Updates from the States: FHWA (August 2014)

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The Federal Highway Administration's (FHWA's) Office of Research, Development, and Technology (RD&T) is located at the Turner-Fairbank Highway Research Center (TFHRC), a federally owned and operated national research facility in McLean, Virginia. This world-class facility houses more than 20 laboratories, data centers, and support facilities, and conducts applied and exploratory advanced research in vehicle-highway interaction, nanotechnology, and a host of other types of transportation research in safety, pavements, structures, human-centered systems, operations and intelligent transportation systems, and materials.

The Office of Infrastructure RD&T conducts and oversees research and development programs that address critical highway infrastructure needs and priorities of national importance. The office is organized under two broad program areas: Pavements and Structures. FHWA's pavement research and development program (pavement materials, pavement design and construction, and long-term pavement performance) provides technologies and solutions to advance both the state of the art and the state of the practice in highway pavement engineering.

In general, FHWA's pavement program covers six focus areas:

1. Pavement Design and Analysis
2. Materials and Construction Technology
3. Pavement Management & Preservation
4. Pavement Surface Characteristics
5. Construction and Materials Quality Assurance
6. Environmental Stewardship and Sustainability

Through an integrated and interdisciplinary approach, concrete pavement research at the Turner-Fairbank Highway Research Center is carried out by the following teams of highly experienced engineers and scientists:

Pavement Design & Construction - advances knowledge and technology associated with all aspects of pavement design, performance assessment, prediction technology, and construction. This includes developing procedures and processes to enable pavement modeling to optimize pavement performance and safety, incorporate life-cycle costs for design selection, conduct forensic analyses, and develop performance-based specifications. The team also develops construction management guidelines, specifications, and other technologies to ensure that what is constructed meets the intent of design.

Long-Term Pavement Performance (LTPP) - provides oversight and management of the LTPP program, a comprehensive study of in-service pavements. Originally part of the Strategic Highway Research Program, the LTPP program is now administered by the FHWA with active input from all U.S. State departments of transportation and with the cooperation of all 10 Canadian provincial transportation agencies. The LTPP team collects pavement performance data and conducts studies that help practitioners improve pavement design, construction, maintenance, and preservation practices.

Exploratory Advanced Research (EAR) - addresses the need to conduct longer-term and higher-risk breakthrough research with the potential for transformational improvements to plan, build, renew, and operate safe, congestion free, and environmentally sound transportation systems. Focus areas for this program include Integrated Highway System Concepts, Nano-Scale Research, Breakthrough Concepts in Material Science, and Technology for Assessing Performance.

Pavement Materials - aims to advance all aspects of pavement materials technology, including evaluation of both traditional (aggregates, asphalt, and portland cement concrete) and innovative materials and additives. The team develops procedures and specifications for materials used in pavement design, maintenance, and rehabilitation to further improve performance and optimize mixture design.

In conjunction with identified research needs, the laboratories and facilities of the TFHRC provide a vital resource for advancing the body of knowledge that has been created and developed by researchers. Concrete pavement research is conducted at the Pavement Testing Facility and at the Highway Materials Complex, which houses the Concrete, Aggregate, and Chemistry Laboratories summarized below.

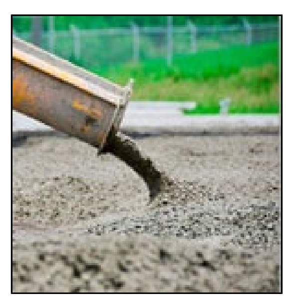
- **Pavement Testing Facility** - conducts rapid pavement testing of full-scale structures to develop and verify new specifications, designs, and test procedures for rigid and flexible pavements. The accelerated loading facility (ALF) is used by pavement and highway research engineers to evaluate the durability of both new and existing pavement materials and to help develop smoother and more cost-effective highway systems. Loading machines are able to evaluate durability of both new and existing pavement materials by applying wheel loads corresponding to many years of service.
- **Concrete Laboratory** - researchers evaluate new test methods, conduct concrete materials research, develop mixture design and analysis procedures for concrete pavements, and provide concrete forensics. This laboratory is comprised of components dedicated to the study of concrete curing, hydration, durability, mechanical properties, petrography, and aggregate materials and sample preparation. Furthermore, it employs state-of-the-art equipment, including a dynamic shear rheometer (DSR) and isothermal calorimeter.
- **Aggregate Laboratory** - provides facilities for testing, characterizing, and preparing aggregate materials for evaluation in concrete, asphalt, and granular base course mixtures as well as trouble-shooting and forensic investigation of performance in pavement and structures applications.
- **Chemistry Laboratory** - purpose of this laboratory is to conduct fundamental studies of highway materials aimed at understanding failure mechanisms and superior performance, advancing state-of-the-art characterization tools, and testing and developing new materials.

To learn more about FHWA concrete pavement research and the previously discussed facilities, follow the links below:

- Turner-Fairbank Highway Research Center
- Office of Infrastructure R&D
- Overview of Laboratories
- Exploratory Advanced Research

Ongoing & Proposed FHWA Research

Effect of High-Range Water Reducer on Air System and Freeze-Thaw Resistance



FHWA is beginning an investigation to determine how a combination of different high-range water reducing (HRWR) admixtures and air-entraining agents (AEA) can affect the freeze-thaw resistance and air void system of plain, binary, and ternary mixtures.

The motivation behind this study is that most of the current specifications that set limits for freeze-thaw resistance are based on research conducted decades ago with admixtures that, in most cases, do not reflect the chemistry of the ones currently in use. Additionally, cements have changed and the use of supplementary cementitious materials has increased, creating a different set of possible incompatibilities that may ultimately affect the ability of the concrete to resist the adverse impact of freeze-thaw action in colder regions.

The objectives of this study are to determine how HRWR affect the air system and freeze thaw durability of the concrete and how HRWR affect the necessary AEA dosages.

This project is contributing to research objectives identified in CP Road Map Track 1: Materials and Mixes for Concrete Pavements. For additional information on this project, please contact Ahmad Ardani.

Impact of Amorphous NAS on Mechanical Performance of High-Volume Fly Ash Mixtures

Calcium silicate hydrate (C-S-H) and calcium hydroxide (CH) are the two main products of portland cement hydration. The replacement of a portion of the portland cement with fly ash helps to convert the calcium hydroxide into the stronger and more desirable C-S-H. Additional C-S-H is developed from the alkali activation of calcium-rich particles in the fly ash.

As the volume of fly ash is increased, there comes a point where the benefits of fly ash substitution are offset by the dilution of the portland cement, leading to performance problems experienced in high-volume fly ash (HVFA) mixtures.

A potential solution to this dilemma may be the incorporation of nano aluminosilicate (NAS). It has been observed that NAS is effective in promoting reaction of C3A (tricalcium aluminate) to form ettringite gel (C-A-S-H) in portland cement paste. Because C-A-S-H has superior strength properties versus C-S-H, it is hypothesized that the use of NAS could help offset the mechanical performance problems of HVFA mixtures.

A research project is proposed to study the effects of amorphous NAS in the reaction of HVFA and to test the ability of NAS in enhancing the mechanical performance of HVFA mixtures.

This project will contribute to research objectives identified in CP Road Map Track 1: Materials and Mixes for Concrete Pavements. For additional information on this proposed project, please contact Ahmad Ardani.

Influence of Aggregate Characteristics on Concrete Performance

Often neglected components of concrete are the fine and coarse aggregates, even though they typically occupy approximately 70% of the concrete volume. For most concrete mixes, locally available aggregates are used with little characterization beyond their grading, specific gravity, moisture content, and absorption properties to be used in the mixture proportioning calculations. However, the physical and chemical characteristics of the aggregates can have a significant impact on concrete performance. A fundamental understanding of the relationship between aggregate characteristics and concrete performance would enable prudent selection/blending of aggregate sources and the optimization of sustainable concrete mixtures.

There are several drivers providing the impetus for this research. First, the sustainability movement in concrete is strongly grounded in reducing the cement content of concrete mixtures as cement has the largest CO2 and energy footprint of the concrete ingredients. One method to reduce cement usage is to increase the aggregate content of the mixture. Secondly, the country is facing a looming aggregate shortage. Understanding the relationships between aggregate characteristics and concrete performance will provide a basis for aggregate selection and blending in sustainable materials such as crushed returned concrete aggregate.

The proposed research will evaluate at least 10 different coarse aggregates. Characteristics beyond the typical ones described above will be determined. The analysis will take advantage of new technology such as the FHWA Aggregate Image Measurement System (AIMS) to characterize the shape, angularity, and texture of concrete aggregates. The aggregates’ modulus (stiffness) will be determined and the interfacial transition zone (ITZ) between the aggregates and hydrating cement will be examined using microscopy techniques. Concrete specimens will then be prepared with the aggregates and the fresh and hardened properties will be evaluated.

This project is contributing to research objectives identified in CP Road Map Track 1: Materials and Mixes for Concrete Pavements. For additional information on this proposed project, please contact Ahmad Ardani.

Super Air Meter for Assessing Air-Void System Properties of Fresh Concrete

Dr. Tyler Ley of Oklahoma State University (OSU) and his research team have developed a device named the Super Air Meter (SAM). SAM is a modified ASTM C231 Type B pressure meter capable of assessing air-void parameters of fresh concrete mixtures in addition to the air content. The results of the measurement obtained from SAM can be used to correlate with ASTM C457, Parameters of Air-Void System in Hardened Concrete and ASTM C666, Resistance of Concrete to Rapid Freeze and Thawing.

The concrete lab at Turner-Fairbank Highway Research Center (TFHRC), in collaboration with OSU, has initiated a comprehensive study in validating the measurement obtained from SAM with 72 concrete mixtures with different w/c ratios, air contents, natural vs. synthetic air entrainers, three different aggregates, and with and without water reducing agents. The results obtained from SAM will be compared against a newly purchased RapidAir 457, automated air-void analyzer device at TFHRC. In addition, this study will attempt to correlate the results obtained from ASTM C666 with SAM data.

The Primary objective of this study is to examine the feasibility of using SAM for measuring spacing factor and also predicting freeze-thaw susceptibility of cementitious mixtures.

This project is contributing to research objectives identified in CP Road Map Track 1: Materials and Mixes for Concrete Pavements. For additional information on this project, please contact Ahmad Ardani.

About the CP Road Map E-News

The ***CP Road Map E-News*** is the newsletter of the Long-Term Plan for Concrete Pavement Research and Technology (CP Road Map), a national research plan developed and jointly implemented by the concrete pavement stakeholder community. To find out more about the CP Road Map, or to get involved, contact Steve Klocke, 515-964-2020.

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