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16. Abstract

The purpose of this study was to evaluate a bonded steel fiber reinforced concrete overlay on an existing 8-inch CRC pavement on Interstate 10 south of Baton Rouge, LA. The project objectives were to provide an overlay with a high probability for long term success by using a concrete mix with high cement content, internal reinforcement, and with good bonding characteristics.

The existing 16 year old CRC pavement had carried twice its design load and contained only a few edge punch-out failures per mile. A 4-inch concrete overlay was designed for a 20-year service life. An additional level of reinforcement-bonding was provided which utilized curb type reinforcement bars epoxied into the existing slab. The primary purpose in the additional reinforcement was to provide positive bonding at the slab edges where thin overlays have a tendency to debond due to curling and/or warping. A 9-inch tied concrete shoulder was added to increase the pavements structural capacity.

The overall Serviceability Index of the pavement increased from 3.4 to 4.4 with measured Profile Index levels typically below the 5-inch per mile specification. Test revealed excellent bond strengths, and reduced edge deflections by 60% under a 22,000 pound moving single axle loading. Cores taken over transverse cracks in the overlay indicated reflection cracking from the transverse cracks in the original pavement. The final results reveal an estimated 35% of these cracks have reflected through and debonding has not occurred at the pavement edges. Anticipation of reflective cracking was one consideration in using the steel fibers which provide three-dimensional reinforcement.

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DESIGN AND CONSTRUCTION OF A BONDED FIBER CONCRETE OVERLAY OF CRCP

FINAL REPORT

BY

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RESEARCH REPORT NO. 266
RESEARCH PROJECT NO. 90-1P(B)

Conducted by
LOUISIANA TRANSPORTATION RESEARCH CENTER,
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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

March 1993

ABSTRACT

The purpose of this study was to evaluate a bonded steel fiber reinforced concrete overlay on an existing 8-inch CRC pavement on Interstate 10 south of Baton Rouge, LA. The project objectives were to provide an overlay with a high probability for long term success by using a concrete mix with high cement content, internal reinforcement, and with good bonding characteristics.

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IMPLEMENTATION STATEMENT

After successfully using the construction technique of a fiber concrete overlay a second project was designed and constructed (State Project No. 450-11-0027) on I-10 between La 30 and La 44 near Gonzales, La., and was recently completed in the fall, 1992. This site also contained approximately one mile of SHRP, SPS-7, test sections. Other projects using this type of construction technique include State project 450-10-90, located on I-10 between La 42 and La 73 which is scheduled to begin construction in the spring of 1993. Also scheduled for contract letting is State project 450-11-34, located between La 73 and La 30, which is scheduled for October 1994. Each of these projects have or will employ the design and construction procedures evaluated in this study.

The use of fibers in thin bonded concrete overlays has enabled LDOTD to increase the existing CRC pavement cross section's structural capacity by 50%, and increasing the current design service life to 20 years.

SI UNIT CONVERSION FACTORS*

To Convert from	To	Multiply by
	Length	
foot	meter (m)	0.3048
inch	meter (m)	0.0254
yard	meter (m)	0.9144
mile (statute)	kilometer (km)	1.609
	Area	
square foot	square meter (m^2)	0.0929
square inch	square meter (m^2)	0.000645
square yard	square meter (m^2)	0.8361
	Volume (Capacity)	
cubic foot	cubic meter (m^3)	0.02832
gallon (U.S. liquid)**	cubic meter (m^3)	0.003785
gallon (Can. liquid)**	cubic meter (m^3)	0.004546
ounce (U.S. liquid)	cubic meter (m^3)	0.03382
	Mass	
ounce-mass (avdp)	kilogram (kg)	0.02835
pound-mass (avdp)	kilogram (kg)	0.4536
ton (metric)	kilogram (kg)	1000
ton (short, 2000 lbs)	kilogram (kg)	907.2
	Mass per Volume	
pound-mass/cubic foot	kilogram/cubic meter (kg/m^3)	16.02
pound-mass/cubic yard	kilogram/cubic meter (kg/m^3)	0.5933
pound-mass/gallon (U.S.)**	kilogram/cubic meter (kg/m^3)	119.8
pound-mass/gallon (Can.)**	kilogram/cubic meter (kg/m^3)	99.78
	Temperature	
deg Celsius (C)	Kelvin (K)	$t_k=(t_c+273.15)$
deg Fahrenheit (F)	Kelvin (K)	$t_k=(t_F+459.67)/1.8$
deg Fahrenheit (F)	Kelvin (K)	$t_c=((t_F-32)/1.8)$

*The reference source for information on SI units and more exact conversion factors is "Metric Practice Guide" ASTM E 380.
**One U.S. gallon equals 0.8327 Canadian gallon.

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INTRODUCTION

Continuously reinforced concrete pavements (CRCP) became a standard rigid pavement design for Louisiana's interstate construction in the decade of the 1970's. A total of 127 centerline miles were constructed on three interstate routes, all 8-inches thick with identical section design details. Cross sectional area of the steel was 0.6% with river gravel used as coarse aggregate.

Performance of CRCP under heavy interstate traffic varied, with several projects experiencing longitudinal cracking and multiple edge punch out failures within only 5 years of service. Typically those pavements were reconstructed prior to 10 years of age. Many of the remaining CRCP projects, including the subject overlay project, began to develop failures within 10 years of service. Previous performance has shown that this mode of failure continues at an increasing rate if not arrested.

In 1989, the LDOTD selected a CRCP for overlay which contained several edge punch out failures per mile in an attempt to arrest the failures by thickening the 8-inch slab sufficient to carry continued interstate loads. The project selected for bonded concrete overlay was a sixteen year old, 4-lane section of Interstate 10, located south of Baton Rouge. The design objectives were to provide an overlay with a high chance of long term success by providing strong concrete with internal reinforcement and excellent bond.

Some of the design variables used to increase the probability of long term performance included: (1) Concrete reinforced with steel fibers and a high cement factor, (2) a clean, textured bonding surface, (3) edge bond reinforcement which pinned the overlay along slab edges, and (4) full-width, tied concrete shoulders.

PROJECT COSTS

The total cost for the 5.2 mile project was $5,618,356 of which $1,033,768 or $16.85 per square yard was for the 2.2 mile long bonded concrete overlay and $61,242 or $1.00 per square yard was for surface preparation. Major cost items other than the overlay costs required to complete this project included the removal and replacement of pavement for the transitions at bridges, PCC shoulder construction, signs and barricades, temporary pavement markings, temporary detour roads, mobilization, and precast barriers.

CONTRACT TIME

The contractor was given two hundred and forty calendar days (240) to complete the rehabilitation of both roadways. An incentive and decentive clause was placed in the contract.

The incentive clause provided the contractor an additional \$5000.00 per day for a maximum of thirty (30) days or \$150,000.00 total. The decentive clause would fine the contractor \$5000.00 for each day exceeding the completion date limitation up to thirty days maximum or a fine of \$150,000.00. The contractor developed and maintained a rapid pace and completed the entire contract in 173 days or 72% of the allotted contract time, thus receiving the full benefit of the incentive clause. This was a benefit to the contractor, the state and the traveling public as the safety liability and length of traffic delays were decreased.

SCOPE

The scope of this study was limited to the evaluation of the construction and performance of the 4 inch bonded fiber reinforced concrete overlay placed on I-10 between Seigen Lane and La 42. The design, construction techniques and materials sampling and testing were documented as a part of this study.

A performance evaluation was conducted over a 3-year period. The performance evaluation consisted of limited deflection testing, bond strength determinations, and visual inspections. Propagation of transverse reflective cracking was monitored in four (4) randomly selected sections within the construction project. A full debonding survey was not attempted due to the length of the project and the extensive traffic control that would be required, however, a random debonding survey was conducted.

METHODOLOGY

PROJECT INFORMATION

The project selected for resurfacing was a 4-lane section of Interstate 10, located in the southern part of East Baton Rouge Parish as shown in Figure 1. The entire construction project length was 5.2 miles located between Siegen Lane in Baton Rouge and La 42 (Highland Road).

The existing pavement consisted of 8-inches of Continuously Reinforced Concrete Pavement (CRCP) constructed over a 4" thick asphaltic concrete base and lime-treated soil. The roadway contained 8-inch thick HMAC shoulders with no provision for pavement drainage. The 1990 ADT was 41,000 vehicles per day with 22% truck traffic. Traffic figures indicate that this roadway has carried approximately twice the design load for an 8-inch CRC pavement since opening to traffic in 1974. Longitudinal cracking and edge failures were first observed in 1984 indicating that structural failures probably occurred near the time the pavement had carried its 20-year design load. The 16 year old CRCP also had an average transverse crack spacing estimated to be 4.5 feet. Prior to overlay the pavement contained two to three edge failures per mile and a measured AASHTO Serviceability Index of 3.4. This section was chosen for rehabilitation before any further deterioration of the pavement occurred and reconstruction was necessitated.

OVERLAY AND SHOULDER DESIGN

The total projected 18-kip load for a 20 year design resulted in an estimate of 39 million applications. Calculations using Louisiana's AASHTO design procedure indicated that a thickness of 12 inches was required to carry anticipated loads. Based on these calculations a decision was made to thicken the existing 8-in slab with 4-inches of bonded concrete. The typical cross section is shown in Figure 2.

A 9-inch thick tied concrete shoulder was designed for both the 10-foot outside and the 4-foot inside shoulders. The shoulders were designed to be tied to the original 8-inch pavement and to be jointed every 15 feet with 1 1/4-inch dowel bars for load transfer spaced on 24-inch centers.

It was important that any edge punchouts or other pavement deterioration be patched before resurfacing the existing pavement. The overlay utilized reinforced concrete because of

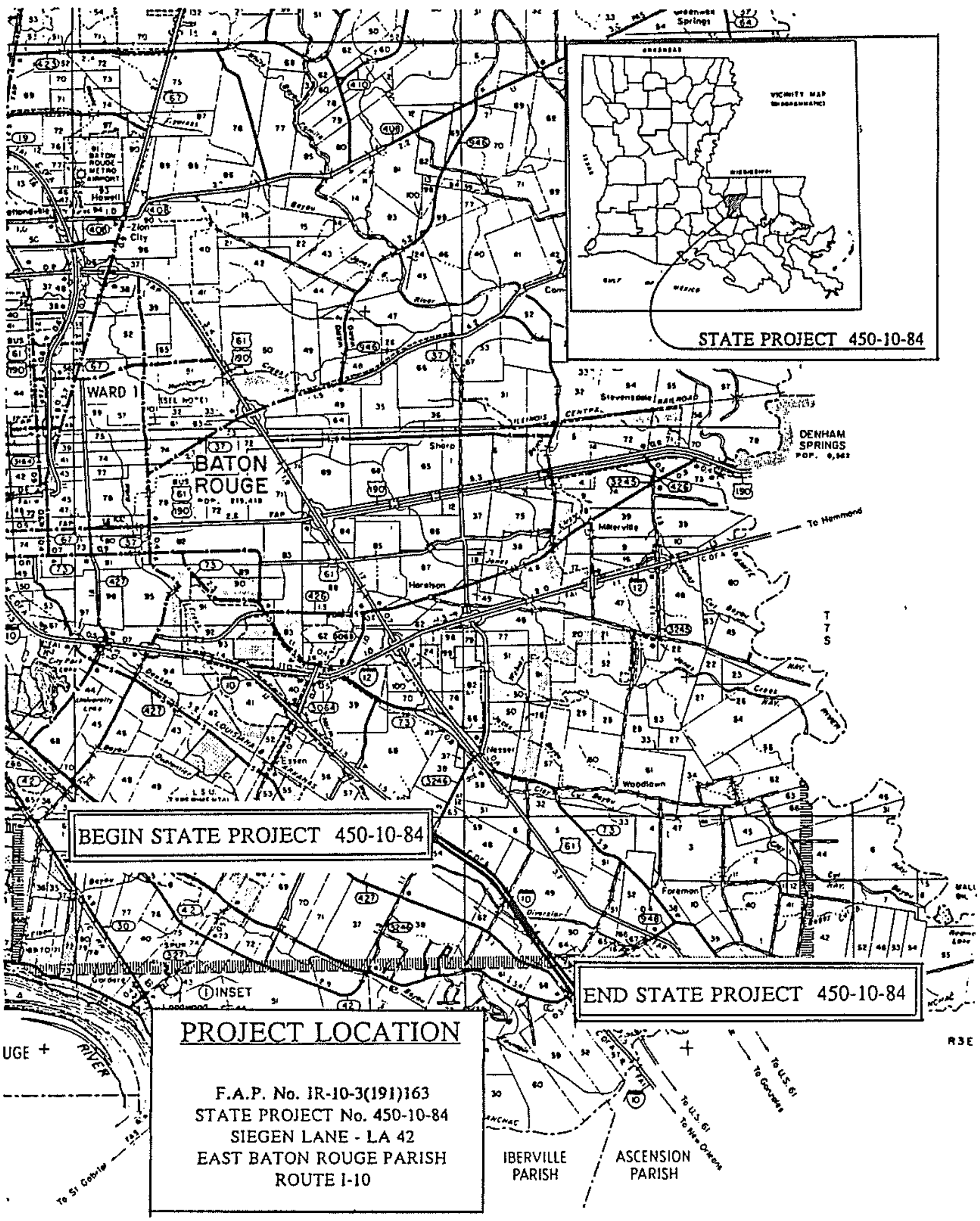
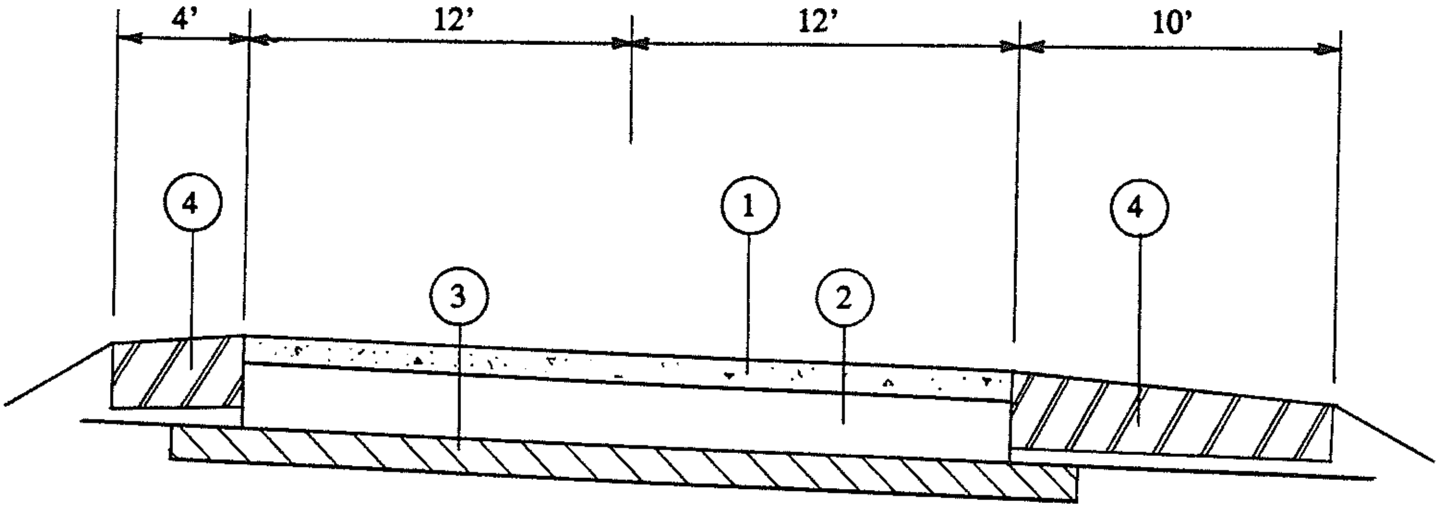


Figure 1. Project Location.

I-10 CONCRETE OVERLAY
SIEGEN LANE - LA 42
STATE PROJECT No. 450-10-84



TYPICAL SECTION

1. New 4" Bonded Fiber Concrete Overlay.
2. Existing 8" Continuously Reinforced Concrete Pavement.
3. Existing 4" Asphaltic Concrete Base.
4. 5" Milled Asphaltic Concrete Shoulder; 9" New Tied Concrete Shoulder.

Figure 2. Typical Cross Section.

the original pavement was continuously reinforced and contained many transverse cracks. With the expectation of reflective cracking, steel fibers were added to the concrete mix because of its ability to provide three dimensional reinforcement and to enhance ductile properties. It is anticipated that crack propagation will be minimized with the use of the steel fibers and will remain tight, preventing the cracks from opening.

CONSTRUCTION

The project was constructed in two phases, performing the westbound roadway construction in Phase I and the eastbound roadway construction in Phase II. A positive concrete barrier was employed in the opposite roadway of that being constructed throughout the length of the entire project. Although a slight slow down of traffic was noticed in this area, the traffic managed to flow throughout its duration. The positive separation proved to be an effective barrier as vehicles were unable to cross the centerline and very few accidents were reported with no fatalities.

REPAIR OF CRCP

It was required that the severe edge failures and any longitudinal cracks be patched before placing the overlay. Most of the repairs were minor with the exception of one area on the eastbound roadway: A one hundred sixteen foot (116') long by twenty-four foot (24') wide full depth patch located under the Pecue Lane overpass.

All patching of CRCP was accomplished in accordance with standard LDOTD patching procedures and the reinforcement was replaced in-kind with appropriate lapping of steel. The patches were cured a minimum of seven days prior to surface preparation.

SURFACE TEXTURE

The contractor had the option of using roto-milling or shot blasting to clean the surface and obtain the specified 0.045 inch average texture depth. The contractor elected to use shot-blast equipment with steel shot between .046 inches and .055 inches in diameter. This material was recycled and reused during its operations. A test conforming to DOTD TR 617 was randomly performed throughout the operations to ensure the average texture depth requirement. The overall mean texture depth achieved was .060" with a standard deviation of .009". The specified minimum average texture depth was easily obtained on this project since the existing surface contained a transversely tinned finish. It was required that the old pavement markings be completely removed. This was only an occasional problem which required an extra pass of the shot blaster or was removed with other mechanical means.

EDGE BONDING REINFORCEMENT

An edge reinforcement technique similar to curb bars was included to discourage debonding along the slab edges which may result due to curling or warping stresses in the concrete overlay. The technique utilized curb-type reinforcement bars epoxied into the existing slab surface, 8-inches from each edge of pavement as shown in Figures 3 and 4. The inverted U-shaped bars were 4-feet long and placed on 6-foot centers. The plans called for the bars to be placed in the center of the 4-inch overlay (two inches above the existing surface). This was considered adequate clearance for concrete flow under the bar since the top size aggregate in the mix was limited to 1/2-inch. Internal vibrators were required to be located on each side of the edge bonding reinforcement to maximize consolidation in this area. Transverse construction joints in the overlay were required to coincide with a reinforcement bar on each slab edge to pin the overlay to the original slab at these locations.

GROUT SLURRY

A stiff slurry grout consisting of seven gallons of water to one bag of cement was applied as a thin, even coat onto the cleaned dry concrete surface just ahead of the paver. The contractor initially had problems with the spray nozzle becoming clogged. He eventually removed the nozzle and allowed the slurry to run from the open hose and used brooms to sweep the material into place, making sure the entire roadway was sufficiently covered.

CONCRETE MIX DESIGN

Concrete mix design for the overlay included 85 pounds per cubic yard of deformed steel fibers conforming to ASTM A-820, Type I or Type II. The nominal length of the fiber was specified to be not less than one-inch nor greater than two inches with an aspect ratio not less than 40 nor greater than 60. The fibers selected were one inch in length and deformed at the ends resulting in an aspect ratio of 42. A minimum of 7.5 sacks of cement per cubic yard was required with a maximum water/cement ratio of 0.40. A slump of 1" - 2½" was specified to be measured after adding the fibers. Both a water reducing set retarder and an air entraining agent were required. The total air content was lowered to 3.5% $\pm$ 0.5% (percent by volume) from Louisiana's typical slip form mix specification of 5% $\pm$ 2% to minimize the chance of upward swings in air content which may affect bond strength.[1]

The aggregate used was a Louisiana river gravel which is readily available. The gradation and concrete batch plant mix design is as shown in Table 1. Several trial batch mixes where made before the proper slump and air content was achieved. The steel fibers were added in with the aggregates via a conveyor belt and mixed using 85-90 pounds of fibers per cubic yard.

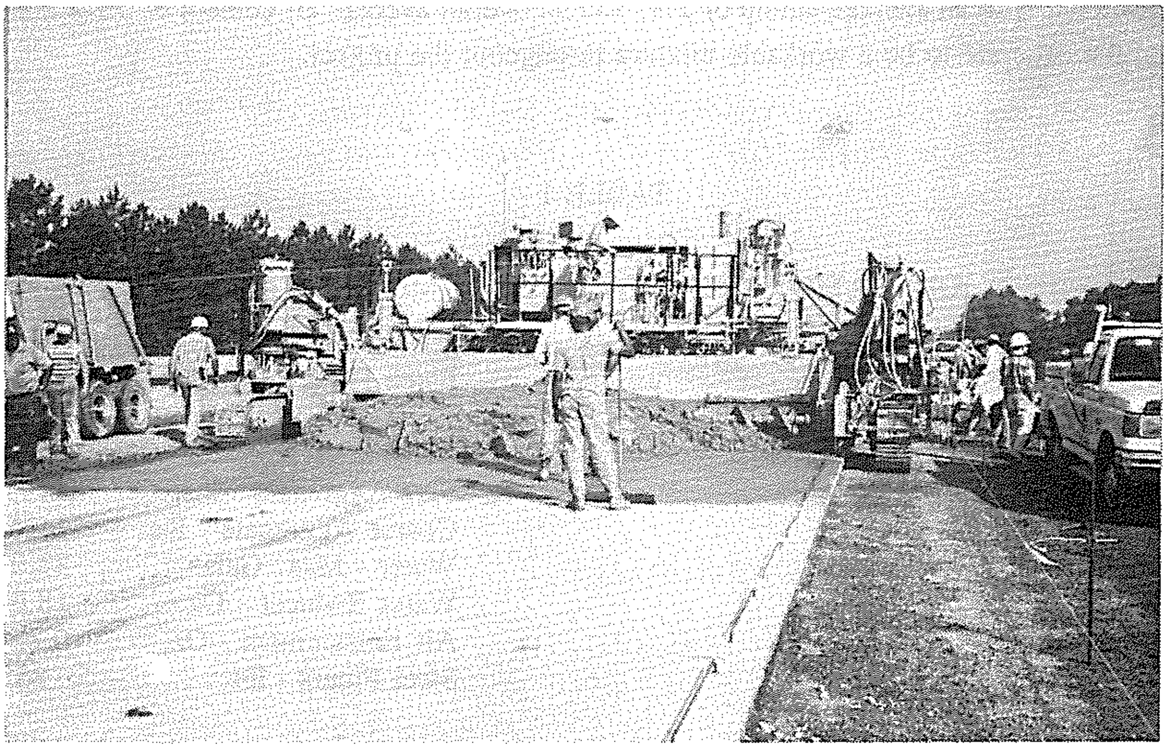


Figure 3. Cleaned surface with edge bonding-reinforcement bars.

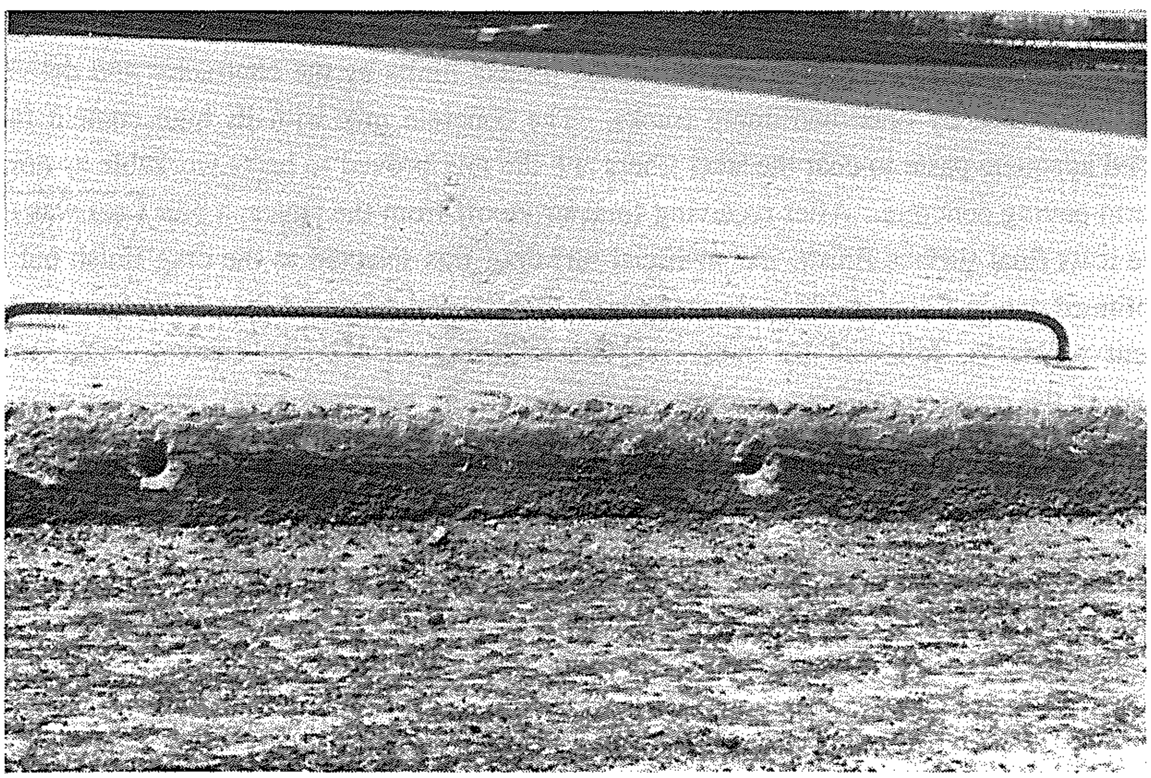


Figure 4. Edge bonding-reinforcement bars were no. 5 bars, four-feet long, raised two inches above the concrete.

The slump and air contents of the mix were consistent throughout the project, conforming to the specifications, with an average slump of 1½" and an overall average air content of 3.2%. This enabled the concrete to be a workable mixture throughout the project.

TABLE 1

GRADATION AND BATCH PLANT MIX DESIGN

Gradation Requirements

U.S. Sieve	% Passing (by Weight)
¾	100
½	90 - 100
No. 4	15 - 60
No. 16	0 - 5
No. 200	0 - 1

Batch Plant Job Mix

Cement - lbs.	705
Fine Aggregate - lbs.	1435
Coarse Aggregate - lbs.	1435
Water - Max. Gals.	33.0
Water Reducer - Oz.	18.0
Air Entrainment - Oz.	0.86
Steel Fibers - lbs.	85

PAVING OPERATIONS

The steel fiber reinforced concrete overlay was placed and finished with a slip-form paver utilizing a taut string line control to a minimum thickness of four (4") inches. The concrete was mixed at a batch plant set up near the end of the project limits by the contractor and delivered to the paving area by open-bed dump trucks. The concrete mix with its high cement factor provided adequate paste to coat the steel fibers and the mix proved to be as workable as normal slip form paving concrete. After receiving final strike-off from the paver, a bull float was used to give it its final surface finish. An artificial turf drag was selected as the drag finish but was discontinued due to fibers catching on the material. A burlap drag was then substituted with no apparent problems, followed by transverse tine texturing on 1/2-inch centers. Due to the thinness of the concrete overlay, a white pigmented curing compound was applied at one and one half times the normal application rate to enhance the curing process. The centerline longitudinal joint was sawed within twenty-four hours of paving to a width of ¼" and a 1" depth. The joint was then filled with a silicone joint filler material. Finally the overlay was covered with a clear plastic membrane after several hours of set time and remained in place for a minimum of seventy-two hours. Project requirements limited the temperature of plastic concrete to 90°F. This proved to be only an occasional problem while paving the west bound roadway in which the measured concrete temperature exceeded the specification by only a few degrees. The contractor elected to pave the east bound roadway during evening hours to avoid upward temperature swings. Temperature restrictions on plastic concrete have subsequently been revised to a maximum of 95° for placement of any future concrete overlay mixes in Louisiana.

TESTING

CONCRETE TESTING

Cylinders were made and tested by the district forces for compressive strengths at twenty-eight (28) days for an average of 6,147 psi. Test specimens were also made by LTRC's concrete research laboratory personnel consisting of 6" diameter cylinders and 6"×6"×20" beams to be used in determining compressive strengths and flexural strengths. These specimens were air cured for the first 24 hours and then transported to the concrete research laboratory for further curing. The average test results for these specimens are shown in Table 2.

TABLE 2

AVERAGE TEST RESULTS

	West Bound Roadway	East Bound Roadway
Slump, inches	1.05	1.42
Air Content, %	3.4%	3.3%
Compressive Strength,		
7 - Day, psi	5,232	5,035
28 - Day, psi	6,523	6,272
Flexural Strength,		
7 - Day, psi	700	682
28 - Day, psi	823	774
Modulus of Elasticity, psi	5,759,775	5,511,372
Poisson's Ratio	0.164	0.146
No. of Fibers per sq. in.	7.74	7.59

OVERLAY BOND STRENGTH

There were two methods used to estimate overlay bond strength. One was the Iowa DOT shear collar method where a core of the overlay is sheared at the bond interface using the collar device mounted in a laboratory compression tester.[2] The other method was an ACI procedure which subjects the specimen to a direct pull attempting to debond the overlay as depicted in Figure 5. The latter method was found to be suitable for field evaluation since a core is drilled through

Figure 5. ACI pull test in the field.

the overlay and into the original pavement approximately 1-inch below the bond interface. Next a threaded connection cap is epoxied to the top of the core and allowed to cure for several hours. Finally the pull apparatus is screwed into the connection cap and the force required to debond the specimen is recorded. Field tests revealed that the failures occurred either at the epoxy bond interface or at delaminations in the original pavement layers. Additional cores were taken on the east bound roadway, removed and taken to the laboratory to repeat this test so that the epoxy could be allowed additional time to cure. A device was developed to hold the specimen in place for testing in the laboratory as shown in figures 6 and 7.

Bond strength data are tabulated in Table 3 for both the shear collar and direct pull test procedures. The average bond strength measured with the shear collar was 943 psi which significantly exceeds the 200 psi minimum as specified by Iowa DOT. The average pull strength was 128 psi which exceeds the 100 psi minimum set forth by ACI for multi-component epoxy adhesives used to bond fresh concrete to hardened concrete (ACI 503.2-79).[3]

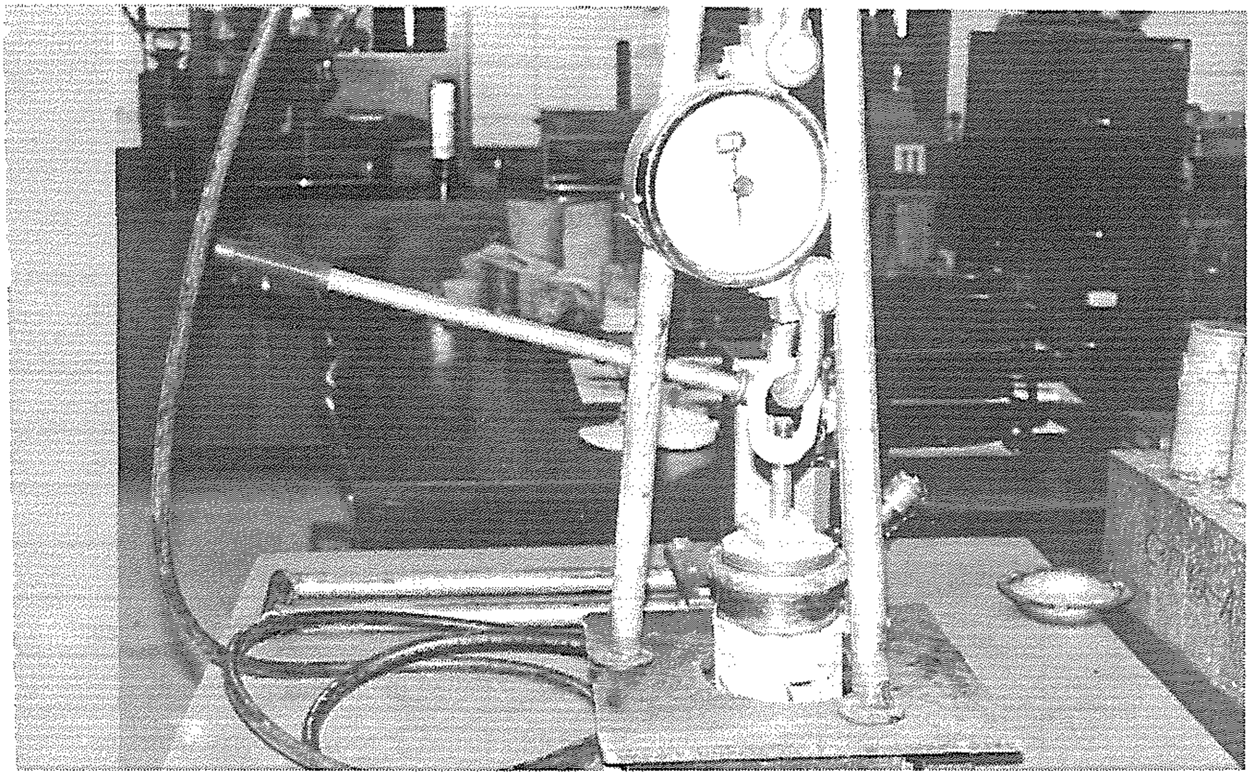


Figure 6. Cores of bonded overlay pull tested in laboratory.

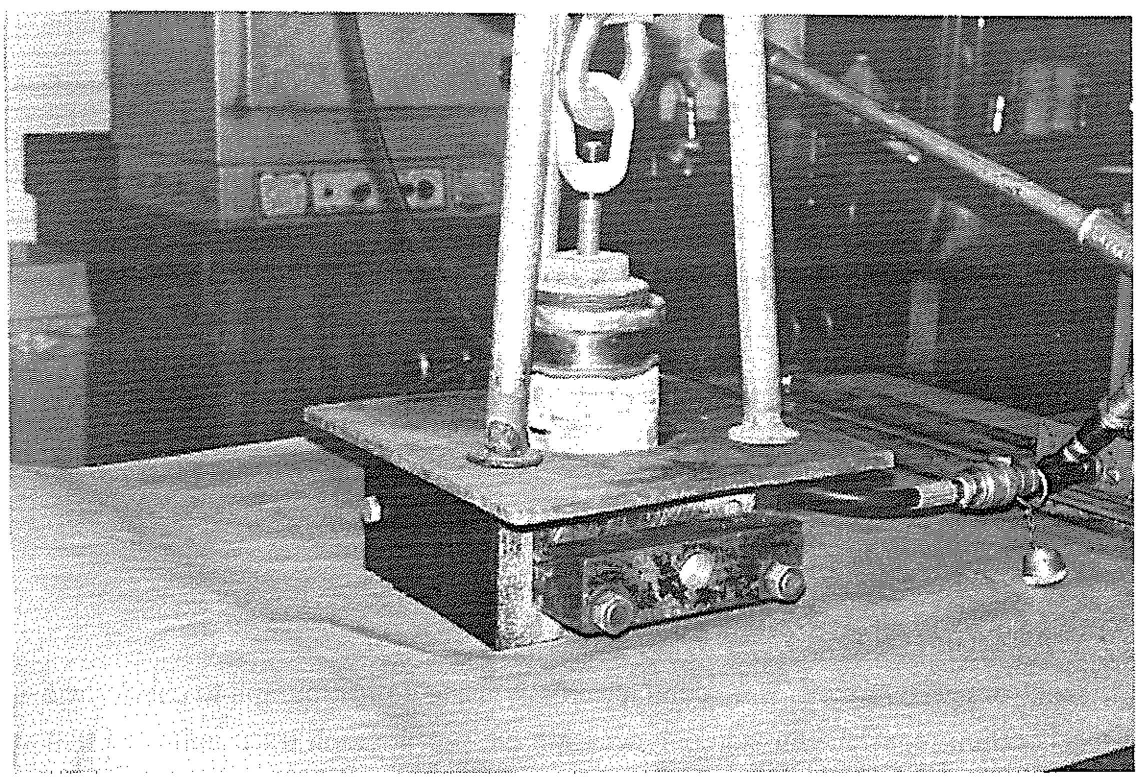


Figure 7. Hold down apparatus for laboratory Pull-out test.

TABLE 3

OVERLAY BOND STRENGTH
SHEAR COLLAR AND DIRECT PULL TESTS

CORE LOCATION	SHEAR COLLAR, PSI	DIRECT PULL, PSI	LOCATION OF FAILURE IN DIRECT PULL TEST
1	906	86	Field - Failed at epoxy/overlay interface.
2	832	91	Field - Failed at epoxy/overlay interface.
3	836	-	Field - Core removed by Contractor.
4	816	-	Field - Core damaged by vehicle.
5	1290	118	Field - Failed at epoxy/overlay interface.
6	736	6	Field - Failed in existing pavement.
7	1129	36	Field - Failed at epoxy/overlay interface.
8	1145	145	Field - Failed at epoxy/overlay interface.
9	1107	91	Field - Failed at epoxy/overlay interface.
10	916	95	Field - Failed at epoxy/overlay interface.
11	884	91	Field - Failed at epoxy/overlay interface.
12	868	91	Field - Failed at epoxy/overlay interface.
13	868	* 111	Lab - Failed at bond interface.
14	1063	* 159	Lab - Failed at bond interface.
15	1033	48	Lab - Failed in old concrete.
16	664	* 115	Lab - Failed at bond interface.
Average	943	128	

* Only values used in determining the average.

SURFACE SMOOTHNESS AND RIDE QUALITY

Quality control measurements were conducted daily using a profilograph to check the 5-inch per mile specification requirement. On one occasion the profilograph trace indicated that an entire days paving was significantly out of tolerance, resulting in a Profile Index of 12-inches per mile. A thorough examination of the paving equipment resulted in the discovery of an equipment sensor which was malfunctioning. After replacement of the sensor the Profile Index returned to the 5-inch per mile level on subsequent paving lots. It is important to note that without daily quality control testing with the profilograph the paving equipment problem would have gone undetected during construction. The overall ride quality of the pavement improved from an AASHTO Serviceability Index of 3.4 to 4.4 after placement of the concrete overlay as measured with the Mays Ride Meter (MRM).

DEFLECTION TESTING

An indication of the reduction in edge deflection attributable to the fiber concrete overlay and to the tied concrete shoulder was provided by measuring deflections induced by a slowly moving 22,000-pound single axle load. The test procedure was performed at six locations spaced 200 feet apart with the first site beginning near the Pecue lane overpass on the westbound roadway. The load was applied two feet from the outside pavement edge while measuring the time-deflection profile with transducers and an oscilloscope recording system. The concrete overlay resulted in a reduction in edge deflection of approximately 50%. The 9-inch tied concrete shoulder reduced the deflection another 10% for a total reduction of 60%, as calculated from the data in Table 4.[4]

OVERLAY CRACKING

A survey of transverse cracks prior to overlay indicated that the CRCP contained an average crack spacing of approximately 4.5 feet. As mentioned earlier, there were four test areas of 200 feet each used for monitoring the reflective cracks. Two of these were located in the east bound roadway and the other two were located in the westbound roadway as shown in Figure 8. The first indications of reflective cracking became apparent approximately three months after the overlay was completed. After one year of service 32% of the cracks had reflected through and after almost three (3) years of service only 35% of the cracks had reflected through in the monitored test areas. In all locations surveyed the reflection cracks are tight and are not expected to present a problem in overlay performance.

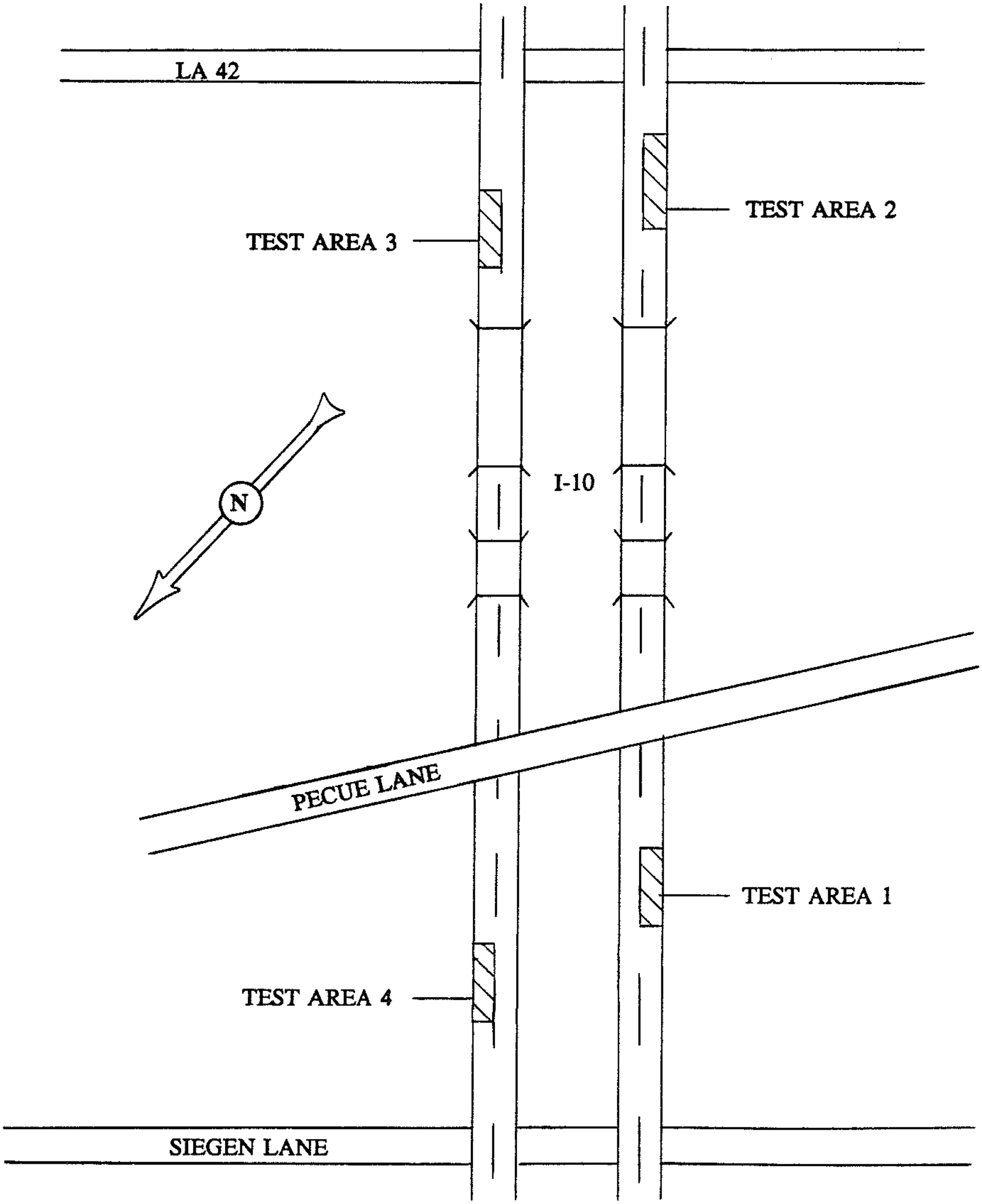


Figure 8. Test Section Locations.

TABLE 4

NON-DESTRUCTIVE
EDGE DEFLECTIONS UNDER A MOVING 22,000 LB. LOAD

	AVERAGE EXPERIMENTAL RESULTS	
Stages	Pavement Deflection	Standard Deviation
Pre-Construction	0.00624 in.	0.00062
Pre-Overlay, after Shldr. milling 5"	0.00665 in.	0.00164
After Concrete Overlay	0.00344 in.	0.00100
Post-Construction With Tied Shoulders	0.00249 in.	0.00083

PERFORMANCE EVALUATION

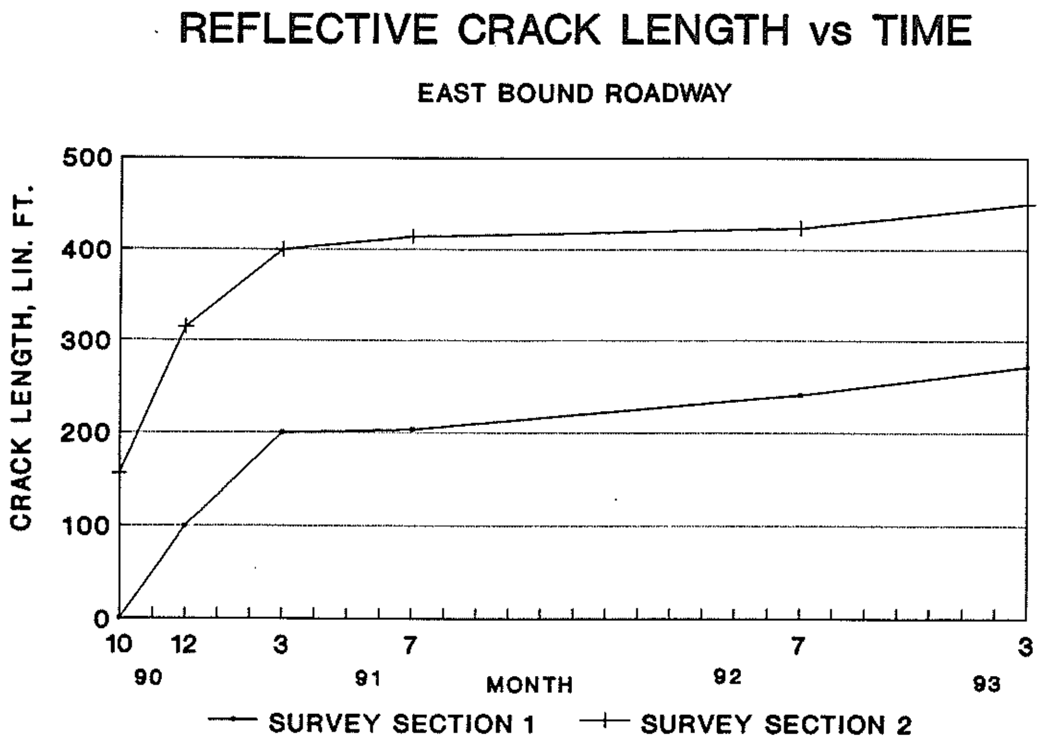
The most recent (2/93) evaluation consisted of visual inspections to determine reflective transverse cracking and any longitudinal cracking, sonic responses to determine debonding, and roughness measurements obtained using the Mays Ride Meter (MRM).

The graphs in Figure 9 illustrate the amount of reflective cracking developed during the evaluation period (10/90 - 2/93). Based on the average crack spacing of 4.5 feet prior to construction, only 35% of the cracks have reflected through. The graphs also indicate that most of the reflective cracks occurred within six months after construction and only a slight increase has occurred since that time. Test sections 1 and 4 are located closer to the west end of the project while test sections 2 and 3 are located nearer to the east end of the project. Test sections 2 and 3 are also located on an embankment fill area and although the curves follow the same pattern, this may explain why they have a higher threshold.

This evaluation has also revealed only two small areas where debonding has occurred which were observed over the length of the entire project. The first is located in the east bound lane approximately 100 ft. east of the Pecue Ln. overpass. The area of debonding is approximately 35 square feet. The second area is located in the west bound roadway within Survey Section 3. The area of debonding is approximately 72 square feet. Each of these areas are located adjacent to a construction joint and appear to be a result of construction procedures. Edge reinforcement bars were intentionally located to cross the construction joints in expectation of bonding problems.

Two short longitudinal cracks of 15 feet or less were found in the west bound roadway, only several feet off the centerline of the roadway. These cracks are thought to have reflected through the overlay. In all locations surveyed, the reflective cracks appear to be tight and are not expected to pose a problem in the performance of the overlay.

The overall ride quality of the roadway remains virtually unchanged with an average AASHTO Serviceability Index of 4.3.



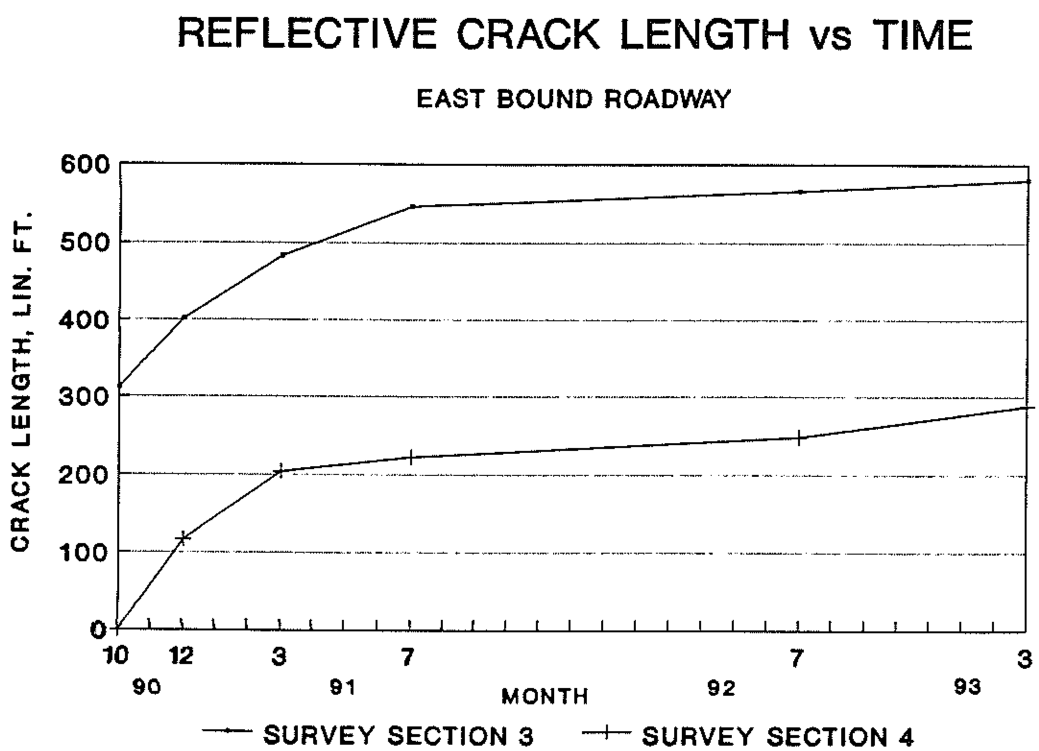


Figure 9. Reflective crack lengths vs time.

CONCLUSIONS

1) A four-inch fiber concrete overlay has been successfully bonded to a sixteen year old CRCP which had carried twice its design load. The overlay was constructed in an attempt to arrest progressive development of edge failures and to provide slab thickness designed for 20-years of interstate highway loading.

2) After one year of service 32% of the transverse cracks had reflected through the bonded overlay; after almost three years of service, only 35% of the transverse cracks had reflected through; therefore the amount of cracks reflecting through appear to be leveling off and are held tight by internal steel fiber reinforcement and edge reinforcement.

3) A combination of water-cement grout and a clean, textured surface provided excellent bond between fresh and hardened concrete as indicated in the results of both the Iowa Shear Collar test and the ACI Direct Pull-out test.

4) Slab deflections at the edge of the pavement were reduced an estimated total of 60% with the addition of the 4" fiber concrete overlay and the 9" tied-concrete shoulder. This major reduction in deflection reflects a significant enhancement in load carrying capacity.

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