



Transportation Literature Search

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Lowering Cementitious Levels in Rigid Pavement Mixtures

Prepared for
Wisconsin Highway Research Program
Concrete Pavements Technical Oversight Committee

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Transportation Literature Searches are prepared for WisDOT staff and principal investigators to heighten awareness of completed research in areas of current interest. The citations below are representative, rather than exhaustive, of available English-language studies on the topic. Primary online resources for the literature searches are OCLC's [WorldCat](#) and [TLCat](#), U.S. DOT's [TRIS Online](#), the National Transportation Library ([NTL](#)), TRB's [Research in Progress \(RiP\)](#) and other academic, engineering and scientific databases as appropriate. Links to online copies of cited literature are noted when available. Hard copies may be obtained through the WisDOT Library at library@dot.state.wi.us or 608-264-8142.

SUMMARY

We found three studies, and two more in progress, that bear on issues of reducing total cementitious materials content in rigid pavement designs. One cited study focuses on water-cementitious materials content, a mixture characteristic related to cementitious materials content levels; another on the related performance issue of reducing shrinkage cracking; the third on design methods for reducing such materials in self-consolidating concrete.

The **Research in Progress** studies are of more direct interest. The first focuses on reduction of total cementitious materials content, the second on performance prediction of low cementitious materials mixes.

KEYWORDS

cementitious, material, content, quantity, low, lower, reduce, reduction, durability, design, vary, variation

CITATIONS

Title: Effect of w/cm and High-Range Water-Reducing Admixture on Formwork Pressure and Thixotropy of Self-Consolidating Concrete

Author(s): Kamal H. Khayat, Joseph Assaad

Date: May/June 2006

Doc ID/URL: *ACI Materials Journal*, Vol. 103 (3), May/June 2006: 186-193.

<http://www.concrete.org/MEMBERS/103-m21.pdf>.

Description: 8 pp.

Contents: An experimental program was undertaken to evaluate the effect of water-cementitious material ratio (w/cm) and type of high-range water-reducing admixture (HRWRA) on the development of formwork pressure that can be exerted when using self-consolidating concrete (SCC). Pressure variation was monitored using an experimental column measuring 2800 mm in height. The tested mixtures were proportioned with a similar initial slump flow consistency of 650 ± 15 mm. Three w/cm of 0.36, 0.40, and 0.46 and three types of HRWRA (polycarboxylate, polynaphthalene sulphonate, and polymelamine sulphonate) were investigated. Variations in lateral pressure were related to the thixotropy of the concrete. Test results show that the variations in lateral pressure and thixotropy of SCC are significantly affected by the w/cm . Irrespective of the HRWRA type, mixtures proportioned with 0.46 w/cm exhibited greater initial pressure and lower thixotropy compared with mixtures made with a w/cm of 0.40 and 0.36. This is related to the higher water content and lower coarse aggregate volume in concrete proportioned with the higher w/cm , which can lead to a reduction in shear strength properties of the plastic concrete. The rate of pressure drop and increase in thixotropy with time, however, were greater in mixtures made with a higher w/cm . This is attributed to the lower HRWRA demand that can lead to sharper fluidity loss with time. For any given w/cm , the type of HRWRA appears to have a limited effect on initial lateral pressure. Compared with naphthalene- and melamine-based HRWRA, the use of polycarboxylate-based HRWRA in SCC resulted in lower rate of pressure drop with time. This is reflected by the greater fluidity retention of the mixtures containing the

polycarboxylate-based HRWRA. The incorporation of a water-reducing agent in mixtures made with polynaphthalene sulphonate-based HRWRA is shown to increase lateral pressure development of the plastic concrete over time. Copyright ©2006, American Concrete Institute. All rights reserved.

Title: Improving Concrete Mixture Designs for Reduced Shrinkage in High Performance Concrete

Author(s): Savita Goel, Paul J. Tikalsky, Andrea J. Schokker

Date: March 2003

Doc ID/URL: FHWA-PA-2002-040-97-04 (81-2); PTI 2003-27. Final Report.

Description: 126 pp.

Contents: High -Performance concrete (HPC) is the concrete designed to produce a durable structure for the specific environmental and structural conditions. In the Commonwealth of Pennsylvania, concrete durability of bridge decks is primarily influenced by deterioration mechanisms such as shrinkage, freeze-thaw, scaling, corrosion of embedded reinforcement bars, compressive strength, and alkali-silica reactivity. This study characterizes HPC mixtures to minimize shrinkage in the bridge decks. A shrinkage prediction model is an important tool for a design engineer, particularly when designing special structures such as very tall buildings, very long-span bridges, cooling towers, etc. This study evaluates shrinkage as per the prediction models Bazant and Baweja, 2000 (B3); Gardner, 2000 (GZ); ACI 209, 1997 (ACI) and Branson to assess their validity for high-performance concrete mixtures containing supplementary cementitious materials, chemical admixtures and low water-to-cementitious materials ratio. The results show that HPC can be economically designed to minimize shrinkage strains for concrete bridge decks. The necessary changes to current practice include the **reduction in total cementitious content**, increased use of ternary cementitious mixtures, rapid initial curing procedures, curing concrete a minimum of 7 days, and maintaining a modest w/cm ratio.

Title: Optimizing self-consolidating concrete with limestone filler by using statistical factorial design methods

Author(s): A. Ghezal, K. H. Khayat

Date: May 2002

Doc ID/URL: *ACI Materials Journal*, Vol. 99 (3), May 2002: 264-272.

Description: 9 pp.

Contents: Self-consolidating concrete (SCC) is typically proportioned with relatively high contents of cementitious materials and chemical admixtures, leading to relatively high material costs. Such costs can be tolerated in high-value-added applications, especially if cost savings can be realized from using SCC. However, efforts are still needed to reduce material costs for SCC to gain wider acceptance in a variety of applications. In addition to proper material selection and sound mixture proportioning, incorporation of readily available fillers can enable **reduction in cement and admixture contents**, leading to savings in costs. This paper presents results from an experimental program in which response surface methods were employed to optimize a 4-component concrete containing limestone filler subject to 8 performance criteria.

RESEARCH IN PROGRESS

Title: Economical Concrete Mix Designs Utilizing Blended Cements, Performance Based Specifications, and Rational Pay Factors

Principal Investigator(s): n/a; Christ G. Dimitroplos, Project Manager, 602.712.7850, cdimitroplos@azdot.gov

Start Date: 10/1/2006

RIP URL: <http://rip.trb.org/browse/dproject.asp?n=12494>

Sponsor Organization: Arizona Department of Transportation

Contents: There is a need to contain the escalating costs of construction projects through the use of economical concrete materials and rational acceptance criteria. This is a proposal to increase competitiveness among project bidders by improving the procedures for materials selection, specifications, and also pay factors for contract administration. A preliminary study conducted for joint ADOT/ARPA committee has indicated that there are significant potential cost savings through the **reduction of minimum specified cement content** in various grades of concrete. Such reductions however must be accomplished so that the performance of final product is not jeopardized. This project will utilize and evaluate recent advances in performance enhancing mineral admixtures and supplementary cementitious materials, in addition to QC parameters used for specification and acceptance criteria in order to develop economical concrete mixtures. This project will promote better quality and economics of using concrete materials by focusing on the: (1) mix design formulation based on economy, superior performance, quality control, and durability; (2) better utilization of mineral admixtures such as fly ash through reducing the minimum cement requirements for 2500 psi and 3000 psi concrete mixtures; and (3) evaluation of the acceptance criteria and pay factor adjustment methods based on a bonus/penalty factors in improving quality control and specification procedures.

Title: Using Cement Paste Rheology to Predict Concrete Mix Design Problems

Principal Investigator(s): Anol Mukhopadhyay, Texas Transportation Institute, 979.845.1713

Start Date: 9/1/2006

RIP URL: <http://rip.trb.org/browse/dproject.asp?n=12161>

Sponsor Organization: Texas Department of Transportation

Contents: The current Texas Department of Transportation (TxDOT) specification Item 421 recommends using low water-to-cementitious material ratio, **low total cementitious material content** and encourages judicious use of supplementary cementitious materials (SCMs), chemical admixtures and cements with low C3A and soluble alkali for better workable and durable paving concrete. However, complex interaction between C3A contents, sulfate contents in pore solution, SCMs and chemical admixtures sometimes creates poor cement-admixture compatibility and can give rise to inadequate early workability or premature loss of workability along with setting time and heat evolution abnormalities. Therefore, it is necessary to identify those incompatibilities before the actual placement in order to avoid the problems in the placing and curing process. It is anticipated that cement paste (cement + SCMs + chemical admixtures) rheology measurements could be a good indicator to identify those incompatibilities.

Therefore, the purpose of this research project is to develop an easy to use, relatively inexpensive field laboratory test and equipment to predict potential concrete mixture incompatibilities between the sulfate system, mineral and chemical admixtures through the direct measurement of cement paste rheology. The research team proposes the dynamic shear rheometer (DSR) and Brookfield type rotational viscometer as a potential candidate test methods to measure cement paste rheology. A preliminary investigation on measuring viscosity of cement grout using rotational viscometer is very promising. The work will be performed through (i) detailed laboratory investigation with powerful design of experiments, and (ii) field validation and establishing acceptance criteria.