Impact of Curing Temperature on Permeability of Cementitious Waste Forms

John R. Harbour and M. Frances Williams, SRNL

Objectives

- Measure the hydraulic conductivities of LAW cementitious waste forms (in this case, Saltstone) as a function of curing temperature
- Use the Unsaturated Flow Apparatus (UFA) centrifuge method to measure permeabilities and compare results with those obtained using a conventional permeameter (MACTEC)
- Correlate dynamic Young's moduli values with the hydraulic conductivities for these mixes
- Monitor changes in the microstructure with curing temperature using Scanning Electron Microscopy (SEM)

Experimental

Cementitious Materials

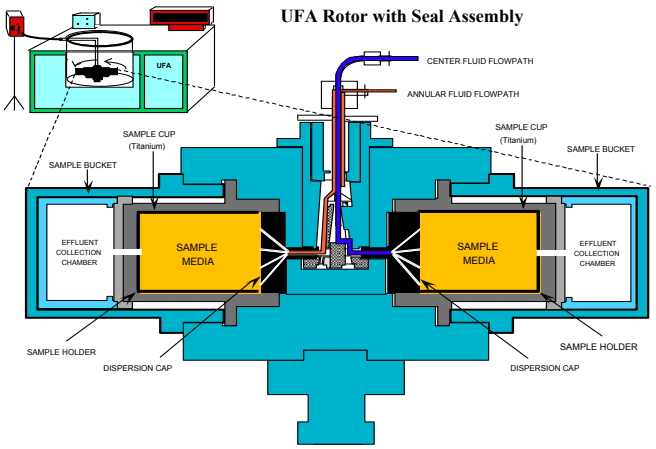
Material	Category	Vendor	Premix wt %
Portland Cement	Type II	Holcim	10
Blast Furnace Slag	Grade I	Holcim	45
Fly Ash	Class F	SEFA	45

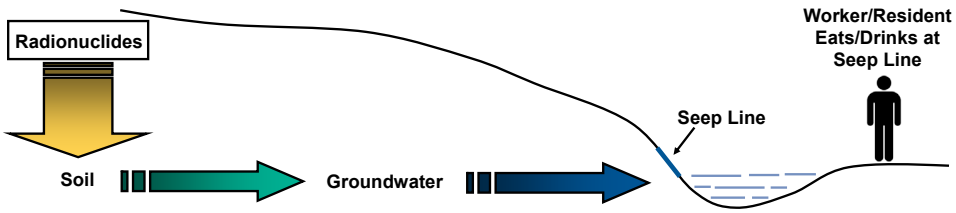
Simulated Waste Streams (M)

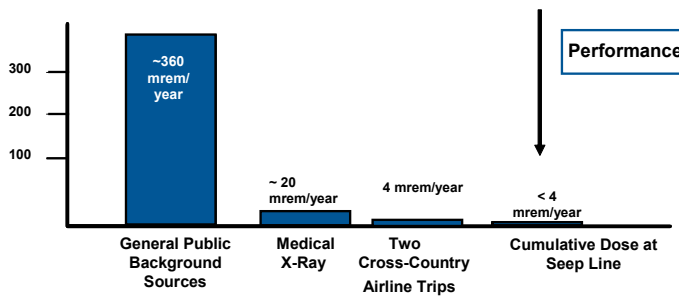
Material	Low Aluminate	High Aluminate
NaOH (free OH)	1.80	1.80
$NaNO_3$	2.36	2.36
$NaNO_2$	0.55	0.55
Na_2CO_3	0.18	0.18
Na_2SO_4	0.06	0.06
$Al(NO_3)_3 \cdot 9H_2O$	0.05	0.22
$Na_3PO_4 \cdot 12H_2O$	0.01	0.01

Permeability UFA

The UFA system is an ASTM method for measuring liquid permeability of porous materials. The technique uses a centrifuge with continuous flow of liquid through the sample during centrifugation. The pore (or permeant) solution is collected as shown.







Performance Objective

Input to the Performance Assessment

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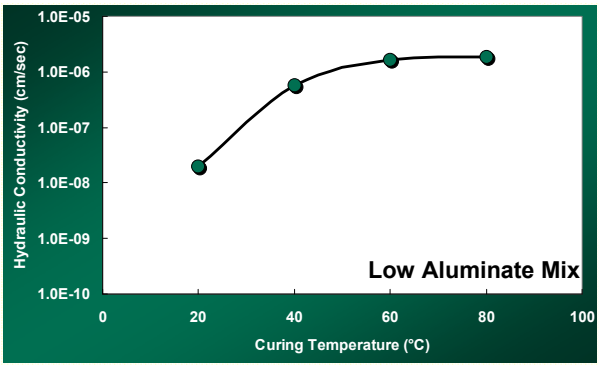
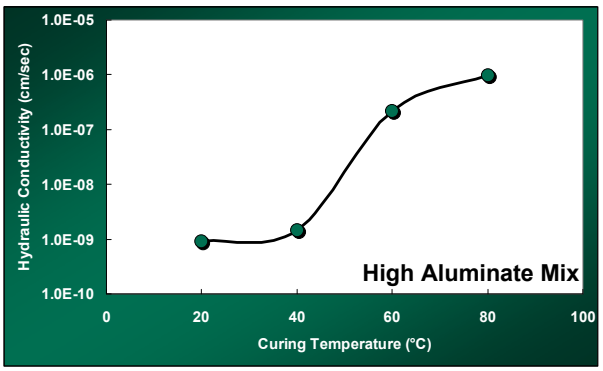
Hydraulic Conductivity vs. Curing Temperature of the Grout Mixes

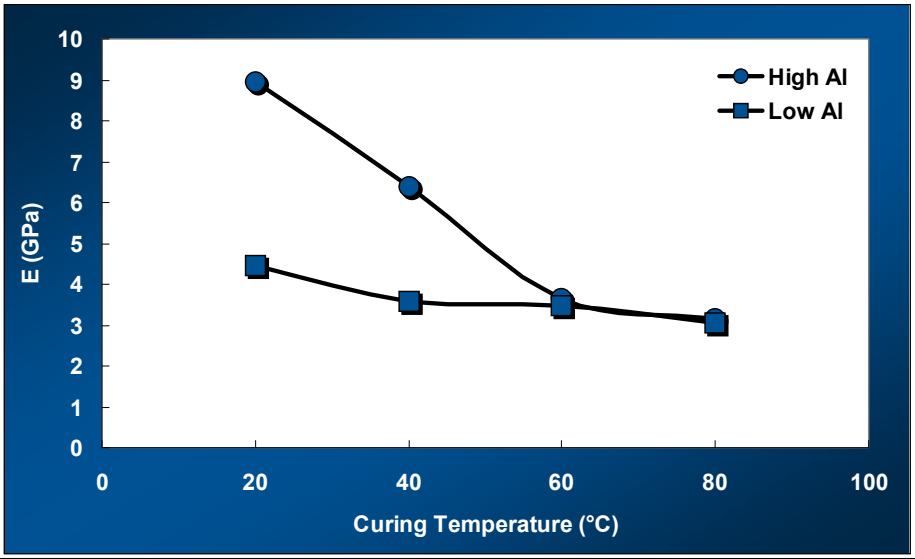




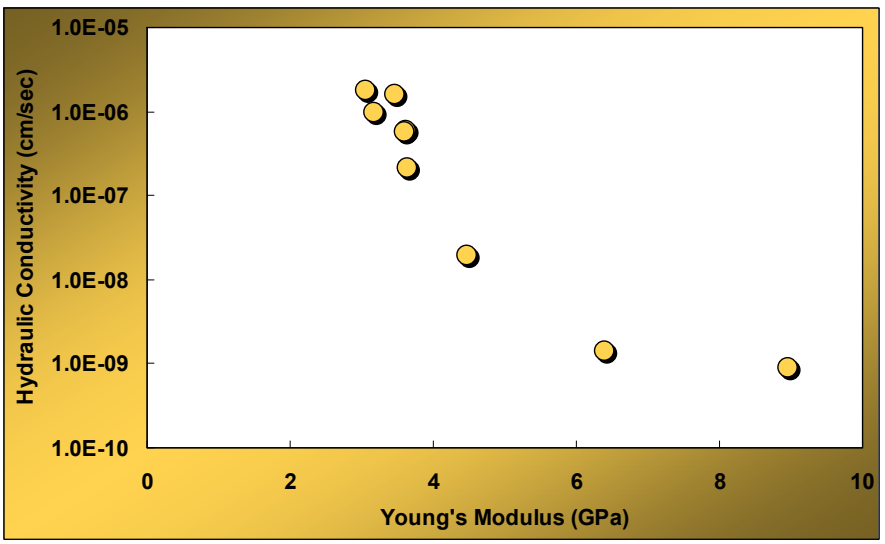
These Figures show the significant dependence of hydraulic conductivity on curing temperature. These measurements were performed after 28 days of curing.

Dynamic Young's Modulus (E) vs. Curing Temperature

For 20 °C curing, the higher aluminate mix has a higher E value. However, the E values for the low and high aluminate mixes become identical at higher curing temperatures



Hydraulic Conductivity vs. Young's Modulus



This figure (containing both low and high aluminate mixes) shows that E values can be used to evaluate the performance of the Saltstone mixes

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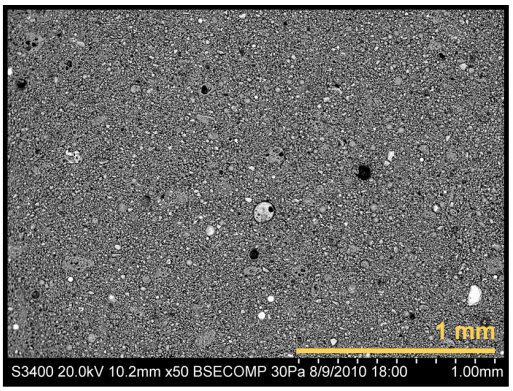
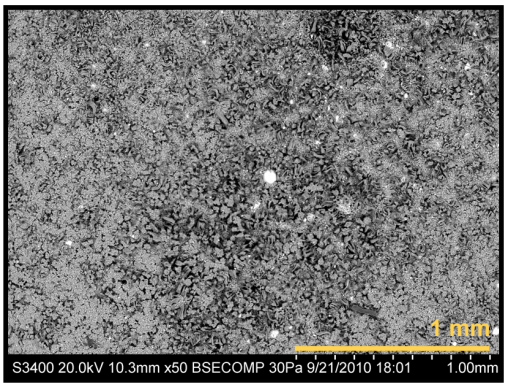
SEM Images of the Cured Grouts as a Function of Curing Temperature – David Wingard Clemson

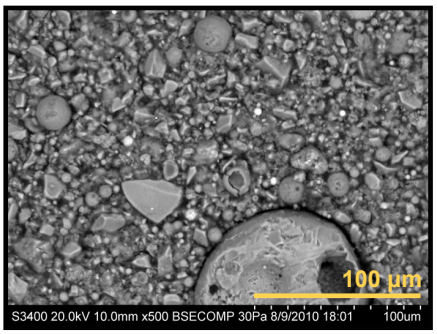
40 °C Polished



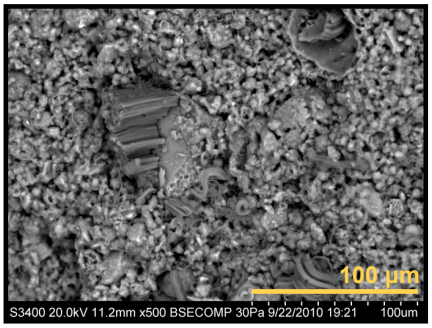
60 °C Polished



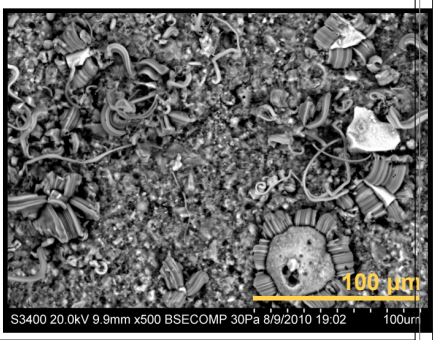
40 °C Polished



60 °C Fractured

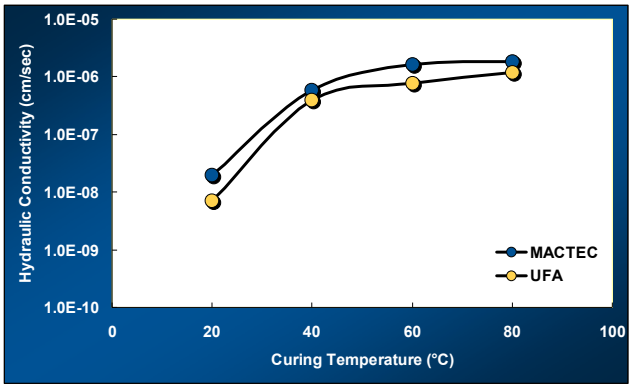


60 °C Polished



Comparison of MACTEC vs. UFA Permeability Measurements

These data demonstrate that the permeability results from the UFA system are consistent with results obtained using a conventional permeameter (MACTEC)



Low Aluminate

Conclusions

- **Hydraulic conductivities increase significantly with increasing curing temperature**
- **Dynamic Young's modulus values correlate with the hydraulic conductivities**
- **The UFA centrifuge method agrees with the results using the conventional permeameter method but with a bias**
- **SEM reveals changes in the microstructure as a function of curing temperature that appear to correlate with permeability changes**

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