OREGON DEPARTMENT OF TRANSPORTATION

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SPR Quarterly Progress Report
October 1, 2007 through December 31, 2007

Date: January 22, 2008

TO: Technical Advisory Committee Members:
Tim Rogers, FHWA
Tony Kojundic, Silica Fume Association
Mike Luttrell, ODOT
Richard Hart, PE, ODOT
Norris Shippen, ODOT
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FROM: Steve Soltesz, Research Coordinator (ph: (503) 986-2851)

1. Project

Abrasion-Resistant Concrete Mix Designs for Bridge Decks
SPR 622

2. Key Dates

Start Date for ODOT: October 2004
Completion Date for ODOT: December 2009

3. Principal Investigators

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4. Progress

- Established the air entraining agent (BASF/MB-AE 90) dosage for the ODOT Class 4350 "control mix" for water-to-cement (w/c) ratios of 0.30, 0.35, and 0.40. This was accomplished by measuring the air content of several mixtures at the same w/c ratio and at differing dosages of the air entraining (AE) agent and then developing a linear regression equation used to predict the AE agent dosage as a function of the mass of cement.

- Mixed and cast cylinders and beams of the control mix with water-to-cement ratios of 0.30, 0.35, and 0.40. Performed requisite tests on the freshly mixed concrete (i.e., air content, unit weight, slump, and temperature). Initiated curing of the cast specimens in lime-saturated water baths at 23°C.

- A TAC meeting was held on November 27, 2007 to review progress made to date as well as to discuss the experiment design for the laboratory test program. The TAC recommended further investigation of using "large" coarse rock in concrete as a means to attain better abrasion resistance. The TAC also recommended investigating the use of steam curing for conditioning the concrete specimens prior to conducting the performance tests.

- Examined the literature in more detail in an attempt to determine whether using a larger maximum size of coarse rock (e.g., 1½ or 1¼ inch versus ¾ inch) in a concrete mixture is more likely to produce a more abrasion-resistant concrete mixture than one containing smaller rock (e.g., ¾ inch or smaller), but with 100% crushed faces (i.e., quarried rock). Reviewed abrasion test results developed by Jim Hinds at the North Pacific Division Materials Laboratory of the Concrete and Dam Safety Section of the Portland District U.S. Army Corps of Engineers (USACE). Based on the additional review of the literature and review of the USACE data, it was surmised that there is a higher likelihood of developing a more abrasion-resistant mixture using crushed rock. Hence, it was decided to pursue mixtures containing readily-available, ¾ inch crushed rock rather than investigating mixtures with a larger maximum aggregate size of the coarse rock.

- Contacted Jordan Pelphrey at Knife River (Harrisburg, Oregon plant) and Tom Roberts of Central Pre-Mix in Spokane, Washington to discuss methods used for steam curing of products (e.g., bridge girders) and cylinders cast for quality control purposes. Also reviewed a paper provided by Tony Kojundic detailing a method used by Dr. Hooton of the University of Toronto for steam curing laboratory-prepared and cured specimens in a study on the influence of silica fume on chloride resistance of concrete. These efforts revealed significant similarity amongst the three methods with only slight differences in the elevated temperature employed. Based on these findings, it was decided to utilize a steam curing regime that closely emulates that used by Knife River.

- Set up and ran inaugural tests using the abrasion tester. Initial tests indicated that less than 1 mm of wear occurred on a concrete paver (readily available at a local home improvement outlet) subjected to 120 minutes of abrasion using 220 and 120 grit silicon carbide blast media (60 minutes of abrasion with each size of grit). Based on these initial tests, with minimal wear, new abrasion pads were designed to accommodate replaceable tungsten carbide studs, with 12 studs per abrasion pad, in an attempt to get more wear in about the same time frame using the studded pads rather than the blast media grit.

5. Problems

- Additional delay to the project (approximately two weeks) has resulted from removal of large equipment from Graf Hall. This activity utilized the space where the concrete

work is being done to accommodate a crane and large lift truck needed to remove the equipment.

- OSU has yet to receive the sonometer that was ordered in July 2007. The manufacturer has promised to ship the equipment in mid January 2008.

6. Work Planned for Next Quarter

- Conduct tests on the control mix hardened concrete (i.e., density, compressive strength, and flexural strength). Summarize and analyze the results to select the mixture with the greatest w/c ratio (most economical mix) that meets the requirements of a Class 4350 mixture.
- Fabricate the abrasion pads incorporating the tungsten carbide studs. Conduct trial abrasion tests to determine the efficacy of the new pads. Determine final testing protocol for the abrasion tests.
- Conduct trial tests using the sonometer.
- Borrow the chloride ion penetration equipment from ODOT and conduct trial tests to become familiar with the apparatus and test protocol.
- Finalize the experiment design for the laboratory testing program.
- Mix and cast specimens the control mix test specimens and conduct the performance tests as defined by the experiment design.
- Finalize the mix designs for the four experimental mixtures. These will incorporate silica fume plus slag and silica fume plus fly ash as supplementary cementitious materials as well as gravel and crushed rock as the type of coarse rock. Mix and cast cylinders and beams for the purposes of mix design verification. Conduct tests on the freshly-mixed concrete (i.e., air content, slump, density, and temperature). Initiate curing of these specimens.

7. Finances

SPR Project Summary

VENDOR	FY'04	FY05	FY06	FY07	FY08	FY'09	FY'10	TOTALS
ORIGINAL BUDGET	$ 14,000	$ 164,000	$ 25,000	$ 25,000	$ 12,000	$ -	$ -	$ 240,000
REVISED BUDGET	$ -	$ 21,810	$ 33,019	$ 312	$ 70,601	$ 99,087	$ -	$ 224,829
EXPENDITURES - VENDOR	$ -	$ 21,810	$ 33,019	$ 312	$ -			$ 55,141
BALANCE	$ -	$ -	$ -	$ -	$ 70,601	$ 99,087	$ -	$ 169,688

ODOT	FY'04	FY05	FY06	FY07	FY08	FY'09	FY'10	TOTALS
ORIGINAL BUDGET	$ 1,626	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ -	$ -	$ 21,626
REVISED BUDGET	$ -	$ 5,747	$ 9,795	$ 7,107	$ 4,000	$ 4,000	$ 2,000	$ 32,649
EXPENDITURES - ODOT	$ -	$ 5,747	$ 9,795	$ 7,107	$ -	$ -		$ 22,649
BALANCE	$ -	$ -	$ -	$ -	$ 4,000	$ 4,000		$ 8,000

PROJECT	FY'04	FY05	FY06	FY07	FY08	FY'09	FY'10	TOTALS
ORIGINAL BUDGET	$ 15,626	$ 169,000	$ 30,000	$ 30,000	$ 17,000	$ -	$ -	$ 261,626
REVISED BUDGET	$ -	$ 27,557	$ 42,814	$ 7,419	$ 74,601	$ 103,087	$ 2,000	$ 257,478
EXPENDITURES - PROJECT	$ -	$ 27,557	$ 42,814	$ 7,419	$ -	$ -	$ -	$ 77,790
BALANCE	$ -	$ -	$ -	$ -	$ 74,601	$ 103,087	$ 2,000	$ 179,688