How do we treat cement in performance assessment?

Fiona Neall
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Outline

• Using cement-based materials
  ➢ The pros
  ➢ The cons
• How do we account for cement-based materials in PA?
• What are the problems?
• What might we do better?
• Not a comprehensive review but intended to be thought-provoking
Using cement-based materials
Using cement-based materials

• Structural concrete
• Shotcrete linings of underground openings
• Grouting of fractures for groundwater/stability control
• Cement-based backfill mortars
• Waste package - containers & grouts

Advantages:
✓ Convenience as an engineering material
✓ Flow properties for grouts
✓ Cost and convenience as a backfill/grout
✓ Centuries of experience and knowledge
✓ ‘Favorable’ chemical properties
Using cement-based materials

- Structural concrete
- Shotcrete tunnel/vault linings
- Grouting of fractures for groundwater/stability control
- Cement-based backfill mortars
- Waste package grouts

Disadvantages:
- Chemical incompatibility with host rock
- Chemical incompatibility with other EBS components

For L/ILW – the pros tend to outweigh the cons
For HLW and spent fuel – the cons outweigh the pros
Results for the OPA Reference Case (Nagra 2002)

Top figure: Spent fuel
Middle: HLW
Bottom: LL-ILW
Treating Cement in L/ILW Assessments

1. Cement chemical degradation
   • key process $\rightarrow$ high pH conditions in the near field
Chemical degradation of cement in saline groundwater (Campbell & Krupka 1997)
1. Cement chemical degradation
   • key process → high pH conditions in the near field
   • We want to know:
     • how long it lasts, and
     • what affects how long it lasts
   • Cement degradation modelling is based on:
     ✓ good understanding of the chemical system
     ✓ reasonable thermodynamic database
     † often an unrealistic, simplistic transport model that is said to be ‘conservative’
Treating Cement in L/ILW Assessments

2. How do we apply transport to cement degradation?
   a) Mixing tank model of the near field
      - all the radionuclides are mixed homogeneously into ‘model cement’ and then ‘leached out’ of the resulting material
   b) ‘Conservative’ transport assumptions in the vault/tunnel and waste packages
      - no benefit is taken for barrier functions in waste packages
      - preferential transport through more permeable volumes is not considered
      - no link between chemical changes and physical properties, particularly, permeability
Treating Cement in L/ILW Assessments

3. Does this conservatism matter?
   • Are the conservatisms truly conservative?
     ➢ i.e. can you demonstrate that they do result in less favourable performance?
Mixing Tank v. Transport Within the Vault

Radionuclides ‘leached’ as cement degrades
→ ? releases higher at early times

Radionuclides transported from failed WPs, sorb/co-ppt in backfill until backfill is degraded → ? lower early releases but higher later releases
3. Does this conservatism matter?
• Are the conservatisms truly conservative?
  ➢ i.e. can you demonstrate that they do result in less favourable performance?
• Is it useful if you’re comparing concepts?
• Is it useful if you’re trying to optimise the concept you have?
• Are your regulators happy that this approach demonstrates an appropriate level of understanding of your disposal system performance?
What’s My Point?

• A lot of good scientific work being done on cement-based materials and radioactive waste, e.g.
  ➢ extending understanding of the interaction between radionuclides and cement
  ➢ release of radionuclides from cement wasteforms
  ➢ impact of degrading organics on cement matrices
  ➢ how aging and carbonation of cement affects degradation and high pH longevity

• But why are we bothering with the detailed chemistry if we’re neglecting the transport?
Wish List (some are already on the radar..)

• Improved understanding of how chemical changes during degradation impact on permeability and transport
• Improved understanding and depiction of heterogeneity in transport models for ILW vaults and caverns
• Improving understanding of the role of ‘other’ processes:
  - carbonation (atmospheric, groundwater and organic waste-related) on cement degradation and transport properties (and for the ADZ for HLW/SF disposal)
  - co-precipitation (carbonate, sulphate, C-S-H minerals) on radionuclide retardation
• Should there be a Task in this WG on building the processes into less conservative/more realistic transport model?
Take Away Thoughts…

• Are we thinking about how projects aimed at improving understanding and knowledge of cement-based materials can feed into the safety assessment at each programme stage?

• In order to incorporate processes in SA models, what extra steps do we need to take?

I think we could do a lot more with a cementitious near field if we paid more attention to transport