LATEX MODIFIED FIBROUS CONCRETE

Experimental Feature
Final Report

by

William J. Quinn
Research Coordinator

and

Leon G. Brock
Research Coordinator

OREGON STATE HIGHWAY DIVISION
Research Section
Salem, Oregon 97310

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Sundial - Sandy River Section

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INTRODUCTION

In November 1980, a contractor requested permission to use a 1.5 inch thick Latex Modified Fibrous Concrete (LMFC) overlay in lieu of a 2.5 inch low slump concrete (Iowa System) or a 2.5 inch unreinforced latex modified concrete. The overlays were to be on four bridge decks within the Sundial - Sandy River Section.

At the time the request was made, the contractor gave a presentation to state engineers on the benefits of using this new material. He pointed out the LMFC was reported to reduce reflective cracking in previously placed deck overlays. Since Oregon was having problems in this area, conditional approval was granted by the engineers.

The Latex Modified Fibrous Concrete used consisted of approximately 85 lbs of steel fibers per cubic yard of 8 sack latex modified concrete. The 1 1/2 inch overlay thickness was permitted due to the reported greater flexural strength of latex modified concrete with fiber. The steel fibers used were Dramix ZP 50/.50.

Before the project began, laboratory work was identified that would be required before construction. This report discusses the results of that laboratory study, the construction techniques used, the major problems encountered during construction and the results of six post construction inspections.

LABORATORY FINDINGS

The laboratory testing was done to determine the optimum cement and latex modifier content of the mix. Since the steel fibers made it impractical to produce the mix with portable mixers at the jobsite, the time required by the material for satisfactory mixing and placement was critical. The final mix design was chosen so that the material could be mixed, transported, placed and finished without tearing the latex film.

Two methods of mixing the LMFC were tested, a pan-type mixer and a small drum mixer. The pan-type mixer caused the fibers in the first trial batch (A) to ball up after prolonged mixing. Attempts to redistribute the fibers back into the concrete were unsuccessful. Therefore, the drum mixer was tried and selected for the remaining trial batches.

The batches were tested to determine their workability, 7 and 14 day compressive strengths, and the cement content. The water-cement ratio and the latex content were held constant (see Table 1).

At various intervals, the mixing was suspended and the concrete surface was finished with a trowel to judge the workability of the LMFC. In addition, test cylinders of each batch were taken after 20 minutes of mixing (see Table 2).

After 25 minutes of mixing, it was determined the 7 sack mix was too dry and the steel fibers did not separate well, but the workability of the 8 and 9 sack mixes was considered good. The lubricating effect of the latex appeared to be a significant factor in increasing workability. Also, the results tabulated in Table 2 indicated that an 8 sack mix was optimum, since it was found that excessive latex decreased compressive strength.

PREPARATION

During the initial survey of the structures prior to overlaying, chloride ion samples were removed from the bridge decks and analyzed. The following values represent the chloride ion content at the 0" to 1.0" 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

A visual examination of all four bridge decks was made to determine the location of delamination and serious deck cracking. No major delaminations were found, but there were many large deck cracks in all but the westbound Troutdale Overcrossing. On the eastbound Troutdale Overcrossing, there were several transverse cracks in the bays adjacent to the interior bents. Some of these cracks were visible both on the top and bottom of the deck. Two of the largest cracks were routed and patched with polymer concrete to prevent them from reflecting through the future overlay. The location of all major cracks was recorded to study the effectiveness of the LMFC in resisting reflective cracking.

Both Sandy River bridges had many transverse deck cracks in all the steel spans, but no additional repairs were made before the overlay was placed.

CONSTRUCTION

The Latex Modified Fibrous Concrete components were weighed into ready mix trucks by a portable batch plant located approximately 10 minutes from the bridge site. The components were then loaded by the batch plant operator into the trucks and mixed briefly before the latex modifier and steel fibers were added. All ingredients were mixed together en route to the deck. The mix components weights were verified and recorded by the state inspector.

One hour before overlaying, the deck was prewetted with clean water to provide a damp surface upon which to place the LMFC. Latex modifier was used as a primer and placed by brooming into the deck. As the LMFC was deposited on the primed deck, it was spread with shovels and rakes in front of the finishing machine's screed. The mix was generally sloppy and easy to work, yet there was no noticeable aggregate segregation.

An old, remodeled Bidwell deck finishing machine was used to finish and consolidate the overlay. It consisted of two augers in front of a six foot long vibratory screed and a float pan. The screed was positioned parallel to the roadway centerline. The performance of this machine is questionable because it failed to consolidate the concrete within 15 inches of each curb. It may also have contributed to the resulting poor ride of the surface. The tined finish, which was specified for the overlay, was difficult to achieve and uneven in depth because of the steel fibers. When the tining tool was raked across the concrete surface, it dislodged and dragged fibers out of the concrete material. This produced some tearing of the surface. The finished deck was very rough and caused an unpleasant ride, most likely due to presence of the steel fibers and the tining process. The tined finish had to be removed in the wheel paths with diamond tipped saw blades, and concrete grinding with a multiple blade drum was required before the overlays were accepted.

A serious construction error occurred on one lane of the eastbound Troutdale Connection Overcrossing. On the west end of the bridge, the contractor waited 90 minutes to cover the freshly placed concrete. This error caused shrinkage cracks to immediately appear in the surface of the overlay. Cores removed from the affected area revealed the cracks were approximately 3/8" deep. Latex modifier was subsequently applied to the faulty area to seal the cracks. This application appeared to be satisfactory and the repair was accepted.

The balling of the steel fibers was a continuous problem on all four bridge overlays, but it appeared to be worse with the drier mixes. This required aggregate and balls of fiber up to 4 inches in diameter to be removed from the concrete after it was deposited on the deck.

There was a definite lack of quality control in batching the LMFC (see 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.

Three 6"x 6"x 19" LMFC beams fabricated in the field were sent to the laboratory to determine the modulus of rupture. 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.

SHORT TERM EVALUATION

The 3 month overall rating of the Latex Modified Fibrous Concrete was fair. A survey of the decks on all four bridges indicated the overlays were all well bonded to the substrate concrete. No cracking was found on the Troutdale Connection Overcrossing. The EB Sandy River Bridge had some serious cracking at expansion joints and three widely separated areas of tight minor cracking such as those which may occur during construction or curing. The large and frequent transverse cracks which were prominent before construction in the steel spans of the Sandy River Bridges did not reflect through the LMFC.

Before grinding, measurements using a 5 foot straightedge indicated an extremely rough wave-like finish on the deck, 1/8 inch in depth, on approximately 18 inch centers, which caused an unpleasant ride. The tined finish placed on the overlays was non-uniform in depth, mainly because of the steel fibers. However, the finishing machine had been poorly maintained and this may have contributed to the problems. Although many steel fibers were visible on top of the overlay, they were laying horizontally, and presented no problem to vehicular tires.

LONG TERM EVALUATION

A visual inspection was performed nine months after completion of construction. The overlay was wearing well with little or no rutting in the wheel tracks. Two small areas of map cracking had appeared approximately 50 feet from the east end of the EB Sandy River structure. The joints on three of the four structures showed moderate deterioration, with some spalling and cracking.

Twelve months after construction a visual inspection and chain drag were performed. Two areas of delamination were found on the WB Troutdale structure, one approximately 14 square feet near bent 2, and one approximately 28 square feet over the overlay meet line near bent 1. The joints at piers 1 and 4 of both Sandy River structures showed cracking in several small areas. A few cracks were visible near the midpoints of several spans on both of these structures.

Thirty-six months after construction a visual inspection and chain drag were again performed. The WB Troutdale structure showed approximately 90 square feet of delamination adjacent to the overlay meet line, with slightly less than 1 square foot of spalling near the west end. The Sandy River structures showed approximately 20 linear feet of cracking and spalling along the expansion joints and transverse meet lines. The visible cracking noted in 1982 was slightly worse.

A final inspection performed 47 months after completion of construction showed little or no change from the thirty-sixth month inspection.

CONCLUSIONS

Two positive items should be noted when rating the Latex Modified Fibrous Concrete: the cracking, delamination and spalling occurred only on the edges of the overlays near the overlay meet lines; the majority of each overlay remained intact and well bonded. Secondly, the large, frequent, transverse cracks which were prominent in the steel spans of both Sandy River bridges did not reflect through the overlay, even after 4 years in service.

However, because of the many problems encountered during construction, the less than desirable riding surface and the serious cracking, delamination and spalling along joints, the overall rating of the LMFC overlay system was poor, and it is NOT recommended for future use until the problems have been eliminated.

Table 1

LATEX MODIFIED FIBROUS CONCRETE
Mix Design

Ingredients in lbs/cy	Mix A & C (8 sack)	Mix B (7 sack)	Mix D (9 sack)
Cement	752	658	846
Latex Modifier	235	206	265
Water	96	84	107
Fibers	85	85	85
Coarse Agg.	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 lb/cf	Core 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

* Cement content as determined by lab analysis of test cylinders.