

Concrete Materials Research at the National Institute of Standards and Technology

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**Engineering Laboratory
National Institute of Standards and Technology**

NIST - (formerly) National Bureau of Standards

Who We Are:

NIST is a non-regulatory federal agency within the U.S. Department of Commerce

Mission

Promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life.

NIST - Materials and Construction Research

Reinforced Concrete Design and Analysis

- WTC Investigation

Measurement and Modeling of Polymeric Materials

- Environmental Exposures - UV, Temperature & RH

Construction Metrology

- Precision/Assured Placement

Measurement and Models of Concrete Materials

- Predicting Performance and Service Life

NIST - Concrete Materials Research

Modeling Cement Hydration

- cellular automata, kinetic Monte Carlo, ...

Characterization

- cement, fly ash, slag, aggregates, concrete

Doubling Service Life

- modifying the pore solution

Rheology

- combined measurement and modeling

Effect of Cracks on Transport

- performance of existing structures

NESCC

Nuclear Energy Standards Coordination Collaborative

- ANSI & NIST
- Ambler Thompson (NIST)

NESCC works to facilitate and coordinate the timely identification, development, and revision of standards for the design, operation, development, licensing, and deployment of nuclear power plants.

- Task Groups:
 - Concrete Materials Report - March 1, 2011

NIST 4sight - <http://ciks.cbt.nist.gov/4sight>

Concrete Performance Prediction Tool

Developed for Performance Assessment

Concrete in Saturated Environments:

- no wetting/drying
- no temperature fluctuations
- no materials database

Limited Degradation Modes:

- corrosion, sulfate erosion, leaching/acid attack

Parameter Uncertainty Monte Carlo

Estimated Service Life Distribution Function



Physico-Chemical Performance Models

Conceptual Model - Random Porous Media

- Pores containing aqueous solutions (pH = 13)
- Soluble mineral phases in contact with the solution
- The environment is in contact with the pore solution
- Dissolution/Precipitation affect transport coefficients

Model the Physics and Chemistry

- Diffusive transport through concentrated aqueous solutions
- Chemical reaction through thermodynamic models
- Electro-diffusion, permeation, binding, moisture transport, ...

Material/Environment - Initial/Boundary Conditions

- Existing structures are merely a special case

Physico-Chemical Performance Models

Accelerated Testing

- Chicken's Egg Problem
- Quantify boundary/initial conditions - simulate response

Performance-Based Tests

- Validate models
- Quantify materials and environment
- Estimate the performance

Optimal Monitoring and Maintenance

- Kalman/Bayesian Filtering - combine modeling and measurements
- Reduced uncertainty
- Increased time between observations

Cement Barriers Partnership (CBP)

<http://www.cementbarriers.org>

DOE - NRC - NIST - SRNL - Vanderbilt U. - ECN - SIMCO Technologies

Unified Performance Assessment Tool:

- Developed for new construction, but applicable to existing
- STADIUM - www.stadium-software.com
- LeachXS - www.leachxs.com

NIST Role:

- Unified Microstructure-Transport Coefficient Model
- Reference/Validation Data

Lessons Learned

Condition Assessment - Materials Database - RSL Modeling

Activities in these areas must be coordinated to ensure that the inputs/outputs from these activities are compatible.

Partnering with NRC helps to ensure that the programmatic outputs and outcomes meet the needs of both the applicant and the regulator.