National Concrete Consortium Performance Engineered Mixtures

Jason Weiss, Oregon State University - Date September 20th, 2017

Update on Pooled Fund (First a Look Back)

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TARGET: Improve Long-Term Durability

- Freeze-Thaw
- Salt Damage
- Chloride Ingress
- ASR

- Shrinkage & Cracking

Worked to develop an overall framework

Identified sections

- 6.5
- 6.6
- 6.7
- 6.8

Weiss et al. 2015

This is work done prior to the current pooled fund and led to a large portion of AASHTO PP-84

Performance Approach

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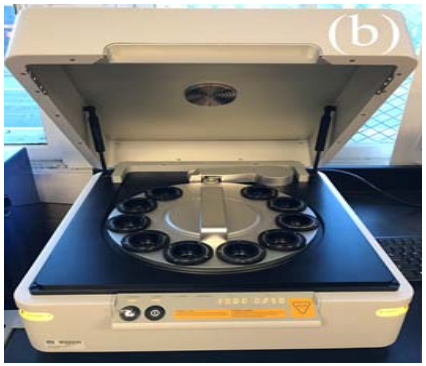
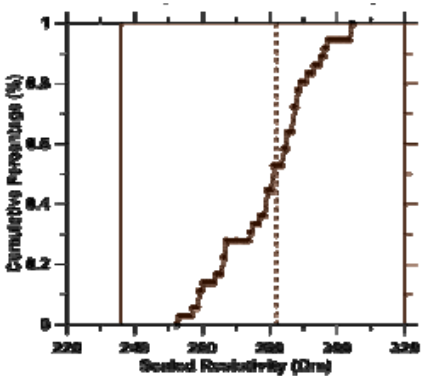
Step 1	Step 2	Step 3	Step 4
Assess Materials Using Standard AASHTO or ASTM tests	Transform Test Results into Material Properties	Relate Material Properties to Service Life Using Exposure	Use Service Life to Establish Performance Grades





Barde et al. 2007

Think about Models

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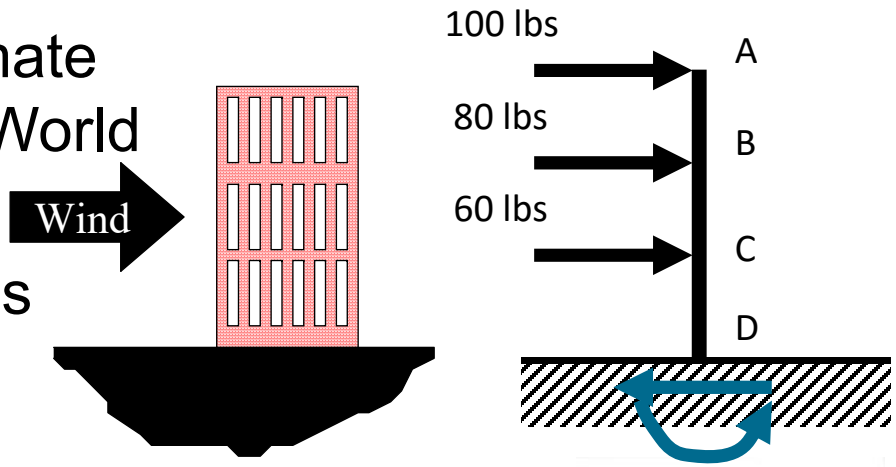
- **Idealization -** Creating an Approximate Mathematical Model to Assess the World
- **Example** - How Forces Act on A Structure and Cause Deformations
- **Not Exact** – Engineers Must Understand Approximations etc...



- **All models are wrong, but some models are useful**. (G. Box)
- Can models push us in the correct direction, these will improve with time if we have 'good form and inputs'

Weiss et al. 2001

Toward FT SLM

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Develop the Sorption Based Modeling Concept

Relating the saturation level in concrete to a theoretical critical limit of saturation

Develop Testing Procedures to Evaluate Concrete Mixtures

Developed Testing for Critical Saturation, Absorption, and Degree of Saturation

Evaluate Properties of Typical Paving Mixtures

Measuring typical values of the properties of typical pavements

Work with SHA's on Shadowing Field Projects for PEM/PRS

Implementing Shadow Specifications in 17/18

Add in Statistical Variation To Assess Reliability

Using Monte Carlo Simulation of Measured Properties to Relate Variability to Life

Weiss et al. 2017

FT Service Life Model

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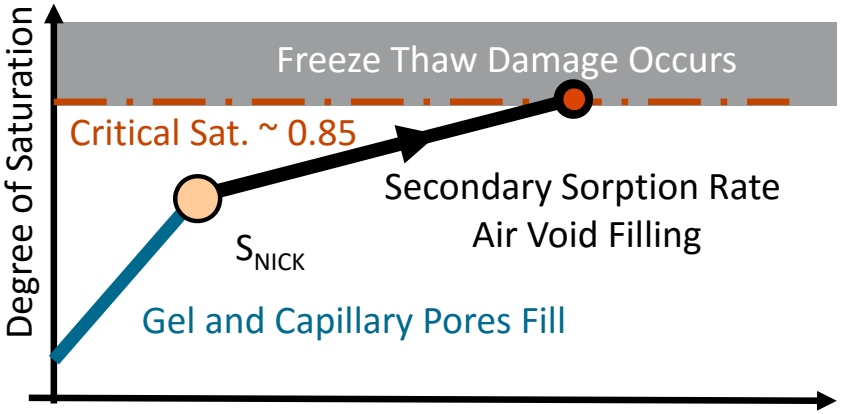
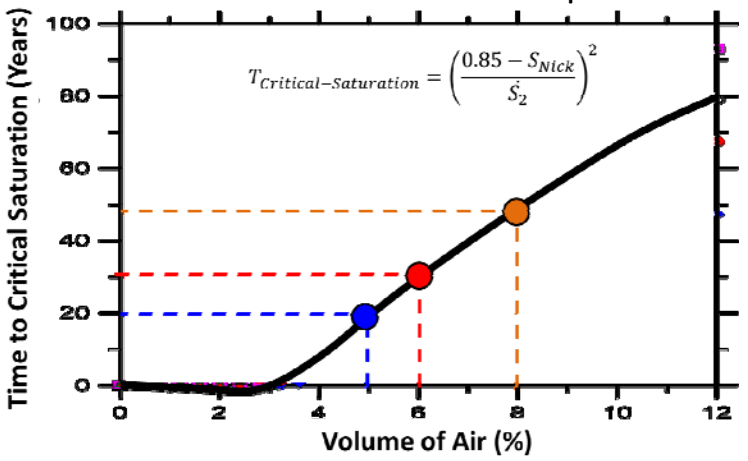
- Simple sorption based model is shown
- Important to recognize that we are not predicting FT damage; rather we are predicting a limit state
- Great framework
- Lets discuss the model inputs (tests that we will measure)



Li et al. 2010



Weiss et al. 2014

FT Model Inputs

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Name				
Key Variable	**Matrix Saturation**	**Critical Saturation**	**Secondary Sorption**	**Drying Factor**
	S_{Matrix}	**$S_{Critical}$**	**dS_2/dt**	**ϕ**
Level 1 - Test	Sorption Test	LGCC Test	Sorption Test	Beginning Tests
Level 1 – Model	OPC PB Model	Develop – 20%	Develop – 85%	Develop – 5%
Level 2 – Test	Bucket Test	N/A	NDT Test	Not Yet
Level 2 - Model	SCM GEM Model	N/A	Not Yet	Not Yet
Current SOTP	To Submit 1 T/M	To Submit 1T	To Submit 1 T/M	Assume Value

Weiss et al. 2016

Developing Test Methods

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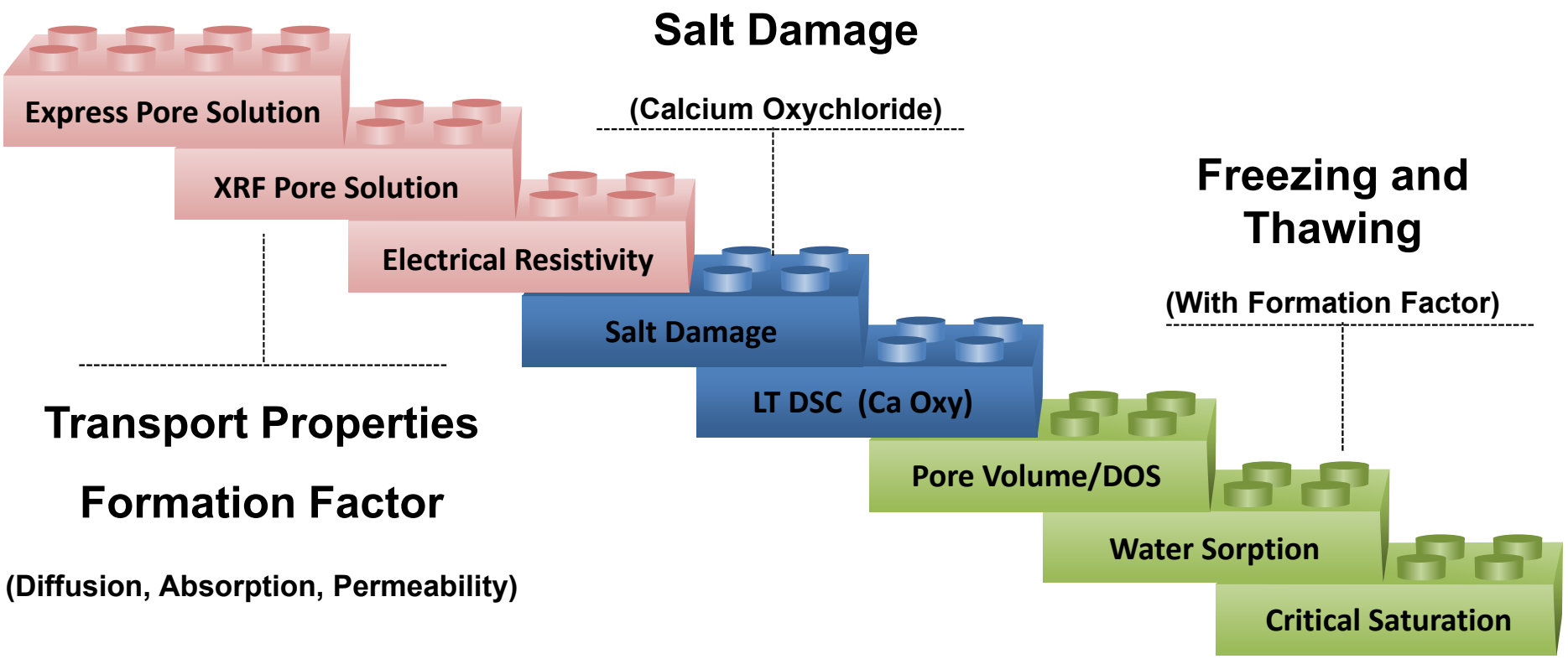

Weiss et al. 2017

Projected Timeline

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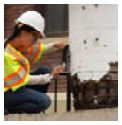
Step 1

Early Fall

Pore Volume
Water Sorption
Degree of Saturation



Step 2

Late Fall

Minor Revisions of
Resistivity
LTDSC

Step 3

Spring

Express P. Soln
P Soln Analysis
(Test and Calc)

Step 4

Summer

Salt Damage
Critical Saturation

Weiss et al. 2017

Stage 3: OSU Approach

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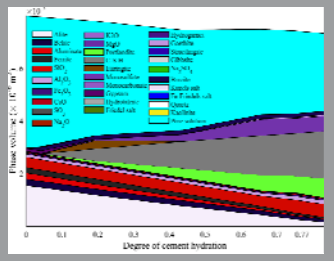
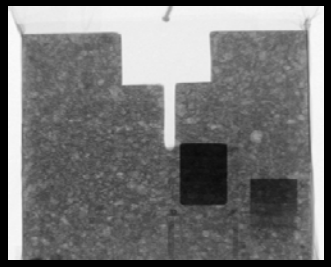
Unify Transport Tests and F

Goal:
complete theoretical framework to enable F-factor to replace existing transport tests first principles



GEMS & Reactive Transport

Goal:
Use computational models to simplify and complement field testing



Water Transport & Implications

Goal:
Use quantitative neutron radiography to better understand moisture content and movement

Rapid Test for Water Content

Goal:
Use test methods to measure water content before placmeent

Weiss et al. 2016

Unify Test Methods

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Unify Transport Tests and F

Goal:
complete theoretical framework to enable F-factor to replace existing transport tests first principles

- Currently there are many transport tests that measure the ‘same thing’
- Few people have taken the time to work toward unifying the test methods
- Work underway to unify various test methods (e.g., D via Barrett et al. 2015)
- Series of ‘unifications to be ready by the end of the calendar year (more to do)
- Reduces tests & simplifies specifications

Weiss et al. 2016

GEMS Modeling

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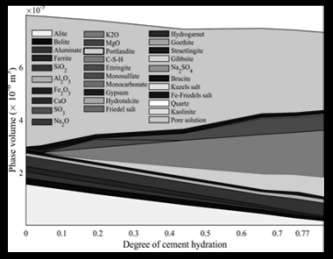
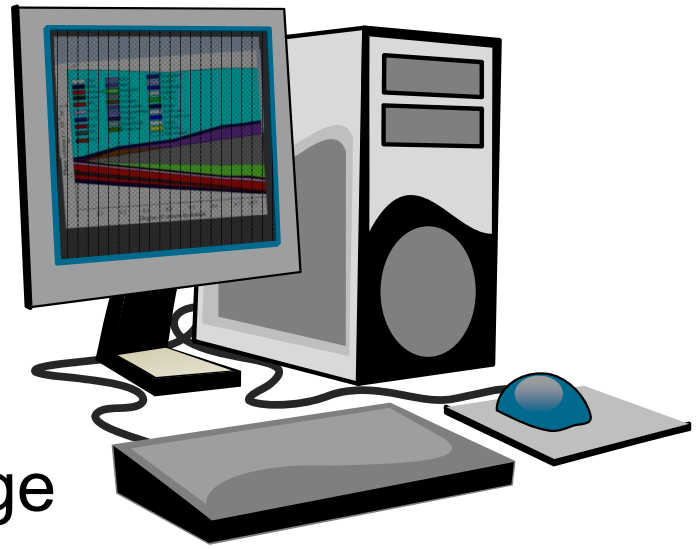


GEMS & Reactive Transport

Goal:
Use computational models to simplify and complement field testing

- We know that moving forward we will use less OPC and more OPC+SCM mixtures
- Can we predict the reaction products and their volume
- Can we use these predictions inform the PEM models
- Simplify tests with simulation knowledge



Weiss et al. 2016

Water Transport

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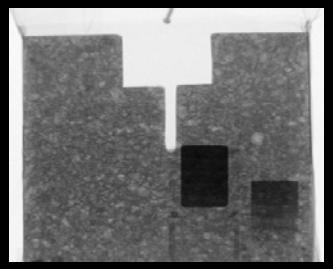
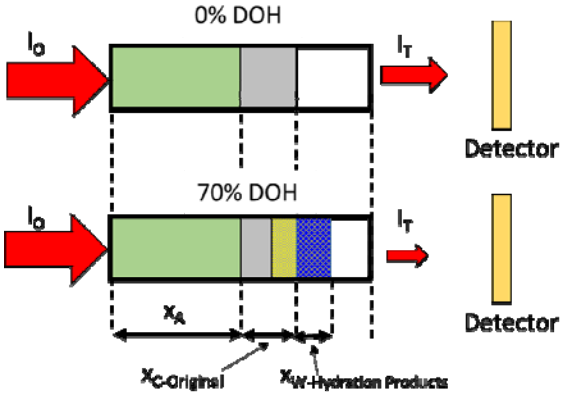
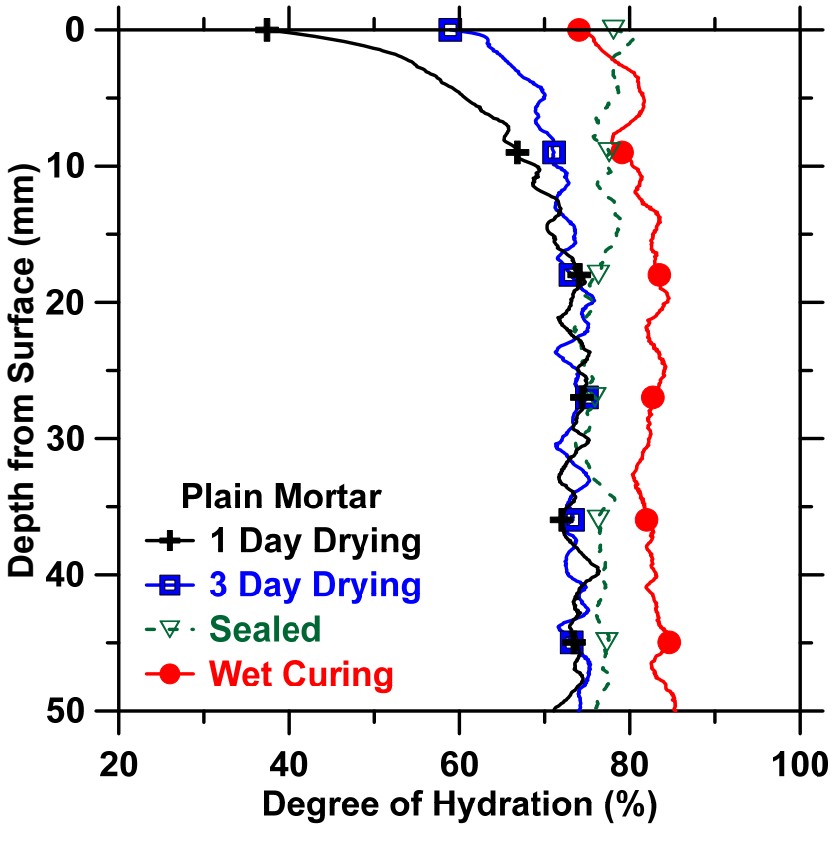


Water Transport & Implications

Goal:
Use quantitative neutron radiography to better understand moisture content and movement

- Durability is related to curing and/or fluid transport
- Use of NR





Khanzadeh et al. submitted

Rapid Water Content

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Rapid Test for Water Content

Goal:
Use test methods to measure water content before placement

- Working on a test method that can be used for fresh concrete
- Very comfortable with it in the lab, additional work is needed to make sure it is robust and ready for the field
- At the current time we know that temperature corrections are very important as well as the role of ionic species which we are working on

Poursaee et al. 2010, Isgor et al. 2014

Summary

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- AASHTO PP84 is moving forward with great support from NCC, FHWA, and all of you … thank you
- Our goal – Use tests that can be related to performance, simple tests and physical models
- Framework has started still much to do – implement to fundamentals
- Please let us know as you begin to implement locally, happy to help

Thank you

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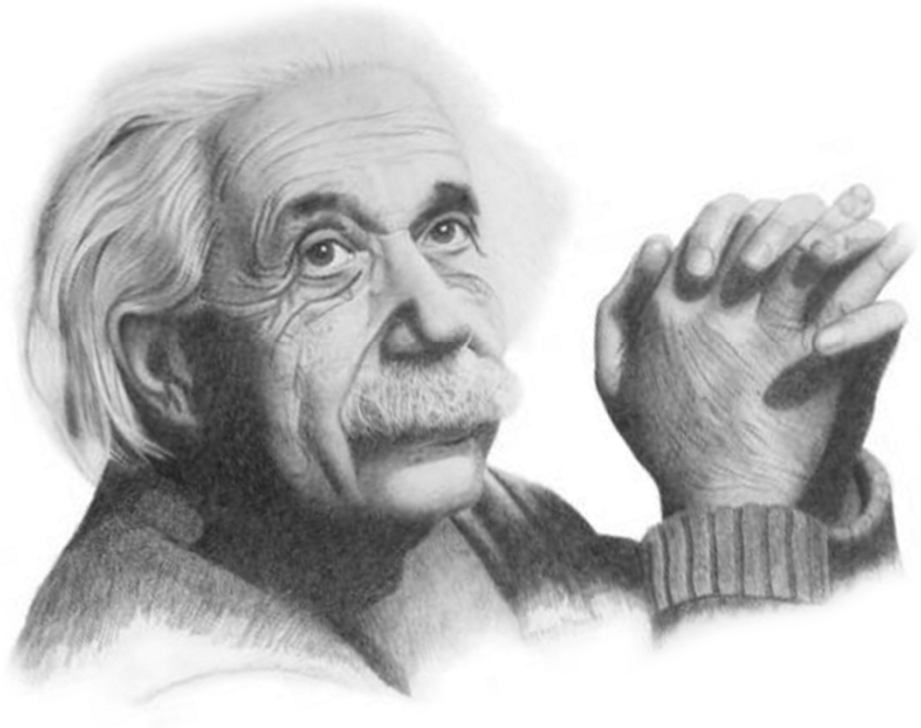

Imagination is more important than knowledge.

- Albert Einstein

https://www.researchgate.net/profile/William_Weiss6