Updates from the States: Federal Highway Administration's Turner-Fairbank Highway Research Center (May 2011)

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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: Pavement and Structures. FHWA's pavement research and development (pavement materials, pavement design and construction, and long-term pavement performance) provide 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 performance 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 Advance Research (EAR) - addresses the need to conduct research on 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 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:

- TFHRC: http://www.fhwa.dot.gov/research/tfhrc/
- Office of Infrastructure R&D: http://www.fhwa.dot.gov/research/tfhrc/offices/infrastructure/
- Overview of Laboratories: http://www.fhwa.dot.gov/research/tfhrc/labs/
- Exploratory Advanced Research: http://www.fhwa.dot.gov/advancedresearch/index.cfm

Highlights

The following provides more detail on five of the past and currently ongoing research projects at the Turner-Fairbank Highway Research Center.

1. Fly Ash Workshop at Turner-Fairbank Highway Research Center
2. HIPERPAV® (High Performance Concrete Paving)
3. Definition and Determination of Remaining Service and Structural Life
4. Implementation of JPCP PRS by State Highway Agencies
5. Coefficient of Thermal Expansion (CTE) Ruggedness Test

Fly Ash Workshop at Turner-Fairbank Highway Research Center

On September 29-30, 2010, the Federal Highway Administration (FHWA) at the Turner-Fairbank Highway Research Center (TFHRC) held a workshop on the use of fly ash in concrete mixes titled, "Steps Needed in the Research & Development of New Specifications for the Proper Inclusion of Fly Ash into Concrete Mixtures for Highway Pavements and Transportation Structures." The workshop was attended by representatives from fly ash suppliers, power plants, practitioners, academia, contractors, and governmental agencies including FHWA and State DOTs. In all, 50 interested researchers and stakeholders attended the 2-day workshop. Presentations covered a wide range of topics dealing with production and characterization of ashes, reviewing existing fly ash specifications and their limitations. They also included topics related to performance-based specifications, fly ash beneficiation, and their overall use and proportioning in concrete mixtures, using fly ash to address chemically induced distresses such as alkali-silica reactivity (ASR) and sulfate attack. Other topics of interest included using fly ash as a sustainable way of reducing the carbon dioxide (CO2) footprint associated with production of cement, reducing the need for raw materials, using alternative cementitious materials in concrete and using as much as 100 percent fly ash-based cementing materials in concrete. Compatibility and incompatibility issues related to the use of fly ash including quality control and quality assurance programs and barriers limiting greater fly ash usage were also discussed. This workshop can be categorized under CP Road Map Track 13: Concrete Pavement Sustainability. To obtain further information, follow the link below:

http://www.asrtwg.com/references/Fly%20Ash%20Workshop.pdf

HIPERPAV® (High Performance Concrete Paving)

HIPERPAV® software was first released in 1996, followed by an updated version in 2005. The software program allows users to predict early-age concrete pavement behavior based on user-defined inputs for environmental, design, and construction conditions. The user inputs variables such as ambient weather conditions, thickness of pavement, mix design, time of placement, and type of curing. Mathematical models then calculate the progression of the concrete's strength gain and developing stresses for the first 72 hours after placement. In the new HIPERPAV III®, an enhanced moisture transport model has been developed, incorporated into the software, and was released in January 2010. The improved moisture model captures the interaction between pavement design, materials, environmental, and construction inputs and provides a more realistic characterization of moisture transport in the slab and its effect on early-age drying shrinkage, warping stresses and strength development in the slab. The Transtec Group, under FHWA contract, is currently working on further enhancing the HIPERPAV III® software program to include additional features including: automatically downloading weather data from the National Weather Service website, and adding a slag aggregate input into HIPERPAV III® along with default thermal properties including coefficient of thermal expansion, specific heat, and thermal conductivity. This research is an example of work categorized under the CP Road Map Track 3: High-Speed Nondestructive Testing and Intelligent Construction Systems. For more details regarding this software, click on the link below:

http://www.fhwa.dot.gov/publications/research/infrastructure/pavements/09048/index.cfm

Definition and Determination of Remaining Service and Structural Life

Pavement remaining service life (RSL) concept has been in use, directly or indirectly, for many years. However, there exist multiple definitions and methods for determination of RSL. As examples, one of the definitions proposed by Vepa et al, in 1996 is, "the extent of the useful life remaining in a pavement section subjected to traffic and environmental forces, expressed in years/traffic or percentage of life left." Another commonly understood definition is, "the years till the next rehabilitation or overlay." Michigan DOT uses the definition, "the life remaining in a pavement before a major rehabilitation or reconstruction is the most cost effective fix to apply." A survey by Wisconsin DOT on service life in 2004 found that four distinct definitions within fourteen states that responded. RSL has been complicated by the move from "worst-first" approach of rehabilitation to "lowest-life-cycle-cost" (LLCC) based preservation approach. In the former, it is common for agencies to address rehabilitation when functional or structural failure occurs and the definition of RSL as

the time to functional or structural failure has worked well and the use of performance models based on surface condition (PSR, roughness, cracking) for the prediction RSL has been sufficient. However, with a LLCC based preservation approach, the surface condition based RSL may provide neither the true RSL nor one appropriate for the varying objectives. Under the pavement preservation approach, pavements receive treatments early in their life, before they actually fail, either functionally or structurally. Therefore, a surface condition based RSL may only represent the last preservation treatment and not the true RSL of the pavement system. Further complicating this issue is the concepts of long lasting and perpetual pavements that assumes optimally timed preservation treatments. The objective of this effort is to critically review the current and emerging roles of RSL and develop a framework and methodologies for measures that are robust, unambiguous and support the business and engineering decisions in managing pavements. This work is an example of research that can be categorized under CP Road Map Track 3: High-Speed Nondestructive Testing and Intelligent Construction Systems. Additional information is accessible via the following link:

http://www.fhwa.dot.gov/research/tfhrc/projects/projectsdb/projectdetails.cfm?projid=HRDS-000110

Implementation of JPCP PRS by State Highway Agencies

The effort to develop and implement performance-related specifications (PRS) for rigid pavement construction has focused on Jointed Plain Concrete Pavements (JPCP). Notable accomplishments under FHWA contracts thus far have been the development of PaveSpec 3.0 software to help the user develop, analyze, and apply a job-specific PRS; and the development of Level 1 PRS and their use on JPCP projects in Indiana, Florida, Tennessee, and Wisconsin. FHWA, along with State Highway Agencies and the concrete paving industry, has now identified three significant needs with respect to the continued implementation of JPCP PRS. These are: 1) the incorporation of Mechanistic-Empirical Pavement Design Guide (MEPDG) models in the PRS; 2) the continuation of assistance to States who wish to implement PRS; and 3) the development of a plan for the Statewide implementation of PRS. The resulting PaveSpec 4.0 software will utilize closed form models for cracking, faulting, spalling, and IRI to predict performance and adjust payment. This work is an example of CP Road Map Track 11: Concrete Pavement Business Systems and Economics. More information can be sought by clicking on the following link:

http://www.fhwa.dot.gov/research/tfhrc/projects/projectsdb/projectdetails.cfm?projid=HRDS-000098

Coefficient of Thermal Expansion (CTE) Ruggedness Test

The interest in CTE testing has increased significantly in the past few years due to the fact that it was observed to be one of the most important inputs of the Mechanistic-empirical pavement design guide (M-E PDG) for pavement design. FHWA was one of the pioneers in carrying out coefficient of thermal expansion (CTE) tests of concrete pavements over the past 10 years. To date, over 2200 specimens have been tested, mostly cores for the Long Term Pavement Performance (LTPP) database. TFHRC has been working on the refinement of the current test method (AASHTO T 336) and carrying out a ruggedness test in conjunction with other laboratories. After the completion of the ruggedness test an inter-laboratory study is planned. This project can be categorized under CP Road Map Track 1: Performance-Based Concrete Pavement Mix Design System. Further information can be found at the link below:

http://www.fhwa.dot.gov/research/tfhrc/projects/projectsdb/projectdetails.cfm?projid=HRDS-000101

CP Road Map Track Status

Figure 1 depicts concrete pavement research projects that are currently ongoing and are categorized according to the appropriate CP Road Map Track. Following Figure 1, titles for each of the projects are listed.

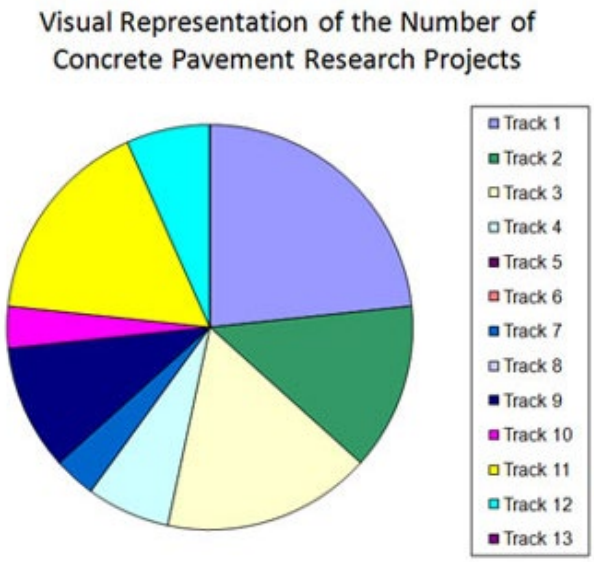

Figure 1. TFHRC Concrete Pavement Research Categorized by CP Road Map Track

Currently Ongoing Research

Currently ongoing concrete pavement research projects at the Turner-Fairbank Highway Research Center, and how they align under the CP Road Map, are listed here.

Track 1: Performance-Based Concrete Pavement Mix Design System

- Pavement Mix, Lab of the Future; Development of Concrete Pavement Road Map Track 1 Lab Protocols
- Develop/Improve American Association of State Highway and Transportation Officials Concrete Coefficient of Thermal Expansion (CTE) Test
- Greatly Increased Use of Fly Ash in Hydraulic Cement concrete for Pavement Layers and Transportation Structures
- Extending the Season for Concrete Construction and Repair, Phase III
- Turner-Fairbank Highway Research Center Staff Alkali Silica Reaction (ASR) Research into Rapid Tests and Gel Identification
- Increased Use of Fly Ash and Other Recycled Materials in Concrete Pavement Mixtures
- Fundamental Materials Characterization Using X-Ray Computed Tomography

Track 2: Performance-Based Design Guide for New and Rehabilitated Concrete Pavements

- Pavement Shear Strain Response to Dual and Wide Base Tires
- Integrated Software to Optimize Design, Construction, Evaluation and Performance of Concrete Pavements
- A Fresh Look Towards Revamping Falling Weight Deflectometer Testing and Analysis to meet Mechanistic-Empirical Design and Analysis
- Relationships Between Laboratory Measured and Field Derived Properties of Pavement Layers

Track 3: High-Speed Nondestructive Testing and Intelligent Construction Systems

- Computer-based Guidelines for Curing Concrete
- Upgrade HIPERPAV III
- Use of Radio Frequency Identification Tags in Pavements
- Improved Methods For Determination of Pavement Remaining Life
- Improved Reliability Modeling And Analysis for Primary Pavement Distress Models of Mechanistic-Empirical Design Guide

Track 4: Optimized Surface Characteristics for Safe, Quiet, and Smooth Concrete Pavements

- Relating Ride Quality And Structural Adequacy For Pavements

Track 7: High-Speed Concrete Pavement Rehabilitation and Construction

- Support for the Continued Development Of Constructability Analysis for Pavement Rehabilitation Strategies

Track 9: Concrete Pavement Accelerated Testing and Long-Term Data Collection

- Optimization of Data Collection for Pavement Management
- Long-Term Pavement Performance Traffic Data Collection Activities

Track 10: Concrete Pavement Performance

- Creating Smart Pavements that Monitor and Report on Pavement Condition

Track 11: Concrete Pavement Business Systems and Economics

- Standardized Methods Life-Cycle Cost Analysis
- Addressing Needed Research to Implement Jointed Plain Concrete Pavements Performance-Related Specifications
- Nanoscale Sensors for Structural Health
- Nanoscale Approaches for Inhibiting Corrosion: Multifunctional Nanomaterials and Processes for Infrastructure Repair and Corrosion Inhibition
- CP Road Map Operations Support

Track 12: Advanced Concrete Pavement Materials

- Ultra-High Performance Concrete Program (UHPC)
- High-Performance Stress-Relaxing Cementitious Composites for Crack Free Pavements and Transportation Structures

Track 13: Concrete Pavement Sustainability

- Fly Ash Workshop at Turner-Fairbank Highway Research Center
- Develop and Deploy a Frame Work for the Proper Use and Proportioning of SCMs Into Concrete Mixtures for Pavement and Structures

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 Dale Harrington, dharrington@snyder-associates.com, 515-964-2020.

Newsletter staff

- Dale Harrington, Snyder and Associates, Program Manager
- Rob Rasmussen, The Transtec Group, Program Specialist
- Sabrina Garber, The Transtec Group, Program Specialist
- Jesse Kwilosz, The Transtec Group, Program Specialist
- Sabrina Shields-Cook, National Concrete Pavement Technology Center, Editor

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The National Concrete Pavement Technology Center at Iowa State University provides operations support services to the CP Road Map program.
CP Tech Center

2711 S. Loop Drive, Suite 4700
Ames, IA 50010
Phone: 515-294-5798
Fax: 515-294-0467
Email: Program Management ~ Communications ~ Webmaster