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16. Abstract

A thin-bonded overlay on the south Loop 610 in Houston was constructed in July and August of 1983. The objective of this project is to continue periodic monitoring of the thin-bonded overlay project. The project contained five experimental sections consisting of two and three-inch depths, non-reinforced with both chopped wire and wire mesh enforcement. Bonding included surface preparation with a cold mill, sand blasting, and group over a dry surface.

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INITIAL CONSTRUCTION REPORT

"EXPERIMENTAL THIN-BONDED OVERLAY
PAVEMENT IN HOUSTON, TEXAS"

Project 561 Initial
(DTFH71-83-3952-TX-15)

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November, 1985

DISCLAIMER STATEMENT

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INITIAL CONSTRUCTION REPORT: EXPERIMENTAL THIN-BONDED CONCRETE OVERLAY PAVEMENT IN HOUSTON, TEXAS

Pavement History

The pavement is on IH-610 (South Loop) between Cullen Road and Calais Street in Houston, Texas. One thousand feet of thin-bonded overlay were placed on the four eastbound lanes in five test sections of 200 feet each.

The original concrete pavement was completed in June, 1970 and served as the surface until the thin-bonded overlay was constructed in the summer of 1983. The original pavement is a continuously reinforced concrete pavement (CRCP), 8-inches thick with a percent longitudinal steel reinforcement, P=0.5 percent. The CRCP rests on a 6-inch thick cement treated subbase of gravel screenings, on a 6-inch thick compacted subgrade.[1]

An estimated 23,600,000 18-kip equivalent single axle load applications were applied to the pavement from its construction in 1970 to the present (1984 data). The present annual average daily traffic (AADT) is 137,500 with 5 percent trucks. The above data do not include access road traffic.

The pavement prior to placing the overlay was selectively repaired using polymer concrete as a patching material. All longitudinal cracks were routed out 3/4-inch wide and 3/4 to 1-inch deep, then filled with dry sand into which a liquid monomer was added.[2]

The types of defects in the original CRCP surface were primarily spalled transverse cracks, longitudinal cracks, and patches. While these were not seen as an immediate threat to the load carrying capacity of the structure, they required increasing amounts of maintenance and caused increasing inconvenience to its many users.[1] Since it was felt that some form of rehabilitation would be necessary in the near future, the decision was made to place an experimental thin-bonded overlay.

Construction Operations and Methods

To begin preparation for overlaying, the existing concrete pavement surface was scarified by a milling machine. The milling depth was between 1/4 and 3/8-inch.

Cuttings were then removed and the surface broomed to reveal the chipped surface. The longitudinal joint sealing material was removed using jackhammers. Sandblasting followed, to leave a clean, textured surface.

At this stage, clean, sound concrete was exhibited. Transverse cracks which had a marked appearance at the surface, now looked tightly closed; this was a sign that the original CRCP was structurally adequate. It was also revealed that the polymer concrete patching material had penetrated deeply into the cracks.[1]

The last phase of the pavement surface preparation consisted of air blasting as closely in time as possible to the grouting and paving operations. Following air blasting, double polyethylene sheets were spread in the middle of the two lanes to overlay; concrete dump trucks were allowed to back up on these sheets. In this way, the prepared pavement surface was free from tire imprints and engine and transmission oil drippings. It should be noted that no repair work (e.g. joint or crack sealing, deep patching, slab jacking) was necessary on the prepared CRCP surface, which appeared to be in excellent condition.[1]

The prepared surface was dry to allow absorption of the bonding grout. The grout consisted of water, cement, and a water-reducing plasticizer, Daraweld-C. The water-cement ratio was approximately 0.62 by weight or 7 gallons of water per sack of cement. The plasticizer gave the bonding grout a creamy consistency. Immediately prior to paving, the grout was uniformly broomed onto the full width of the prepared CRCP surface. The contractor exercised care to insure that all portions received a thorough, even coating and that no excess grout collected in pockets. The grout application rate was limited to prevent drying of the grout before it was covered with the new concrete.[1,3]

The following test sections were constructed. Each section is four lanes in width and 200 feet long.

(1) Two-inch thick plain concrete overlay.
(2) Two-inch thick steel-reinforced (welded wire fabric) concrete overlay.
(3) Three-inch thick steel-reinforced (welded wire fabric) concrete overlay.
(4) Three-inch thick steel fiber (Bekaert Dramix ZP 50/50) reinforced concrete overlay.
(5) Two-inch thick steel fiber (Bekaert Dramix ZP 50/50) reinforced concrete overlay.

For the construction of the test sections, seven sacks of cement per cubic yard, 1/2 inch coarse aggregate, and 4.5 gallons of water per sack formed the mix. The fiber-reinforced concrete, however, had 8 sacks of cement per cubic yard and 5 gallons of water per sack. To control temperature, ice was added to all loads. A potential problem with thin bonded overlays is the possibility of differential movement between the original pavement and overlay, with resultant debonding at the interface. To make this less likely, the same course aggregate source, Colorado river gravel, was used for the overlay as for the original CRCP.[3]

The concrete was batched at a central plant, and hauled in ready-mix trucks to the construction site. The trucks were loaded at six cu. yd. (less than 80 percent of capacity). The concrete was dumped onto the grouted pavement surface and spread manually. A transverse concrete finisher guided by rails was used to consolidate and finish the concrete to grade. The inspector took frequent readings to insure that the nominal specified thicknesses were obtained. Surface texturing consisted of transverse metal tine finish (i.e., wire combing), and was accomplished by hand from a working bridge.[1]

Following surface texturing, a white pigmented impervious curing component was spread uniformly onto the overlay surface from a second working bridge. Within 24 hours of a pour, the pavement edge and centerline longitudinal joints were saw cut. The centerline longitudinal joints were cut to a nominal 1 inch depth and sealed with a hot-poured asphaltic material.[1]

Figure 1 is a cross-section of the existing pavement and overlay.[3]

Following is a more specific account of how the sections were constructed[3]: On July 22, 1983, 200 feet of 2-inch non-reinforced concrete was placed in lanes 1 and 2. The concrete was supplied in six trucks. To each load, 150 oz. of "Mighty 150", a plasticizing agent, was added. The average slump was 3.75 inches and the average air content was 4.0 percent. The average seven-day flexural strength obtained from the beam test was 823 psi.

On July 26, 1983, 200 feet of 2-inch steel reinforced concrete were placed in lanes 1 and 2. The wire fabric size used was 6 inches by 12 inches with end laps of 12 inches and edge laps of 6 inches. The concrete was transported in six trucks with an average slump of 4.3 inches and an average air content of 2.3 percent. An average of 150 oz. of "Mighty 150" was added at the site to each truckload before the slump was recorded.

On July 28, 1983, a 3-inch steel-reinforced overlay was placed in lanes 1 and 2. The concrete was transported in eight trucks. The average slump recorded was 5.2 inches and the average air content was 5.2 percent. Two beams prepared from concrete from the fifth truck

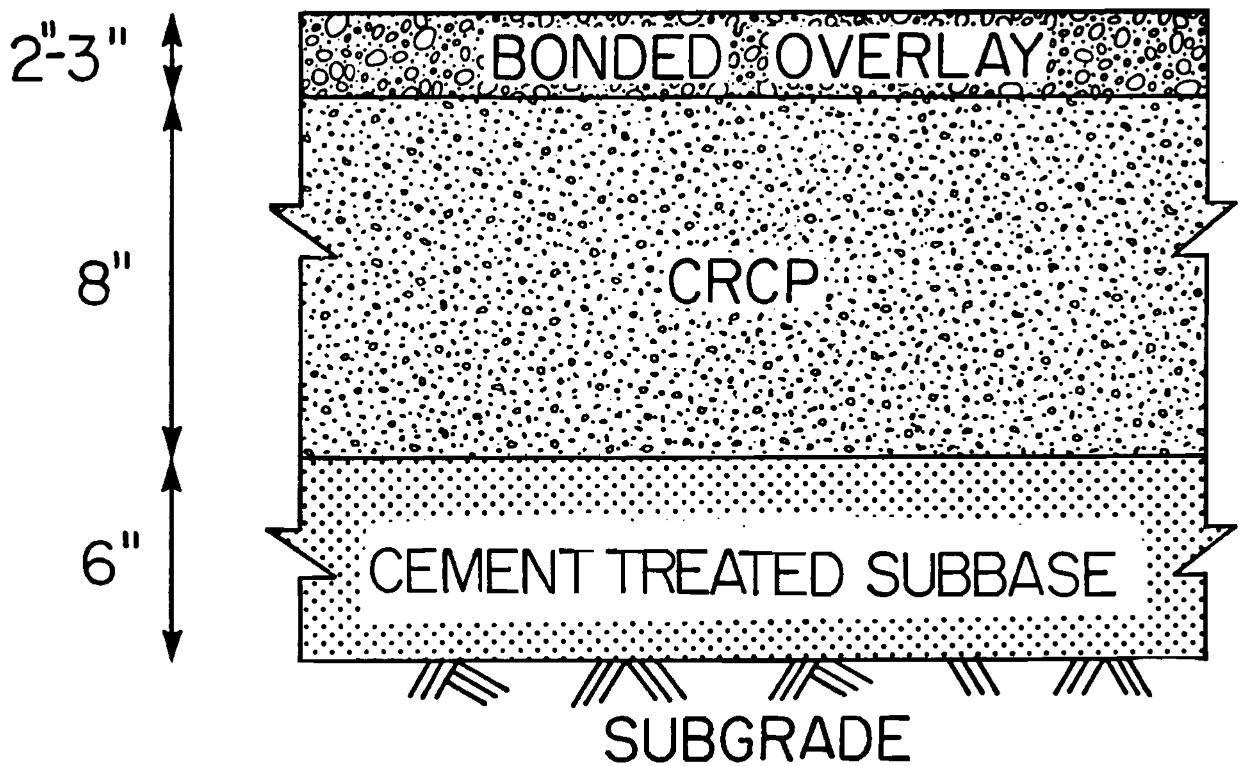


Fig 1 . Cross-section of typical pavement structure.

had an average seven-day flexural strength of 870 psi. To each of the truckloads an average of 150 oz. of "Mighty 150" was added before the slump was recorded.

On August 3, 1983, 200 feet of 2-inch fiber-reinforced concrete was placed in lanes 1 and 2. The fibers were added in 66 pounds bags at the rate of 2 bags per minute. The specifications required 85 pounds of fibers per cubic yard of concrete. The concrete was transported in six trucks. The average slump was 4.5 inches and the average air content was 4.6 percent. Out of concrete transported in the fourth truck, two beams were cast which had an average seven-day flexural strength of 920 psi.

On August 15, 1983, 200 feet of 2-inch non-reinforced and 200 feet of 2-inch steel-reinforced concrete were placed in lanes 3 and 4. The average slump was 3.9 inches and the average air content was 4.0 percent. Two beams each were cast from the concrete transported by the sixth and the eighth truck. The average seven-day flexural strengths were found to be 730 psi and 798 psi, respectively.

On August 20, 1983, the work resumed, after the area was affected by Hurricane Alicia. The concrete was transported in nine trucks. The average slump was 3.6 inches and the average air content was 3.1 percent. Two beams were cast out of concrete transported by the second truck and the average flexural strength was 840 psi.

On August 27, 1983, 200 feet of 3-inch fiber-reinforced and 200 feet of 2-inch fiber-reinforced concrete were placed in lanes 3 and 4. The concrete was transported by fifteen trucks. Most of the concrete in the eleventh, twelfth, and thirteenth trucks was not used because the concrete screed had to be moved back to refinish some concrete. Part of the twelfth truck was dumped, but the rest was sent back to the plant. The average slump recorded was 4.8 inches and the average air content was 5.0 percent. One beam each was cast from concrete out of the eighth and the fifteenth trucks. The average seven-day flexural strengths were found to be 838 psi and 898 psi respectively. These two lanes were opened to traffic on the evening of September 3, 1983, giving the last concrete placed six curing days.

To ensure that the concrete reached its design strength, two control tests were performed during the construction phase of the overlay. One was the slump test and the other was the flexural test on the beams. The air content of the concrete was also measured. The slump ranged from 2.5 inches to 8 inches. The flexural strength ranged from 730 psi to 992 psi; the mean strength was 872 psi.

Weather Conditions During Overlay Operation

Date	High Temp.	Low Temp.	Precip.	Cloud Cover
7/22/83	92°	72°	none	fair
7/26/83	94°	74°	none	fair
7/28/83	95°	73°	none	fair
8/1/83	93°	73°	1/100-in. rain	partly cloudy
8/3/83	90°	71°	none	mostly cloudy
8/15/83	95°	76°	none	fair
8/18/83	Hurricane Alicia struck Houston/Galveston area			
8/20/83	93°	75°	trace rain	partly cloudy
8/27/83	93°	75°	trace rain	partly cloudy

Visual Evaluation of the Overlay

Results of visual condition surveys, including crack mapping, appear in Departmental Research Report Number 561-2. For all reports concerning this project, the lanes are numbered consecutively from lane 1, the innermost lane, to lane 4, the outermost lane.

From Table 1, it can be seen that construction of the thin bonded overlay resulted in a large reduction in the number of cracks.1 Average crack width was also reduced. Table 2 shows that spalling, which was widespread before the overlay, did not occur after construction of the overlay.[1] No maintenance on the thin bonded overlay has been performed to date.

TABLE 1 CRACKING IN THE VARIOUS DESIGN SECTIONS (FT.)

	Longitudinal Cracking			Transverse Cracking		
Section Type	Before (May 83)	After (Feb 84)	% Reduction	Before (May 83)	After (Feb 84)	% Reduction
2" NR	323	245	24	264	81	69
2" R	200	202	-1	305	116	62
3" R	291	247	15	289	223	23
3" F	393	4	99	288	28	90
2" F	348	60	83	119	11	91

TABLE 2 SPALLING IN THE VARIOUS DESIGN SECTIONS (ACTUAL COUNT)

SECTION TYPE	MINOR SPALLING		SEVERE SPALLING	
	BEFORE	AFTER	BEFORE	AFTER
2" NR	17	0	109	0
2" R	18	0	82	0
3" R	9	0	103	0
3" F	15	0	87	0
2" F	4	0	17	0

Tests and Samples

Dynaflect test points were located approximately on the centerline of each lane, at cracks and at midspans within each section. The same points were tested before and after construction. Tables 1, 2, 3, and 4 show deflections for each lane for the five test sections, before and after construction. Table 5 shows percent reduction in deflections for each of the five sensors of the Dynaflect for each of the five sections. It is apparent from table 5 that the greatest reduction in deflection is achieved in the 3-inch steel reinforced section at cracks, for all five sensors.[4]

A month after the overlays were placed, field cores were obtained by random sampling. Direct shear tests were performed on 29 cores. Field core shear strength results are shown in Table 8.[3] Since the cores from the inner lane had a mean strength of 186 psi and those obtained from outer lanes had a mean strength of 220 psi, it could be concluded that lane location does not have a significant effect on the shear strength at the interface. Figure 2 shows the mean shear stress obtained under the different conditions.[3]

Since the cores with grout and Daraweld-C as a bonding agent had a mean shear strength of 135 psi, and those with no grout at the interface had a strength of 213 psi, it may be concluded that the dry surface without grout during dry weather conditions results in higher shear strength at the interface. This result agrees with the laboratory findings that the dry surface with no grout at the interface gave rise to higher shear strength at the interface.

The lowest shear strength obtained was 79 psi, compared with 24 psi, the highest shear stress expected at the interface, giving a factor of safety greater than 3.[3]

Measurements

Road profile measurements in all four lanes were made with a GMR profilometer. The data gathered from the two trailing wheels of the profilometer were digitized, then processed with the "VERTAC" computer program to arrive at estimates of Serviceability Index.

Mean serviceability Indices obtained from runs of the profilometer before and after overlay construction are shown in Table 9. Generally, a decrease in S.I ranging from 6 to 44 percent occurred after construction. This can be attributed to lack of stringent grade control during construction, short transitional sections, and relatively small (200 feet) sections which may have induced sampling error. In addition, the surface texturing method used may have had an effect on the serviceability index; for the original CRCP, surface texturing was achieved by burlap drag, whereas for the thin bonded concrete overlay, this was done by metal tining, resulting in a grooved surface. It should be noted that the S.I. values are still high (greater than 3.0 in most cases), indicating a good overall ride.[1]

Analysis of Costs

The cost to the Department of the thin-bonded overlay, including scarification but excluding traffic control was $159,319.50, or $30/S.Y. No account of traffic control costs was made. Preparation of old pavement before constructing the overlay was $7293, or $1.37/S.Y.

TABLE 3. SUMMARY OF MEAN DEFLECTIONS AND STANDARD DEVIATIONS (mils) AT MIDSPAN BEFORE CONSTRUCTION

Lane-Sect.	No. Ob-serv.	Sensors No. 1		Sensors No. 2		Sensors No. 3		Sensors No. 4		Sensors No. 5	
1-A	9	50.67	(2.65)*	47.89	(2.67)	42.78	(3.67)	40.33	(2.74)	35.67	(2.45)
1-B	11	52.83	(5.56)	50.45	(4.11)	43.64	(2.54	39.55	(2.16)	34.00	(1.48)
1-C	9	50.56	(6.60)	47.44	(6.15)	42.00	(3.77)	38.00	(2.24)	31.56	(1.51)
1-D	11	50.73	(4.58)	47.64	(3.80)	41.73	(2.41)	37.36	(1.43)	30.91	(1.22)
1-E	10	43.20	(2.04)	40.10	(2.02)	36.20	(1.99)	34.00	(1.89)	29.30	(1.95)
2-A	10	52.70	(3.74)	49.00	(3.02)	44.20	(2.46)	41.70	(2.16)	36.30	(2.00)
2-B	11	57.64	(7.95)	53.82	(6.66)	46.55	(5.41)	42.73	(4.15)	35.64	(2.87)
2-C	10	55.70	(11.05)	52.40	(8.24)	45.10	(5.38)	41.30	(4.19)	34.20	(3.61)
2-D	11	54.18	(7.95)	50.31	(6.46)	44.73	(4.24)	39.91	(3.33)	33.55	(3.42)
2-E	10	50.20	(4.24)	47.20	(3.55)	43.30	(4.00)	39.70	(4.19)	34.50	(4.15)
3-A	9	60.67	(6.76)	57.44	(6.29)	49.67	(4.74)	46.33	(3.81)	39.22	(2.95)
3-B	12	64.00	(6.93)	60.50	(6.04)	53.08	(4.94)	48.42	(4.01)	40.67	(3.39)
3-C	11	66.55	(5.57)	61.64	(4.52)	52.91	(3.42)	47.09	(2.70)	39.18	(2.14)
3-D	11	57.27	(8.22)	54.36	(6.93)	47.45	(5.26)	43.09	(3.86)	36.82	(3.40)
3-E	9	54.56	(5.98)	51.11	(6.31)	46.78	(5.09)	42.89	(4.96)	37.56	(4.30)
4-A	9	63.22	(7.71)	58.78	(7.45)	51.78	(4.92)	47.11	(4.48)	40.11	(3.59)
4-B	12	64.33	(7.43)	60.00	(6.13)	52.42	(4.52)	47.08	(3.87)	39.42	(3.18)
4-C	10	58.60	(5.08)	54.10	(4.04)	47.00	(2.91)	41.90	(2.42)	34.80	(1.93)
4-D	11	48.09	(3.56)	44.55	(1.04)	39.91	(0.83)	36.55	(1.13)	30.82	(0.75)
4-E	9	47.56	(2.40)	45.56	(2.51)	41.33	(2.60)	38.56	(2.30)	33.22	(2.05)

*Note: Numbers in parenthesis denote standard deviation.

TABLE 4 SUMMARY OF MEAN DEFLECTIONS AND STANDARD DEVIATIONS (mils) AT CRACKS BEFORE CONSTRUCTION

Lane-Sect.	No. Ob-serv.	Sensors No. 1	Sensors No. 2	Sensors No. 3	Sensors No. 4	Sensors No. 5
1-A	9	54.22 (3.83)*	49.11 (2.37)	43.22 (1.86)	39.78 (2.54)	35.00 (2.00)
1-B	11	57.82 (6.10)	51.00 (4.22)	44.00 (2.79)	39.73 (1.85)	33.45 (1.86)
1-C	9	58.00 (4.97)	50.78 (4.41)	43.67 (3.39)	39.00 (2.65)	32.00 (1.94)
1-D	11	53.55 (2.54)	48.00 (2.37)	41.00 (1.79)	36.82 (1.60)	31.18 (2.32)
1-E	10	49.50 (4.12)	45.20 (4.47)	39.70 (4.88)	36.40 (4.84)	31.60 (5.52)
2-A	10	53.80 (3.01)	49.30 (2.06)	44.10 (1.52)	41.10 (0.88)	36.30 (1.16)
2-B	11	59.00 (7.80)	53.82 (5.79)	57.18 (5.02)	42.64 (3.85)	36.45 (3.47)
2-C	10	58.40 (9.36)	53.10 (8.46)	45.30 (6.60)	40.70 (5.33)	34.50 (3.78)
2-D	11	56.73 (8.57)	51.82 (7.03)	44.45 (4.78)	40.76 (3.80)	34.00 (3.69)
2-E	10	52.20 (3.88)	47.70 (4.57)	42.50 (4.55)	39.70 (4.79)	34.40 (4.97)
3-A	9	60.44 (6.42)	56.44 (5.85)	48.89 (4.26)	45.00 (3.20)	38.22 (2.49)
3-B	12	64.08 (7.29)	59.83 (6.32)	51.50 (4.58)	47.33 (3.50)	39.67 (2.81)
3-C	11	69.55 (6.36)	64.58 (5.29)	54.73 (4.24)	48.73 (3.20)	40.27 (2.53)
3-D	11	58.82 (8.02)	54.64 (7.32)	47.45 (5.63)	42.64 (4.43)	36.27 (3.85)
3-E	9	56.22 (5.04)	50.78 (3.80)	45.22 (3.87)	41.33 (4.00)	35.22 (3.31)
4-A	9	63.78 (8.93)	59.00 (7.87)	53.00 (6.71)	48.00 (5.07)	41.22 (4.21)
4-B	12	64.25 (6.05)	59.75 (5.41)	51.75 (4.07)	46.83 (3.07)	39.17 (2.52)
4-C	10	61.20 (5.92)	55.90 (5.38)	47.80 (3.43)	42.40 (3.41)	35.10 (2.51)
4-D	11	48.45 (2.02)	45.55 (1.57)	39.91 (1.51)	36.73 (1.42)	31.00 (1.55)
4-E	9	47.67 (1.41)	45.22 (1.72)	41.22 (1.86)	38.23 (1.87)	33.11 (1.83)

*Note: Numbers in parenthesis denote standard deviations.

TABLE 5. SUMMARY OF MEAN DEFLECTIONS AND STANDARD DEVIATIONS (MILS) AT MIDSPAN AFTER CONSTRUCTION

Lane-Sect.	No. Observ.	Sensors No. 1	No. 2	No. 3	No. 4	No. 5
1-A	9	48.00 (1.87)*	45.56 (1.59)	42.78 (1.48)	40.11 (1.54)	36.11 (1.36)
1-B	11	49.27 (5.71)	46.27 (4.98)	42.09 (3.75)	38.36 (3.11)	33.91 (2.26)
1-C	9	47.11 (4.08)	43.89 (3.41)	39.78 (2.82)	37.22 (2.11)	31.67 (1.50)
1-D	11	46.91 (5.13)	44.82 (4.47)	40.73 (3.20)	37.73 (2.37)	32.55 (2.34)
1-E	10	44.30 (3.06)	42.60 (3.03)	39.70 (3.30)	37.10 (3.51)	33.60 (3.34)
2-A	10	49.80 (3.19)	47.50 (2.88)	43.80 (2.25)	41.70 (2.31)	37.60 (1.90)
2-B	11	46.18 (3.66)	44.00 (3.41)	39.82 (2.60)	37.18 (1.94)	32.64 (1.96)
2-C	10	44.90 (4.93)	43.10 (4.23)	39.10 (2.77)	36.80 (2.04)	31.70 (1.64)
2-D	11	46.73 (2.24)	44.45 (2.11)	40.36 (1.86)	37.09 (1.51)	32.36 (1.36)
2-E	10	41.90 (2.42)	39.90 (2.33)	37.10 (2.47)	34.70 (2.58)	31.00 (2.11)
3-A	9	51.78 (8.11)	49.67 (8.41)	46.00 (8.89)	44.00 (8.60)	39.44 (8.69)
3-B	12	48.50 (4.06)	46.17 (3.88)	42.17 (3.81)	39.58 (3.34)	34.33 (3.14)
3-C	11	47.18 (3.52)	45.09 (3.21)	41.27 (2.54)	38.64 (2.94)	33.91 (2.51)
3-D	11	45.09 (4.91)	43.55 (4.80)	40.09 (4.18)	37.82 (3.63)	33.36 (3.32)
3-E	9	45.67 (4.95)	44.33 (4.77)	41.00 (4.36)	39.33 (4.12)	34.56 (4.30)
4-A	9	55.22 (7.07)	52.00 (6.54)	48.33 (5.32)	44.22 (3.99)	39.56 (3.36)
4-B	12	54.33 (4.16)	51.17 (3.54)	46.92 (2.84)	42.75 (2.34)	37.33 (1.97)
4-C	11	45.91 (2.39)	43.00 (2.05)	39.73 (1.62)	37.00 (1.18)	32.09 (1.22)
4-D	11	39.64 (1.43)	37.55 (1.21)	34.91 (0.70)	33.18 (0.75)	29.27 (1.01)
4-E	9	41.56 (2.88)	39.89 (2.89)	37.33 (2.96)	35.78 (2.73)	31.00 (2.24)

*Numbers in parenthesis denote standard deviations.

TABLE 6 SUMMARY OF MEAN DEFLECTIONS AND STANDARD DEVIATIONS (mils) AT CRACKS AFTER CONSTRUCTION

Lane-Sect.	No. Observ.	Sensors No. 1	No. 2	No. 3	No. 4	No. 5
1-A	9	47.56 (1.13)*	44.78 (1.48)	41.89 (1.45)	39.11 (1.62)	35.44 (1.13)
1-B	11	46.91 (4.48)	44.09 (4.50)	40.45 (3.83)	37.27 (3.50)	32.73 (3.13)
1-C	9	47.89 (4.51)	44.22 (3.83)	39.67 (3.54)	36.67 (2.69)	31.33 (2.24)
1-D	11	47.55 (6.74)	44.18 (5.67)	39.82 (4.45)	36.91 (3.86)	32.00 (3.32)
1-E	10	45.00 (2.16)	42.40 (2.01)	38.60 (1.65)	36.30 (1.57)	32.10 (1.37)
2-A	10	50.50 (2.99)	47.70 (2.50)	43.80 (1.87)	41.50 (2.07)	37.30 (1.44)
2-B	11	47.91 (3.48)	44.55 (2.50)	39.91 (1.76)	37.00 (1.84)	32.45 (2.62)
2-C	10	46.80 (4.08)	43.40 (4.22)	38.80 (3.58)	35.90 (2.81)	31.10 (1.91)
2-D	11	50.09 (2.34)	45.64 (2.11)	40.55 (2.25)	37.73 (2.97)	31.73 (1.90)
2-E	10	46.30 (3.56)	42.70 (3.50)	38.40 (3.03)	35.20 (2.57)	31.40 (2.99)
3-A	9	48.56 (3.94)	46.67 (3.39)	42.89 (2.85)	40.89 (2.09)	35.89 (1.76)
3-B	12	48.25 (4.27)	46.00 (3.72)	42.08 (2.87)	39.33 (2.31)	34.58 (1.78)
3-C	11	48.18 (3.12)	45.73 (3.07)	41.82 (2.96)	39.27 (2.72)	34.36 (2.87)
3-D	11	45.18 (3.66)	43.36 (3.41)	39.91 (2.55)	37.36 (2.20)	32.82 (2.04)
3-E	9	48.33 (5.61)	46.44 (5.85)	43.00 (5.98)	40.09 (5.73)	36.33 (5.29)
4-A	9	54.11 (7.67)	51.33 (7.14)	48.22 (5.70)	44.44 (4.72)	40.00 (3.94)
4-B	12	52.33 (6.46)	49.17 (5.81)	44.75 (4.69)	41.33 (3.89)	35.75 (2.90)
4-C	11	46.09 (2.51)	42.82 (2.36)	38.91 (1.71)	36.09 (1.22)	31.36 (1.43)
4-D	11	38.82 (1.40)	37.18 (1.33)	34.45 (1.04)	33.00 (0.77)	25.36 (0.92)
4-E	9	41.11 (2.62)	39.33 (2.87)	36.56 (3.09)	35.00 (3.24)	30.67 (2.69)

*Numbers in parenthesis denote standard deviation.

TABLE 7. PERCENT REDUCTION IN MEAN DEFLECTIONS PER DESIGN SECTION

			Cracks	Midspan
Section A 2-inch, non-reinf.	% $\overline{X}_1$	=	0.13	0.10
	% $\overline{X}_2$	=	0.09	0.08
	% $\overline{X}_3$	=	0.06	0.04
	% $\overline{X}_4$	=	0.04	0.03
	% $\overline{X}_5$	=	0.01	- 0.03
Section B 2-inch, reinf.	% $\overline{X}_1$	=	0.20	0.17
	% $\overline{X}_2$	=	0.18	0.17
	% $\overline{X}_3$	=	0.18	0.13
	% $\overline{X}_4$	=	0.10	0.08
	% $\overline{X}_5$	=	0.09	0.08
Section C 3-inch, reinf.	% $\overline{X}_1$	=	0.24	0.21
	% $\overline{X}_2$	=	0.22	0.19
	% $\overline{X}_3$	=	0.17	0.15
	% $\overline{X}_4$	=	0.14	0.11
	% $\overline{X}_5$	=	0.10	0.08
Section D 3-inch, fiber	% $\overline{X}_1$	=	0.17	0.15
	% $\overline{X}_2$	=	0.15	0.13
	% $\overline{X}_3$	=	0.10	0.10
	% $\overline{X}_4$	=	0.08	0.07
	% $\overline{X}_5$	=	0.05	0.03
Section E 2-inch, fiber	% $\overline{X}_1$	=	0.12	0.11
	% $\overline{X}_2$	=	0.09	0.09
	% $\overline{X}_3$	=	0.07	0.07
	% $\overline{X}_4$	=	0.06	0.05
	% $\overline{X}_5$	=	0.03	- 0.001

TABLE 8 SHEAR STRENGTH (PSI): FACTORIAL REPRESENTATION OF SHEAR STRESS RESULTS OF FIELD CORES

		Overlay Type					
		Plain Concrete		Reinforced Concrete		Fibrous Concrete	
Bonding Agent	Thickness (inches)	Inside	Outside	Inside	Outside	Inside	Outside
Grout and Daraweld	2	238 (13)	347 (5)	356 (6)	165 (16)	111 (22)	247 (17)
		---	407 (7)	233 (11)	---	95 (26)	166 (27)
		---	---	301 (12)	---	---	---
		---	---	83 (14)	---	---	---
Grout and Daraweld	3	---	---	79 (10)	115 (20)	130 (24)	---
		---	---	---	95 (23)	---	---
No Grout	2	254 (1)	---	241 (4)	---	---	---
		205 (25)	---	237 (8)	---	---	---
		197 (28)	---	142 (18)	---	---	---

Note: Figures within brackets are core numbers.

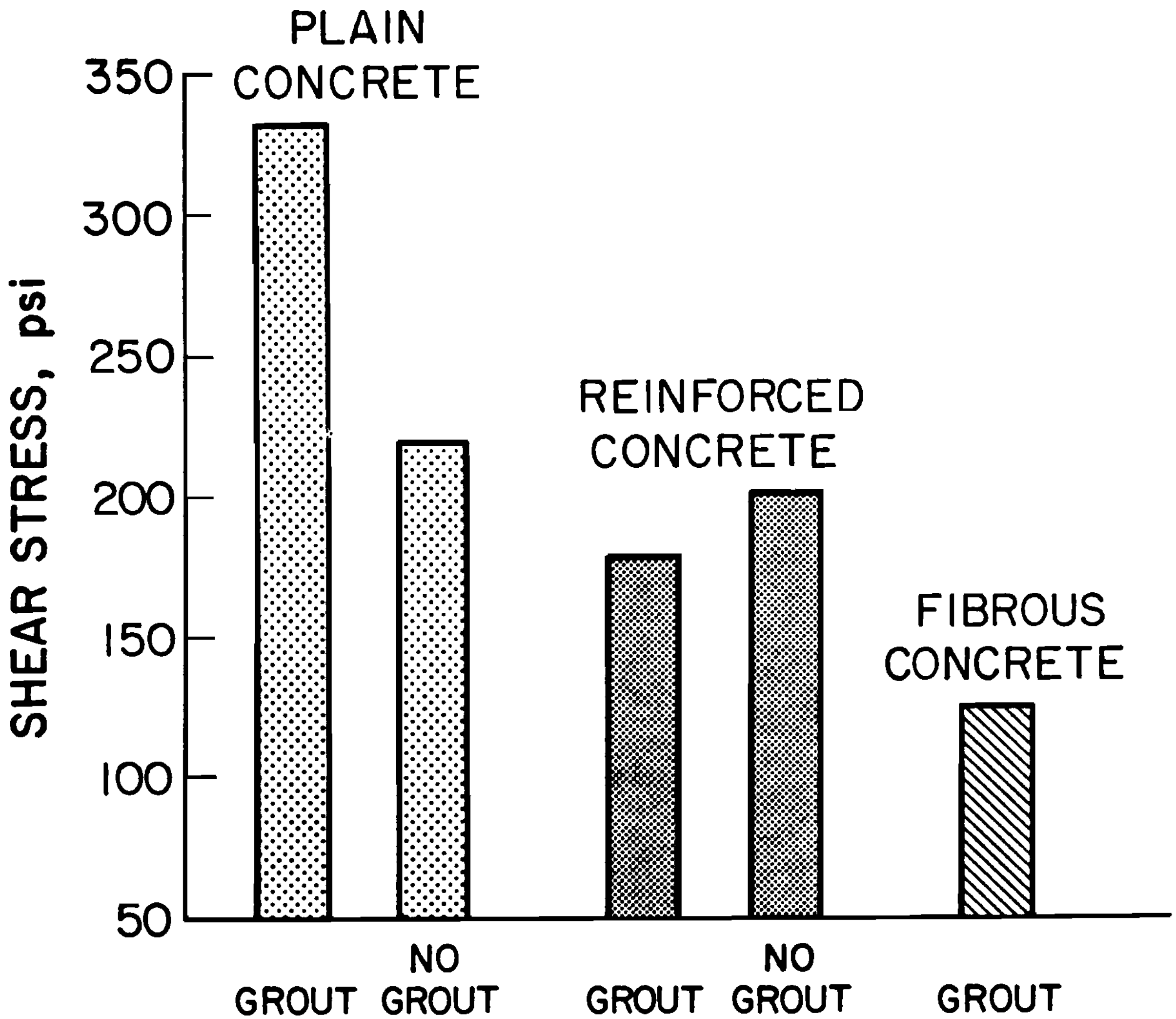
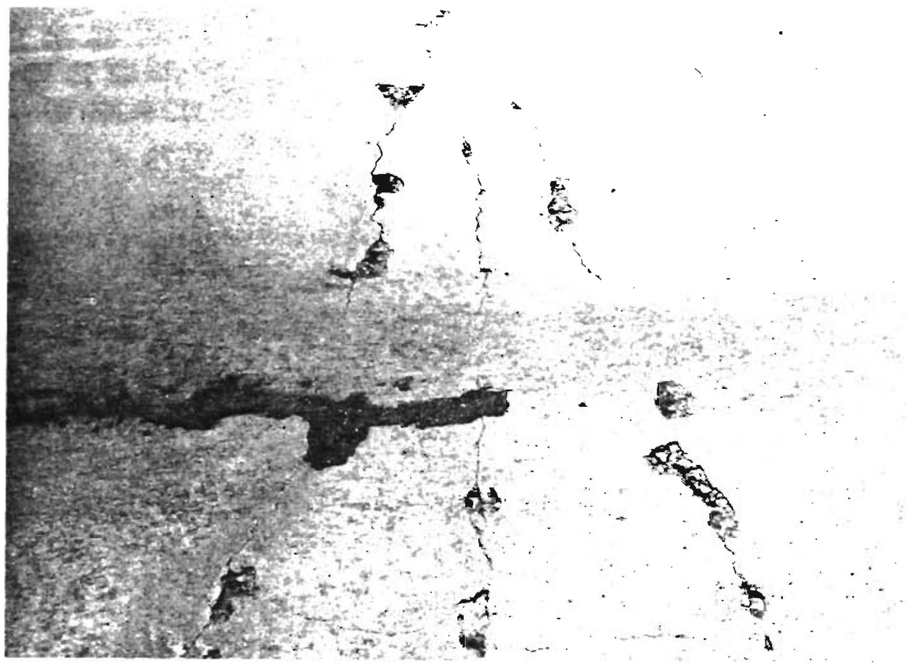


Fig 2 Field cores.

TABLE 9 MEAN SERVICEABILITY INDEX (S.I.) CHANGE BEFORE AND AFTER CONSTRUCTION.

Location		S.I.	S.I.	% S.I.
Lane	Section	Before	After	Decrease
Lane 1	2" NR	2.37	3.49	- 47
	2" R	3.67	3.35	+ 9
	3" R	2.68	2.78	- 4
	3" F	3.57	2.44	+ 32
	2" F	4.22	2.36	+ 44
Lane 2	2" NR	3.70	3.66	+ 1
	2" R	3.58	2.96	+ 17
	3" R	3.72	3.23	+ 13
	3" F	3.77	3.33	+ 12
	2" F	4.42	3.03	+ 31
Lane 3	2" NR	4.11	3.07	+ 25
	2" R	3.93	3.23	+ 18
	3" R	3.90	3.45	+ 12
	3" F	4.08	2.62	+ 36
	2" F	4.44	3.25	+ 27
Lane 4	2" NR	3.30	3.19	+ 3
	2" R	3.62	3.40	+ 6
	3" R	3.94	3.11	+ 21
	3" F	3.95	2.70	+ 32
	2" F	3.93	3.24	+ 18

Notes: - Minus sign indicates an S.I. increase.
- Lane numbers increase from median to outside shoulder.



Lateral cracking and spalling on IH-610 test section before construction of thin bonded overlay.

Longitudinal cracking on IH-610 test section after crack filling and milling, before construction of thin bonded overlay.

A portion of the IH-610 thin bonded overlay test section with evident lateral cracks.

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