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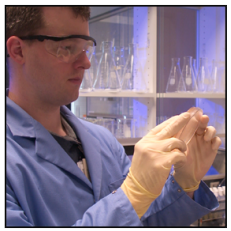
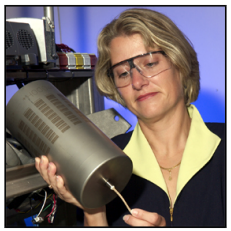
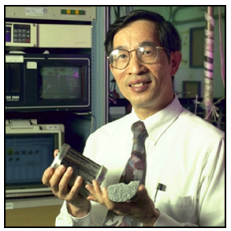
We Put Science To Work

CBP
PA Support Initiatives

Greg Flach

13 April 2010


Performance Assessment Community of Practice Technical Exchange

Richland WA

SRNL-MS-2010-00071

PA support approach

- **Look for**
  - "openings" in PA schedule
    - preparation
    - review
  - cementitious material issues
  - opportunities to reduce uncertainty with marginal additional effort
- **Collaborate with PA owner on key inputs and results interpretation**

Saltstone PA review schedule

Timeline in September 2009

- **Mar 2009** — **Issue Rev. A to DOE-SR**
- **Jun 2009** — **Issue Rev. B to DOE-HQ**

  ↕ **DOE-HQ (LFRG) review**

- **1 month** — **Issue Rev. C to NRC**

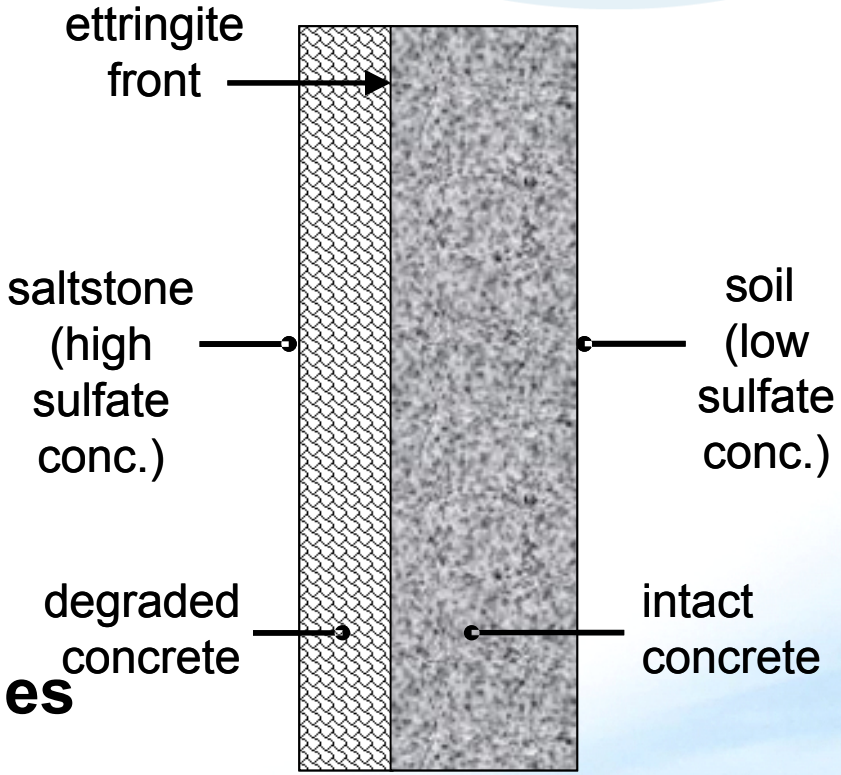
  ↕ **Opportunity for supplemental analyses**

- **6-9 months** — **Issue Rev. 0**

Opportunity

PA baseline analysis of external sulfate attack:

- **STADIUM® code used to predict formation of ettringite (expansive)**
  - Single-layer analysis
  - Transport properties not affected by ettringite front
- **Simple damage model**
  - Ettringite = physical damage (e.g. cracking, spalling)
- **Effective hydraulic properties by averaging**



Uncertainties

- **Conditions at interface between Saltstone and concrete?**
- **Does physical damage occur?**
- **Under unsaturated conditions would cracking accelerate, hinder or not affect the rate of sulfate attack?**
  - ~100 - 1000 cm suction

Support initiatives

- **Two-layer simulations**
  - leverage STADIUM simulations for CBP "Task 7"
  - refined inputs compared to PA
- **Damage mechanics coupled to reactive transport**
  - add damage mechanics model to LeachXS/Orchestra
  - Sarkar et al. 2010, Cement & Concrete Composites 32

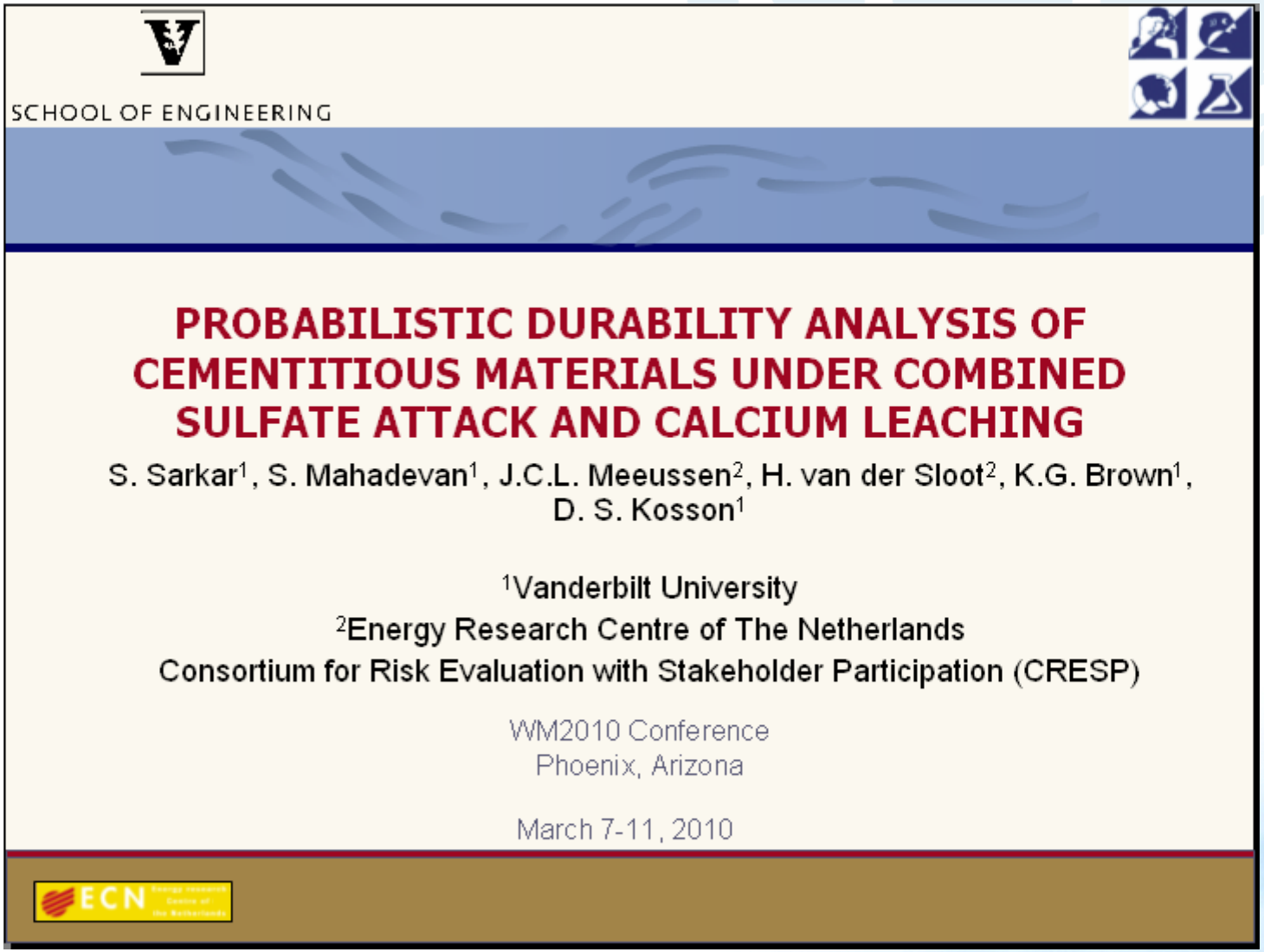
Insights from STADIUM two-layer analysis

Analyses performed by Dr. Eric Samson (SIMCO):

- **Sulfate at the saltstone-concrete interface**
  - initial concentration is lower than PA
  - concentration decreases through time, whereas PA uses a constant value
- ☺

Damage mechanics analysis

WM2010



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PROBABILISTIC DURABILITY ANALYSIS OF CEMENTITIOUS MATERIALS UNDER COMBINED SULFATE ATTACK AND CALCIUM LEACHING

S. Sarkar[1], S. Mahadevan[1], J.C.L. Meeussen[2], H. van der Sloot[2], K.G. Brown[1], D. S. Kosson[1]

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Consortium for Risk Evaluation with Stakeholder Participation (CRESP)

WM2010 Conference
Phoenix, Arizona

March 7-11, 2010

ECN

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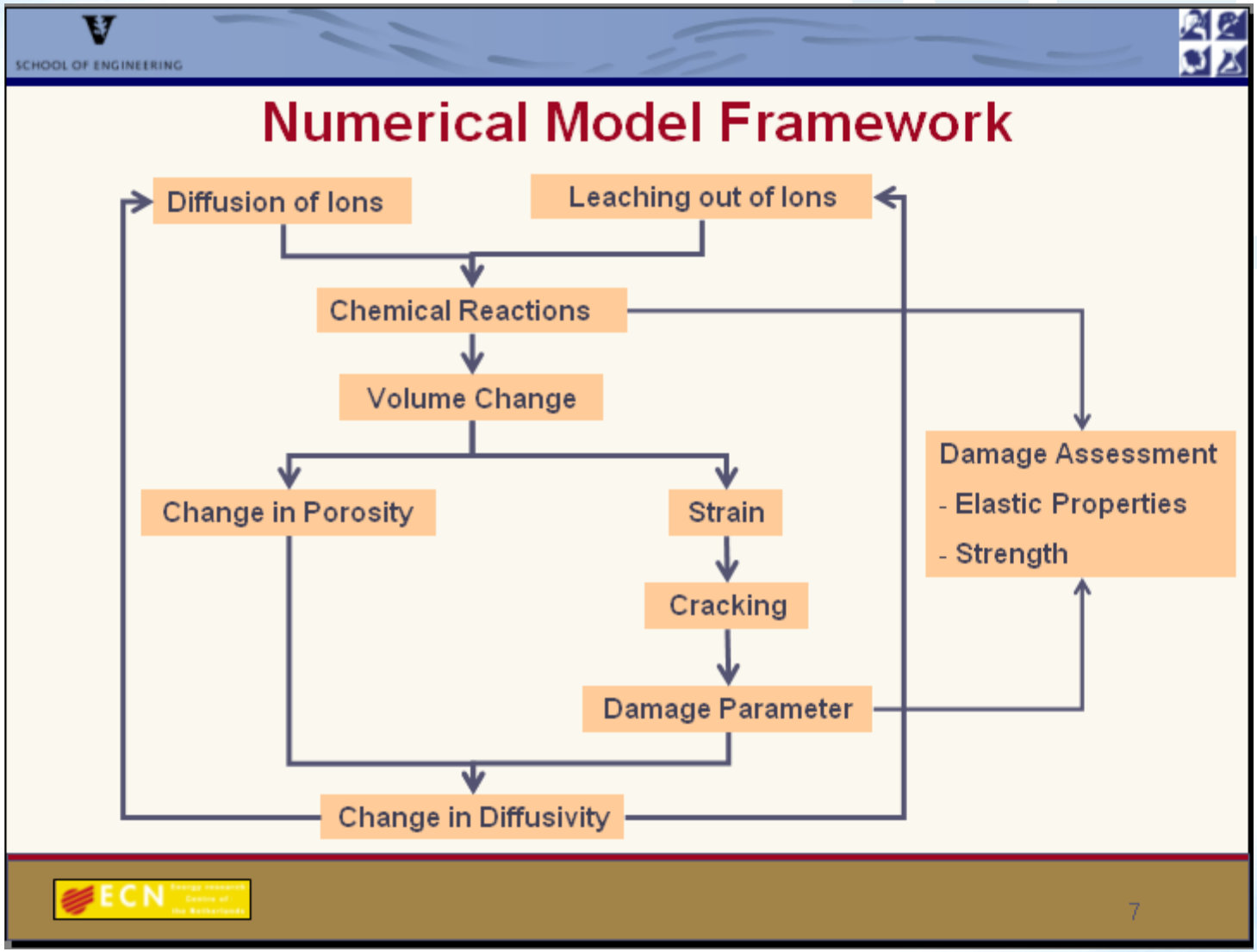
Damage mechanics analysis



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Damage mechanics analysis

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Damage Accumulation due to Cracking

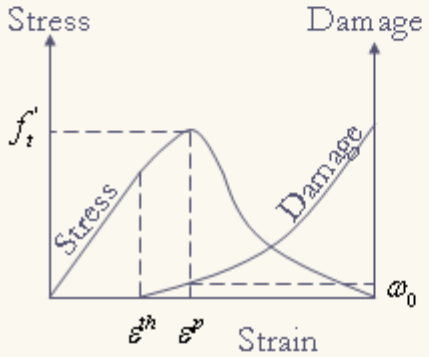
- Nonlinear Ascending Region
  (Karihaloo, 1995, Budiansky and O'Connell, 1976)

Crack density parameter

$$C_d = k\left(1 - \frac{\varepsilon^{th}}{\varepsilon}\right)^m$$

Damage parameter

$$\omega \approx \frac{16}{9} C_d$$



- Nonlinear Descending Region
  (Nemat-Nasser and Hori, 1993)

Fracture Mechanics

$$\frac{\sigma}{f_t'} = \sqrt{\frac{\tan(\pi\omega_0/2)}{\tan(\pi\omega/2)}} \quad \text{and} \quad \frac{w}{w_0} = \frac{\sigma}{f_t'}\left(\frac{\log(\sec(\pi\omega/2))}{\log(\sec(\pi\omega_0/2))}\right) - 1$$

Effective Young's Modulus

$$E_{eff} = \overline{E}(1-\omega)$$

$\overline{E} \rightarrow$ Homogenization scheme

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Damage mechanics analysis

Status

- Awaiting laboratory measurements to initialize model
- Results in expected in Summer 2010

Anticipated PA support

- **Gas and liquid phase carbonation and oxidation of slag-bearing concrete and saltstone**
  - key to Tc-99 immobilization
  - LeachXS/Orchestra development underway
- **Corrosion environment for steel tank sandwiched by cementitious materials**
  - tank closures, D&D