

Slide 1

ILT


HMEC
Highway Materials Engineering Course

Lesson 11: Hot Topics

Portland Cement Concrete (PCC)

U.S. Department of Transportation
Federal Highway Administration


MODULE
G




Learning Outcomes

By the end of this lesson, you will be able to:

- Describe current and emerging initiatives, trends, technologies, and potential issues affecting PCC

 This lesson will take approximately 60 minutes to complete.

 U.S. Department of Transportation
Federal Highway Administration**MODULE 6****HOT TOPICS****LESSON 11****2**

National Transportation Product Evaluation Program (NTPEP)



- The NTPEP is one of the technical service programs offered by AASHTO
- The primary goal of the program is to provide cost-effective evaluations for the State DOTs by eliminating duplication of testing and auditing by the States and duplication of effort by the manufacturers that provide products for evaluation
- The NTPEP provides a very valuable clearing house function for new products including reinforcing steel, corrosion mitigation products, and so on
- Prior to adopting new materials, many States rely on the NTPEP evaluations and reports for performance and application data

Availability of Materials



- Materials availability for PCC can pose a significant challenge for any project, particularly for large projects:
 - Changing the cement source can result in the need to re-evaluate the mix proportioning
 - Changing aggregate types may also result in a need for re-proportioning the mix
 - Admixture effectiveness and compatibility must be evaluated when one or more new admixture types is introduced or the manufacturer or source is changed
- Other materials that may experience regional shortages include:
 - Embedded steel (rebar, dowels, dowel baskets, etc.)
 - Aggregates of suitable quality for base, granular fill, embankments



Have your projects ever experienced material shortages? If so, how were they resolved and what were the impacts on the project schedule?



Buy America Act



- The Buy America Act of 1983 (and subsequent revisions) impacted transportation-related projects in various ways
- The FHWA rules regarding adoption are summarized below:
 - The Secretary of Transportation shall not obligate any funds unless steel, iron, and manufactured products used in such projects are produced in the US
 - Applies to iron and steel products and their coatings that are to be permanently incorporated into the project
 - In its 1983 rulemaking, the FHWA determined that Buy America did not apply to raw materials and waived its application to manufactured products, although it was in the statute, based on the public interest
 - Lack of adequate domestic supply resulted in a 1995 nationwide waiver for iron ore, pig iron, and reduced/processed/pelletized iron ore



What is your experience with the Buy America Act? Has it impacted any jobs you have been involved with?



Buy America Act

- A clarification memo of the provisions of the Buy America Act was released on December 21, 2012.
- As currently enforced, the Buy America Act pertains only to:
 - Iron products
 - Steel products

 This memo can be referenced at:
<http://www.fhwa.dot.gov/construction/contracts/121221.cfm>

 U.S. Department of Transportation
Federal Highway Administration

MODULE 6

HOT TOPICS

LESSON 11

6


Mechanistic Empirical Pavement Design Guide (MEPDG)




- The mechanistic portion of the MEPDG requires detailed knowledge of material behavior, far exceeding design methodologies
- The following inputs represent key PCC parameters:
 - Modulus of rupture
 - Elastic modulus
 - Poisson’s ratio
 - Coefficient of thermal expansion
- In addition, numerous variables related to the PCC mix design and performance characteristics are now required



Are there any questions pertaining to PCC properties and the MEPDG?

PCC Quality 

- Quality requirements are dictated through specifications that have evolved as new performance measures are identified
- As we gain more insight into performance characteristics, new test procedures are developed or improved to facilitate monitoring (for instance, the rapid chloride permeability test, air void analyzer, ASR characterization tools, etc.)
- Keep in mind that some developments are focused on improving the basic materials while others are in response to a defined need such as the coefficient of thermal expansion required for the MEPDG
- How we define key quality characteristics will continue to evolve

 U.S. Department of Transportation
Federal Highway Administration


MODULE 6

HOT TOPICS LESSON 11

8

Performance Specifications

- Specifications are of two general types:
 1. Method or prescriptive specifications dictate how things are to be done in order to achieve a specifiable goal (for example, you will use 564 lbs. of cement per cubic yard of PCC)
 2. Performance specifications provide a required end result (for example, the owner required 750 psi flexural strength at 28 days, so it is up to the contractor to develop a mix to achieve that requirement)
- Performance specifications foster innovation and have resulted in the development of many new processes and state-of-the-art equipment
- Performance specifications are a driving force to develop new and improved materials and methods (for instance, development of the air void analyzer to provide more meaningful information than simply the entrained air content)

U.S. Department of Transportation
Federal Highway AdministrationMODULE 6HOT TOPICSLESSON 119

Prescription to Performance Specifications




- The Prescription to Performance Specifications (P2P) Initiative for PCC has been led by the National Ready Mixed Concrete Association (NRMCA)
- Development has focused on strength and other mechanical properties along with requirements for durability and serviceability
- Performance specifications for PCC have been evolving for decades as new and improved correlations are developed linking performance to measurable and verifiable properties




Environmental Issues

- Environmental issues are at the forefront of many discussions regarding transportation-related projects
- Some of the issues pertaining to PCC include the following:
 - Portland cement manufacturing
 - Use of fly ash in PCC mixes
 - Disposal of wash or rinse water (transit mix and dump trucks)
 - Sustainability (reuse of PCC)



PCC Sustainability Issues

- PCC sustainability has been the focus of continued research by industry, academia, and others
- The primary focus areas include the following:
 - Material production
 - Production efficiency
 - Recycling
 - Utilization of ground limestone and blended cements to lower the carbon footprint during production
 - Construction operations
 - Expedited construction
 - More efficient techniques and more fuel-efficient equipment
 - Utilization of industrial byproducts
 - Fly ash
 - Blast furnace slag

 **MODULE 6** **HOT TOPICS** **LESSON 11** **12**

PCC Sustainability Issues



- Energy use and emissions
 - Vehicle fuel consumption
 - Pavement thermal performance
 - Artificial lighting
- Refer to FHWA-HIF-15-002, Chapter 6 of “Toward Sustainable Pavement Systems: A Reference Document” for details


http://www.fhwa.dot.gov/pavement/sustainability/ref_doc.cfm



Are you aware of the current research in these areas?

Supplementary Cementitious Materials (SCMs) Usage

| Advantages | Disadvantages |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| SCMs have been used in PCC for many years and have proven to be a valuable addition in terms of mitigating alkali silica reactivity, increasing the paste content for certain applications, economizing the mix, etc. | Fly ash contains trace amounts of mercury and other heavy metals, and as such, is the subject of continued controversy due to environmental concerns |
| Utilization of SCMs in PCC mixes dramatically reduces amount of these industrial byproducts placed in landfills | Efforts by the EPA to categorize fly ash as a hazardous material has been somewhat relegated to the "back burner," but may be reconsidered in the future |

 U.S. Department of Transportation
Federal Highway Administration

MODULE 6

HOT TOPICS LESSON 11


14

Treatment and Use of Waste Water


- Wash water or rinse water from truck cleanout and equipment wash down can contain significant amounts of partially hydrated cement and fines
- Due to the presence of the cement, the water is highly alkaline
- Depending on the location, regulations regarding discharge can range from very stringent to minimally controlled
- Regardless of the location, discharge adjacent to a waterway is prohibited
- In urban areas, transit mix trucks typically discharge the wash water into settling pits at the production plant

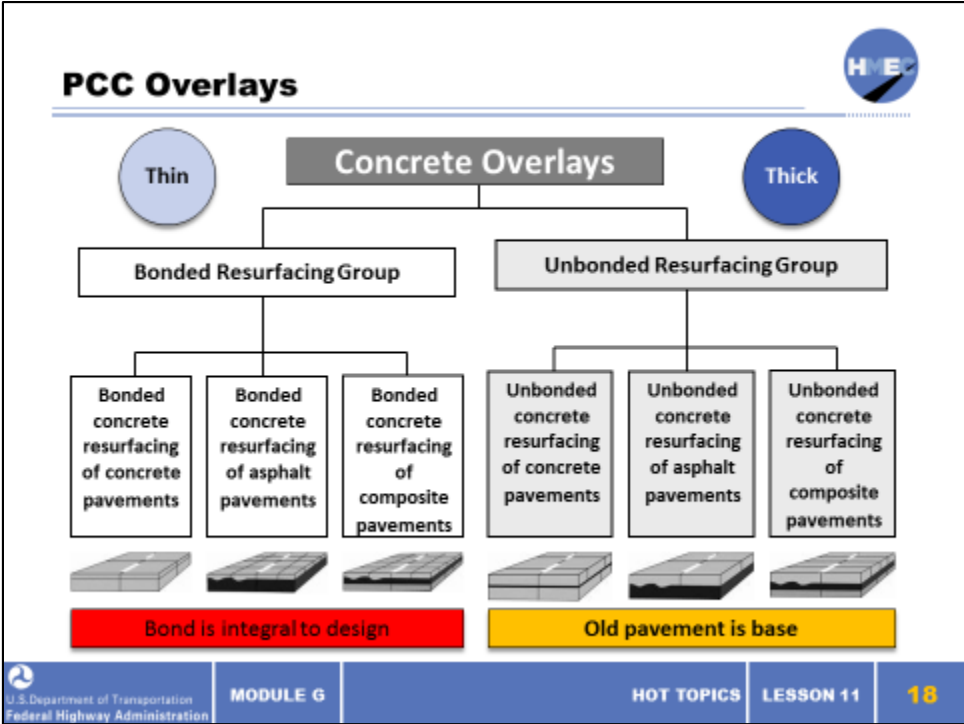
| | | | | |
|---------------------------------------------------------------------|-----------------|-------------------|------------------|-----------|
| U.S. Department of Transportation Federal Highway Administration | MODULE 6 | HOT TOPICS | LESSON 11 | 15 |
|---------------------------------------------------------------------|-----------------|-------------------|------------------|-----------|

Greenhouse Gas Emissions



- Greenhouse gas emissions have received considerable attention in recent years and may influence future production and the use of various construction materials
- The production of Portland cement is an energy-intensive process with fossil fuels used to heat the materials in the kiln
- Continued refinement of the cement manufacturing process has significantly reduced the greenhouse gas emissions for plants operating in the US
- Fuel consumption during aggregate recovery and processing, construction operations, and user costs due to traffic delays all must be factored in the overall “energy footprint”

| | | | | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------------------|------------------|-----------|
|  U.S. Department of Transportation Federal Highway Administration | MODULE 6 | HOT TOPICS | LESSON 11 | 16 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------------------|------------------|-----------|





Thin Bonded Overlays

- Thin bonded overlays were pioneered more than 25 years ago and are widely accepted worldwide as a viable technology to prevent structural and functional failures in asphalt pavements under certain conditions
- The design of thin bonded overlays is accomplished with specialty or conventional design procedures as outlined in the following reference:
 - http://www.cptechcenter.org/technical-library/documents/Overlays_Design_Guide_508.pdf
- Application and construction of thin bonded overlays may be found in the following reference:
 - http://www.cptechcenter.org//technical-library/documents/overlays/guide_concrete_overlays_2nd_ed.pdf

Bonded PCC Overlays



- Conventional bonded overlays are generally applied to pavements in good condition in which an improvement to structural capacity or surface characteristics is desired
- These overlays can be placed on existing PCC, asphalt, or composite pavements
- In order for these relatively thin overlays to perform well, they must bond to the existing pavement and form a monolithic structure
- Loss of a bond means poor performance
- The design of these types of overlays is generally well established using conventional methods
- The construction techniques are fairly standard other than the surface preparation necessary to achieve a bond

Q&A Can anyone share their experiences regarding bonded PCC overlays? Where have they been used and what has been the level of performance?

Unbonded PCC Overlays



- Unbonded overlays are the most widely used PCC overlay type and can be used on existing pavements in very poor conditions
- This type of overlay is generally thick and is designed as a new pavement with the existing pavement functioning as a base course
- Bonding to the existing pavement must be avoided in order to prevent reflective cracking and the propagation of the existing distresses
- The design and construction of these types of overlays is well established and the performance history has been very good

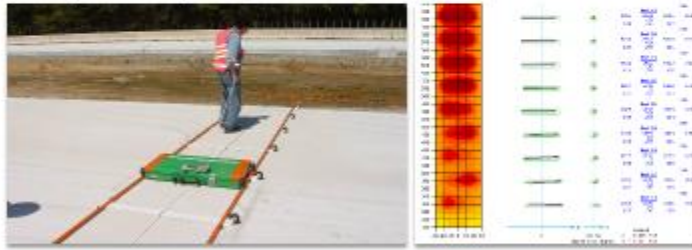


Can anyone share their experiences regarding unbonded PCC overlays?
Where have they been used and what has been the level of performance?

Non-Destructive Embedded Steel Locator (MIT SCAN2)




- Dowel bars and tie steel must be accurately placed in order to function as designed
- The MIT SCAN2 device is a rapid and very accurate means to determine dowel and tie bar locations at both at transverse and longitudinal joints




What is the current method in your State to determine the location of embedded steel? Do you have experience with the MIT SCAN2 device?

Super Air Meter (SAM)

- Air entrainment has been discussed at length throughout this module, as well as its importance to freeze-thaw resistance
- A pressure meter is commonly used to determine the total air content but not the bubble size distribution
- The Super Air Meter (SAM) can determine both the air content and the volume of bubbles smaller than 300 microns
- The results of this device have shown good correlation with the spacing factor, and therefore, the effectiveness of the entrained air




The image shows the Super Air Meter (SAM) device, a complex piece of laboratory equipment used for measuring air content and bubble size distribution in concrete. It consists of a main cylindrical chamber with a pressure gauge on top, a smaller chamber, and various valves and tubes. A blue ball and a wooden handle are also visible next to the device.


 U.S. Department of Transportation
Federal Highway Administration **MODULE 6** **HOT TOPICS** **LESSON 11** **25**

Self Consolidating Concrete (SCC) Applications and Use




- Typical uses have included heavily reinforced walls and other structural sections, drilled shafts, slabs on grade, and other applications where conventional consolidation is problematic
- Some benefits of SCC include the following:
 - Faster placement
 - Less labor required for placement
 - Potentially more economical
 - Faster transit mix truck turnaround (reduced cycle time)
 - Ideal for limited access pours
 - Good for pumping
 - High flowability with little segregation

 Can anyone discuss about the use of SCC in their State? Where has it been used, and were there issues pertaining to its use, cost, etc.?





Curing

- The most significant advancement in curing is a lithium-based compound that has numerous advantages over conventional curing compounds
- Advantages of the compound are that it:
 - Can be applied earlier than conventional curing compounds
 - Eliminates surface restraint cracks (micro-cracking)
 - Retains high internal moisture content
 - Reduces permeability
 - Increases long-term durability
 - Produces an additional cement gel
 - Promotes a more efficient hydration process



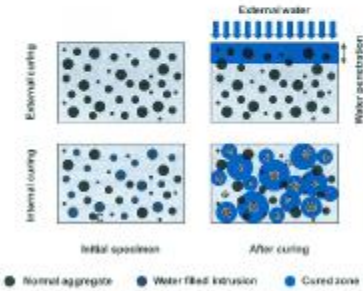
Has anyone's agency evaluated lithium cure? If so, what were the benefits and limitations?

| | | | | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------------------|------------------|-----------|
|  <p>U.S. Department of Transportation Federal Highway Administration</p> | MODULE 6 | HOT TOPICS | LESSON 11 | 27 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------------------|------------------|-----------|



Internal Curing

- Internal curing makes use of saturated lightweight aggregate to provide a ready source of water for hydration
- Internal curing is very beneficial under adverse placement conditions where normal curing techniques are ineffective or difficult to apply in a timely manner



External curing

Initial position **After curing**


Internal curing

Initial position **After curing**


External water
Water penetration


● Normal aggregate ● Water-filled keelson ● Cured zone

U.S. Department of Transportation
Federal Highway Administration **MODULE 6** **HOT TOPICS** **LESSON 11** **28**

**Internal Curing Applications and Use**

- The water provided by the aggregates in this case does not contribute to the mix water, and therefore, the w/c ratio
- There are numerous benefits to internal curing including the following:
 - Reduction in autogenous shrinkage
 - Reduction in plastic shrinkage cracking
 - Improved hydration
 - Less susceptible to early age thermal cracking
 - Reduction in the cracking potential

 Let's have a discussion and answer some questions.


 U.S. Department of Transportation
Federal Highway Administration

MODULE 6

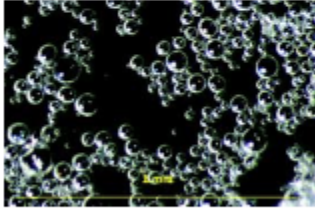
HOT TOPICS LESSON 11


29


Microspheres for Freeze-Thaw Resistance



- A recent development in admixture technology is the use of microspheres for freeze-thaw resistance
- These microscopic plastic spheres are used in place of traditional air-entraining admixtures
- The microspheres are introduced as a liquid admixture at the time of batching
- Testing has shown that the microspheres are stable during mixing and placement



 Has your agency used this technology, and if so, where?

 U.S. Department of Transportation
Federal Highway Administration

MODULE 6

HOT TOPICS

LESSON 11

30

Other Current Topics



- Are there any additional topics that you may have heard about that you would like to discuss?



 Does anyone want to share anything they may have come across in terms of PCC utilization, technology advancements, or any other issues of interest?

 U.S. Department of Transportation
Federal Highway Administration

MODULE 6

HOT TOPICS


LESSON 11

31

Resources – Appendix B




- Module G has an extensive Resources list
 - As do other modules
- In many cases a simple internet search will provide sufficient information for most common issues
- The compiled resources list should not be considered the final say as current research is underway in many areas of PCC technology



Lesson Outcomes Review

You are now able to:

- Describe current and emerging initiatives, trends, technologies, and potential issues affecting PCC

| | | | | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------------------|------------------|-----------|
|  <p>U.S. Department of Transportation Federal Highway Administration</p> | MODULE 6 | HOT TOPICS | LESSON 11 | 33 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------------------|------------------|-----------|
