R&T UPDATE
Concrete Pavement Research & Technology

ACPA REPORTS HIGHLIGHTS OF 82ND ANNUAL TRB MEETING

PART 2: DESIGN, MATERIALS, CONSTRUCTION

This R&T Update is the last of a two-part series reporting on the latest research & technology in concrete pavements, presented at the 82nd Annual Meeting of the Transportation Research Board, held in Washington, DC from January 12-16, 2003. Copies of most of the technical papers can be downloaded from the ACPA website at www.pavement.com/techserv/RT4.02.pdf. Links directly to the papers are available after each article through the Adobe Acrobat online version of this R&T issue. Please contact Debbie Howard at dhoward@pavement.com or 847-966-2272 if you have any questions.

Minnesota Fine-Tunes their High Performance Concrete Pavement

Minnesota DOT presented the latest of a series of changes to their High Performance Concrete Pavement (HPCP) specification, which has been used on one pilot project so far: I-35W in the Twin Cities. The intent of the HPCP program is to build durable pavements, not necessarily stronger and thicker pavements. Mn/DOT is designing their high performance concrete pavements to last 60 years. Joint distress was one of the primary considerations for a 60-year design, as deterioration of the concrete at transverse joints has been a recurring problem. Poor quality concrete resulting from improper air and a high water cement ratio were targeted as the reason for early deterioration. A second, joints-related, issue was corrosion of the epoxy coated dowel bars and subsequent loss of load transfer. Based on the preliminary results from the pilot project, the differences for future HPC projects from the standard Mn/DOT specification will include: increasing average air content from 6.0% to 7.0%, tighter limits on aggregate absorption, well-graded aggregate gradation, increasing design thickness from 20 to 35 years, and utilizing stainless steel-clad dowel bars for load transfer. In analyzing the pilot projects, Mn/DOT has found that the 60-year high performance design results in the same life cycle cost as a 35-year design, despite a higher initial cost. (03-3169, 03-4123)

Physical Properties of Concrete Made with Recycled Aggregates

A laboratory investigation into the relationships between the various physical properties of recycled aggregate concrete (RAC) was presented by researchers from the University of Tennessee. The existing American Concrete Institute (ACI) relationships for normal-strength concrete were evaluated to determine their validity for RAC. Tests were performed on three different RAC mixes to obtain their compressive strength, modulus of rupture, splitting tensile strength, and modulus of elasticity. Based on this, the commonly accepted ACI relationships for the prediction of the modulus of rupture and the splitting tensile strength for normal-strength concrete were found to be adequate for the prediction of these properties for the RAC. However, the ACI equation overestimated the modulus of elasticity of the RAC by about 9%, primarily because of the amount of comparatively low-strength old mortar contained in the recycled concrete. An alternative relationship, which is more accurate for RAC, was developed in the study. (03-3878)

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Use of High Volumes of Fly Ash in Concrete Pavement

In the late 1980's and early 1990's the Minnesota Department of Transportation experienced a significant number of concrete paving projects with lower than anticipated compressive strengths. An investigation into the cause indicated that the water content of the concrete being placed in the pavements was significantly higher than what was in the project mix designs. In 1992, a research project was conducted to look at the effects of increasing the total cementitious content of concrete by substituting Class C fly ash for Type I Portland cement on an even cost basis. A laboratory study evaluated the strength development of several concrete mixtures with fly ash contents of 15, 20, 25, and 33%. The study showed that the higher fly ash content mixtures had equivalent or improved strength and permeability, lower water/cementitious ratio, and would not significantly affect the concrete price. Test sections were constructed on US 52 south of Rochester Minnesota during the summer and fall of 1992 using the laboratory mix designs. Samples obtained from the pavement immediately after construction and in 1999 confirm that the strength and permeability characteristics of the high fly ash content mixes (25 and 33%) were superior to the standard mixture with 15% fly ash. Reviews in 2002 confirm that performance of all of the test sections is equivalent after 10 years with no noticeable surface distress in any of the pavement on the entire project. (03-4398)

Alternative Dowel Bar Materials

ACPA member Applied Pavement Technology presented the current state-of-the-art in alternative dowel bar materials. According to their study, most of the alternative dowel material projects built to date have been high performance concrete pavement projects, and have included one or more of the following materials:

- fiber reinforced polymer (FRP) bars (cost 2-3 times as much as epoxy coated)
- fiber reinforced polymer (FRP) tubes filled with cement (cost 1.5 to 2 times as much)
- plastic-coated steel bars (same to slightly higher cost)
- solid stainless bars (cost 6-10 times as much)
- stainless clad bars (3-4 times as much)
- stainless tubes filled with cement (2-4 times as much)

Some of the findings from pilot projects include:

- some slight problems securing FRP & stainless bars to the baskets; they tend to want to slide out
- FRP bars do not work with dowel bar inserters (DBI's) because they are too lightweight and will move out of alignment
- dowel basket assemblies with stainless clad and particularly solid stainless bars are extremely heavy to move and require 2-3 extra workers to handle and place
- short-term performance of all types has been good; no long-term performance information is available yet

Effect of the Material Properties of Concrete on Joint Performance

A University of Illinois study researched the key material characteristics that affect shear load transfer at joints in concrete pavement, and thereby affect joint behavior and performance. These factors are aggregate size, aggregate type, and concrete strength. Data from the study show that the ratio of aggregate size to joint opening is an important factor that determines the mechanism for effective shear resistance. Larger maximum size aggregates and tighter joints result in better

load transfer. The impact of aggregate type on joint performance becomes more pronounced at higher loadings and larger crack widths. Los Angeles Abrasion and crushing values were determined to see whether they can be used as good tools for predicting the performance of a given aggregate. These tests were found to be good indicators of aggregate interlock performance. The study also distinguishes between concrete compressive strength and the concrete strength at the crack interface. The intact compressive strength has no or negligible effect on joint performance, while an increase in strength at the crack wall enhances the performance of joints under loading. (03-3518)

FHWA-Sponsored Study Recommends Texturing Methods

An FHWA-sponsored study, conducted by ACPA member Applied Pavement Technology, involves compiling a synthesis of the current "state of the practice" on concrete pavement texturing practices, including burlap drag, longitudinal and transverse broom, artificial turf drag, transverse tining, longitudinal tining, and other more specialized techniques such as exposed aggregate, chip sprinkling, plastic brushing, and porous concrete. Texturing of hardened concrete is highlighted as well, including diamond grinding, diamond grooving, and abrading (shotblasting). Noise on different textures is also discussed. Recommendations for surface texturing are given, based on roadway design speed: for roadways designed for less than 45 mph, burlap, turf, or broom surfaces are adequate, as long as minimum texture depth is met (using sand patch test for example). For roadways designed for 45 mph or more, the recommended texture is traditional burlap or turf drag right behind the paver, combined with random transverse or longitudinal tining. (03-3957)

Curing Compounds Put to the Test

A Minnesota study compared six different curing compounds to curing with plastic sheeting, water curing, and no curing whatsoever. As would be expected, the top curing methods, resulting in higher strength and lower permeability concrete, were water curing and plastic sheeting. The individual performance of the six curing compounds varied, but those with higher "percent solids" in their composition helped concrete achieve higher strength and lower permeability. (03-4014)

Effect of Curing Compound on Smoothness

A study of concrete pavements in Kansas showed the effect of curing on as-constructed smoothness and subsequent roughness development. Ten test sections on five newly-built projects on Interstate routes 70 and 135 were selected. At each site, one section was cured with a double application of curing compound compared to single application currently specified. It was found that single curing compound application results in lower as-constructed IRI values, but double application helps to decrease roughness development in the long run, possibly due to lower differential volume change of the concrete. (03-2301)

Bump Finder for Lightweight Inertial Profilers

Profilograph traces have historically been the only ways to locate rough spots for bump grinding. A new report, co-authored by principal investigator for the ACPA Profiler Repeatability Assessment Study, Steve Karamihas, presents a method whereby lightweight inertial profilers can be used to locate portions of a new pavement that need to be diamond-ground to enhance smoothness and improve the pavement to within specification tolerances. (03-3720)

Profiler Accuracy

Engineers from Arizona DOT studied the inadequacy of the existing ASTM E950 method to define the bias of inertial profilers in the measurement of pavement profiles and proposed an improved bias calculation method. An analysis of the profile measurements and International Roughness Index (IRI) of four pavement locations was conducted and the results show that there is no statistical correlation between the profile biases and IRI bias. It demonstrates that a profiler classified as having high accuracy in measuring profile by ASTM E950 or other proposed bias criterion does not necessarily provide an accurate measurement of IRI. The authors recommend that the accuracy of a profiler in the measurement of IRI should be evaluated independently when IRI, instead of profile, is used for a smoothness specification or other purposes. (03-2506)

End-Result Specification for Air Void Parameters in Hardened Concrete

The Ontario Ministry of Transportation (MTO) has been moving towards end-result specifications since the 1980's for concrete. In 1997, MTO introduced an end-result specification for concrete quality including requirements for air void parameters of the hardened concrete. This was intended to introduce a more significant durability component into the ministry's acceptance process for concrete, to ensure long-term performance and extend the service life of concrete highway structures in the province. It was also intended to eliminate direct involvement by MTO staff in on-site concrete acceptance. Concrete mix design and on-site acceptance of concrete is the responsibility of the contractor and prequalified testing personnel. Many prescriptive factors have been eliminated (including minimum cement content) to allow the contractor flexibility in utilizing locally available materials. Since the specification was implemented in 1997, information from 75 contracts compiled through 2001 revealed that in excess of 95% of the test results (on a lot basis) were within specification. No discernable difference in project costs were noted by the MTO following adoption of the end-result specification on hardened air voids. Only 16 results out of approximately 1200 tests were shown to be out of specification. Slipform paving produced more favorable results than hand placement with only 1 out of 224 tests performed showing an out-of-specification spacing factor. (03-3330)

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