Updates from the States: California (July-August 2011)

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The California Department of Transportation (Caltrans) is responsible for identifying concrete pavement research needs and developing associated standards, specifications, and test methods. Strategic direction is provided by the Caltrans Pavement Program Steering Committee (PPSC), while the Pavement Management Council (PMC) is responsible for establishing appropriate practices for concrete pavement design, construction, rehabilitation, and maintenance. In addition, the Rock Products Committee (RPC) coordinates research efforts between Industry and FHWA. Within the Caltrans Pavement Program, there are two main offices associated with concrete pavement research:

- **Pavement Management and Performance** - responsible for monitoring concrete pavement performance by measuring pavement condition and optimizing pavement rehabilitation and maintenance strategies. Highway data is collected using vehicles that evaluate pavement condition including roughness, cracking, and faulting, which is subsequently processed by specialized software to optimize pavement rehabilitation and maintenance strategies.
- **Concrete Pavements and Foundations** - develops tools, standards, and guidance for a wide range of concrete pavement topics. These areas include rigid and composite pavement systems, concrete pavement foundations, economic analysis, and the impact of traffic and climate.

Caltrans has also established a strong partnership with the University of California Pavement Research Center (UCPRC). UCPRC conducts basic and applied research in an effort to improve concrete pavement structures, materials, and technologies, and state-of-the-art facilities are utilized to meet these objectives. Together, Caltrans and UCPRC have a series of ongoing and completed research projects that seek to address the following research areas:

- **Pavement Management System (PMS)** - supporting the implementation of a PMS that has the ability to track changes made over time to pavement sections and monitor long-term pavement performance. Preliminary performance models are being developed and used to help identify optimal treatment selection and timing, life cycle cost analysis strategies, and further budget allocation.
- **Pavement Smoothness** - focusing on methods of designing and constructing smoother concrete pavements, and maintaining smoothness over longer periods. This area also includes identification of better methods of measuring and characterizing smoothness, and relating smoothness to pavement design, construction, maintenance, and rehabilitation practices.
- **Pavement Preservation** - providing information needed for guides and decision support systems for the selection and timing of concrete pavement preservation treatments. The work also includes the evaluation of new types of treatments and improvements to existing treatments.
- **Quiet Pavements** - evaluating new and better-maintained pavements that actively reduce noise generated by traffic. This work also includes development of new pavement surfacing materials and textures, and investigation of the interaction of noise with other variables.
- **Best Construction Practices** - evaluating new materials and practices that increase construction quality and efficiency. Continued development of the construction and traffic analysis tool, CA4PRS,

and further analysis of energy use and emissions associated with pavement construction are also top priorities.

- **Mechanistic-Empirical (M-E) Design** - continuing the development, evaluation, and calibration of M-E design procedures, and collection of laboratory and field testing data to support M-E design and implementation. M-E analysis procedures are being used to create simplified design tools for routine use and ensure compatibility with the PMS.
- **Long-Life Pavements** - focusing on design and construction practices that will improve the performance and service life of pavements. Long-life pavements will also reduce congestion, travel time, and accidents associated with frequent construction and maintenance activities. Studies of long-life pavement structures, with an emphasis on long-term monitoring and documentation of their performance, is critical to research efforts.
- **Recycling & Sustainability –**finding ways of reusing or recycling sound, in-place materials for pavement construction. Work will continue to quantify, evaluate, and improve existing pavement recycling techniques. Studies also focus on the evaluation and improvement of environmental sustainability of pavement recycling techniques.

In addition to the UCPRC, Caltrans partners with various other researchers including the California Pavement Preservation Center, FHWA, and private consultants. Caltrans is also an active participant in various Transportation Pooled Fund (TPF) studies. To learn more about these research facilities, please follow the links below:

- Caltrans: http://www.dot.ca.gov/hq/maint/Pavement/Pavement_Program/
- UCPRC: http://www.ucprc.ucdavis.edu/
- California Pavement Preservation Center: http://www.csuchico.edu/cp2c/
- TPF: http://www.pooledfund.org/

Highlights

The following provides more detail on four recently completed concrete pavement research projects.

1. Construction and Traffic Analysis of Interstate 15 Concrete Pavement Reconstruction Project
2. Laboratory Evaluation of Corrosion Resistance of Steel Dowels in Concrete Pavement
3. Evaluation of Rigid Pavement Long-Life Strategies
4. Construction and Preliminary HVS Tests of Pre-Cast Concrete Pavement Slabs

Construction and Traffic Analysis of Interstate 15 Concrete Pavement Reconstruction Project

The 2008 report, *Construction and Traffic Analysis of Interstate 15 Concrete Pavement Reconstruction Project*, authored by C. Kim, E.B. Lee, and C.L. Monismith, documents the rehabilitation of a 3.2-mile section of concrete pavement on Interstate 15 in Devore, California. This rapid rehabilitation project was completed over the course of six weekend closures, and replaced the existing concrete pavement with 12 inches of PCCP over a 2-inch asphalt concrete (AC) base. During this project, traffic monitoring and construction studies were conducted to determine overall impact on the traveling public and quantify productivity. The traffic study showed that traffic management plans (TMP) were successfully implemented, as evidenced by large reductions in traffic demand and motorist acknowledgment of detour guidance. It has also enabled the work zone traffic capacity observed in this project to be utilized for future capacity estimation models. The construction study involved the collection of data during the four main construction activities: 1) demolition of the existing pavement, 2) milling, 3) AC paving, and 4) PCC paving. These activities were performed simultaneously and always completed either on time or ahead of schedule. In addition, construction was monitored using a software program called CA4PRS that is designed to estimate pavement rehabilitation production and ultimately enhance the productivity database for use in future projects. To read more about this project, follow the link below:

http://www.ucprc.ucdavis.edu/PDF/4.6_Devore%20II%20RR_Stg%206.pdf

This research is meeting objectives outlined in CP Road Map Track 3: Intelligent Construction Systems and Quality Assurance for Concrete Pavements.

Laboratory Evaluation of Corrosion Resistance of Steel Dowels in Concrete Pavement

Recent research performed by the UCPRC is discussed in the 2007 report, *Laboratory Evaluation of Corrosion Resistance of Steel Dowels in Concrete Pavement*. In this report, authors Mauricio Mancio, Cruz Carlos Jr., Jieying Zhang, John T. Harvey, and Paulo J. M. Monteiro investigate the performance of several types of steel dowels, and provide recommendations for their use in concrete pavements subjected to various environmental conditions. The researchers examined the corrosion potential for seven types of steel dowels: bare carbon steel, stainless steel-clad, grout-filled hollow stainless steel, micro-composite steel, carbon steel-coated with flexible epoxy, and carbon steel-coated with non-flexible epoxy. The study was conducted in three phases, all of which employed a significant amount of laboratory testing in order to simulate a corrosive environment and identify active corrosion. Two of the phases utilized dowels cast in concrete beam specimens with joints; permeability, cement type, and aggregate size were different between these two phases. The third phase examined three concrete slabs extracted from a dowel bar retrofit project in the State of Washington, as well as cores taken from the transverse joints of field slabs throughout the state. Test results from all three phases concluded that stainless-steel clad and hollow stainless steel bars offer the greatest protection against corrosion, while the carbon steel bars consistently showed the lowest resistance. To obtain a copy of this report, please click on the following link:

http://www.ucprc.ucdavis.edu/PDF/Corrosion%20Rpt%20UCPRC-RR-2005-10_Final.pdf

This research can be categorized under CP Road Map Track 6: Innovative Concrete Pavement Joint Design, Materials, and Construction.

Evaluation of Rigid Pavement Long-Life Strategies

The 2007 report, *Evaluation of Rigid Pavement Long-Life Strategies*, by authors D. Jones, J. Harvey, and E. Kohler, assesses Caltrans long-life rigid pavement rehabilitation strategies designed to add at least 30 years of service life with minimal required maintenance and disruption to road users. The research objectives were met through a desktop study, including design analysis and computer modeling, in addition to laboratory testing of concrete materials and heavy vehicle simulator (HVS) testing of two experimental pavement sections. Evaluation of structural design options, such as tied concrete shoulders and doweled joints, with respect to cracking and joint distress was a key objective. In addition, researchers evaluated concrete pavement durability and structural performance as a function of construction techniques, mix design variables, and cement types. A large number of pertinent recommendations have been suggested for implementation, including agency-wide mechanistic-empirical design procedures and the use of construction productivity analysis tools. For more information about this study, follow the link below.

http://www.ucprc.ucdavis.edu/PDF/Final%20Stg%206%20Concrete%20Summary%20UCPRC-SR-2006-01.pdf

This work is an example of CP Road Map Track 2: Performance-Based Design Guide for New and Rehabilitated Concrete Pavements.

Construction and Preliminary HVS Tests of Precast Concrete Pavement Slabs

The report, *Construction and Preliminary HVS Tests of Pre-Cast Concrete Pavement Slabs*, authored by Erwin Kohler, Louw du Plessis, and Hechter Theyse, highlights the construction and testing of an experimental pavement section comprised of ten precast slabs known as the Super-Slab® System. The main objective of this research is to help determine how the performance of the precast panels compares to other jointed plain concrete pavement (JPCP) rehabilitation strategies currently employed by Caltrans. To achieve this, the researchers conducted testing to determine possible failure mechanisms of the Super-Slab® panels and identify possible constructability issues. Construction of the pavement section involved three primary activities: construction of a cement-treated base (CTB), placement of the precast slabs, and grouting of the slabs. Subgrade strength was evaluated using a Dynamic Cone Penetrometer (DCP), and FWD testing was used to determine the elastic modulus of the CTB and precast slabs before grouting. The slabs were also instrumented with displacement sensors and thermocouples to measure deformation caused by temperature changes. In addition, Heavy Vehicle Simulator (HVS) testing was conducted before grouting occurred, and revealed that the Super-Slab® System is fully capable of withstanding a high level of traffic without observable or measurable damage. Fortunately, the grouting process proved to be successful, and the measured load transfer efficiency (LTE) across transverse joints was close to 100 percent. Further information regarding this project can be sought by following the link below:

http://pubs.its.ucdavis.edu/publication_detail.php?id=1173

This research is helping to fill knowledge gaps outlined in CP Road Map Track 8: Concrete Pavement Construction, Reconstruction, and Overlays.

CP Road Map Track Status

Concrete pavement research projects that are currently ongoing, and recently completed, in addition to Transportation Pooled Fund participation, are depicted in Figure 1. These projects are categorized according to the appropriate CP Road Map Track. Following Figure 1, each of the projects are listed and categorized.

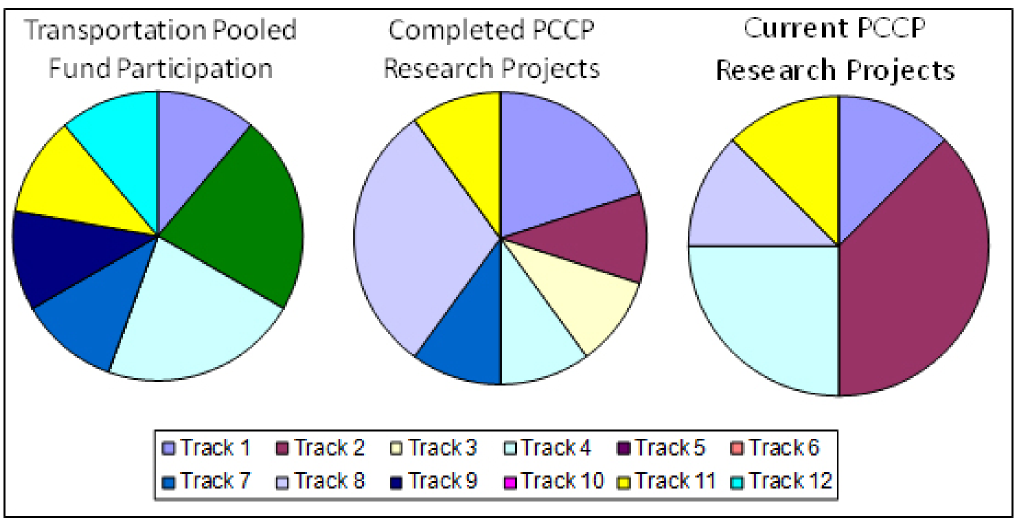

Figure 1. Concrete Pavement Research in California Categorized by CP Road Map Track

Transportation Pooled Fund (TPF) Studies

Concrete pavement research work in California includes work done under various TPF projects. These projects, and how they align under the CP Road Map, include the following.

Track 1: Materials and Mixes for Concrete Pavements

- TPF-5(117) Development of Performance Properties of Ternary Mixes
- TPF-5(149) Design and Construction Guidelines for Thermally Insulated Concrete Pavements (Mn/ROAD Study)

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

- TPF-5(001) Soil Mixing Methods for Highway Applications

- TPF-5(183) Improving Foundation Layers

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

- TPF-5(063) Improving the Quality of Pavement Profiler Measurement
- TPF-5(139) PCC Surface Characteristics: Tire -Pavement Noise Program Part 3 - Innovative Solutions /Current Practices

Track 7: Concrete Pavement Maintenance and Preservation

- TPF-5(042) Investigation of the Long-Term Effects of Magnesium Chloride and Other Concentrated Salt Solutions on Pavement and Structural Portland Cement Concrete

Track 9: Evaluation, Monitoring, and Strategies for Long Life Concrete Pavement

- TPF-5(070) International Conference on Accelerated Pavement Testing

Track 11: Concrete Pavement Economics and Business Management

- TPF-5(159) Technology Transfer Concrete Consortium

Track 12: Concrete Pavement Sustainability

- TPF-5(042) Recycled Unbound Pavement Materials (Mn/ROAD Study)

Currently Ongoing Research

Currently ongoing research projects, and how they align under the CP Road Map, are listed here.

Track 1: Materials and Mixes for Concrete Pavements

- Coefficient of Thermal Expansion in PCC Pavement Design and Specification

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

- New Approach to the Prediction of Fatigue Damage in PCC
- Early-Age Cracking Performance
- Pavement Performance Modeling

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

- Implementation of New Quieter Pavement Research
- Continued Monitoring of Selected Quieter Pavement Test Sections

Track 8: Concrete Pavement Construction, Reconstruction, and Overlays

- I-680 Pavement Rehabilitation and Southbound HOV Lane Extension

Track 11: Concrete Pavement Economics and Business Management

- Life-Cycle Cost and Environmental Life-Cycle Analysis for Composite Pavements

Recently Completed Research

Recently completed projects (i.e., ones that have been completed since 2007) and how they align under the CP Road Map, are listed below.

Track 1: Materials and Mixes for Concrete Pavements

- Laboratory Evaluation of Corrosion Resistance of Steel Dowels in Concrete Pavement
- Laboratory Evaluation of Fiber-Reinforced Polymer Dowel Bars for Jointed Concrete Pavements

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

- Evaluation of Rigid Pavement Long-Life Strategies

Track 3: Intelligent Construction Systems and Quality Assurance for Concrete Pavements

- Construction and Traffic Analysis of I-15 Concrete Pavement Reconstruction Project

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

- Tire–Pavement Noise Results From California PCCP and HMA Pavements

Track 7: Concrete Pavement Maintenance and Preservation

- Construction and Test Results on Dowel Bar Retrofit HVS Test Sections

Track 8: Concrete Pavement Construction, Reconstruction, and Overlays

- Construction and Preliminary HVS Tests of Pre-Cast Concrete Pavement Slabs
- Performance of the Crack, Seat, and Overlay Rehabilitation Technique for Concrete Pavements in California
- I-15 Ontario Project: Technology Implementation for Accelerated Concrete Pavement Rehabilitation

Track 11: Concrete Pavement Economics and Business Management

- Life Cycle Cost Analysis of Dowel Bar Retrofit

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.

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