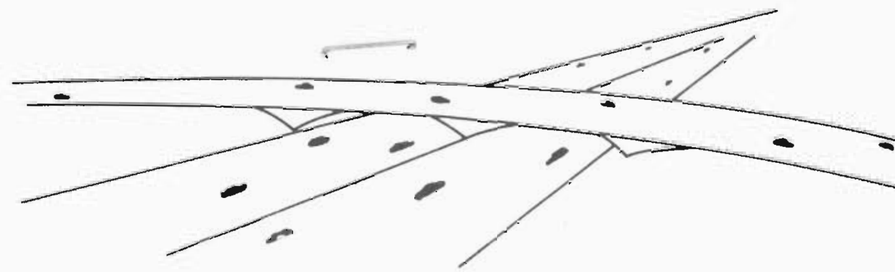

DEPARTMENTAL RESEARCH

Report Number SS 9.1

FIBROUS CONCRETE OVERLAY

TEXAS HIGHWAY DEPARTMENT

Special Report 9.1

FIBROUS CONCRETE OVERLAY

Interstate Highway 10

In Beaumont, From Washington

Boulevard, Southwest 1.39 Miles

Jefferson County, Texas

By

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INTRODUCTION In recent years, a distressing number of failures have been occurring in the continuously reinforced concrete pavement on Interstate Highway 10. Consequently, a concrete pavement repair and asphaltic concrete overlay project was let in the City of Beaumont, from Washington Boulevard, Southwest approximately 1.39 miles, to Ashland Oil, Incorporated, to restore this facility to a satisfactory condition.

Because of the intense interest in fibrous concrete generated throughout the local construction community, it was decided to place an experimental test section, an overlay as part of the Interstate Highway 10 asphaltic concrete paving project, to determine whether fibrous concrete was both feasible and economical for use by the Texas Highway Department.

The test overlay was approximately eighty feet in length, twenty-four feet in width and an average of three and three-eighths inches thick. The amount of concrete utilized in this section was twenty cubic yards, furnished by the Transit Mix Concrete and Foundation Company and placed by the project contractor, Ashland Oil, Inc. as extra work on a force account basis. The steel fibers were furnished by United States Steel Corporation at no cost to the Highway Department, in one cubic foot cartons of forty pounds each.

The fibrous concrete overlay was placed in two consecutive twelve foot width pours on the eastbound main lane of Interstate Highway 10 with traffic being confined to alternate single lanes for each pour. The average daily traffic for this eastbound section of Interstate Highway 10 is approximately 7500 vehicles per day with considerable heavy truck traffic.

TRIAL BATCH On August 15, 1973, a trial batch of one-tenth cubic yard was mixed to provide local experience in mixing technique and in working with the steel fibers. The mix was proportioned as follows:

51.7 Lbs. Cement (Type III)

22.5 Lbs. Fly Ash

20.0 Lbs. Steel Fibers (USS Fibrecon - 0.010" x 0.022"x 1")

120 Lbs. Gravel (3/4" Max. Size)

152.5 Lbs. Sand

3.3 Gal. Water

0.33 Oz. Air Entraining Admixture (Sika AER-Sika Chemical Corp.)

2.2 Oz. Water Reducing Admixture (Retarder)(Plastiment-Sika Chemical Corporation)

Initially, the sand, gravel and approximately 70% of the water was placed in the mixer. The retarder and air were then added with steel fibers being introduced gradually by hand to insure uniform mixing. The fibers were observed to be distributed evenly throughout the mix. Lastly, the fly ash and cement were added and mixed thoroughly.

Two slump tests were made, one immediately after mixing and the other approximately fifteen minutes later. The first slump was 1 1/8" and the second was 2 1/8".

Four test beams were made to be broken at 24, 48, 72 and 120 hours respectively. The surfaces of the beams finished off satisfactorily and the overall appearance of the test batch was satisfactory.

The results of the beam breaks were: 24 hours - 663 PSI; 48 hours - 944 PSI; 72 hours - 1034 PSI; and 120 hours - 970 PSI. The 120 hour specimen appeared to have been contaminated with a foreign material which emitted a "diesel fuel" odor. This probably accounts for the relatively low break of the 120 hour beam. Examination of the broken specimens revealed the following:

1. Failure in all cases occurred by the fibers "pulling out" of the concrete rather than fracture of the steel.

2. Distribution of the fibers throughout the break was extremely good indicating that fiber distribution throughout the mix was successful. (See Photo #1)

In general, the trial batch was worth the effort because it accomplished the objective of familiarizing those concerned with mixing techniques and handling of the material. One important fact gained from breaking of the test beams was

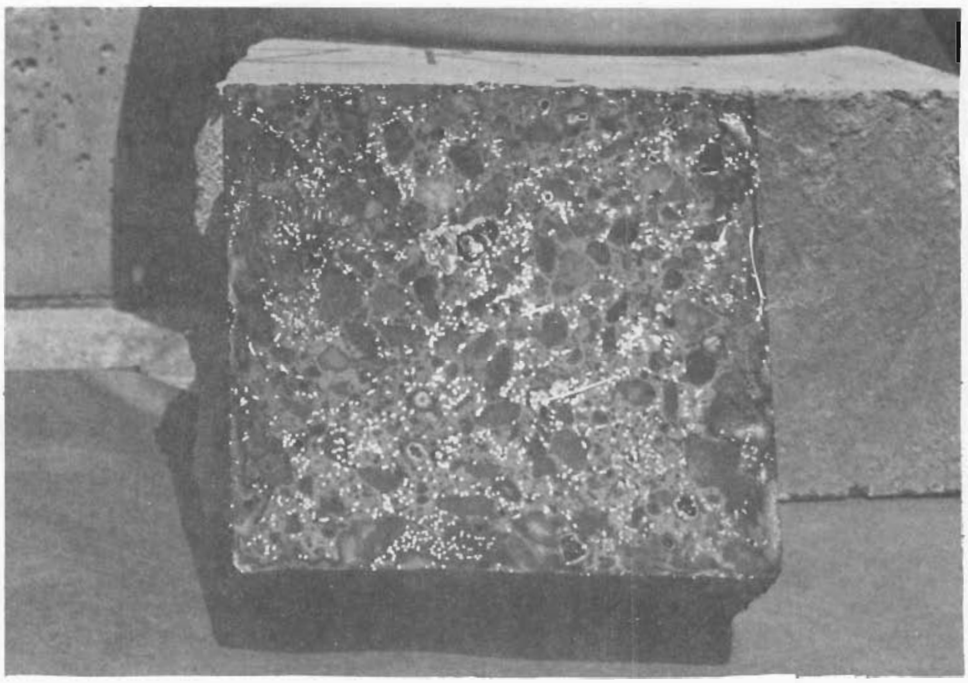


PHOTO NUMBER 1

that due to the large increase in strength from 24 hours to 48 hours, and the relatively small increase from 48 hours to 72 hours it would be safe, if necessary, to open the proposed overlay to traffic after 48 hours.

<u>MIXING</u> Two separate pours were made, the first on the inside lane (12'x79') was placed on September 21, 1973; the second on the center lane (12'x81') was placed on October 1, 1973. The average thickness of the two slabs was slightly less than three and one-half inches.

The procedure used for mixing was the same for both pours. Ten cubic yards was placed each day, and it was mixed and delivered to the job in 5 cubic yard loads. An outline of the procedure for mixing and approximate time required for each step is as follows:

1. The truck was first charged with all of the gravel sand, water, air and retarder for a five yard batch, in the same manner as normal concrete at a central batching plant. Loading time is approximately five minutes.
2. The truck was then moved around to where a dragline with a hopper containing the fly ash was waiting. The fly ash was then dumped into the mixer truck. This operation required approximately three minutes.

3. The truck was then moved to a location where the fibers were introduced by hand. The boxes of fibers and the workers (usually four) were put on a platform which had constructed on it a table with a chute to funnel the fibers into the truck. The entire platform was then lifted into place over the mixer with a fork lift. The workers then separated the fibers by hand and pushed them down the chute into the mixer. (See Photo #2) The total amount of fibers for a five yard load (approximately 950 pounds) was put into the truck in approximately forty minutes. The mixer was agitating the entire time the fibers were being introduced. Care was taken to make sure the fibers were well dispersed as they went into the mixer truck.

4. The truck was then moved into place and the Type III Cement was introduced into the mix. The loading time was approximately two minutes. The truck, then left the plant for the job site.

FIBROUS CONCRETE DESIGNS:

	DESIGN #1 (First Pour)	DESIGN #2 (Second Pour)
Gravel	1,438 Lbs/CY	1,220 Lbs/CY
Sand *	1,300 Lbs/CY	1,498 Lbs/CY
Water	33 Gal/CY	34.1 Gal/CY
Cement	517 Lbs/CY	517 Lbs/CY
Fly Ash	225 Lbs/CY	225 Lbs/CY

PHOTO NUMBER 2

	DESIGN #1 (First Pour)	DESIGN #2 (Second Pour)
Fibers	188 Lbs/CY	192 Lbs/CY
Air Entraining Admixture	3.3 Oz/CY	3.3 Oz/CY
Water Reducing Admixture	22 Oz/CY	22 Oz/CY

*Design #1 called for 1300 Lbs/CY of Sand - due to a batching error, 1523 Lbs/CY of sand was actually placed in the mix.

PLACING Since traffic interference had to be kept at a minimum, the area of the fibrous concrete overlay was kept open to traffic until the last possible moment. Upon closing the area to traffic, the existing concrete was cleaned of extraneous matter and the forms set. Since the overlay to be placed was less than standard in thickness, special wooden forms were fabricated and anchored to the existing pavement. On arrival of the first transit mix truck at the job site, the existing pavement was sprayed lightly with water and the fibrous concrete placement began.

On the first pour, an error in batching of the mix resulted in an additional 223 Lbs. of sand being added above the design amount. The resulting mix was too stiff and approximately two gallons of water per cubic yard had to be added to obtain satisfactory workability. The slump after the addition of the water was two inches.

On the second pour, the problem of workability was eliminated by a slight adjustment in batch design and a workable mix was obtained with the design water content.

Some difficulty was encountered initially with screeding and finishing. A vibrating screed was used and at first was only pulled longitudinally causing it to tear gaps or holes in the surface. (See Photo #3) This problem was rectified by simply moving the screed in a sawing motion as it was moved forward. An attempt to use a straight edge to finish the surface was unsuccessful because it would pull the fibers from the surface. A long handle metal float was then used which provided a satisfactory surface. The surface was then given a broom finish. (See Photo #4, for resulting texture) No attempt was made to tie the two slabs together and there is a longitudinal construction joint between the two slabs.

A problem encountered which caused the most concern was the "balling up" of fibers in the mix. During the placing operation, numerous round concrete coated balls, approximately two to four inches in diameter, were noticed. Several of these balls were broken apart and were found to consist of an inner core of fibers coated with grout on the outside. The fibers were so tightly packed together that it took considerable effort to break them apart. Although the entire quantity of fibers in these balls probably consisted of less than one percent of the total, the balls are undesirable and should be eliminated from the mix.

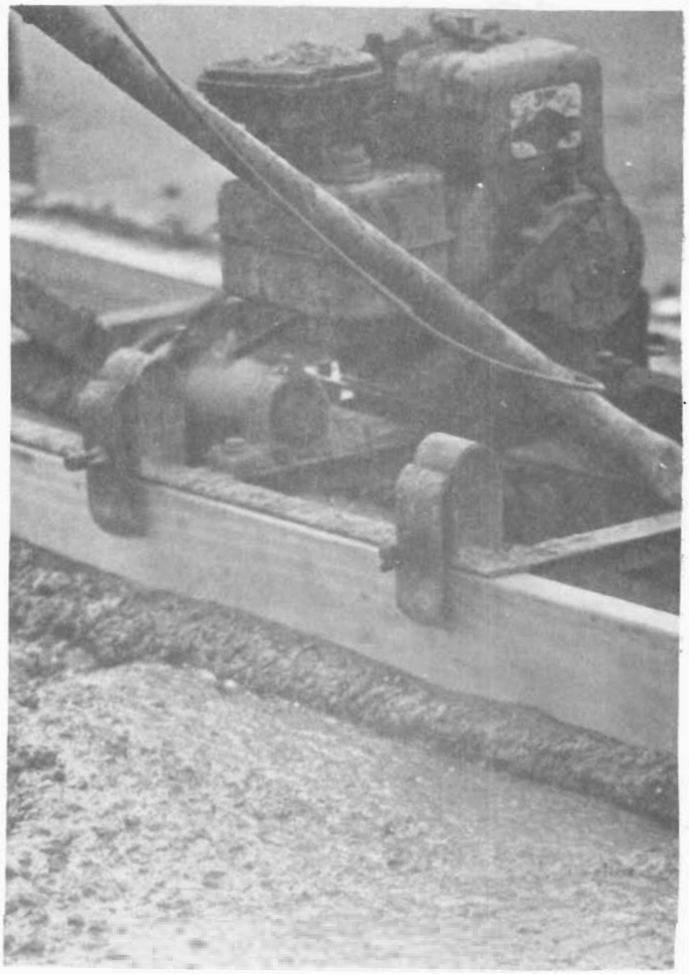


PHOTO NUMBER 3

PHOTO NUMBER 4

We are not certain what caused these fiber balls but the following are possibilities and should be considered:

1. One explanation is as the fibers are introduced into the mixer truck some of them fall into an empty vane at the rear of the mixer and stack up against the mixer blade. As the mixer rotates, the concrete from the adjacent vane is dumped on top of this row of fibers and possibly causes some to stick together. In the process of continued mixing, the fiber balls are formed.

2. There was some speculation that excess agitation during mixing caused the fibers to be attracted to each other and cause the balls.

3. As it was necessary to separate the fibers by hand it is possible that the fibers were not completely segregated before being introduced into the mix.

Although we are not certain as to the cause of the fiber balls they should be eliminated and we feel that further working with the material will reveal the cause and the solution to the problem. The workers commented that the material is very difficult to work because of its stiffness and adhesive characteristics. (See Photo #5) We believe that these characteristics would not present any particular problem with the use of proper machinery for placing the fibrous concrete.

PHOTO NUMBER 5

MISCELLANEOUS DATA AND COMMENTS

TEST BEAMS Using standard THD procedures, test beams were made during each pour with the following results:

	DATE MOLDED	DATE BROKEN	CURING DAYS	INDIVIDUAL BEAM FLEXURAL STRENGTH P S I	AVERAGE FLEXURAL STRENGTH P S I
Pour 1	9-21-73	9-24-73	3	673	765
	9-21-73	9-24-73	3	857	
	9-21-73	9-26-73	5	719	801
	9-21-73	9-26-73	5	883	
	9-21-73	9-28-73	7	795	835
	9-21-73	9-28-73	7	874	
Pour 2	10-1-73	10-3-73	2	802	817
	10-1-73	10-3-73	2	831	
	10-1-73	10-4-73	3	725	766
	10-1-73	10-4-73	3	807	
	10-1-73*	10-6-73	5	991	991

* At the request of D-9 the companion beam was sent to Austin unbroken for their examination and testing.

Although the beam break results are somewhat erratic, an analysis of the beam breaks indicate the flexural strength of the second pour material was considerably higher than the first pour material but less than that made during the trial batch. One explanation for this would be that the additional sand in the first pour caused the beams to break lower and although the distribution of fibers throughout all beams were good the beams made during construction did not have the excellent fiber distribution of the trial batch beams.

CRACKS Examination of the concrete overlay after construction operations were finished revealed that there were several surface cracks six inches to twelve inches in length in the first slab poured. Later examinations during the month of October have shown these to be merely surface cracks which have not increased in size or length and apparently will not present any problem.

The second slab was poured over an area of pavement with considerable amounts of failed area and thus far there have been cracks noted in three different locations. Prior to the placement of the fibrous concrete overlay, the topography of the existing cracks in the pavement were recorded and plotted. All three of the cracks found in the fibrous concrete overlay have occurred directly over old existing cracks in the original pavement. The first two cracks are completely through the entire thickness of the fibrous overlay; the third crack is not so severe; the locations are as follows:

1. The first crack which was discovered occurred directly over a joint between the original pavement and a patch placed by State Maintenance Forces earlier. This crack was discovered three days after the pour and prior to any traffic traveling over the patch.

2. The second crack was first observed ten days after pouring. This crack occurred over an area of existing pavement which was extremely distressed and which would

have been removed and patched using conventional methods had the fibrous concrete overlay not been used. (See Photo #6)

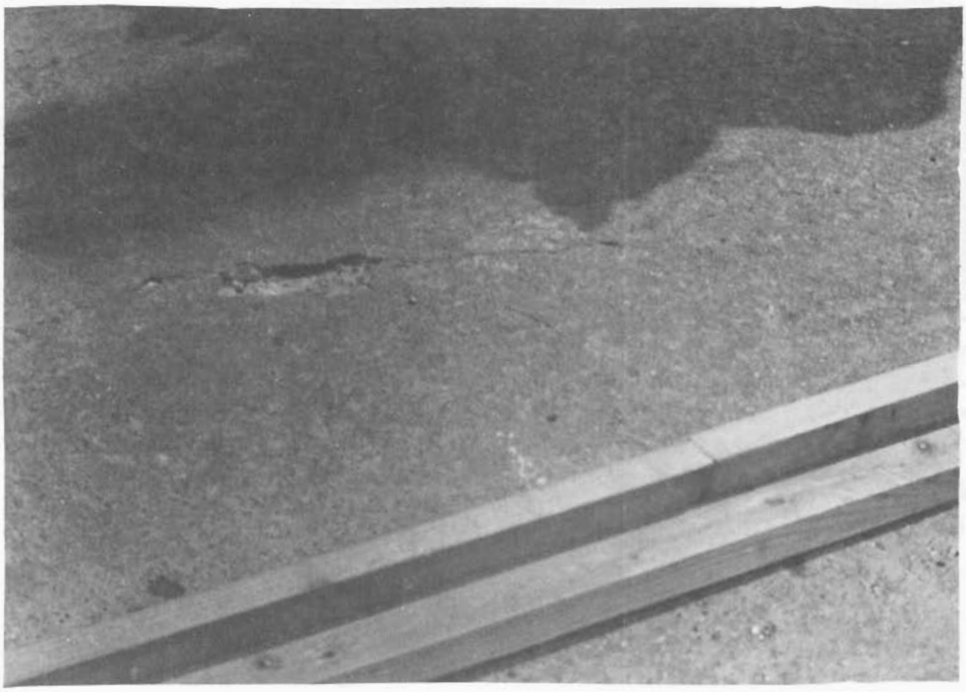
3. The third crack was first observed fourteen days after pouring. This crack, although it extends practically the entire width of the lane, does not appear to be as severe as the other two and is located directly over an existing traverse crack in the original pavement.

At the present time, the cracks present no problem and no increase in size has been noted since the initial discovery. Future examinations will be necessary before a conclusion can be made as to whether the cracks are a detriment to the overlay.

<u>COSTS</u> The work was performed as extra work on a Force Account basis by the contractor. A breakdown of the approximate amount of monies spent is as follows:

Labor	$1,700.00
Equipment	$ 800.00
Material	$1,700.00 *
TOTAL	$4,200.00

* Includes $700.00 ($0.18 Lb.) for fibers which were actually furnished to Highway Department free of charge.



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For the twenty cubic yards poured this works out to $210. per cubic yard. Considering this was an experimental project with such a small quantity of material and no previous experience in handling the material, the price is certainly reasonable.

As far as the economy of using this material is concerned, we will simply have to evaluate the material upon its performance in the future. We do feel that the three inch overlay in the location chosen is a very severe test. Included in the center lane overlay were two 12' x 12' areas which would have been patched by conventional methods at a cost of $2,300 had we not chosen this location for the experiment.

RECOMMENDATIONS For anyone considering possible further experimentation with this material we offer the following suggestions:

1. Try several one-tenth cubic yard trial batches to gain experience. We feel that the knowledge we gained through the trial batch was well worth the effort. Perhaps, try varying the mixing techniques for introduction of fibers and other materials into the mix.

2. Try varying the thickness of the overlay slab over distressed areas of existing concrete pavement.

3. Try eliminating the bond between the old pavement and the overlay by use of asphaltic material or some other method.

4. Experiment with several different methods of segregating the fibers and keeping them separated until they reach the mixer.

5. Possibly some thought and experimentation should be given to using a combination of a fairly light conventional reinforcing and fibrous concrete for pavement.

CONCLUSION The concrete overlay was deliberately placed in and area of extreme pavement failures with the knowledge that the overlay would be subject to the most severe test possible using actual traffic. At the conclusion of the fibrous concrete overlay operation, the overall impression generated among the many observers was that this material has tremendous potential, but that there are also some inherent difficulties which will have to be overcome as usage increases.

It is also the general opinion that if this overlay section is successful under these difficult field test conditions, then there is a definite place for fibrous concrete in the building material family.

This overlay section will be monitored and evaluated on a continuing basis in the future and the results of this monitoring will be made a part of this report.