Objectives

Sustainability
Improving Service Life of Concrete
Reducing Cement and Clinker
Summary

Improving Sustainability with Internal Curing

Objectives

• Sustainability is a concern for the concrete construction industry
• To discuss potential ways that internal curing can be used in sustainable design
• To understand how service life can be improved by using internal curing
• To understand how internal curing can be used to reduce cement/clinker

The Time is Ripe for Spec Change

• Construction industry is actively developing sustainable solutions
• Three Prong Approach

Improved Service-Life
Sustainability
Reduce Clinker
Reduce Cement Content
The Time is Ripe for Spec Change

- Construction industry is actively developing sustainable solutions
- Three Prong Approach
  - Improve Sustainability
  - Reduce Clinker
  - Reduce Cement Content

Benefits of Internal Curing

- Internal curing increases hydration, reduces porosity, reduces interfacial zones
- Internal curing reduces absorption and reduces chloride diffusion
- Internal curing shows similar freeze-thaw resistance
- Internal curing reduces the potential for cracking – Cracks accelerate fluid ingress and corrosion of reinforcing steel

Service Life Modeling Bridge Decks

- Conventional vs. High Performance
  - Substantial improvements can occur in service life when HPC mixtures are used
  - Model does not account for cracking which shortens life however IC reduces crack risk

Pease et al. 2008
Life Cycle Cost Analysis

- Cusson et al. 2010 reported results of a case study that compared a conventional, high performance and high performance internally cured deck
- 200-mm (8 in) thick bridge deck
- 75 mm (3 in) cover
- Canadian exposure conditions

Cusson et al. 2010 Service Life Model

- Schematic of life cycle model used
- Internal curing improved service life
- 38% lower life cycle cost (5 year recovery)
The Time is Ripe for Spec Change

- Construction industry is actively developing sustainable solutions
- Three Prong Approach

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Cement and CO₂ Production

- Cement accounts for 7-8% of global CO₂ (Mehta 1998)
- Where does CO₂ come from
  - Calcination (50)
  - Combustion (40)
  - Transportation (10)
- Concrete has relatively low carbon emission per unit; however we use a large volume

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Potential Approach for Sustainability

- Reduce the cement (clinker) content of concrete used in transportation structures
- Current limits of 20-25% fly ash
- Can higher volumes of ash be used?
  - Contractors and agencies are concerned with slow strength development
  - Other concerns: slow set time, admixture incompatibilities, scaling, freeze-thaw damage, extended times for moist curing

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Summary
• de la Varga et al. examined potential use of high volume fly ash mixtures (HVFA)
• Typical w/cm 0.42 concrete bridge deck mixture modified using HVFA to obtain similar early age strengths
• Similar paste volume
• Similar workability obtained with chemical admixtures

• As the w/c is reduced and the fly ash volume is increased similar strengths can be obtained at early ages
• Transport properties were also greatly improved
• However, as the w/c is reduced, the autogenous shrinkage and cracking potential can increase

• Internal curing can improve the strength, especially at later ages due to enhanced hydration
• Internal curing has a residual stress that was much lower than the plain mixture, being similar or less than the 0.42 mixture with benefits of 60% less cement, improved strength, and transport
Water Absorption with HVFA

- Conventional mixture shown in blue
- Replacing 60% of the cement with fly ash and using a lower w/c reduces transport
- Internal curing beneficial

Summary

- Internal Curing
  - Increases hydration, uses binder efficiently
  - Reduces the potential for cracking
  - Reduces chloride ingress, delays corrosion
- Service life model
  - Showed improved service life
- SCM can be used to reduce clinker per cubic yard of concrete
  - w/c adjusted to counteract slow strength, improving transport and cracking resistance
  - longer moist curing (offset poor curing)

More Information

- 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.
- 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
- http://www.e spc.org/ContentPage.aspx?id=205&ekmensel=1b7c39fc_61_74_205_1
Acknowledgements/Disclaimer

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• 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 project owner and engineer-of-record.

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