a review of field applications of fibrous concrete

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The use of fibrous concrete as an overlay or resurfacing material has been tested in many field research projects. These projects have been designed to test thickness requirements, fiber requirements, mix design, jointing requirements, placement conditions, and construction procedures. Several tests have been conducted of fibrous concrete resurfacing on airport taxiways, urban expressways, arterials, residential streets, and bridges, and the results of some of these tests are discussed.

• Fibrous concrete is a composite material consisting of a concrete matrix containing a random dispersion of small fibers. The fibers, closely spaced at random angles, reinforce the concrete matrix in all directions. The fibers not only compensate for the relatively low tensile strength and brittle character of concrete but also improve other properties of the composite material. The broken beam section in Figure 1 shows the distribution of 1-in. fibers in a mix containing 120 lb/yd^3.

Laboratory research has shown that among the important changes in the properties are

1. A substantial increase in flexural and tensile strength,
2. An increase in fatigue endurance limit,
3. Higher resistance to abrasion and spalling, and
4. Higher impact resistance.

The degree of improvement depends on a number of factors. Some of the more important factors will be discussed later.

TYPE OF FIBERS

Fibers have been produced from steel, plastic, and glass in various shapes and sizes. The fibers used in the following field applications are flat steel fibers produced either by shearing steel sheets or by cutting or chopping wire into lengths ranging from 1 to 2½ inches. The flat steel fibers are approximately 10 by 22 mils in cross section (Fig. 2), whereas the chopped wire is in the range of 16 to 25 mils in diameter.

MIX DESIGN CONSIDERATIONS

The additional strength imparted to the concrete by the fibers depends on the bond between the fibers and the concrete mortar. With adequate bond, microcracks that develop in the mortar will be arrested upon reaching a fiber, which takes over the tensile stresses from the mortar.

Because the addition of fibers greatly increases the surface area that must be coated with cement paste, a higher percentage of mortar is required to produce a workable mix than is required for normal concrete. The wire segments also contribute to a high internal friction, which also affects the workability of the mixture. Thus fibrous concrete mixes are designed with a higher percentage of fine aggregate and either a higher cement content or the addition of pozzolanic material such as fly ash to improve the lubricating properties of the mortar. Water reducers are frequently used to reduce the water demand of these mixes. Air entrainment is also used to assist in providing increased workability.

The term aspect ratio has been adopted as a convenient numerical parameter describing a fiber. Aspect ratio is the length of a fiber divided by its diameter. For flat fibers the equivalent diameter is used, which corresponds to a diameter of a circle of equivalent cross section.

The state-of-the-art paper on fibrous concrete by ACI Committee 544 recommends aspect ratios from 30 to 150. The projects covered in this report used fibers with aspect ratios in the range of 60 to 100.

It is important to obtain a uniform distribution of fibers during mixing. Gray (1) reported that "it has been the general experience that segregation or balling of fibers during mixing is related to three major factors: the aspect ratio of the fibers, the volume percentage of the fibers, and the mixing procedure." From the standpoint of fiber handling, plant batching, and mixing, it would be desirable to use fibers with the lower aspect ratio; however, from the strength standpoint, it is desirable to use fibers with the higher aspect ratio.

Fiber contents of the mixes used on the experimental projects covered in this report vary from 60 to 265 lb/yd^3. The mix design and mixing procedures are covered under the individual projects.

FIBROUS CONCRETE RESEARCH

Laboratory and field research projects during the past few years indicated that fibrous concrete has great potential advantages for certain applications in the paving field. Since 1967 several pavement slabs have been placed in the field. These early field projects served to develop the techniques for mixing and placing a fibrous concrete mix. Performance of these slabs was promising; however, the installations were usually limited in size because of the availability of fibers and the experimental nature of the early work.

Given the physical properties of fibrous concrete, it is apparent that the material shows great promise as an overlay or resurfacing material.

GOALS OF FIELD RESEARCH PROJECTS

To determine the future potential for this material requires that the performance characteristics of fibrous concrete in pavement overlays receiving normal mixed highway and airport traffic be determined. To do this, field research projects have been placed by cooperative efforts of federal agencies, airport authorities, state highway departments, city engineering departments, fiber producers, cement manufacturers, Michigan and Iowa Concrete Paving Associations, Portland Cement Association, and American Concrete Paving Association. These projects were designed to determine the following:

1. Thickness requirements for fibrous concrete resurfacing for mixed traffic on streets, highways, and airports;

Figure 1. Broken beam showing distribution of 1-in. fibers in mix.

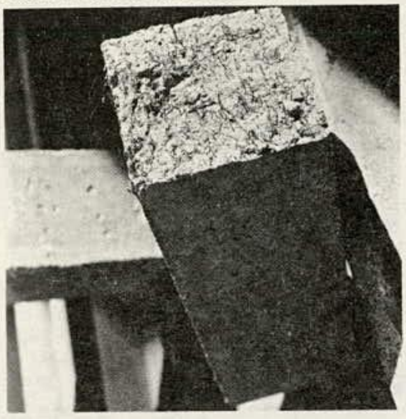


Figure 2. Flat steel fibers produced by shearing steel sheets.

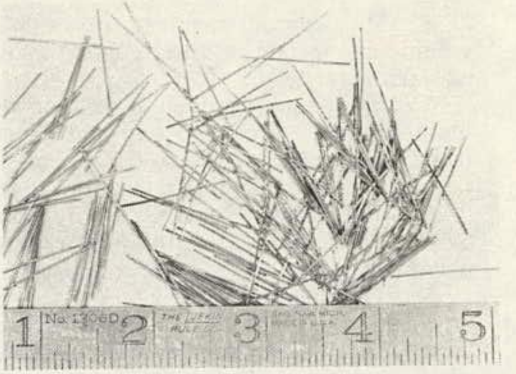


Table 1. Mix design and strength properties of fibrous concrete.

Property	Six-Inch Slab	Four-Inch Overlay
Cement factor (type 1), bags/yd^3	9	9
Water-cement ratio	0.50	0.46
Fine-coarse aggregate ratio	3	3
Maximum size coarse aggregate, in.	$^3/_8$	$^3/_8$
Fiber content, percent (265 lb/yd^3)	2	2
Fiber type	Steel	Steel
Fiber cross section, in.	0.016 ϕ	0.010 × 0.022
Fiber length, in.	1.0	1.0
Test age, days	73	28
Flexural strength, psi	940	1,140
Modulus of elasticity (flexure), psi × 10^6	5.30	5.28
Compressive strength, psi	5,760	6,960
Tensile strength, psi	760	870
Air content, percent	5.5	5.9
Slump, in.	5	$3^1/_4$

Figure 3. Spalling of cracks in base slab before 4-in. fibrous overlay.

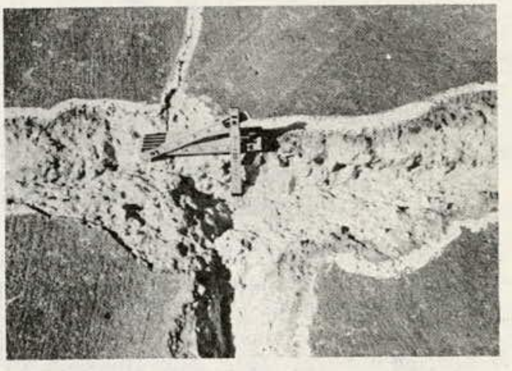


Figure 4. Random (a) longitudinal and (b) transverse cracks in taxiway pavement prior to 6-in. fibrous overlay.

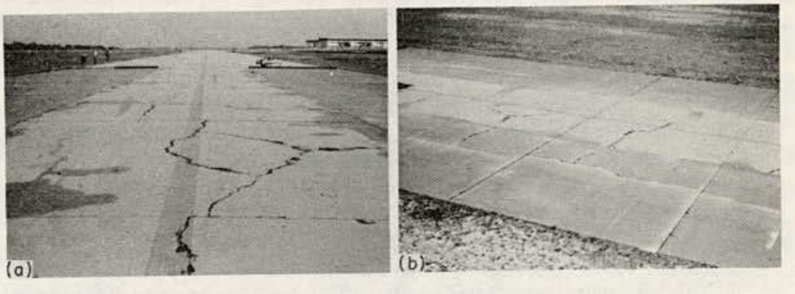


Table 2. Mix design for Tampa Airport fibrous concrete overlays.

Item	Amount	Volume (ft^3)
Cement (at $5^1/_2$ sacks/yd^3), lb	517	2.63
Fly ash, lb	225	1.44
Fibers (1.5 percent by volume), lb	200	0.41
Coarse aggregate ($^3/_4$ in. max), lb	1,200	7.66
Fine aggregate	1,525	9.38
Water	275	4.40
Water-cement ratio of fly ash	0.37	–[a]
Air, oz	3.3	
Water reducer-retarder, oz	38.5	
Air (4 percent)		1.08
Total		27.00

[a]By weight.

Figure 5. Three-quarter-in. aggregate used in fibrous concrete mix for Tampa overlay.

2. Fiber content required for various pavement applications, the influence of traffic volume and weight on fiber content requirements, and the effect of fiber length and type on performance;

3. Mix design required to develop adequate bond between fibers and mortar and the maximum size of coarse aggregate best suited for fiber-reinforced concrete mixes (field research projects have generally used $^3/_8$-in. coarse aggregate as maximum, except on the Tampa Airport overlay in which $^3/_4$ in. was maximum);

4. Jointing requirements for fibrous concrete placed as a bonded, partially bonded, or unbonded overlay and the jointing requirements for a full-depth fibrous concrete pavement;

5. Placement of a fibrous concrete overlay either directly on a jointed concrete pavement or with a separating layer; and

6. Ability of present equipment to mix and place fibrous concrete and the type of fiber handling methods and equipment required on large-scale operations.

FIELD RESEARCH PROJECTS

One of the best examples of the potential of fibrous concrete as a resurfacing material is provided by the heavy load test project conducted by the Corps of Engineers (2) and sponsored by the Construction Engineering Research Laboratory at Champaign, Illinois.

Included in this research project was a 6-in. fibrous concrete slab on a 4-in. sand filter course having a modulus of subgrade reaction of 52 lb/in.^{3}. The test pavements were constructed in June 1971 and included other thicknesses of plain concrete pavement. The test items were trafficked with C5A and dual tandem gear.

One of the test items in this research project was a 10-in. plain pavement that was constructed to test the effects of multiple-wheel heavy gear loading (C5A) on various types of construction joints. After the 10-in. pavement was trafficked to failure, a 4-in. fibrous overlay was placed. Major structural cracks were present, and the cracks had spalled severely (Fig. 3). The 4-in. overlay was of a partially bonded type with the base pavement merely cleaned and moistened prior to overlaying. The overlay was cast monolithically over the entire 50- by 50-ft base pavement. Table 1 gives mix design information for both the slab on grade and the 4-in. resurfacing.

The 10-in. base pavement failed at 950 repetitions of C5A loadings. After the 4-in. overlay was placed, 900 additional load repetitions were applied before the first crack became visible. After 6,900 load repetitions, the test was discontinued, and one working crack was noted. The hairline cracks that developed as loads were applied were located over cracks in the broken base pavement. This certainly is evidence of outstanding performance of a thin overlay on a structurally overloaded base pavement.

The 6-in. fibrous concrete pavement on the weak foundation (K = 52 lb/in.^{3}) withstood 350 load applications of C5A gear before the first visible crack occurred. A number of hairline cracks were evident at 8,700 repetitions, which would not interfere with normal aircraft operations on an in-use pavement. Only one working crack was evident at this time and was located near the center of the slab in a transverse direction.

The measurements of deflections, strains, and subgrade pressures along with observations of the performance under loadings of these test items will provide some of the information necessary to develop a design procedure for fiber-reinforced concrete pavements and overlays.

The Corps of Engineers is continuing to develop design information for fibrous concrete pavements by additional test sections including a 7-in. fibrous concrete slab on a membrane-encapsulated soil and a 4-in. pavement on 17 inches of cement-stabilized clay-gravel. In June 1973 a 1,000-ft section of unjointed fibrous concrete pavement was placed at the Waterways Experiment Station in Vicksburg. The pavement was 4 inches thick and 24 feet wide. The purpose of this installation was to study the crack pattern that would develop in long sections of unjointed fibrous concrete.

TAMPA INTERNATIONAL AIRPORT PROJECT

Two fibrous concrete overlay sections were placed on a taxiway at Tampa International Airport with the cooperative efforts of the local airport authority, FAA, Corps of Engineers, U.S. Steel Corporation, and a local contractor. The taxiway is used by mixed aircraft traffic including the Boeing 747. The 25-ft-wide taxiway lanes had midpanel random longitudinal cracks and some random transverse cracks as shown in Figure 4. It appeared that a subgrade problem existed in this area, and a slight amount of faulting was evident on some of the cracks.

The two sections were placed directly on the old pavement after cleaning and prewetting. One section consisted of three 25-ft lanes, 175 feet long and 6 inches thick, with butt types of longitudinal joints. The longitudinal construction joints matched the base pavement construction joints; however, no transverse joints were cut in the 175-ft-long overlay.

The other section was 4 inches thick and 50 feet square placed in two 25-ft lanes with the longitudinal construction joints in the base pavement centered under the overlay pavement lanes.

Mix Design

The mix design on this project departed significantly from that on other experimental fibrous concrete pavement projects. The maximum size coarse aggregate was ¾ inch (Fig. 5) instead of the ⅜ inch used on other experimental projects. The mix design called for 5½ sacks of cement per cubic yard and 225 pounds of fly ash. The mix design proportions for a 1-yd^2 batch are given in Table 2.

The fibers used on this project were 1-in.-long flat fibers of 10- by 22-mil cross section. The flexural strength of the concrete was 765 psi at 7 days, 830 psi at 28 days, and 1,010 psi at 90 days.

Mixing, Placing, and Finishing

The fibers were furnished in 40-lb boxes and were manually fed onto a conveyor belt that deposited the fibers on top of the aggregates on the charging belt to the mixer. The mixer was a 9-yd^3 Rex tilting mixer equipped with a horizontal premix drum. The concrete was mixed in 4-yd^3 batches to match the capacity of the temporary fly ash handling system. Fiber distribution in the mix was excellent with no balling evident in the mixed concrete. The mixing plant is shown in Figure 6.

The concrete was transported to the paving site in side-dump haul units and spread with a box spreader. A CMI slip-form paver was used to strike off, consolidate, and finish the pavement. A tube float followed the slip-form paver, and the texture was applied with a wire comb. A white-pigmented cure was applied to the pavement. The middle lane of the 6-in. section was textured with a stiff-bristled broom. The procedure is shown in Figure 7.

The significance of this project from the standpoint of pavements is that it demonstrated modern high-capacity paving equipment capable of mixing, hauling, placing, and finishing fibrous concrete. The project also illustrated the need for development of some method of bulk handling of fibers. Mix design changes were also significant.

DETROIT EXPERIMENTAL PROJECT

In October 1972, a 1,100-ft demonstration project was placed on a major urban expressway in Detroit, Michigan. Eight Mile Road is an eight-lane divided highway carrying 100,000 vehicles per day, 18 percent of which is heavy commercial traffic. This project was sponsored by members of the Michigan Concrete Paving Association and the American Concrete Paving Association in cooperation with the Michigan Department of State Highways and the Federal Highway Administration.

This was the largest area of fibrous concrete pavement that had been placed to that date, and it was the first time high production paving equipment was used to pave with fibrous concrete on a highway project.

The 48-ft-wide overlay was placed on an existing concrete pavement consisting of two 10-ft lanes constructed in 1932, one 12-ft lane built in 1954, and 16 feet of new concrete base widening added in 1972. The condition of the base pavement is shown in Figure 8. Surface preparation consisted of blowing out cracks, sweeping with a power broom, and then wetting the surface before the fibrous overlay was placed.

Mix Design

A water reducer-retarder was used during the first paving day and a straight water reducer the second. These proportions were altered slightly for job conditions and for the changes in fiber content. Half the concrete placed each day contained 120 lb of steel fibers/yd^3 and the other half contained 200 lb/yd^3. The mix design was as follows:

Item	Amount
Cement, lb	850
Coarse aggregate, slag (½-in. max), lb	906
Sand, lb	1570
Water (34 gal), lb	283
Fibers (0.016 × 0.010 × 1 in.), lb/yd^3	120 and 200

Equipment

The fibrous concrete was produced in a central mix plant with a 9-yd mixer. Batch size was limited to 6 yards. Agitating trucks transported the concrete to the paving site, about a mile away, and spread it directly on the existing concrete ahead of the paver. The slip-form paver (Fig. 9) was locked to a string line for electronic control of line and grade. A texturing-curing machine with a wire comb textured the surface transversely and applied white-pigmented curing compound (Fig. 10). A tube float machine was used on the first paving day but not the second.

Concrete saws cut a longitudinal joint in the center of each 24-ft-wide placement. On one section of pavement a longitudinal joint was not cut in order to determine whether cracking would develop. The transverse joints were cut by using abrasive blades the first day and diamond blades the second. In each case the joints were sawed the day after paving. Some of the transverse joints were ¾ inch wide spaced at 100 feet, and others were ½ inch wide spaced at 50 feet. No attempt was made to match the joints in the existing concrete pavement. Preformed compression seals (Fig. 11) were installed in the transverse joints, and hot-poured sealant was used in the longitudinal joints.

Fiber Handling

As on other fibrous concrete paving projects to date, the steel fibers were delivered in small boxes in 40-lb lots. Workers opened the boxes of fibers and dumped the amount

Figure 6. Central mix plant with horizontal premix drum (note fiber charging belt at extreme right).

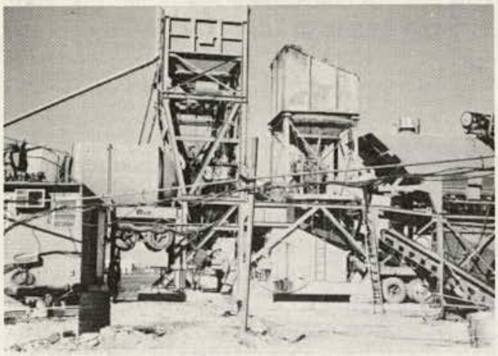


Figure 7. Paving train on 6-in. fibrous overlay.

Figure 8. Condition of base pavement prior to fibrous overlay.

Figure 9. Slip-form paver used on Michigan fibrous overlay.

Figure 10. Equipment used to texture and apply curing compound.

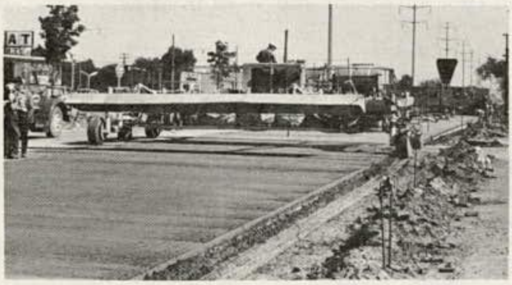
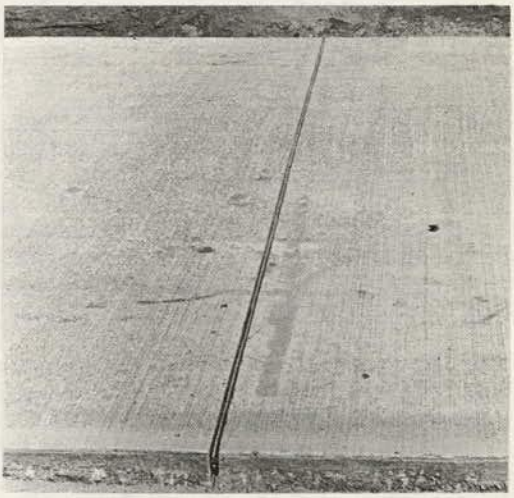


Figure 11. Preformed compression seal in transverse joint.



required for one batch into the bucket of an end-loader. The loader placed the fibers on a table next to a belt feeder where workers, using hand rakes and forks, fed them through an 8-ft-long grizzly onto a high-speed belt. This belt discharged onto the main plant belt, which fed the fibers and aggregates into the mixer drum. The batch cycle generally ranged from 4 to 6 minutes.

Construction Schedule

On October 7, 1972, two of the four eastbound lanes were closed to traffic, and a slip-form paver resurfaced the existing concrete with 3 inches of fibrous concrete. Two days later, the new overlay was opened to traffic, and the remaining eastbound lanes were resurfaced. In two more days, all four lanes were back in service.

This overlay having different fiber contents will be subjected to a heavy volume of mixed highway loadings to determine the effect of fiber content on performance. This project is the first one of sufficient length to study the jointing requirements of a fibrous concrete overlay placed directly on a concrete base pavement.

CEDAR RAPIDS EXPERIMENTAL PROJECT

Four fibrous concrete overlays were constructed in fall of 1972 in Cedar Rapids, Iowa. These projects included the overlaying of an airport taxiway, an arterial street, a residential street, and a bridge. The projects were cosponsored by the Iowa Concrete Paving Association and Battelle Development Corporation in cooperation with the City of Cedar Rapids.

Equipment

The concrete was supplied by a local ready-mix firm. The firm experimented in developing the sequence for charging the truck mixers so as to minimize the formation of balls in the concrete and finally settled on charging 70 percent of the water and all aggregates and then adding the steel fibers. During charging of the fibers, it became necessary to run the truck mixer at mixing speed to prevent balling of the fibers. For each batch the fibers were spread evenly on a table on the second level of the plant and were pushed by hand through a vibrating screen into a chute that charged the mixers. It took from 5 to 15 minutes to charge the fibers depending on fiber size and content. After the fibers were mixed with the aggregates, the cement and the remainder of the water were added. The batch size was limited to 5 yards for the 7-yd mixers.

Concrete Mixes

Aggregates for the fibrous concrete were $3/8$-in. pea gravel and river sand. A typical mix design for the projects is that for the portion of the airport taxiway in which $2\frac{1}{2}$-in.-long fibers were used. It included 752 lb (8 bags) of cement, 750 lb of coarse aggregate, 1,848 lb of fine aggregate, 346 lb of water, 150 lb of steel fiber, and 6 percent air. A water reducer-retarder was used in the airport concrete and a straight water reducer on the other projects. Concrete consistency was maintained at a slump of about 4 inches.

Placing Equipment

The contractor used a variable-width bridge deck paver (Fig. 12) to place and finish the concrete. Workers spread the concrete ahead of the paver with rakes and shovels after the base pavement had been swept and sprinkled with water. Hand finishers behind the paver used aluminum straightedges for smoothing the surface and applied the surface texture with a hand broom. White-pigmented curing compound was sprayed on the finished surface at the airport, but on the street projects the concrete was cured by emulsified linseed oil.

Figure 12. Bridge deck paver used to place concrete on Cedar Rapids project.

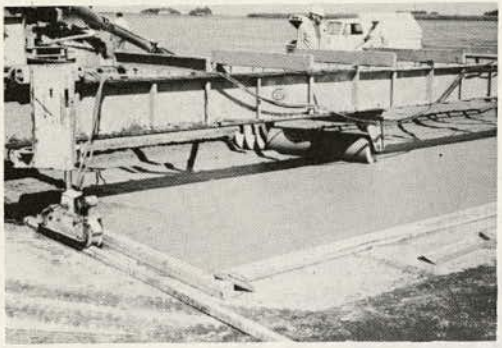


Figure 13. Crack pattern on Greene County project.

Table 3. Greene County fibrous concrete experimental resurfacing.

Section No.	Section Length (ft)	Pavement Type	Pavement Thickness (in.)	Cement Content (lb)	Fiber Length (in.)	Fiber Content (lb)	Pavement Bonding	Transverse Joints	Longitudinal Joints	Comments
1	450	A-4	5	569	—	—	Partial	At 20 feet	Yes	Dowels at 3 ft c. to c.
2	450	A-4	4	569	—	—	Partial	At 30 feet	Yes	6 × 6 mesh
3	200	A-4	4	569	—	—	Bonded	See plan	Yes	CRC anchor section
4	600	A-4	4	569	—	—	Unbonded	See plan	Yes	CRC elastic joints
None	100	A-4	3 to 4	569	—	—	Unbonded	See plan	Yes	Transition section
5	600	A-4	3	569	—	—	Unbonded	See plan	Yes	CRC elastic joints
6	200	A-4	3	569	—	—	Bonded	See plan	Yes	CRC anchor section
7	400	Fibrous	3	600	1	60	Partial	At 40 feet	Yes	Transverse joints cut full depth
8	400	Fibrous	3	750	2½	60	Partial	At 40 feet	Yes	250 ft of 2½-in. fibers; remainder 1 in.
9	400	Fibrous	3	600	1	100	Partial	At 40 feet	Yes	Transverse joints cut full depth
10	400	Fibrous	3	750	1	100	Partial	At 40 feet	Yes	
11	400	Fibrous	3	750	2½	100	Unbonded	At 40 feet	Yes	
12	400	Fibrous	3	750	1	100	Bonded	At 40 feet	No	
13	400	Fibrous	3	600	1	60	Partial	At 40 feet	Yes	
14	400	Fibrous	3	500 + 234 FA	1	100				
15	400	Fibrous	3	500 + 234 FA	2½	100	Partial	At 40 feet	Yes	
16	400	Fibrous	3	600	2½	60	Partial	At 40 feet	Yes	
17	400	Fibrous	3	750	1	60	Partial	At 40 feet	Yes	
18	400	Fibrous	3	600	1	160	Partial	At 40 feet	Yes	
19	400	Fibrous	3	750	1	160	Partial	At 40 feet	Yes	
20	400	Fibrous	3	750	2½	160	Unbonded	At 40 feet	Yes	
21	400	Fibrous	3	750	2½	100	Bonded	At 40 feet	Yes	
22	263.1	Fibrous	3	500 + 234 FA	1	160	—	See plan	Yes	On grade
23	159.7	Fibrous	3	750	1	160	Bonded	See plan		Bridge
24	499.2	Fibrous	3	600	1	100	Partial	See plan	Yes	Curb section
25	478	Fibrous	3	750 Chem Comp	2½	100	Unbonded	At 40 feet	No	
26	400	Fibrous	2	750	2½	160	Partial	At 40 feet	Yes	
27	400	Fibrous	2	600	1	100	Partial	At 40 feet	Yes	
28	400	Fibrous	2	750	1	100	Partial	At 40 feet	Yes	Transverse joints cut full depth
29	400	Fibrous	2	750	1	100	Bonded	At 40 feet	Yes	
30	400	Fibrous	2	750	1	160	Partial	At 40 feet	Yes	
31	400	Fibrous	2	600	1	100	Partial	At 40 feet	No	
32	400	Fibrous	2	750	1	100	Partial	At 40 feet	No	
33	400	Fibrous	2	600	1	160	Partial	At 40 feet	Yes	
34	400	Fibrous	2	750	1	160	Partial	At 40 feet	Yes	
35	400	Fibrous	2	750	2½	100	Unbonded	At 40 feet	Yes	
36	400	Fibrous	2	750	2½	100	Bonded	At 40 feet	Yes	
37	400	Fibrous	3	600	2½	60	Partial	At 40 feet	No	
38	400	A-4	4	569	—	—	Partial	At 30 feet	Yes	6 × 6 mesh
39	400	A-4	5	569	—	—	Partial	At 20 feet	Yes	Dowels at 3 ft c. to c.
40	200	Fibrous	3	500 + 234 FA	1	100	Partial	Various	No	
40A	218.1	Fibrous	3	500 + 234 FA	1	160	—	At 40 feet	Yes	On grade

Information on the individual projects in Cedar Rapids follows.

Airport—The airport overlay varies from 1 to 3 inches thick across a 75-ft-wide concrete taxiway. It was paved in 37½-ft passes. The base concrete has longitudinal joints at 12½-ft intervals and transverse joints spaced at 20 feet. The overlay pavement has no joints except the longitudinal construction joint in the center.

Two concrete mixes were used. One was a nine-bag mix with 200 pounds of 1-in.-long, 16-mil-diameter steel fibers per cubic yard. The other was an eight-bag mix with 150 pounds of 2½-in.-long, 25-mil fibers per cubic yard.

Arterial—A 200-ft-long overlay, 25 feet wide and 2½ inches thick, was placed on Fifth Avenue, a heavily traveled one-way street in Cedar Rapids. The base was an asphalt surface on a brick pavement. Streetcar tracks down the center had reflected through the surface. The fibrous overlay was not jointed.

A nine-bag mix was used on this project. One-inch-long, 16-mil steel fibers were added at the rate of 250 lb/yd^3 for half the section and 200 lb/yd^3 for the rest.

Bridge Deck—A 3-in.-thick, 12-ft-wide, 150-ft-long fibrous overlay was placed on a wooden plank bridge deck that had been cleaned of loose asphalt and covered with a double layer of polyethylene sheeting. There were no joints in the overlay. Two and a half-inch-long, 25-mil steel fibers were added at 150 lb/yd^3 to the eight-bag concrete mix. The traffic count was 30,000 vehicles per day.

Residential Street—On October 5 a 28-ft-wide, badly scaled old concrete pavement on Danbury Street was resurfaced from curb to curb with 2½ inches of fibrous concrete for a length of 150 feet. One-inch-long, 16-mil fibers were added at 175 lb/yd^3 to the eight-bag concrete mix used on this overlay.

These projects will serve to provide information on the relative effect of fiber length and content on performance. The projects will also provide information on the effect of different traffic volumes and weights on performance.

GREENE COUNTY, IOWA, EXPERIMENTAL PROJECT

One of the most ambitious projects planned to date is an experimental fibrous overlay project in Greene County, Iowa. The Greene County engineer, along with the Iowa Research Council, the Iowa Concrete Paving Association, and the concrete paving industry, conducted a full-scale (3.03 miles) fibrous concrete overlay research project. The purpose is to study and evaluate the relative performance of various fibrous concrete overlay designs and to compare their performance to that of other concrete overlay designs. The research project involved the widening and resurfacing of an unjointed concrete pavement built in 1920-21. The pavement crack pattern is shown in Figure 13.

Variables in the fibrous concrete sections included overlay thickness (2 and 3 inches), cement content (600 and 750 lb/yd^3), fiber content (60, 100, and 160 lb/yd^3), fiber length (1 and 2½ inches) and type, and condition of bond with the old slab. Special sections included one that used shrinkage-compensating cement and one with a partial replacement of cement with fly ash. The mix designs developed by Kesler at the University of Illinois are based on 7-day flexural strengths of 600, 800, and 1,000 psi.

Sections of 3- and 4-in. continuously reinforced overlay with elastic joints were included in the study. The joints were formed at 8-ft intervals by placing parting strips on the old pavement, and a bond breaker was applied to the reinforcing steel at the joint locations. Control sections of 5-in. conventional plain and 4-in. mesh-reinforced concrete overlay were included.

Joint spacing on the fibrous concrete sections was at 40 feet. Six of the test sections had no longitudinal joint. Two sections had neoprene preformed seals in the transverse joints. All other joints had hot-poured sealant. Lean-mix concrete was used for widening the existing 18-ft pavement to 22 feet.

This project is the first one of sufficient length to compare the effect of variations in thickness, fiber content and length, concrete strengths, and placement conditions (bonded, unbonded, or partially bonded). Table 3 gives details of the test sections built under this Greene County research project.

SUMMARY

The field research projects discussed in this report along with laboratory research projects will serve to provide the information necessary to develop the design parameters for fibrous concrete pavement such as thickness, jointing, fiber content, fiber geometry, mix design, and the construction procedures necessary for this new material.

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2. Gray, B. H., and Rice, J. L. Fibrous Concrete for Pavement Applications. Construction Engineering Research Laboratory, Department of the Army, Champaign, Ill., Rept. M-13, April 1972.