FIBER REINFORCED CONCRETE DETENTION POND

Construction Report

Experimental Features
Project No. OR 90-04

N.E. 181st Avenue Interchange Section
Columbia River Highway (Interstate 84)

By

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ABSTRACT

This project involves the construction of two polypropylene fiber reinforced concrete lined detention ponds. The detention ponds are located on the north side of the 181st Avenue Interchange on the Columbia River Highway (I-84) approximately ten miles east of Portland in Multnomah County, Oregon. The project was completed in the Autumn of 1991. The original design called for the detention ponds to be constructed with six inch thick, continuous, welded wire, fabric reinforced concrete over an impermeable geomembrane. An alternate to this design, replacing the welded wire fabric reinforced concrete with polypropylene fiber reinforced concrete, was proposed by the contractor through a no cost price agreement. The decision was made by Oregon Department of Transportation (ODOT) and Federal Highway Administration (FHWA) staff to accept the contractor's proposal and to evaluate the material as an experimental features project.

The replacement of welded wire fabric reinforced concrete with polypropylene fiber reinforced concrete created no problems with respect to mixing, placement, workability, finishability, or visual appearance. The use of fiber reinforced concrete on this project resulted in a small cost reduction relative to the use of welded wire fabric reinforced concrete.

The fiber reinforced concrete should continue to be monitored to ensure that its functional performance is acceptable. If no problems with long-term functional performance are encountered, fiber reinforced concrete should be considered as an alternate to the welded wire fabric reinforced concrete for similar projects in the future.

ACKNOWLEDGEMENTS

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DISCLAIMER

Fiber Reinforced Concrete Detention Pond

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1.0 INTRODUCTION

The use of steel fibers to improve the properties of concrete has been the topic of many studies. Concrete containing steel fibers has been shown to have increased resistance to crack propagation, higher tensile strength, and higher post-cracking ductility than concrete without steel fibers. Studies have shown that concrete reinforced with polypropylene fibers also exhibits these improved properties, as well as, improved resistance to temperature and shrinkage cracking. Steel fiber reinforced concrete has previously been used on Oregon Department of Transportation (ODOT) projects, however, the ODOT has not utilized polypropylene fiber reinforced concrete in construction.

This project involved the construction of two polypropylene fiber reinforced concrete lined detention ponds. The detention ponds are located on the north side of the 181st Avenue Interchange on the Columbia River Highway (I-84) approximately ten miles east of Portland in Multnomah County, Oregon. The project was completed in the Autumn of 1991. The original design called for the detention ponds to be constructed with a six-inch layer of continuous, welded wire, fabric reinforced concrete over an impermeable geomembrane. An alternate to this design, replacing the welded wire fabric reinforced concrete with polypropylene fiber reinforced concrete, was proposed by the contractor through a no cost price agreement. The decision was made by ODOT and Federal Highway Administration (FHWA) staff to accept the contractor's proposal and to evaluate the material as an experimental features project.

2.0 PROJECT DESCRIPTION

2.1 PROJECT LOCATION AND CLIMATE

The project is located on the west and east sides of 181st Avenue, north of the Columbia River Highway (U.S. I-84), ten miles east of Portland, Oregon as shown in Figure 2.1.

The project is in the Willamette Valley climatic region, which is characterized by mild wet winters and moderate dry summers. The average daily temperature of the coldest month (January) is about 37°F. The average daily temperature of the warmest month (July) is approximately 66°F. This area receives an average annual precipitation of 39 inches.

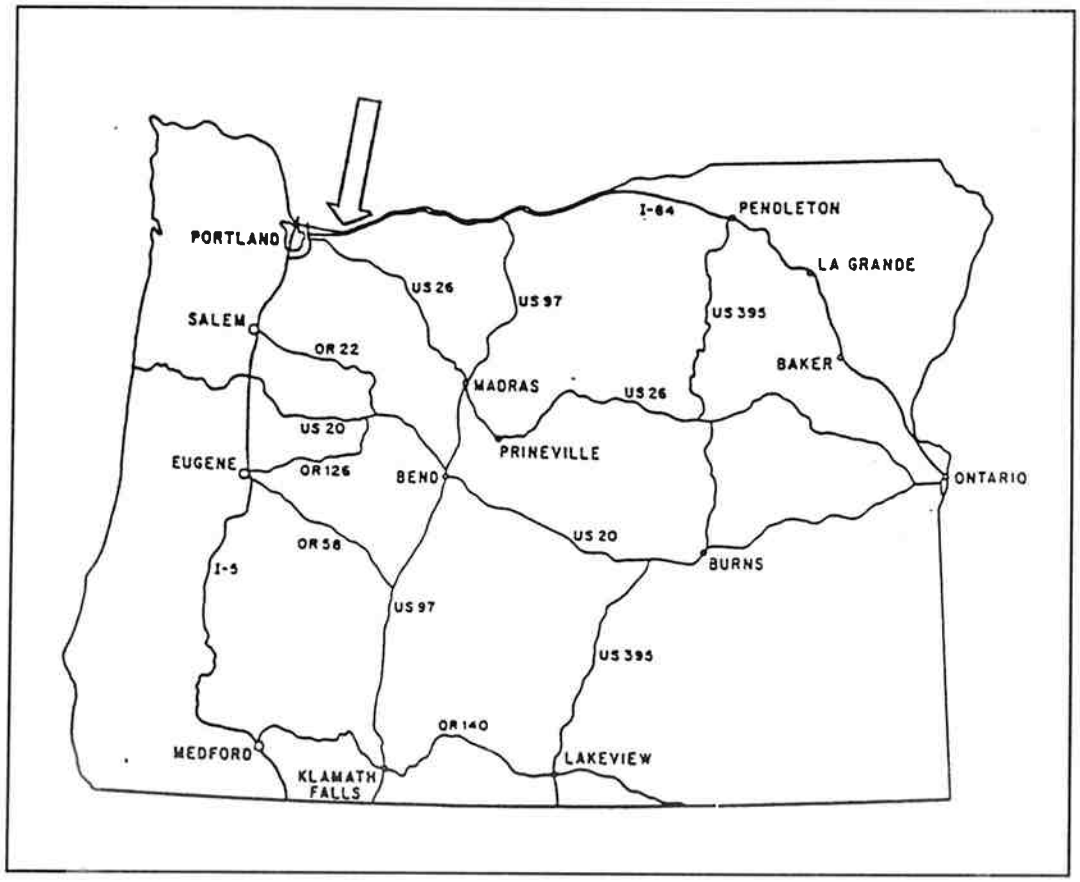


Figure 2.1: Project Location in Oregon

2.2 DESIGN

The detention ponds were designed to be elliptical in shape, approximately 400 feet long and of variable width. The sides of the ponds slope 2:1 (horizontal:vertical). The east pond is four feet deep and the west pond is eight feet deep (see Appendix A for construction plans).

The original design called for a six-inch thick continuous, welded wire, fabric reinforced concrete to be placed over an impermeable polyethylene geomembrane. The contractor proposed the use of Durafiber polypropylene fibers as an alternate to welded wire fabric for use as reinforcement in the detention ponds. In the contractor's proposal, the following reasons were cited for the substitution:

1. The use of the fibers for reinforcement eliminates the danger of puncturing the impermeable membrane with the sharp edges on the steel reinforcement. The chairing system required to suspend the steel reinforcing also poses a potential puncture danger to the liner.

2. The impermeable membrane expands and contracts a great deal with temperature change, which may make it difficult to maintain proper separation between the membrane and the reinforcement as the membrane expands and buckles. Use of the fibers eliminates the requirement for separation between the membrane and the reinforcement.

3. The use of the fibers would expedite the placement process, reducing the construction time and the temperature deviation expansion problem.

ODOT and FHWA staff reviewed the contractor's proposal and approved this experimental features project to use Durafiber reinforced concrete as an "approved equal" to concrete reinforced with welded wire fabric.

3.0 CONSTRUCTION

Two commercial concrete mixes were used in the pond construction. The floors of both ponds were constructed with Ross Island Sand & Gravel Mix Design No. 4401B (Table 3.1), a class 3300, 3/4 inch minus mix, which was also used elsewhere on the project. The sides of the ponds were constructed with Ross Island Sand & Gravel Mix Design No. 5000C (Table 3.1), a class 3300, pea gravel mix developed for gunite applications. Durafiber polypropylene fibers (3/4" in length), manufactured by Hill Brothers Chemical Company, were added to the commercial mixes at the manufacturer's recommended rate of 1-1/2 pounds of fibers per cubic yard of concrete.

	4401B	5000C
Cement	490 lbs.	705 lbs.
Fly Ash	100 lbs.	---
Coarse Aggregate	1,850 lbs.	850 lbs.
Sand	1,118 lbs.	2,031 lbs.
Water	270 lbs.	282 lbs.
Air Content	5.5%	5.0%

Table 3.1: Commercial Concrete Mixes

The fibers were introduced into the truck mixer first and then, the concrete was batched into the truck (this method had been found most effective by the concrete contractor as a result of previous experiences with Durafiber). The concrete was mixed as usual and the fibers were distributed throughout the load. No additional mixing time or other measures were necessary. The fibers had little discernable effect on the plasticity of the concrete mixture. There was some resistance to slumping, but it was not significant.

The fiber reinforced concrete mixture was pumped into place for the pond floors and was gunited into place for the walls. There were no apparent problems with balling or clumping of fibers in the concrete mixture. The fibers appeared to be mixed uniformly throughout the concrete batches and remained well mixed as it was handled for placement. No modifications to standard equipment were required for placement and no problems were encountered as a result of the use of the fibers.

No special methods or tools were required for finishing operations. The finishers commented that it was just a different concrete mixture, requiring experience in dealing with slightly different finishing characteristics. The fiber reinforced concrete did not float as

easily as other concrete mixes when a large float was used. According to the head finisher, this material is very susceptible to added surface moisture (e.g. rain). Surface moisture may wash the fibers and cause the surface fibers to ball. If the surface fibers ball, a high quality surface finish would be difficult to obtain, due to texturing from surface fibers.

Joints were scored transversely at thirty-foot maximum spacing on the pond bottoms during the concrete finishing process with a two-inch deep by 1/4-inch wide blade fastened to a large float. A longitudinal joint 1-1/2 inch deep by 1/4-inch wide was saw cut the length of each pond, after the concrete was sufficiently set up. A construction joint was required around the bottom of each pond where the sides and the bottom meet. Details of construction joints are shown in Appendix A. The sides of the ponds were also scored at thirty-foot maximum spacing with the bladed float during concrete finishing.

Approximately 920 cubic yards of concrete were used to construct the ponds. The total concrete quantity required the use of about 1,380 lbs. of fibers, at the manufacturers recommended rate of 1-1/2 lbs. per cubic yard. The west pond required approximately 230 cubic yards of Mix Design No. 4401B concrete for the floor and 276 cubic yards of Mix Design No. 5000C gunite concrete for the sides. The east pond used approximately 230 cubic yards of Mix Design No. 4401B concrete for the floor and 138 cubic yards of Mix Design No. 5000C gunite concrete for the sides.

The finished appearance of the fiber reinforced concrete is very similar to a normal concrete mixture. Small amounts of fibers were visible on the concrete surface. Photographs of the project are provided in Appendix B.

The added cost of adding fibers to the supplied mix was $7.50 per cubic yard. Additional jobsite labor costs may be considered negligible for the placement and finishing of the fiber reinforced concrete.

4.0 EVALUATION

1. Mixing and Placement Methods

The fibers were introduced into the truck mixer first and then, the concrete was batched into the trucks. The fibers appeared to be uniformly distributed during mixing and placing the concrete. No special equipment was required for mixing and placing the fiber reinforced concrete. No problems occurred as a result of the use of the fibers.

2. Workability and Finishability

No special tools or modified methods were required for finishing the fiber reinforced concrete. The finishers indicated that it was just a different concrete mix with slightly different finishing characteristics. This material is susceptible to added surface moisture such as rain, which washes the fibers and may cause surface balling of the fibers resulting in finishing problems. If the surface fibers ball, a high quality finish is not possible due to texturing of the surface by the fibers.

3. Visual Appearance

The finished appearance is very similar to a normal concrete mixture. Small amounts of fibers were visible on the surface of the finished concrete.

4. Costs

Inclusion of the fibers added $7.50 per cubic yard to the concrete cost. This additional cost was more than offset by the reduction in cost resulting from not using the weld wire mesh reinforcement. There were no additional placing and finishing costs resulting from the use of the fibers.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The replacement of welded wire reinforced concrete with polypropylene fiber reinforced concrete created no problems with respect to mixing, placement, workability, finishability, or visual appearance. The use of fiber reinforced concrete on this project resulted in a small cost reduction relative to the use of continuous welded wire fabric reinforced concrete.

5.2 RECOMMENDATIONS

The fiber reinforced concrete should continue to be monitored to ensure that its functional performance is acceptable. If no problems with long-term functional performance are encountered, fiber reinforced concrete should be considered as an alternate to continuous, welded wire, fabric reinforced concrete for similar projects in the future.

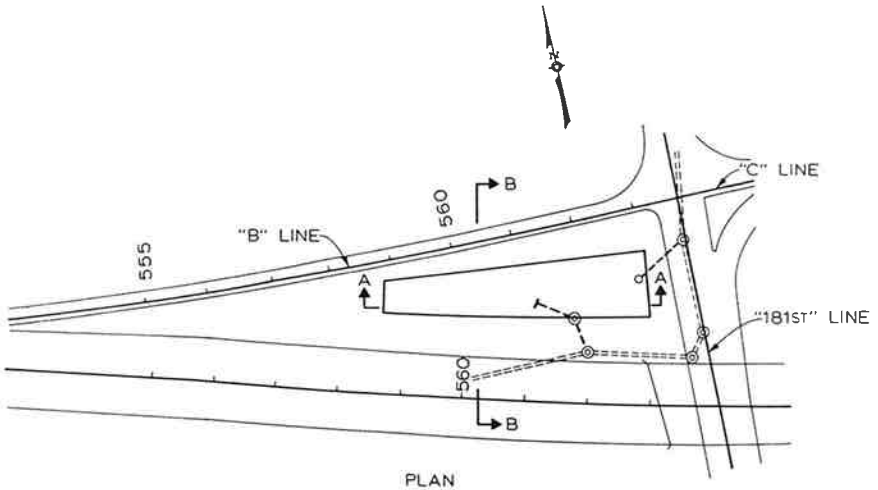
APPENDIX A

CONSTRUCTION PLANS

DETENTION POND SYSTEM DETAILS

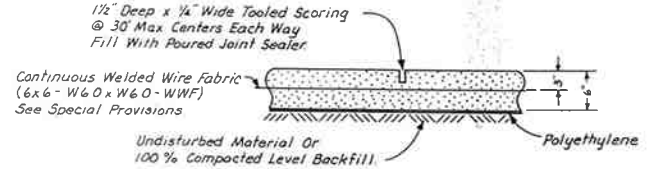
21V-162

N.E. 181ST AVE. INTCHGE. SEC. COLUMBIA RIVER HIGHWAY MULTNOMAH COUNTY				SHEET NO. 2B-6
FED. ROAD DIV. NO.	STATE	PROJECT NUMBER	FISCAL YEAR	TOTAL SHEETS
10	OREGON	I-84-1(12)10		

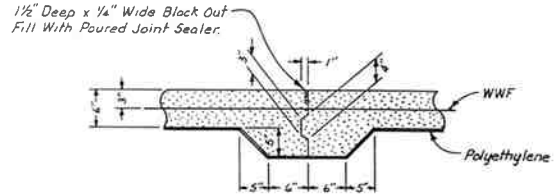


PLAN

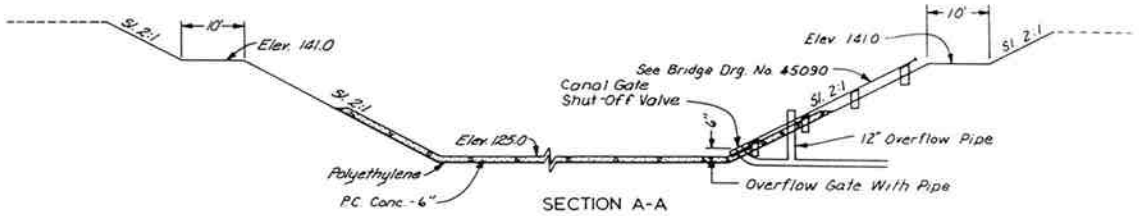
NOTE
Min Splice Length For This
6 x 6 - W6 x W6 - WWF Is 8".



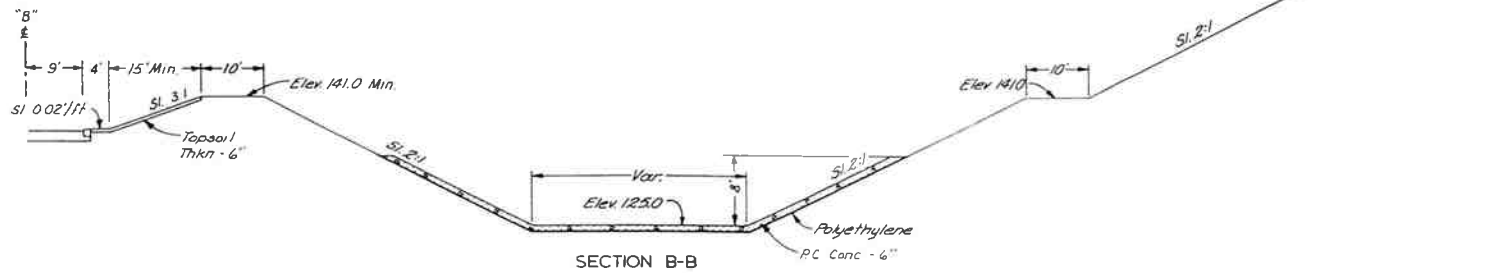
DETENTION POND CONCRETE SLAB



CONSTRUCTION JOINT



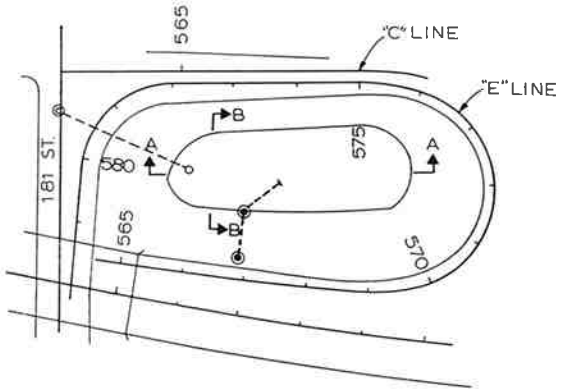
SECTION A-A

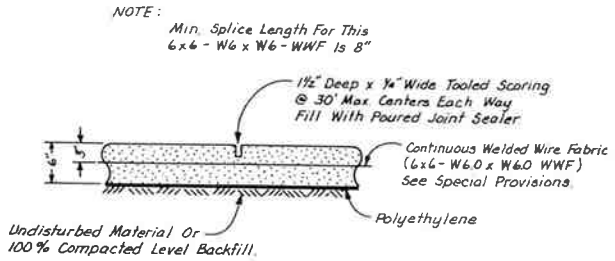


SECTION B-B

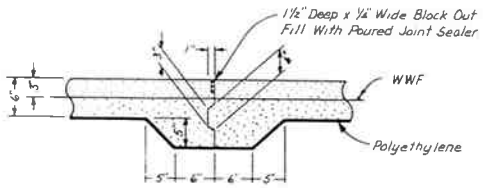
DETENTION POND SYSTEM DETAILS

N.E. 181ST AVE. INTCHGE. SEC., COLUMBIA RIVER HIGHWAY, MULTNOMAH COUNTY				SHEET NO.
				2B-7
FED. ROAD DIV. NO.	STATE	PROJECT NUMBER	FISCAL YEAR	TOTAL SHEETS
10	OREGON	I-84-1(12)10		See Index





DETENTION POND CONCRETE SLAB



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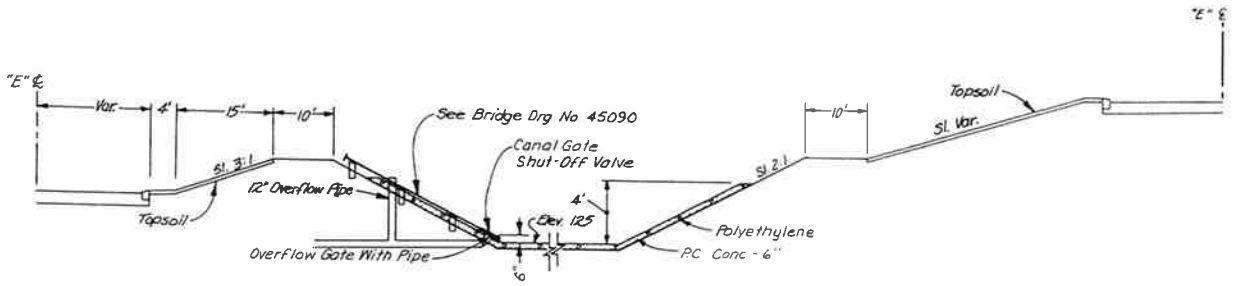

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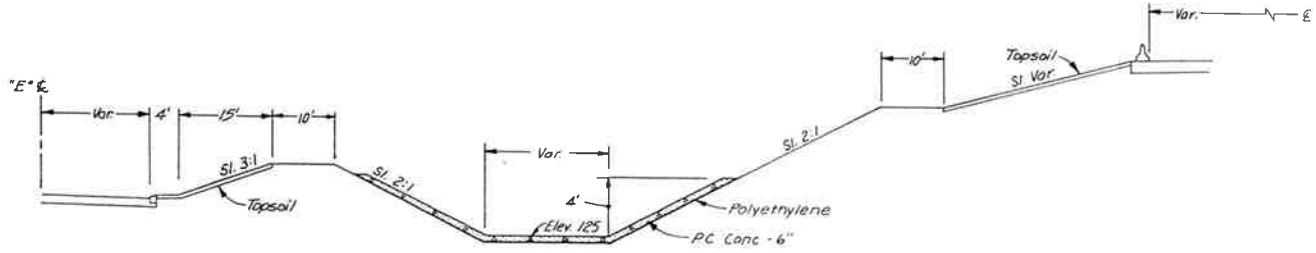

SECTION B-B

APPENDIX B

PHOTOGRAPHS

Figure B.1: Pouring concrete bottom of the East pond

Figure B.2: Completed West pond