Objectives

- Understand difference between external and internal curing
- Understand why the use of internal curing is needed today
- Understand the science of internal curing
- Understand which properties of concrete can be improved with internal curing
- Examine recent steps the industry is taking to implement internal curing

Concrete Problems

- American’s spend 4.2 billion hours a year stuck in traffic
- Bridges (>25%) are structurally deficient or functionally obsolete
- Highways (>33%) are in poor or mediocre condition
- Cracked and spalling concrete
- Corroding steel reinforcement
Curing

- When concrete is placed it is sensitive and can be easily damaged if not treated properly
- We want to maintain appropriate temperature and moisture during the first few weeks
- Proper curing enables concrete to hydrate (chemically react) developing potential strength and durability
- Proper curing reduces stress and cracking potential due to drying or temperature changes
- Important but frequently overlooked step

Objectives
Concrete Problems
Defining Internal Curing
Science of Internal Curing
Internal Curing Applications

External Curing

- Conventional curing works by treating the ‘outside’ of concrete after placement
  - Placing water (water curing) on the concrete surface
  - Placing a curing compound that helps to reduce water loss to evaporation

Objectives
Concrete Problems
Defining Internal Curing
Science of Internal Curing
Internal Curing Applications

Challenges with External Curing

- External curing has worked for centuries, why is something different needed now?
- In an effort to make concrete less permeable (i.e., HPC) we use more low w/c systems with supplementary cement
- While reduced porosity is good for durability, it can limit water movement limiting the effectiveness of water curing
- Supplementary cementitious materials requires longer curing times (slower reactions) and have more chemical shrinkage with hydration

Objectives
Concrete Problems
Defining Internal Curing
Science of Internal Curing
Internal Curing Applications

Jason Weiss, Jason.Weiss@oregonstate.edu  Originally Prepared 2012
Internal Curing

- Internal curing - process by which the hydration of cement occurs when internal reservoirs provide additional water that is not part of the mixing water
- Allows curing to be well distributed
- Allows curing as needed

How Does Internal Curing Work?

- Water can be lost due to drying
- Water can be consumed by hydration resulting in self desiccation

How Does Internal Curing Work?

- Porous lightweight aggregate is 'prewetted' before mixing
- Water moves from the 'pores' in LWA to the paste on demand as needed
- This movement is due to fact that smaller pores want to remain 'water filled'
Internal Curing Applications

- NYDOT using internal curing in bridge decks (map showing bridges as of 2012)
- General experience is positive
- Reduced cracking with no problems to contractor or supplier

Streeter et al. 2012

Objectives
Concrete Problems
Defining Internal Curing
Science of Internal Curing
Internal Curing Applications

Internal Curing Applications

- Building large slabs is complex
- Denver Water 10-Million Gallon Lone Tree Tank No. 2
  - Negligible differences in placing & finishing
  - Opinion – less cracking and maintenance

Bates et al. 2012

Objectives
Concrete Problems
Defining Internal Curing
Science of Internal Curing
Internal Curing Applications

Internal Curing Applications

- RR intermodal facility
  - 250,000 yd³ of low slump IC material
- CRC Paving for TxDOT
  - 6 months 1 crack, 5.5 years minor drying or plastic shrinkage cracking

Friggle et al. 2008
Internal Curing Applications

- Two bridge decks were cast in 2010 at the same time in Monroe Co (Bloomington) IN
- Internally cured bridge: similar workability, higher strength, lower transport and no cracking (3 cracks in the plain bridge)
- Additional bridges being constructed

Summary

- US infrastructure is aging & deteriorating: IC offers one approach to extend the service life of concrete
- LWA can be used as a reservoir to 'hide water' throughout the cross section that can be used during hydration
- Internal curing can reduce shrinkage and shrinkage induced cracking
- Internal curing is being implemented, with examples shown, in practice and showing great potential

Upcoming Modules

- Internal curing increases hydration ‘getting more’ from cementitious materials
- Modules on how to proportion internally cured concrete
- Internal curing reduces shrinkage and the potential for shrinkage cracking
- Internal curing reduces fluid transport (absorption/diffusion) reducing corrosion
- Internally cured concrete can be used to increase the sustainability of concrete
More Information

Objectives

- Internal Curing of High Performance Concretes - Laboratory and Field Experiences, ACI SP-256, Eds. D. Bentz and B. Mohr, American Concrete Institute, CD-Rom, 2008.
- Friggle, T., and Reeves, D., Internal Curing of Concrete Paving Laboratory and Field Experiences, ACI SP-256, Eds. D. Bentz and B. Mohr, American Concrete Institute, 71-80, CD-Rom, 2008.
- The Economics, Performance, and Sustainability of Internally Cured Concrete, ACI SP-290, Eds. A.K. Schlinder, J.G. Grygar, and W.J. Weiss, American Concrete Institute, CD-Rom, 2012 (papers by Bastas, Streeter, DiBella)
- http://www.escsi.org/Content.aspx?id=203&menuen=1b7c39fc_61_74_203_1

Acknowledgements/Disclaimer

- These slides were developed as part of a series for the Expanded Shale, Clay and Slate Institute by Jason Weiss.
- These materials are provided as general information and do not constitute legal or other professional advice.
- Any use of this information in the design or selection of materials for practice should be approved by the owner and project engineer-of-record.