National Concrete Consortium (NCC) E-News July 2018

In association with the CP Road Map Program

The **NCC 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 (515-290-4014).

Moving Advancements into Practice (MAP) Brief

Moving Advancements into Practice (MAP) Briefs describe promising research and technologies that can be used now to enhance concrete paving practices.

The July 2018 MAP Brief, *Using RCA in Pavement Base Products*, provides a summary of constructability considerations, qualification testing, and pavement design considerations for both unbound and bound (stabilized) RCA base applications.

Download the July 2018 MAP Brief.

Videos on Concrete Pavements

Dr. Tyler Ley, Professor of Civil and Environmental Engineering at Oklahoma State University, has developed a series of videos on the Tarantula Curve. The link below includes his latest video as well as access to five other more detailed videos on the same subject: https://youtu.be/V-r4-9OcuyY. (Please note: the five other video links can be found by clicking on "Show More" below the video screen.)

NCC State Survey Summaries

NATIONAL CONCRETE CONSORTIUM

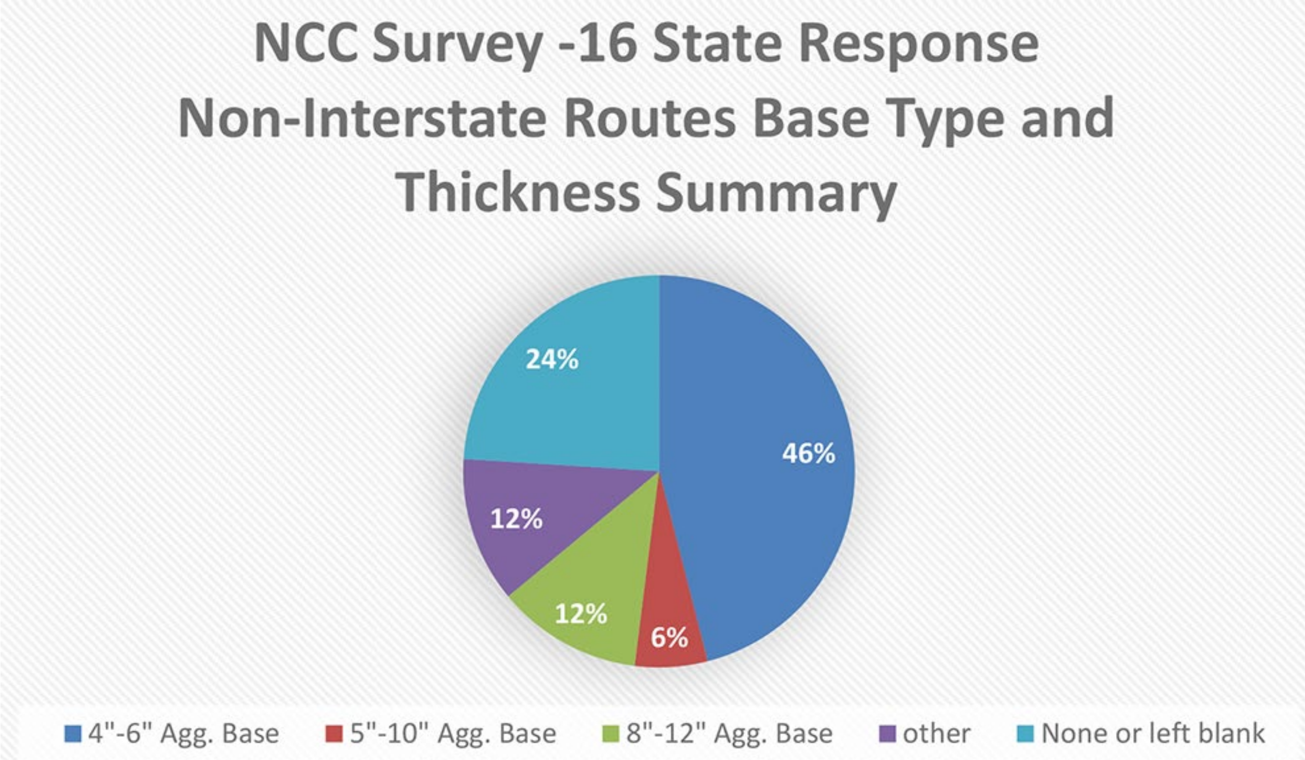
Member states of the National Concrete Consortium (NCC) have the ability to poll other member states regarding specifications, materials, construction, research, or other issues related to concrete paving.

This section highlights some of the questions posed and answers received through the NCC's ListServ feature.

The Missouri Department of Transportation polled the NCC group regarding the use of base type and thickness for portland cement concrete (PCC) pavements (shown here) and hot-mix asphalt (HMA) pavements (not shown here). Sixteen agencies responded for Interstate and non-Interstate highways. Because of the variability in different bases for Interstate highways, the following data show only non-Interstate.

A majority (7) of the agencies responded that they typically use 4 in. to 6 in. aggregate bases for non-Interstate highways.

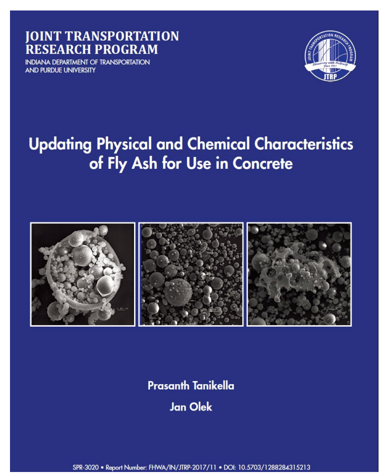
Under the "other" category in the pie chart, two states are covered. Illinois DOT listed its base as 4 in. HMA or PCC stabilized base and Michigan listed its base as 6 in. open graded over 10 in. sand.



News from the Road

News from the Road highlights research around the country that is helping the concrete pavement community meet the research objectives outlined in the CP Road Map. The research projects and the summaries described herein are the products of the researchers and sponsors.

Updating Physical and Chemical Characteristics of Fly Ash for Use in Concrete (report date: December 2017)



This research was an attempt to quantify the effects of fly ashes on the properties of pastes as a function of (a) the mean particle size of the fly ash particles, (b) their fineness, and (c) their chemical composition. In addition, since the type and the amount of glass present in the fly ash significantly affect its reactivity, this property was also included in the investigation. Twenty different fly ashes (both, ASTM Class C and Class F), obtained from power plants in and around Indiana, were characterized during Phase 1 of the study.

The information collected included physical characteristics, chemical composition, and the amount and type of glass present. Phase 2 of the study consisted of evaluation of various properties of binary paste systems (portland cement with 20% of cement of fly replacement). The evaluated properties included the set time, the heat of hydration, the strength activity index, the non-evaporable water content, and the amount of calcium hydroxide formed at different ages. These results obtained from both phases of the study were used to build statistical models for prediction of previously evaluated properties for any hypothetical fly ash with similar characteristics. The models included only the most significant variables, i.e., those which were found to most strongly affect any specific property. The variables to be included in the model were selected based on the adjusted R2 values. As a result of the modeling process, it was found that the sets of statistically significant variables affecting the properties consisted of both physical and chemical characteristics of the fly ash and that the combination of these variables was unique for each property evaluated. When applied to a set of results from two additional (not previously used) fly ashes, the models provided the following residuals of predicted properties:

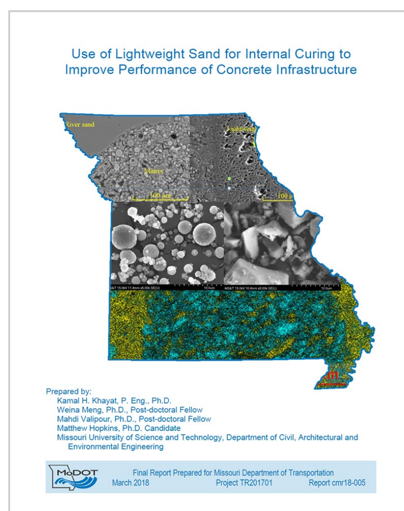
1. Initial set time - 100 minutes for Class F ashes and over 300 minutes for Class C ashes
2. Peak heat of hydration - 0.7 W/kg
3. Time of peak heat - 375 minutes
4. Total heat of hydration - 96 J/kg
5. Calcium hydroxide content at various ages - 0.25% for early ages (1 and 3 days) and 0.5% for later ages (7 and 28 days)
6. Non-evaporable water content - 0.7% for early ages (1 and 3 days) and 5% for later ages (28 days)
7. Strength activity index - range of 1% in Class C ashes and 1% to 2% in Class F ashes (from 7 days to 28 days)

Phase 3 of the study consisted of evaluating the same set of properties but using ternary paste systems (cement and two different fly ashes). The goal for this study was to ascertain the applicability of the weighted sum of the models chosen for the binary paste systems to predict the properties of ternary binder systems. In addition, the analysis as to which of the chosen variables has the maximum effect on the properties was performed. It was found that the properties of the ternary binder systems were not additive in nature, except for strength activity index at 28 days. Lastly, the percent influence of each of the chosen independent variables, which affect the mentioned properties, was calculated along with the unexplained variation (error percentage). The error percentages varied for each of the properties, with set time having the maximum error (almost 50%).

This project was sponsored by the Indiana Department of Transportation through the Joint Transportation Research Program, Purdue University and written by Prasanth Tanikella and Jan Olek. Click here to access the full document.

This project is contributing to objectives identified in CP Road Map Track 1: Materials and Mixes for Concrete Pavements.

Use of Lightweight Sand for Internal Curing to Improve Performance of Concrete Infrastructure (report date: March 2018)


Use of Lightweight Sand for Internal Curing to Improve Performance of Concrete Infrastructure

Prepared by:
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MoDOT
Final Report Prepared for Missouri Department of Transportation
March 2018 Project TR201701 Report cmr18-005

The goal of this project was to develop an effective methodology to use saturated lightweight sand (LWS) for internal curing to enhance concrete performance and prolong service life of concrete structures. High-performance concrete (HPC) mixtures approved by MoDOT for pavement and bridge deck structures were used for the baseline mixtures. Five different types of saturated LWS employed at various contents were investigated to evaluate the optimum dosage of LWS and maximize its effectiveness on enhancing concrete performance. The content of LWS was varied to ensure the introduction of internal curing water that can secure up to 150% of the water consumed by chemical shrinkage during cement hydration (As per ASTM C1761). Performance improvement from the LWS focused mainly on reducing autogenous and drying shrinkage and the resulting cracking potential without sacrificing durability and cost competence. Proper combinations of internal and external curing were found to enhance shrinkage mitigation.

Under 7 days of initial moisture curing, HPC made with the LWS3 resulted in the lowest overall shrinkage. The Bridge-LWS2-150% exhibited the best performance in mitigating autogenous shrinkage where the concrete maintained 160 micro-strain of expansion even after 175 days of age. The lowest drying shrinkage was obtained with the BridgeLWS3-50% mixture (340 micro-strain) at 175 days subjected to 28 days of moist curing.

For the paving HPC, the lowest drying shrinkage at 155 days was obtained with the Paving-LWS3-150% mixture (265 micro-strain) subjected to 28 days of moist curing. Concrete proportioned with the LWS2 expanded shale LWS exhibited the best compressive strength, regardless of the curing regime.

In terms of initial moisture curing duration, the application of 7 days of moisture curing resulted in the highest compressive strength compared with other curing conditions. The 56-day compressive strength of HPC designated for bridge deck construction that was made with the LWS1 was up to 10 MPa (1,450 psi) greater than the Bridge-Reference concrete made without any LWS. The Bridge-LWS2-100% and Bridge-LWS1-50% mixtures exhibited the highest 56-day MOE of 42.5 GPa (6,615 ksi) under Standard curing. The Bridge-LWS3-100% mixture cured under Standard conditions had the highest 56-day flexural strength of 5.5 MPa (800 psi). The mixtures made with LWS2 presented the lowest sorptivity, regardless of the curing condition and LWS content.

The findings from this comprehensive project provided a basis for: (1) new mixture design methodology and guidelines for using LWS for internal curing for bridge deck and pavement applications; and (2) validation of performance improvement when using internal curing and cost competitiveness in the State of Missouri.

This project was sponsored by the Missouri Department of Transportation (SPR) Construction and Materials Division, through the Missouri University of Science and Technology and written by Kamal H. Khayat, P. Eng., Ph.D.; Weina Meng, Ph.D.; Post-doctoral Fellow; Mahdi Valipour, Ph.D., Post-doctoral Fellow ;Matthew Hopkins, Ph.D. Candidate. Click here to access the full document.

This project is contributing to objectives identified in CP Road Map Track 1: Materials and Mixes for Concrete Pavements.

Central Iowa Expo Pavement Test Sections: Pavement and Foundation Construction Testing and Performance Monitoring (report date: February 2018)

The Central Iowa Expo facility located in Boone, Iowa, needed to be reconstructed in 2012 to provide an improved pavement foundation for portland cement concrete (PCC) and pavement with hot-mix asphalt (HMA). This rework created a unique opportunity to conduct pavement foundation research using a range of stabilization construction and testing technologies on about 4.8 miles of roadway.

The Iowa Department of Transportation (DOT) initiated a research project to build the pavement foundation layer (Phase I), construction of the pavement layers (Phase II), and performance monitoring of the pavement systems (Phase III). During Phase I, 16 test sections were constructed, that used woven and non-woven geotextiles and geogrids at subgrade/subbase interfaces; 4 in. and 6 in. geocells in the subbase layer + non-woven geosynthetics at subgrade/subbase interfaces; portland cement (PC) and fly ash stabilization of subgrades; PC stabilization of recycled subbase; PC + fiber stabilization of recycled subbase with polypropylene fibers and monofilament-polypropylene fibers; mechanical stabilization (mixing subgrade with existing subbase); and high-energy impact compaction. A series of laboratory tests were conducted to characterize the soils, determine compaction characteristics, unconfined compressive strength tests on chemical stabilized samples, and freeze-thaw durability. In situ strength and stiffness-based test measurements were performed during construction (in July 2012), about three months after construction (in October 2012), seven months after construction (in January 2012) during frozen condition, and about nine to ten months after construction (in April/May 2013) during spring-thaw.

This project generated significant information regarding the mechanistic properties for pavement foundation support for a range of foundation improvement/stabilization methods. The test sections at this facility are unique in terms of the range of technologies used and for the fact that the performance data particularly isolates the influence of the seasonal changes without any loading. Some significant lessons learned from this project and the limitations of the findings are identified in this report.

This project was sponsored by the Iowa Highway Research Board, Iowa Department of Transportation, and FHWA through the Center for Earthworks Engineering Research Iowa State University. The research and report was by completed by David White, Pavana Vennapusa, Peter Becker, Jesus Rodriguez, Yang Zhang, and Christianna White. Click here to access the full document.

This project is contributing to objectives identified in CP Road Map Track 10: Concrete Pavement Foundations and Drainage.

Evaluation of MIT-SCAN-T2 for Thickness Quality Control for PCC and HMA Pavements (report date: February 2018)

Thickness is currently a pay item for PCC pavements and a quality control item for both PCC and HMA pavements. A change in pavement thickness of 0.5 in. can result in a change of multiple years of service. Current thickness measurements are performed by destructively coring the finished pavement and measuring the thickness of the core. Many times this is performed at the end of the project construction and only five representative samples are collected for each lot.

Devices such as the MIT-SCAN-T2 are excellent examples of non-destructive technology capable of accurately measuring the pavement thickness. The objective was to evaluate the MIT-SCAN-T2 as a non-destructive pavement thickness measuring device for quality control and quality assurance purposes. A ruggedness study was performed in the laboratory to determine factors of influence on thickness measurements. Field evaluations were performed to test the device in actual production conditions. The ruggedness test showed the presence of steel-toe boot, surface area, plate manufacturer, and depth as potentially significant factors. However, the influence of these factors on the measured depth was large, causing significant errors in the depth readings. An additional factorial was performed with a control sample and additional runs, varying only one factor at a time. The readings obtained with this factorial were significantly more accurate, with an error of 0.2 in. for the control sample. These results show that the device is capable of accurately measuring thickness if used within the parameters recommended by the manufacturer. The field results support the finding of the ruggedness study. If all of the negative influencing factors are controlled the MIT-SCAN-T2 can accurately measure the in-place depth of pavement. If any of these factors are present, then results can be skewed heavily.

This project was sponsored by Louisiana Department of Transportation, through the Louisiana Transportation Research Center and the report was completed by Zachary Collier, Amar Raghavendra, Tyson Rupnow, Patrick Icenogle. Click here to access the full document.

This research is contributing to objectives identified in CP Road Map Track 9: Evaluation, Monitoring, and Strategies for Long-Lived Concrete Pavement.

Design and Performance of Cost-Effective Ultra High-Performance Concrete for Bridge Deck Overlays (report date: October 2017)

This is the last of a series of three research reports on Ultra-High Performance Concrete on Bridge decks. The April 2018 E-News contains research reports on 1. Development of Nonproprietary Ultra-High Performance Concrete and 2. Field Testing of a Ultrahigh Performance Concrete Overlay

on Bridge Decks. The main objective of this third research report is to cover the design and performance of cost-effective ultra-high performance concrete (UHPC) for bonded bridge deck overlays.

The high durability and mechanical properties of such repair material can offer shorter traffic closures and prolong the service life of the pavement. In this project, the UHPC was optimized using supplementary cementitious materials (SCMs), proper combinations of sands, and adequate selection of fiber types and contents. Packing density studies included paste, sand, and fiber combinations. The robustness of optimized UHPC mixtures to variations of mixing and curing temperatures was examined. The efficiency of various shrinkage mitigation approaches in reducing autogenous and drying shrinkage of optimized UHPC mixtures was evaluated. This included the use of CaO-based and MgO-based expansive agents, shrinkage-reducing admixture, and pre-saturated lightweight sand.

Optimized UHPC mixtures were cast as thin bonded overlays of 25, 38, and 50 mm thickness over pavement sections measuring 1 x 2.5 m^2. Early-age and long-term deformation caused by concrete, humidity, and temperature gradients, as well as cracking and delamination were monitored over time. Test results indicate that the designed UHPC mixtures exhibited relatively low autogenous shrinkage and drying shrinkage. The G50 mixture had the lowest autogenous and drying shrinkage of 255 μm/m at 28 days and 55 μm/m at 98 days, respectively. All tested UHPC mixtures exhibited high mechanical properties and excellent frost durability. The use of 60% lightweight sand led to significant reduction in autogenous shrinkage from 530 to 35 μm/m. Test results indicate that there was no surface cracking or delamination in UHPC overlays after 100 days of casting.

This project was sponsored by the Missouri University of Science and Technology, Rolla; the Missouri Department of Transportation; and the Federal Highway Administration Office of Transportation Operations and the report was completed by Kamal H Khayat and Mahdi Valipour. Click here to access the full document.

This research is contributing to objectives identified in CP Road Map Track 8: Concrete Pavement Construction, Reconstruction, and Overlays.

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