Latex Modified Fibrous Concrete
Sundial - Sandy River Section

Interim Report

INTRODUCTION

In November 1980, the Siuslaw Construction Company requested permission to substitute a 1.5 inch Latex Modified Fibrous Concrete (LMFC) overlay for either a 2.5 inch low slump concrete (Iowa System) or a 2.5 inch unreinforced latex modified concrete overlay on four bridge decks within the Sundial - Sandy River Section. At that time a presentation was made by OBEC consulting engineers on the benefits of using this new material. The greater flexural strength of the concrete due to the presence of the fiber was the reason cited for reducing the overlay thickness.

The request was studied by state highway engineers before conditional approval was granted. Oregon's problems with cracking in previously placed deck overlays greatly influenced the decision to allow an alternate overlay system.

The LMFC consisted of adding approximately 85 lbs of Dramix ZP 50/.50 steel fibers to each cubic yard of latex modified concrete. An eight sack per cubic yard cement factor was specified instead of the 7.5 sack/cy value usually designated for latex modified concrete mixes.

Before the project began, a work plan was prepared by the Research Section describing the laboratory work that would be performed prior to construction and the method of evaluating the performance of the experimental overlay system. This interim report discusses the results of the laboratory study, describes some of the construction techniques used and the major problems encountered during construction and provides a short term evaluation of the overlay.

LABORATORY FINDINGS

The purpose of testing the Latex Modified Fibrous Concrete in the laboratory was twofold. First, the "maximum allowable work time" for the latex concrete had to be determined because the contractor was prevented from mixing it in a concrete mobile mixer at the bridge site due to the steel fibers. Second, the effects of the steel fibers on workability had to be investigated and the optimum cement and latex modifier content had to be confirmed. When determining the "allowable work time" the ability to finish the concrete surface without tearing the latex film was selected as the prime criteria.

The first trial batch, Mix A, was mixed in a pan-type mixer. The steel fibers separated satisfactorily after they were added into the concrete while mixing was occurring. Initially, the steel fibers were well distributed throughout the concrete but after prolonged mixing some balling occurred. Attempts to redistribute the fibers back into the concrete were not successful.

At various intervals, the mixing was suspended and the concrete surface was finished with a trowel. The workability of the LMFC was judged good after 15 minutes, fair after 30 minutes and very poor after 45 minutes. In addition, two test cylinders were made after 20 minutes of mixing and again after 45 minutes. The average 7 day compressive strength was nearly the same for both sets of cylinders (4,800 psi$^{\pm}$). The results of testing Mix A indicated only a 30$^{\pm}$ minute work time was available to finish the latex modified concrete surface at 68 F and a relative humidity of 44 percent. From other work with latex modified concrete it was concluded that a shorter allowable work time would result at higher temperatures.

Because of the fiber balling problem the last three concrete trial batches were prepared in a small drum mixer.

In the next series of tests the workability and the effects of varying the cement factor and latex content on compressive strength were examined. The cement content was varied at 7, 8 and 9 sacks per cubic yard, while a water-cement ratio of 0.29 and a 3.5 gallon per sack latex loading were held constant. The formulation for each batch is shown in Table 1 and the physical test results are presented in Table 2.

The workability of the 8 and 9 sack mixes was good after 25 minutes of mixing but the 7 sack per cubic yard mix was considered too dry and the steel fibers did not separate well. It appeared the lubricating effect of the latex was a significant factor in increasing workability.

The results of both the 7 and 14 day compressive strength tests indicated the 8 sack per cubic yard mix was optimum and that an excessive amount of latex decreased compressive strength.

FIELD INSTALLATION

Before the overlay was started, all four bridge decks were examined to determine the location of delaminations and serious deck cracking. No major delaminations were found, but there were many large cracks in three of the four decks. Only the Troutdale Connection Overcrossing westbound structure was free of visible deck cracking. There were several transverse cracks in the bays adjacent to the interior bents of the eastbound Troutdale Connection Overcrossing. Some of these cracks were visible both on the top and bottom of the deck. Two of the large cracks near bent 3 were later routed and patched with polymer concrete to prevent them from reflecting through the new overlay. Three other cracks were prepared for an epoxy injection treatment but the contractor did not succeed in his attempted injections. The location of major cracks in the eastbound Troutdale Connection Overcrossing were recorded to study the effectiveness of the LMFC in resisting reflective cracking.

Both Sandy River bridges had many transverse deck cracks in all steel spans. No additional repairs were made at these cracks before the overlay was placed.

During the initial survey of the decks, chloride ion samples were removed and analyzed. The following values represent the chloride ion content at the 0" to 1" depth.

Troutdale Connection O'xing EB	0.35 lb Cl^-/cu yd concrete
Troutdale Connection O'xing WB	0.50 lb Cl^-/cu yd concrete
Sandy River Bridge EB	0.30 lb Cl^-/cu yd concrete
Sandy River Bridge WB	1.70 lb Cl^-/cu yd concrete

The LMFC was batched in a portable batch plant near the bridge site. The sand, coarse aggregate, cement and water were weighed and then loaded into a standard ready-mix truck. The concrete was mixed briefly before the Tylac 97-314 latex modifier and Dramix ZP 50/.50 steel fibers were added to the concrete. All ingredients were mixed together as the truck traveled to the deck. The weight of the components were checked and recorded by a state inspector who was present during all batching. It took approximately 10 minutes for the truck to travel from the batching area to the deck.

One hour before the overlay began the deck was prewetted with clean water to provide a damp surface upon which to place the latex modified fibrous concrete. As the concrete was discharged from the truck, brooms were used to brush some of the latex mortar into the deck as a primer. An attempt was made to cover the latex coated surface with the overlay before it dried. Although the "start up" of each pour was very slow the laydown operation went fairly smooth. As the LMFC was deposited onto the deck it was spread by shovels and rakes in front of the screed of the finishing machine. The LMFC was generally sloppy and easy to move on the deck. Even though the average concrete slump was over 7 inches there was no noticeable aggregate segregation.

The balling of the steel fibers was a continuous problem on all four bridge overlays but it appeared to be worst with drier mixes. Small balls of fibers and aggregate were removed from the concrete after it was deposited on the deck. In some cases the fiber balls were four inches in diameter.

There was a definite lack of quality control in batching the LMFC as can be seen in Table 3. The water-cement ratio varied between 0.30 and 0.44 and the cement factor was consistently below the design value of 8 sacks per cubic yard. The 28 day compressive strength of test cylinders also varied between 2,690 psi and 5,590 psi.

Three 6" x 6" x19" beams were fabricated in the field and sent to the laboratory to determine modulus of rupture of the latex modified fibrous concrete. Using the ASTM C78 test procedure with third point loading, the average stress at failure was 826 psi. This was no improvement over conventional concrete.

An old remolded Bidwell deck finishing machine was used to finish and consolidate the overlay on this project. It consisted of two augers in front of a 6 ft$^{\pm}$ long vibratory screed and a float pan. The screed was positioned parallel to the roadway centerline. The performance of this machine is under investigation because it failed to consolidate the concrete within 15 inches of each curb and the surface on all four bridge decks was extremely rough. Concrete grinding with a multiple blade drum was required before the overlays were accepted.

The tined finish which was specified for the overlay was difficult to achieve because of the steel fibers. When the tining tool was raked across the concrete surface it dislodged and dragged several fibers out of the concrete material. This produced some tearing of the surface and may have contributed to the poor rideability of the overlay.

A serious construction error occurred while the latex modified fibrous concrete was being placed on one lane of the eastbound Troutdale Connection

Overcrossing structure. The contractor failed to cover the freshly placed concrete until 90 minutes after it was placed on the west end of the bridge. This error caused shrinkage cracks to immediately appear in the overlay surface. Cores removed from the affected area revealed the cracks were only approximately 3/8" deep. The latex modifier was subsequently applied to the faulty area to seal the cracks. This application appeared to be satisfactory and the repair was accepted.

SHORT TERM EVALUATION

The overall rating of the Latex Modified Fibrous Concrete was only fair. A survey of the decks on all four bridges indicated the overlays were all well bonded to the substrate concrete but the surface was extremely uneven causing an unpleasant ride. Some serious cracking was found at expansion joints and some minor cracking was found at three widely separated areas on the eastbound Sandy River bridge. The large and frequent transverse cracks which were prominent in the steel spans of both Sandy River bridges did not reflect through the Latex Modified Fibrous Concrete overlay after an average in-service period of three months. No cracking was found in the overlay on the Troutdale Connection O'xing either.

The tined finish placed on all of the overlays was non-uniform in depth mainly because of the steel fibers. It was removed in the wheel tracks however when the surface was cut with diamond tipped saw blades in an attempt to eliminate the rough ride.

Because of the many problems that were encountered during construction and the less than desirable riding surface, the Latex Modified Fibrous Concrete overlay system is <u>not</u> recommended for future use until the construction problems have been eliminated.

Table 1

LATEX MODIFIED FIBROUS CONCRETE
Mix Design

Ingredients	Mix A & C	Mix B	Mix D
		pounds per cubic yard	
Cement	752	658	846
Latex Modifier	235	206	265
Water	96	84	107
Fibers	85	85	85
Coarse Aggregate	1,342	1,435	1,251
Sand	1,342	1,435	1,251

Table 2

LATEX MODIFIED FIBROUS CONCRETE
Test Results

Mix	Time (min)	Workability	Slump (in)	Air Content (%)	Unit Weight (lbs)	Compressive Strength lbs/sq in 7 day	14 day
A	15	good					-
	17		7.00	3.8	143.9	4795(A1)	-
	20	Prepare 2 cylinders - A-1				4895(A1)	-
	30	fair			142.05	4815(A2)	-
	40	poor	5.25	4.8		4770(A2)	
	45	very poor	Prepare 2 cylinders - A-2				

Remarks: Pan Mixer caused the wires to ball up. Allowable mixing time should be limited to 30 minutes to get good finish. Strength was not reduced after 45 minutes work time.

Mix	Time (min)	Workability	Slump (in)	Air Content (%)	Unit Weight (lbs)	7 day	14 day
B	10	fair				3340	3840
	15	fair	4.50	4.2	144.70	3265	4030

Remarks: Mix too dry, wires did not separate well.

Mix	Time (min)	Workability	Slump (in)	Air Content (%)	Unit Weight (lbs)	7 day	14 day
C	10	good	8.00	3.0	144.90	3590	4365
	15	good		1.6*	146.99	3465	4090
	25	good					

Remarks: Good mixing, wires well mixed.

Mix	Time (min)	Workability	Slump (in)	Air Content (%)	Unit Weight (lbs)	7 day	14 day
D	10	good	10.50				
	15	good		2.2	144.34	2830	3665
	25	good		1.2*	145.62	2865	3500

Remarks: Too sloppy, segregation possible. It appears excessive latex content reduced strength.

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* Pot vibrated to release entrapped air.
TEMP = 68 F RELATIVE HUMIDITY 44%

MIX DATA

Mix	Mixer	Cement (sacks/cy)	Latex (gal/sack)	Water/Cement (ratio)
A	Pan	8	3.5	0.29
B	Drum	7	3.5	0.29
C	Drum	8	3.5	0.29
D	Drum	9	3.5	0.29

Aggregate Gradation
50% Coarse - 3/8" to #4
50% Sand

Cure Method: Concrete was covered with wet burlap for first 24 hours then cured in air.

Table 3

LATEX MODIFIED FIBROUS CONCRETE
Construction Mix Data

Date Prepared 1981	Unit Weight lbs/cf	Cement Content sacks/cy	Air Content %	Water/Cement ratio	28-Day Compressive Strength lbs/sq in
3/20	140.0	7.8	4.4	0.35	5,590, 5,575
3/26	134.5	7.6	7.0	0.32	5,030, 5,135
5/07	134.0	7.5	6.7	0.30	4,790
5/19	131.9	7.6	7.5	0.32	4,390
6/23	135.5	7.5	5.8	0.40	4,210
6/26	138.8	7.7	4.2	0.40	4,375
7/02	138.4	7.8	5.0	0.37	5,005
8/13	132.4	7.1	6.0	0.44	2,680
9/25	137.8	7.8	6.0	0.36	5,045, 5,045
11/10	137.6	7.8	6.2	0.33	5,215, 5,210
11/12	137.1	7.6	6.4	0.34	4,930, 4,975

Figure 1

Latex Modified Fibrous Concrete being placed.
Note balling of steel fibers.

Figure 2

Close-up of steel fibers in ball.

Figure 3

Finished Texture on Latex Modified
Fibrous Concrete Overlay