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United States
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FIELD TEST REPORT

I-94 PAVEMENT REPLACEMENT

RICHARDTON, NORTH DAKOTA
SUMMER, 1999

FHWA MCL Project # 9903

Federal Highway Administration
Office of Pavement Technology
HIPT, Room 3118
400 7th Street, SW
Washington, DC 20590

Summary Report

This report summarizes the findings from a concrete materials test program conducted by FHWA's Mobile Concrete Laboratory on concrete interstate paving along I-94 near Richardton, North Dakota (Federal Aid Project IM-5-094(013)080, MCL Project # 9903). During the early summer of 1999, approximately 8 miles of eastbound I-94 near Richardton, ND was reconstructed. The reconstruction involved removing a 36 year old 9" thick dowel-jointed concrete pavement, and replacing it with dowel-jointed plain concrete pavement. A one mile section of the project was constructed with an experimental concrete mixture with 30% of the cement replaced with fly ash.
The subject test program focused on six primary objectives: 1) Comparing mixture characteristics of the typical ND paving mixture versus those of the experimental fly ash mixture, 2) Comparing different initial curing regimes for strength specimens, 3) Comparing flexural to splitting tensile test results, 4) Examining concrete consolidation at transverse joints, 5) Demonstrating several new concrete technologies that were of interest to NDDOT, and 6) Comparing the effectiveness of the longitudinal tie-bar inserter to that of traditional staking. These objectives were established based upon discussions with and requests by NDDOT, FHWA and the general contractor during on-site "pre-construction" meetings in May and June of 1999. In an effort to accomplish these objectives, a test plan was developed that included testing of concrete from the two different mainline paving mixtures, namely the typical NDDOT paving mixture and the "experimental" fly-ash mixture. This test plan involved on-site construction monitoring, quality control testing, casting of specimens as well as laboratory testing over a five week period during June and July of 1999. Results from onsite and subsequent laboratory testing indicate the following:

1. The experimental paving mixture (30% fly ash by replacement of cement) performs as well or better than the typical ND paving mixture (20% fly ash replacing 15% of cement) in terms of strength, stiffness and durability (see Table 1 and Appendix A).

Table 1: Average Strength/Durability Data for Mixture Comparison

Test	ND Standard Mixture (6-17)			ND Experimental Mixture (7-1)		
	Test Age			Test Age		
	7day	28 day	90 day	7 day	28 day	90 day
Slump (in)	2.0			1.5		
Air Content (%)	9.0			7.0		
Unit Weight (pcf)	138.6			141.6		
Compr. Strength (psi)	3045	3810	4990	3080	4170	4975
Flex. Strength (psi)	535	565	615	520	583	758
Split Tensile (psi)	274	323	-	271	371	-
Young's Modulus (psi)	-	4,100,000	4,450,000	-	3,850,000	4,600,000
Rapid Chlor. Perm (Coul.)	7950 top / 5744 avg at 17 weeks			5578 top / 5067 avg at 17 weeks		

2. For the ambient air temperatures experienced during this project, the various initial curing regimes studied resulted in no systematic or significant difference in compressive strengths (see appendix B). The initial curing regimes studied included ASTM field curing (ditch curing – leaving specimens along the interstate ditch), modified ASTM standard curing (box curing – insulated cylinder box without temperature control), and ASTM standard curing (temperature controlled curing box). It should be noted that when ambient air temperatures are appreciably lower or higher than those experienced during this test program (50 F to 85 F), differences in strength may become more apparent.
3. There is a marginal correlation between splitting tensile strengths and flexural strengths (see Appendix C). For these two mixtures, the average 7 day and 28 day splitting tensile strength are approximately 58% of the flexural strengths. The reason for the relatively weak correlation (r^2=0.87) between the two strength measures is probably related to the relatively high variability of the splitting tensile data, although there is no significant difference in how well splitting tensile strength and flexural strength correlate with compressive strength.
4. Additional vibration of the concrete at the joints appears to have little effect on the average volume of permeable pore space. Although there seems to be

approximately 0.9% more permeable void space at the joints than at mid-slab, addition vibration does not appear to reduce this difference. The data does suggest however, that additional vibration at the joints may decrease the average difference in permeable void space between the top and bottom portions of the pavement by nearly 1% (see Appendix D). More data would need to be evaluated to determine whether this is statistically significant in the context of the variability of the void space across the pavement in general.

5. Several concrete technologies that are currently of interest to NDDOT, may be useful for both planning and construction quality control for future projects.
    a. Maturity testing can be effective in estimating the in-place concrete strength to make opening to traffic decisions more easily and less expensively. The maturity data evaluated for this project shows that as long as the mixture proportions stay consistent, maturity testing predicts the in-place concrete strength reasonably well (see Appendix E). As the attached figures illustrate, the second placement (6-30) shows a close conformance of the pavement maturity curve to that of the calibration curve. The first placement (6-17) however, shows a clear departure in the maturity curves from the calibration curve. This is most likely linked to a change in the air content (with the subsequent loss in strength) from 7% at the time of calibration to 9% during the first placement.
    b. The Danish Air Void Analyzer (AVA) quickly measures the entrained air content, spacing factor and specific surface of the plastic concrete. These parameters are very important for the long term durability of concrete. The AVA data suggests that the specific surface and spacing factor for the concrete sampled on 6-29 was 587/in and 0.0086 in, respectively (see Appendix F). Currently, no correlation data (linear traverse results) is available for the samples tested for this project. Unfortunately, we do not anticipate that the linear traverse measurements will be completed in the near future.
    c. HIPERPAV can aid both the State and the contractor in minimizing the potential for uncontrolled cracking of concrete pavements. Although

HIPERPAV conservatively predicted mid-slab early-age transverse cracking for the environmental, mixture, and pavement conditions experienced at this project, it is important to recognize that HIPERPAV gives an indication of potential problems, not necessarily visible early failures. Sources of the overestimation of the pavement stresses may relate to unknown subbase friction values, or an underestimation of creep-relaxation. More accurate pavement strengths can be predicted with calorimetry tests for the specified mix design as well. For a more detailed discussion of the HIPERPAV results, see Appendix G.

d. The paving machine's mechanical tie-bar inserter appears to place the centerline tie bars effectively. The horizontal and vertical alignments of the centerline tie bars were improved when using the automatic tie-bar inserter instead of conventional staking. This was verified by establishing the tie-bar alignment in numerous locations with a Microcovermeter, and confirming their locations with drilled cores in selected locations. In all cases, the microcovermeter established the depth and alignment of the tie-bars within 1/8 inch. For the pavement sections paved with the mechanical tie-bar inserter, the tie-bar alignment is within 0.5" of mid-depth and spaced at 3' +/- 2".

All the raw strength data is included in Appendix H.

If you have any comments or questions about these findings/results, please contact Leif Wathne, Concrete Materials Engineer with the Mobile Concrete Laboratory at (202) 366-1335.