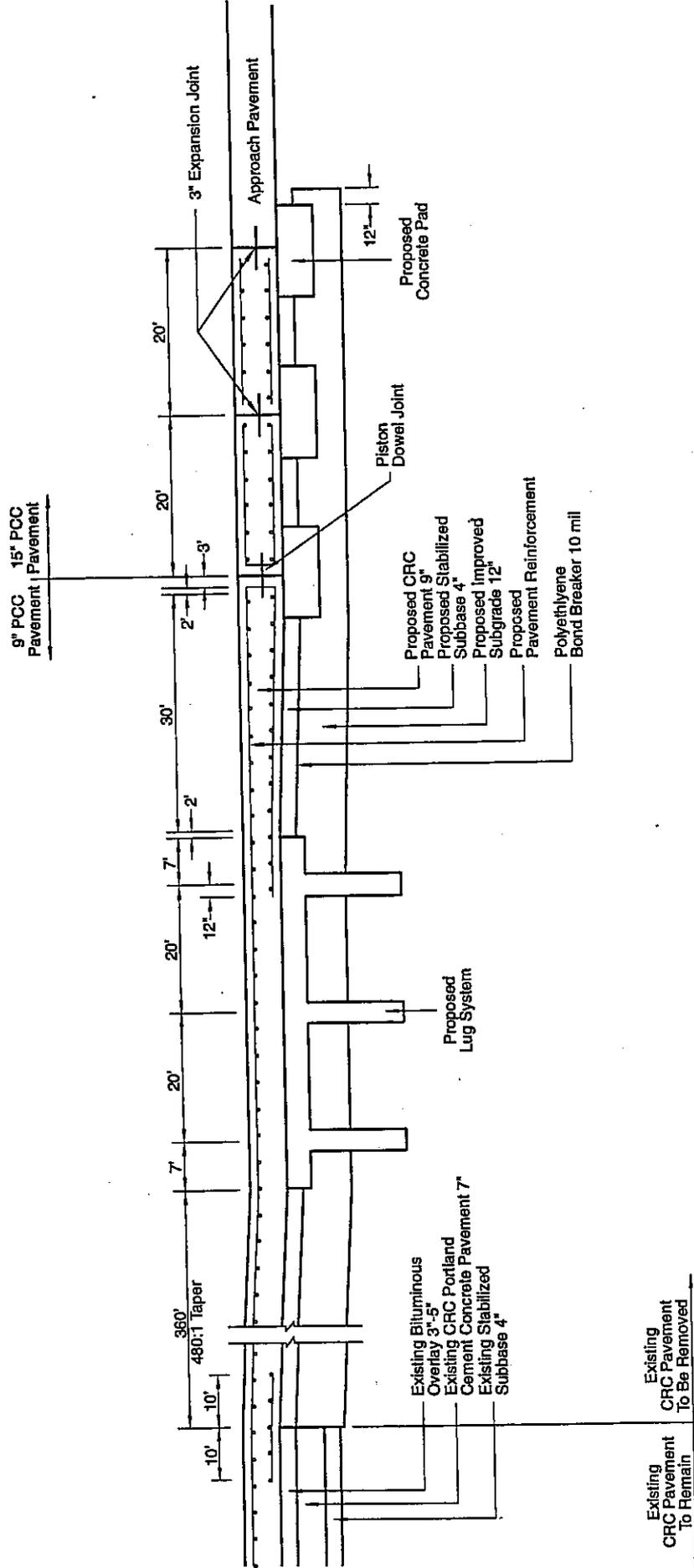


FIGURE 5. Pavement tie in at the Spoon River Bridge.

Not To Scale

# West End Pavement Tie In

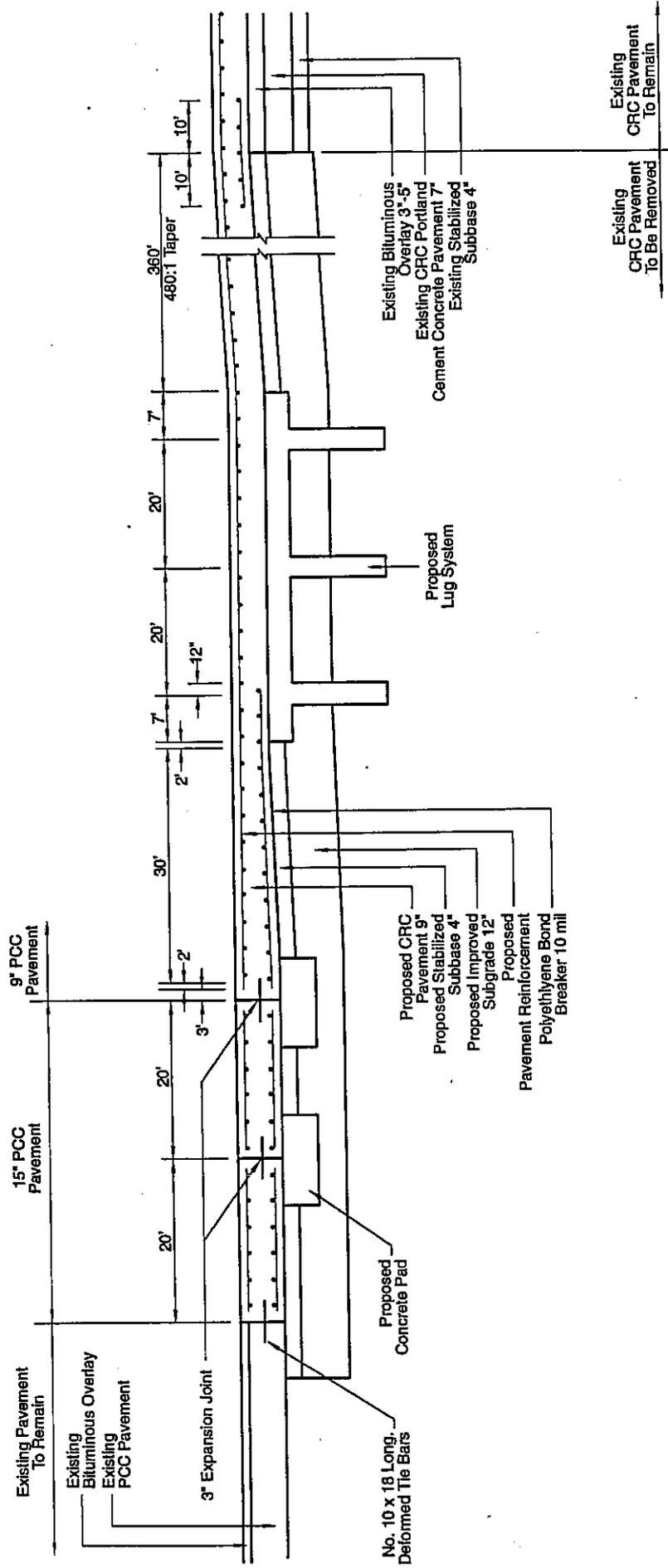


FIGURE 6. Pavement tie in at the west end of the project.

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# Piston Dowel Joint

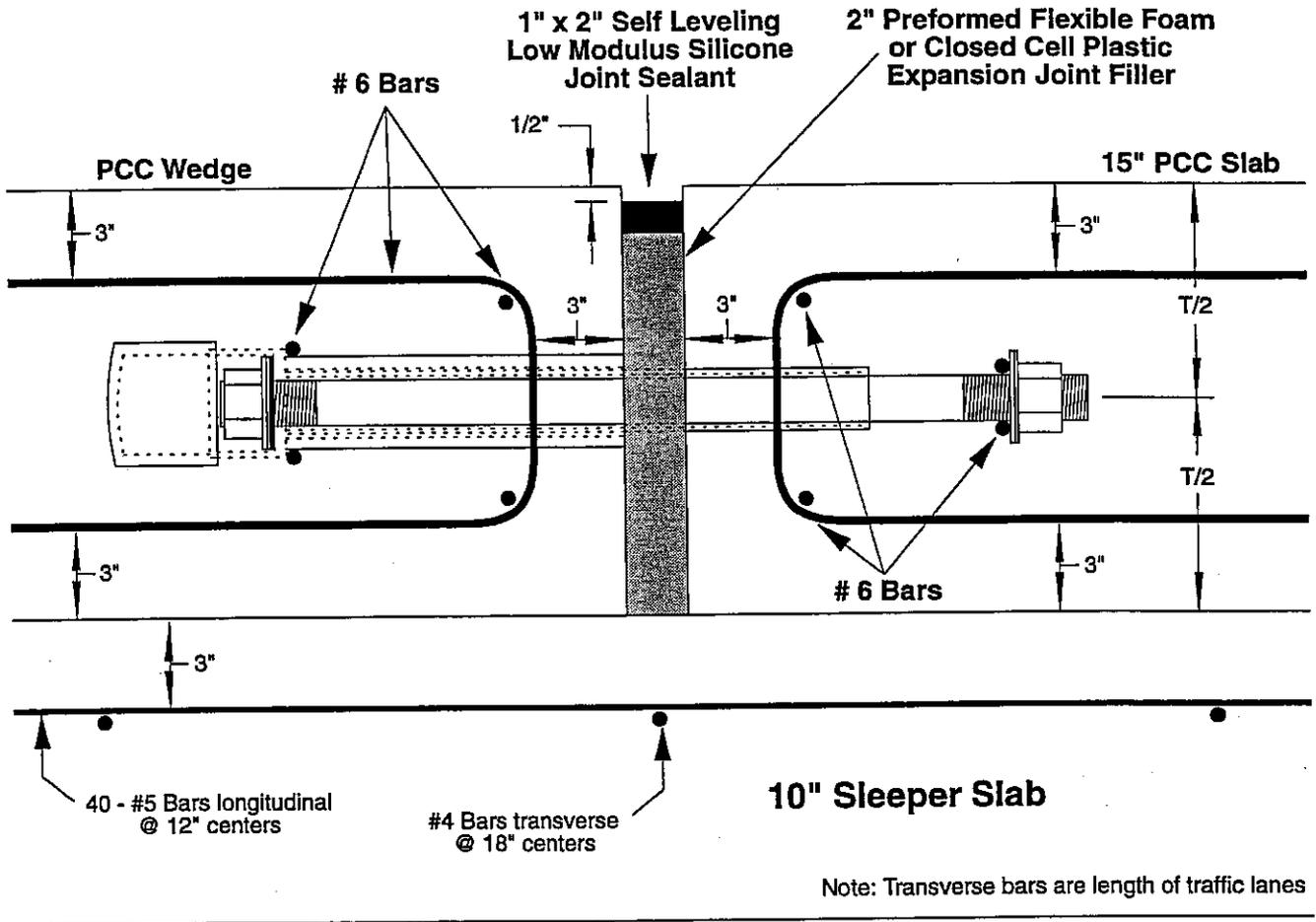


FIGURE 7. The piston dowel joint is an experimental terminal treatment that was designed as a normal expansion joint except special "pistons" are used in place of dowels.

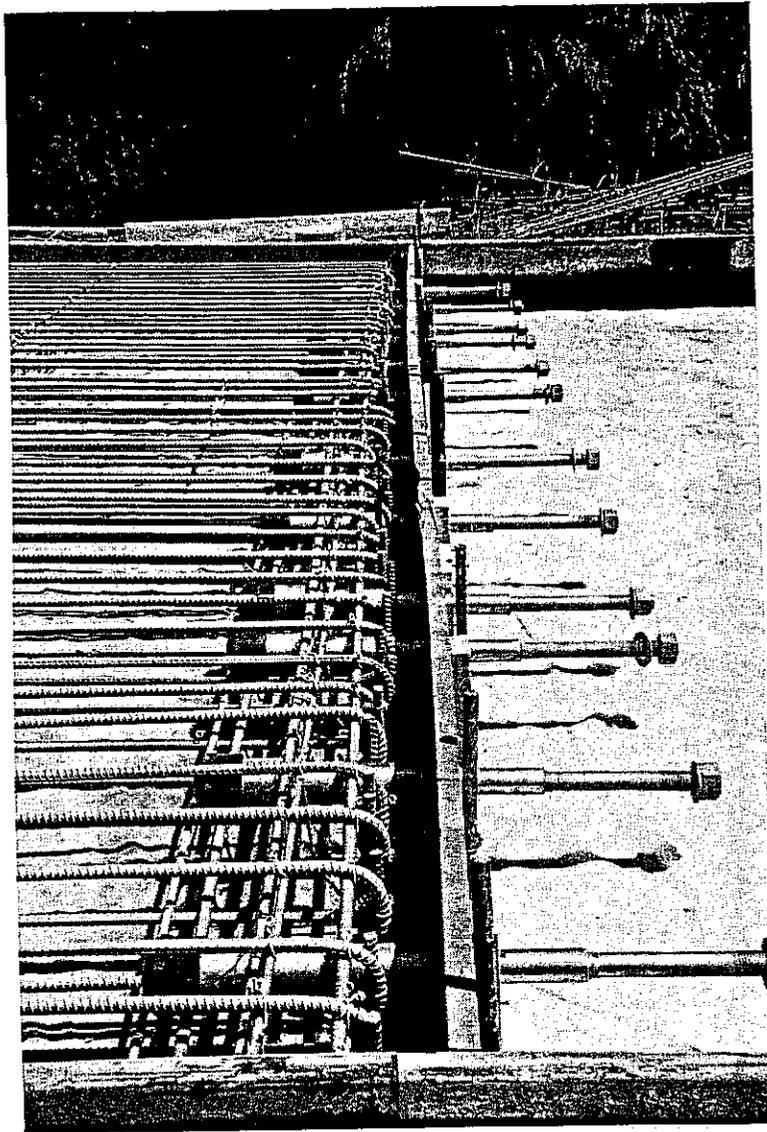


FIGURE 8. Six piston dowels were placed per twelve foot lane.

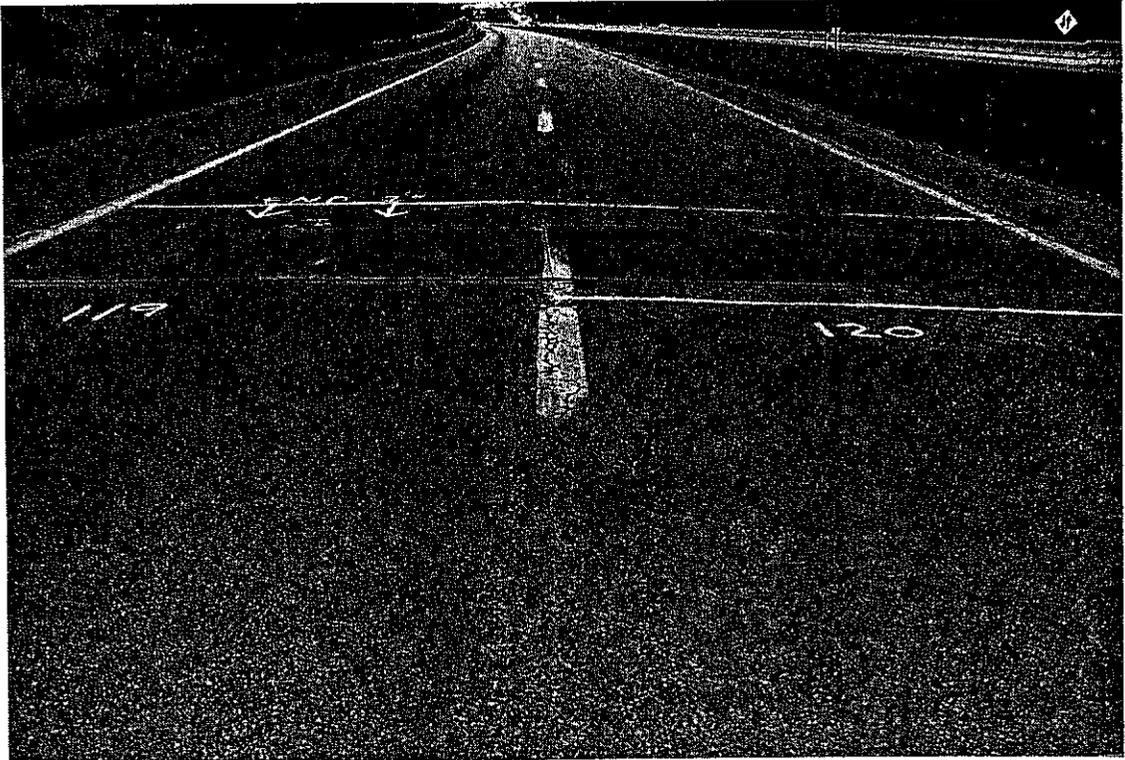


FIGURE 9. All existing concrete patches within the overlay were milled to the existing PCC pavement.



FIGURE 10. Concrete patches were milled down three inches. This was achieved in a couple passes of the milling machine.

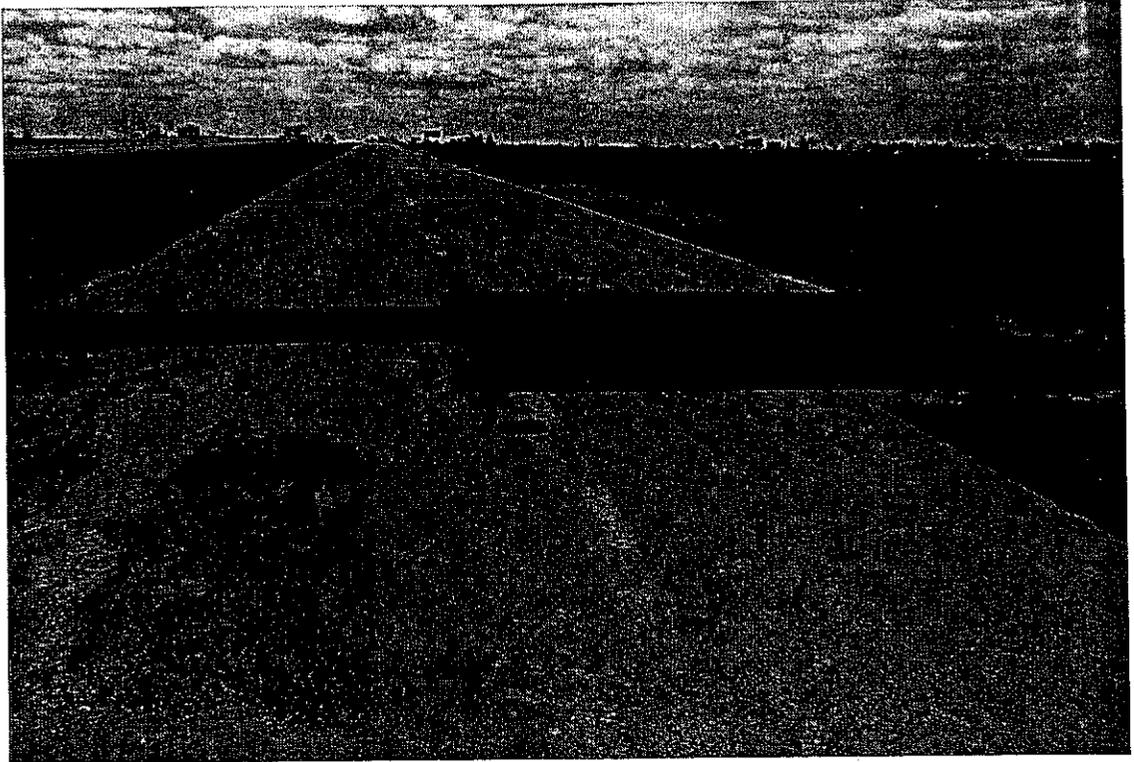


FIGURE 11. The area was cleaned and replaced with bituminous material.

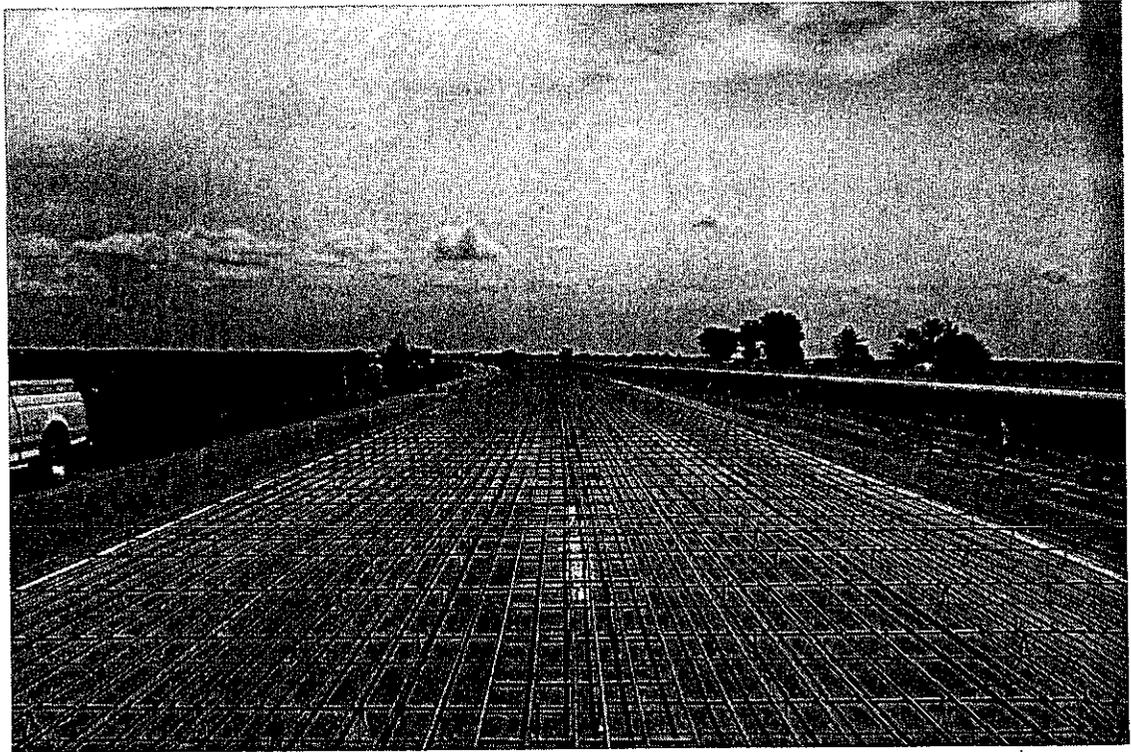


FIGURE 12. Rebar was placed on the existing pavement.

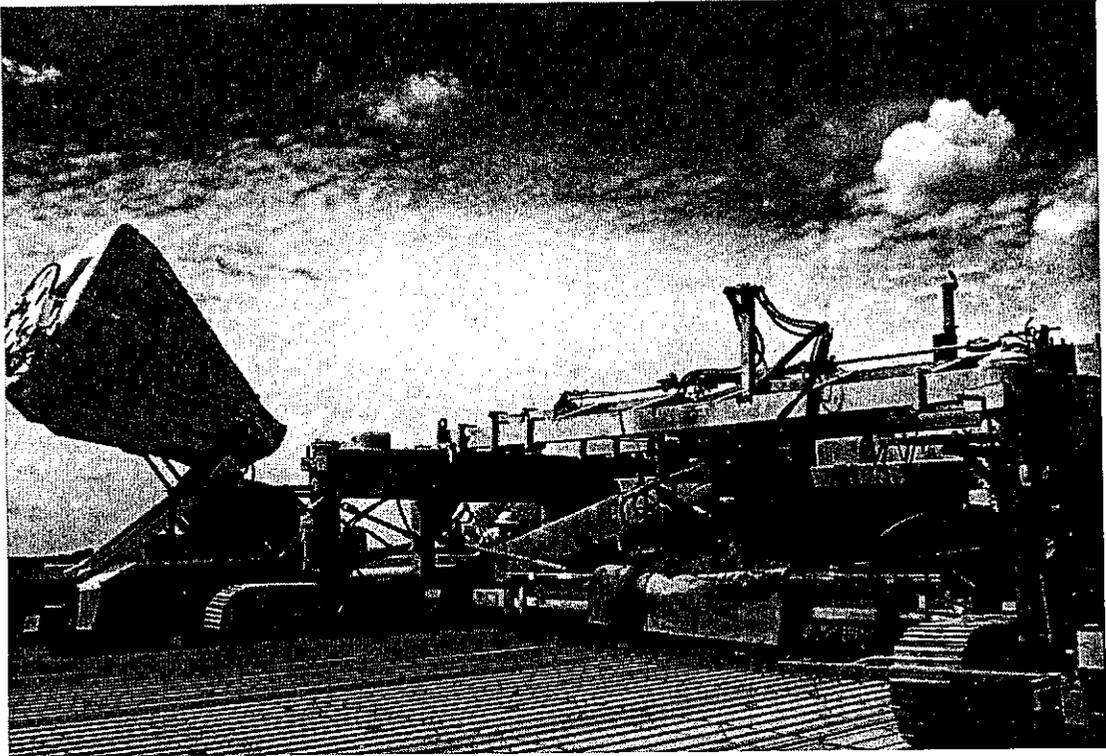


FIGURE 13. The paving operation was the same as paving a new concrete pavement. Concrete trucks dumped into the spreader.

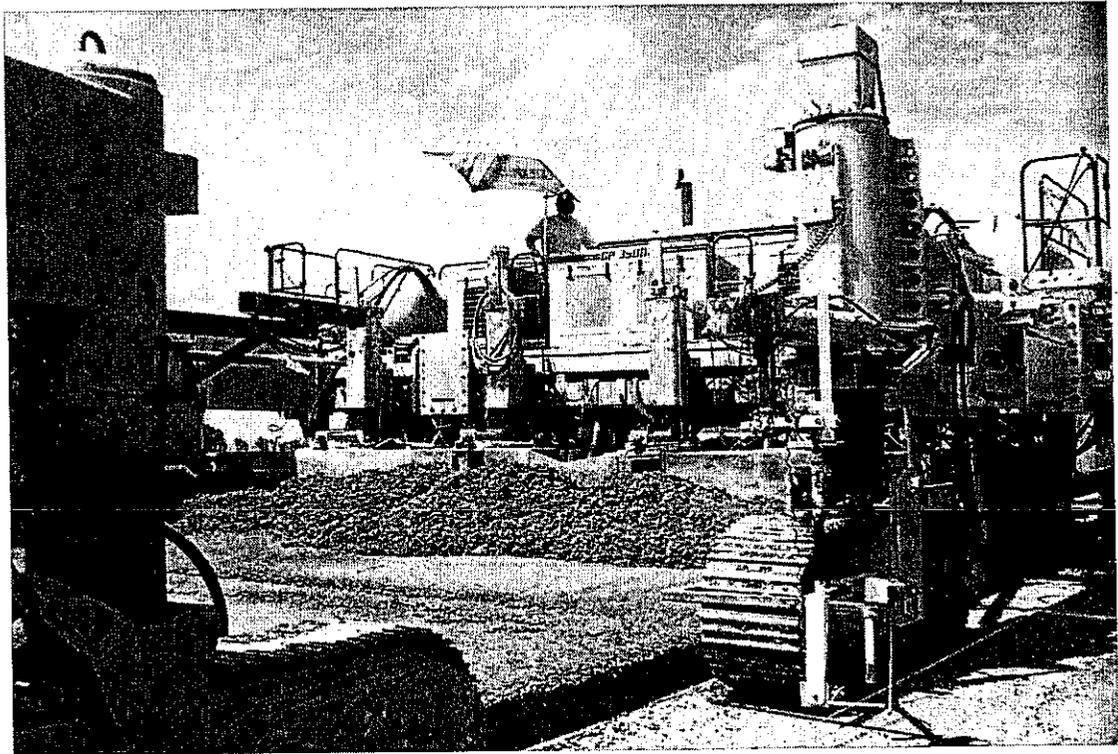


FIGURE 14. The spreader was followed by the paver.

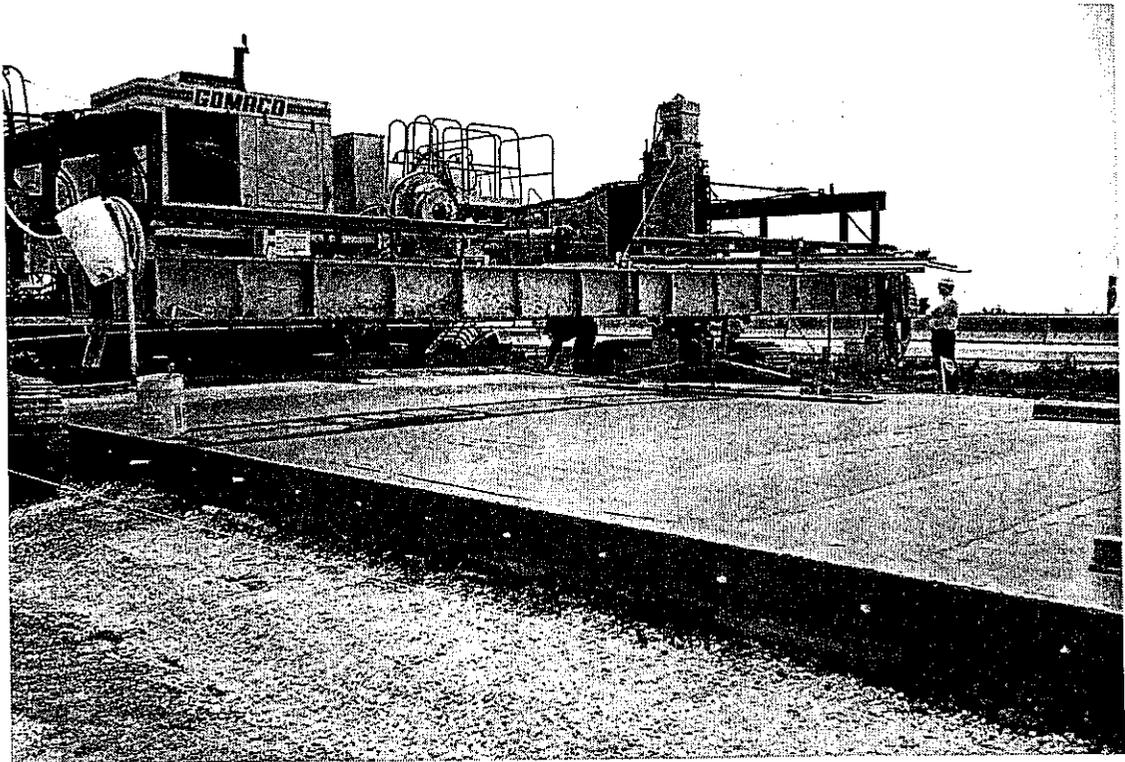


FIGURE 15. As the overlay proceeded through the paver it was burlap dragged and finished by a mechanical float.

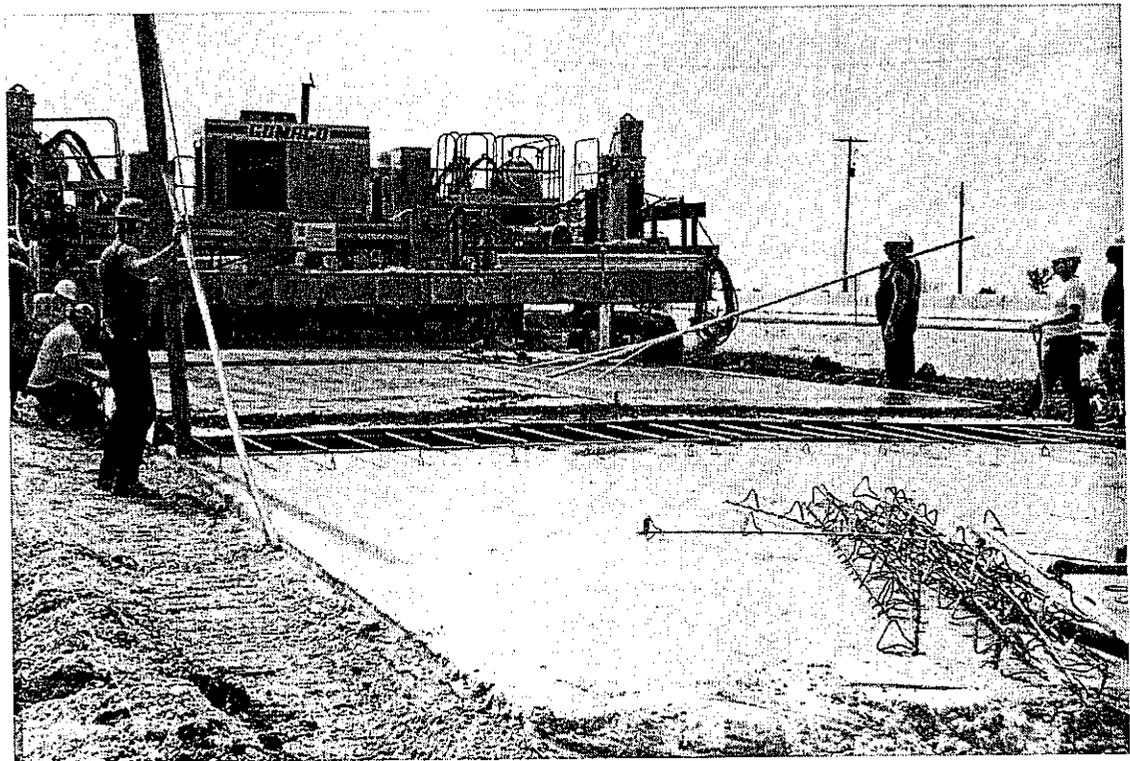


FIGURE 16. Hand finishing followed the burlap drag and mechanical float.

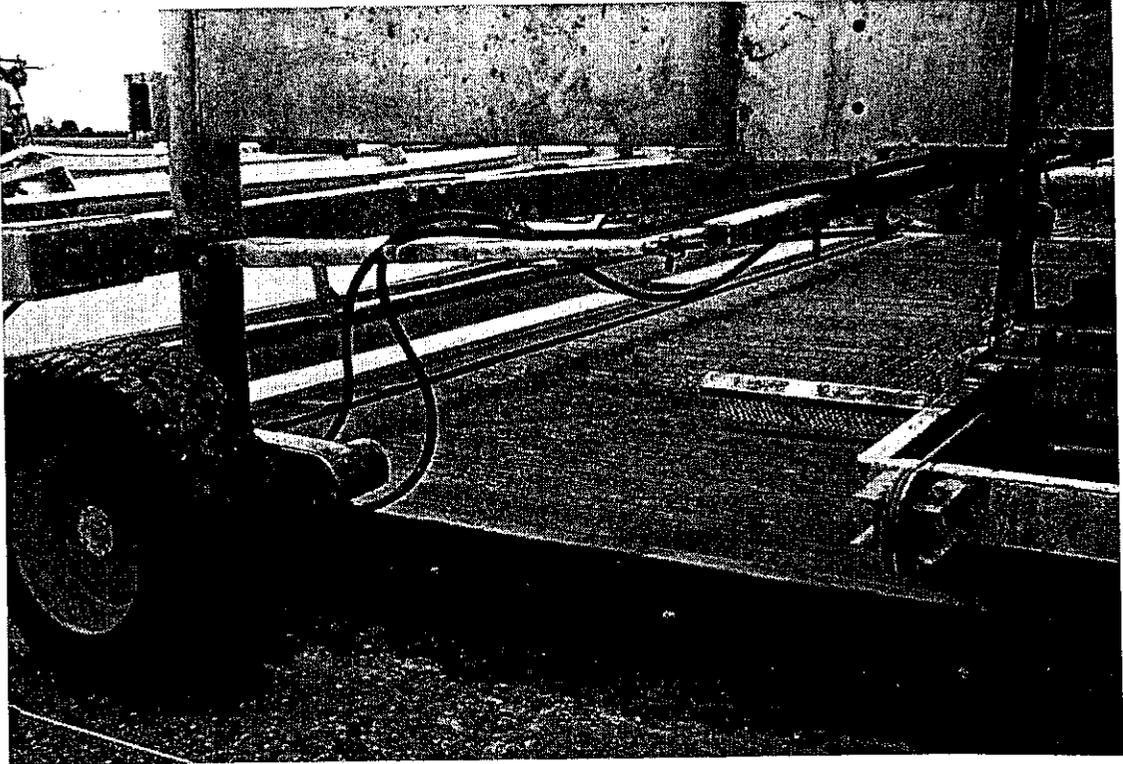


FIGURE 17. The tining machine was preceded by an artificial turf drag.

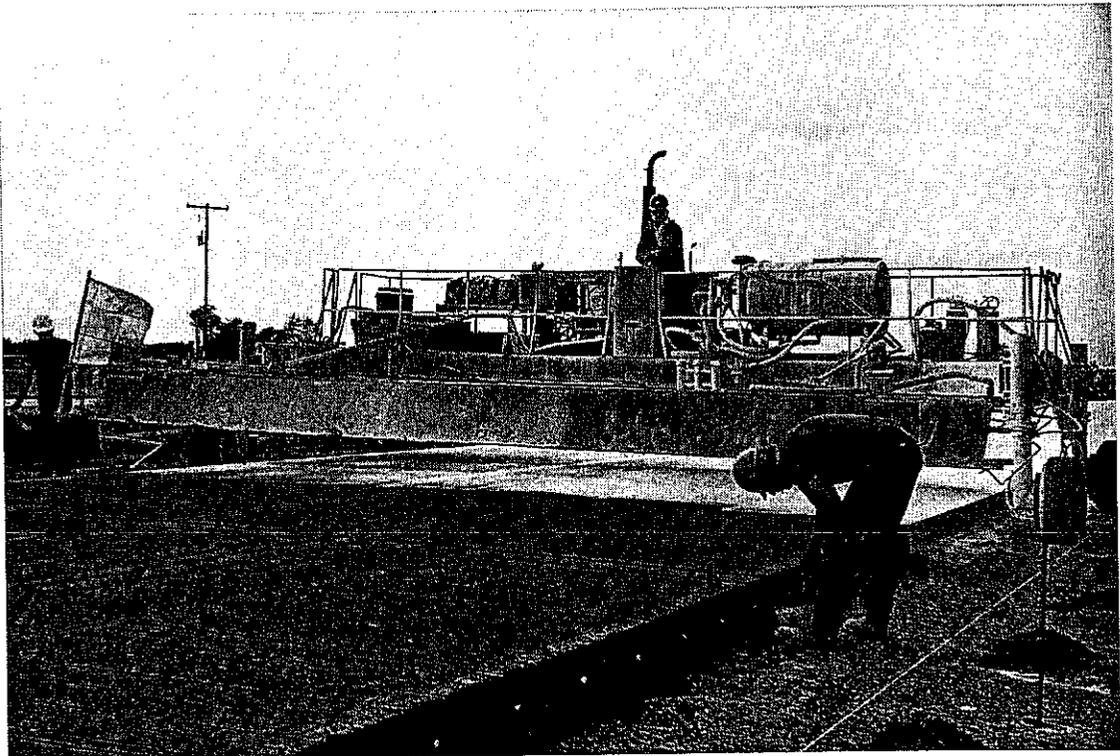


FIGURE 18. After the water sheen disappeared from the pavement the curing machine sprayed curing compound onto the overlay.

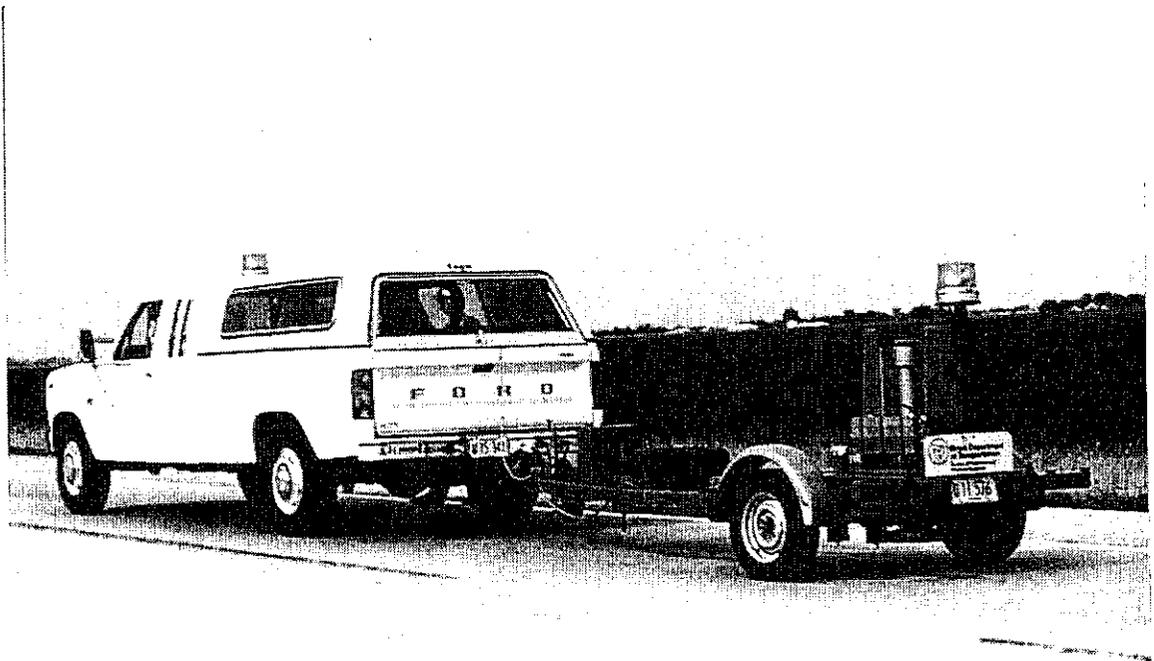
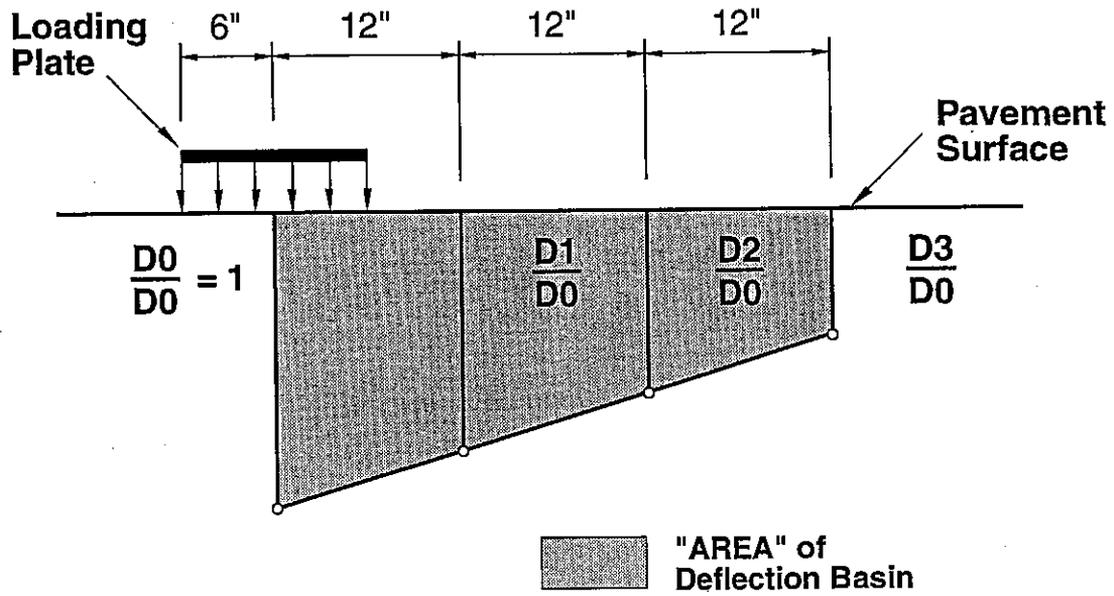


FIGURE 19. Structural testing of the pavement was made with a Dynatest 8002 Falling Weight Deflectometer (FWD). The FWD is a non-destructive device which loads the pavement equivalently to a moving truck load.



$$\text{AREA (inches)} = 6 \left( 1 + 2 \frac{D1}{D0} + 2 \frac{D2}{D0} + \frac{D3}{D0} \right)$$

FIGURE 20. FWD deflection basin area.