

# Updates from the States: Pennsylvania (June 2014)

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PennDOT understands the importance of research, education, and technology transfer activities as they relate to the transportation industry. PennDOT places a focus on research and innovation and realizes that the initial investment will pay great dividends in the future as research innovations drive change and/or business process improvements. For this reason, the Bureau of Planning and Research (BPR) manages and administers a customer-driven, applied Research Program focused on providing solutions to real-world transportation issues and challenges.

The mission of the PennDOT research program is to identify, develop, and conduct strategically focused research, education, and technology transfer projects. The mission is achieved through a contract research program that emphasizes applied research, implementation, performance monitoring, and technology transfer. BPR works closely with all of the functional areas of PennDOT to ensure that the right research projects are being conducted and the results are being implemented through a systematic process. BPR has developed an approach to identify, prioritize, select, and manage needed research that engages senior executives and managers, as well as the subject matter experts located throughout the department. This participation, input, and support ensures that BPR is able to produce research results that are timely and critical.

There are a variety of programs through which PennDOT research needs are met. PennDOT can initiate projects using Transportation Research, Education, and Technology Transfer Invitation to Qualify (ITQ) contracts, which is a competitive bid-based program. The Transportation Pooled Fund (TPF) program enables PennDOT to participate in projects that include other states and affords PennDOT the opportunity to maximize their research funds. PennDOT often collaborates with educational institutes including the Pennsylvania State University (Penn State), the University of Pittsburgh, Temple University, and Carnegie Mellon University.

BPR staff members actively manage each project initiated through the PennDOT Research Program and work to implement the results of completed research projects as they finish. With the help of an Implementation Evaluation Checklist, PennDOT tracks the implementation efforts of each completed project so that customized technology transfer activities can be developed for each project result.

In addition, BPR is dedicated to ensuring that research results are implemented through management of the State Transportation Innovation Council (STIC) and with local government partners through the PennDOT Local Technical Assistance Program.

For general PennDOT information and more information on this process, visit the PennDOT website or the PennDOT Bureau of Planning and Research website.
Following is a description of current PennDOT research projects, TPF involvement, and research completed within the last few years, and an identification of the CP Road Map track into which each project falls.

## Recently Completed Research

### Improved Performance of Jointed Plain Concrete Pavements

Long-term drying shrinkage and early-age plastic shrinkage cracking can affect the performance of jointed plain concrete pavements (JPCPs). The plastic shrinkage cracks develop while the concrete is still fresh. This occurs when the rate of evaporation of the moisture on the surface of the concrete exceeds the bleeding rate. While plastic shrinkage cracking affects the durability, long-term drying shrinkage affects the fatigue life. This study evaluates current Pennsylvania Department of Transportation specifications and practices pertaining to the paving mix design and construction, specifically finishing and curing, and their effects on long-term performance. This specification review was supplemented by a laboratory study to evaluate curing and mix design enhancements.

A review of the performance of in-service pavements revealed plastic shrinkage cracks commonly develop in JPCP constructed in Pennsylvania. The curing and finishing construction practices and specifications were reviewed to identify potential causes and it was found that improvements could be made to reduce the potential for plastic shrinkage cracking. These improvements address both the type of curing compound used as well as the method used for application. It was also found that excessive water added to the pavement surface during the burlap drag finishing is increasing the water-to-cement ratio at the surface, and thereby reducing the strength. This increases the potential for plastic shrinkage cracking as well. Finally, it was determined that the drying shrinkage could be decreased and the durability increased if the water-to-cement ratio was lowered to a target value of 0.40 (but going no higher than 0.42) and a more densely graded aggregate specified.

The curing study included curing compounds with wax, an unnamed resin, and a poly alpha methylstyrene (AMS) resin. The percent resin was also considered. The final two additional curing regimes considered were a wet cure, where the specimen was placed in a water bath, and a dry cure, which had no compound applied. The moisture loss, compressive strengths, and permeability measurements were made as well as surface observations for each of the curing methods.

With regards to moisture loss, it was found that the curing compounds with the wax did perform slightly better than the non-AMS resin. An increase in the percent solids from 37 to 44 percent did result in a lower moisture loss for the AMS resin. The benefit of the increase in the percent solids was not as apparent for the wax-based curing compounds. The moisture loss between the wax based curing compounds was very similar.

This research was completed by Julie Vandenbossche, P.E., Ph.D. at the University of Pittsburgh for the Pennsylvania Department of Transportation. Click here to view a summary of the report.

This work is categorized under CP Road Map Track 5: Concrete Pavement Equipment, Automation, and Advancements.

## Premature Deterioration of Jointed Plain Concrete Pavements

Six sections of jointed plain concrete pavements (JPCP)s throughout the state were selected as candidates for the evaluation of premature deterioration. The data used in performing the evaluation included manual and historic automated distress survey data, falling weight deflectometer data, and laboratory material characterization data from field samples. For these six sections, a variety of issues including material-related distress, fatigue, and construction deficiencies were determined to be the cause of the premature deterioration. Some of the issues identified and lessons learned include the following:

The use of a very open graded subbase (OGS) lead to issues on some of these pavement structures. Loss of support underneath joints and cracks was found for all of the sections with OGS. Since no evidence of pumping was observed in the field, this loss of support is attributed to the consolidation or degradation of the OGS over time. It is well documented that granular bases are used quite successfully by many states and can be a viable base layer option for JPCP. Most of the difficulties with the OGS used by PennDOT can be attributed to the fact that the permeability is so high that the stability of the layer is greatly sacrificed.

Drying shrinkage cracking was observed on the majority of these projects. These cracks typically propagate

to a depth of about 0.75 in. They typically are a greater concern in contributing to material-related distress than fatigue cracking since, although the cracks do not propagate to a significant depth, they make the surface of the pavement more porous. The report recommends proper curing procedures, such as eliminating the soaked burlap drag and proper application curing compound, to reduce drying shrinkage cracking.

Weather conditions present during and immediately after placement of two adjacent pavement slabs can be a significant cause of pavement distress. Until a concrete pavement develops its final set, the stress level in the pavement is zero. The temperature of the pavement when final set occurs is known as the zero stress temperature. For the remainder of the pavement's life, temperatures above the zero stress temperature cause expansion of the slab and temperatures below the zero stress temperature cause contraction of the slab. Placing adjacent pavements during significantly different weather conditions can cause pavement distress due to the potential of one pavement to be in tension while the adjacent slab is in compression. To avoid this, care should be taken to avoid paving adjacent lanes during drastically different temperature conditions.

This research was completed by Julie Vandenbossche et al. at the University of Pittsburgh for the Pennsylvania Department of Transportation. Click here to view a summary of the report.

This work is categorized under multiple CP Road Map Tracks including Track 5, Track 8, and Track 10.

## Establishing Appropriate Inputs When Using the MEPDG to Design Rigid Pavements in Pennsylvania

PennDOT initiated this project to identify each design input in the Mechanistic-Empirical Design Guide (MEPDG) required for the design of jointed plain concrete pavements. The best values for Pennsylvania conditions were established and recommended for each input by: 1. Identifying rigid pavement design inputs for the MEPDG that are currently known for Pennsylvania conditions, 2. Utilizing this data to identify the most critical rigid pavement design inputs for Pennsylvania conditions, and 3. Development of a plan to obtain date if it is currently unavailable.

One of the critical MEPDG inputs identified in the report is the built in temperature gradient. A methodology was developed for establishing this parameter. The work included using four different locations selected throughout the state. Nine slabs were instrumented at each location with two vibrating wire strain gages. This allowed three slabs to be instrumented in the morning, three in the afternoon and three in evening so that the built in gradient for slabs constructed at different times of the day can be defined. Thermocouples were also installed so the temperature profile at the time of set could be determined. Data was collected every fifteen minutes from each sensor for the first 24 hours after paving. A weather station was also used at each site so the weather throughout this 24-hour period could be monitored.

The results of this report are being used by PennDOT to implement the MEPDG design process.

This research was completed by S Nassiri and J. Vandenbossche at the University of Pittsburgh for the Pennsylvania Department of Transportation. Click here to view a summary of the report.

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

## Partial Depth Repairs Restore Structural Capacity of Bridge Decks

Some transportation officials do not allow any structural capacity to be replaced by the application of an overlay; therefore, if a bridge deck is demolished to half its depth and then repaired to its original thickness, it must be structurally rated as if it were only half depth. The objective of this report was to evaluate whether reinforced concrete bridge

deck slabs repaired by means of hydro-demolition followed by application of a latex modified concrete overlay behave in composite or non-composite fashion.

To research this question, full-scale reinforced concrete slabs were subjected to three-point bending until failure. The test slabs included latex modified overlays of varying thicknesses. The test results indicate that all overlaid slabs behaved in a composite manner when compared to plane sections.

This research, entitled "Structural Evaluation of Slab Rehabilitation by the Method of Hydrodemolition and Latex Modified Overlay," was completed at the University of Pittsburg, Swanson School of Engineering by Matthew McCabe and was sponsored by the Pennsylvania Department of Transportation. Click here to view the complete report.

This work is categorized under CP Road Map Track 8: Concrete Pavement Construction, Reconstruction, and Overlays.

## Ongoing Research

In addition to the completed research described above, the following projects are currently ongoing.

### Bridge Deck Cracking: Effects on In-Service Performance, Prevention, and Remediation

The purposes of this project is to identify the causes of early-age cracking in concrete bridge decks, provide recommendations for effective prevention of early-age cracking, assess the effect of cracks on the long-term durability and performance of concrete bridge decks, and to identify the best and most cost-effective (on a life-cycle cost basis) remediation practices to extend the life of bridge decks. Click here for a summary of this project.

### Methodology for Salt Brine in a Winter Services Strategic Plan

This project seeks to improve winter services for the state of Pennsylvania by developing written guidelines for the manufacture, storage, and application of salt brine. In addition, it is hoped the project will provide recommendations for salt brine alternatives and methods to mitigate deicer impact to bridges and pavement. Click here for a summary of this project.

### Connected and Autonomous Vehicles – 2040 Vision

Connected Vehicle research within the U.S. Department of Transportation (US DOT) is a multimodal program that involves using wireless communication between vehicles, infrastructure, and personal communications devices to improve safety, mobility, and environmental sustainability. This research study is based on the assumption that connected vehicle technology will be incorporated into all motor vehicles, including automobiles, freight trucks, and transit buses. Simultaneously, the US DOT has begun researching the implications of autonomous technology, including fully automated vehicles. Using a design year of 2040, this research will evaluate implications on the highway infrastructure within the Pittsburgh region in southwestern PA.

A primary objective of this research is to provide recommendations on how the implementation of connected and autonomous vehicle technologies will affect design and operational considerations on future projects, particularly the complicated issue of when PennDOT should begin to incorporate these changes into the design of future projects, such as the Parkway project in Pittsburgh. Click here for a summary of this

project.

## Additional Information on PennDOT:

In 2010, the Federal Highway Administration (FHWA) introduced the State Transportation Innovation Council (STIC) concept to state departments of transportation and industry partners to foster ownership and pride in establishing a process in which ideas and innovative techniques and processes can be evaluated and implemented quickly and proficiently. Pennsylvania established a STIC comprised of public and private transportation stakeholders, including state and federal agencies, local governments, research organizations and industry partners. The Pennsylvania STIC brings together public and private interests to work together to forge an environment of innovation, imagination, and ingenuity to pursue specific innovations and their rapid implementation to deliver a modern and high-quality transportation system to the citizens of the Commonwealth.

The Pennsylvania STIC established ten Technical Advisory Groups (TAGs) to provide technical expertise on potential benefits and uses of innovations or techniques. The TAGs also serve as champions of the STIC-approved innovations by developing a deployment plan and tracking progress.

For more information on the Pennsylvania STIC, please visit www.moderndot.pa.gov.

## 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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