Saltstone Processing of Low-Level Waste at Savannah River Site

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INTRODUCTION;

The process and safe storage of low-level radioactive waste at Savannah River site is of concern. The Saltstone formulation (a cementitious mixture) must produce a grout waste form that meets both placement and performance properties. Saltstone is a breakthrough process that not only encloses the tanks, but absorbs some of the damaging chemicals to be transported offsite.

METHODOLOGY;

Some of the experiments that will yield results as to the perfect premix ratio for the Saltstone that will be poured into the vaults include:

- **Leach Testing -** Percolating sample for pH, conductivity and release of contaminants
- **Concrete Compression Testing -** Strength of sample
- **Blaine Fineness Testing -** Measures Air Permeability of dry cementitious materials
- **Hydraulic Conductivity Testing -** Measure the capability of a medium to transmit water
- **Moisture Content Analysis -** Performance for Bulk Drying

BLAINE FINENESS TESTING:

- The testing conducted in the Savannah River National Laboratory was followed using the *ASTM C 204-00* Standard Test Method for Fineness of Hydraulic Cement by Air Permeability Apparatus.

❖**Nature of the Apparatus –** The Blaine air-permeability apparatus consists of the following parts:

Image 1: Blaine Fineness Apparatus and instructions

Image 2: Blaine Fineness Apparatus

- Permeability Cell
- Perforated disk
- Filter Paper
- Manometer
- Manometer Liquid
- Timer

❖ Two major reasons why this apparatus was chosen to determine the porosity are:

- Sample testing of NIST Standard Portland cement and the Holcim Portland cement are expensive (approx. $1600)
- Usually takes several work days to get results.

Image 3: 3" x 6" cylinder during compression

Before

Image 4: 3" x 6" cylinder during compression

During

Image 5: 3" x 6" cylinder during compression

After

Image 3: Data input into Compression Machine

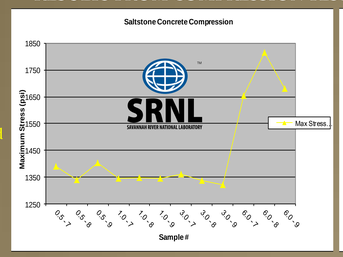
Image 4: Sample in Compression Machine Before Testing

Image 5: Final values from compression testing

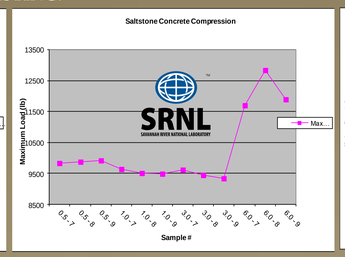
CONCRETE COMPRESSION TESTING:

- The *ASTM C39/C39M – 12* test methods consist of applying a compressive axial load to molded cylinders or cores at a rate which is within a prescribed range until failure occurs.
- Care must be exercised in the interpretation of the significance of compressive strength determinations by this test method since strength is not a fundamental or intrinsic property of concrete made from given materials.
- The results from the concrete compression testing that was conducted on Saltstone samples:
  - (0.5-7) , (0.5-8) , (0.5-9)
  - (1.0-7) , (1.0-8) , (1.0-9)
  - (3.0-7) , (3.0-8) , (3.0-9)
  - (6.0-7) , (6.0-8) , (6.0-9)

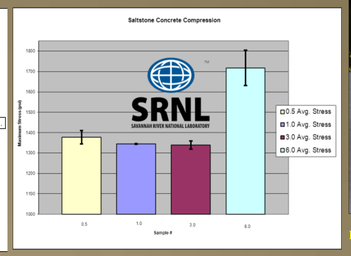
RESULTS FROM COMPRESSION TESTING:



Graph 1: Maximum Stress of each Sample



Graph 2: Maximum Load of each Sample



Graph 3: Avg. Stress of each Sample

These results clearly indicate that the layering process of the pour weaken the concrete sample. But the million dollar question is how much it will weaken the sample. With further examination of the results that were yielded, the 1 layer cylinder performed the best with an average stress level of 1717.33 lb/in² meanwhile all of the other samples gave similar results that lingered around 1350 lb/in² until failure.

LABORATORY TESTING via AMEC Environment & Infrastructure Co.:

- *ASTM D5084-03 Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.*
- AMEC: Environment & Infrastructure Co. has provided us with a full report regarding the hydraulic conductivity of the samples that we have been testing in our laboratories.
- Upon inspections of their report I have the following information:

SAMPLE #	Water Content (%)	Saturated Weight (pcf)	Dry Weight (pcf)	Hydraulic Conductivity (cm/sec)
0.5 - 1	43.7	106.4	74.0	1.6×10^{-9}
0.5 - 2	44.9	105.9	73.1	4.2×10^{-9}
0.5 - 3	44.1	107.6	74.7	3.1×10^{-9}
1.0 - 1	44.3	106.0	73.5	4.0×10^{-8}
1.0 - 2	44.1	106.1	73.7	2.4×10^{-7}
1.0 - 3	43.8	105.9	73.6	1.8×10^{-7}
3.0 - 1	44.8	107.1	74.0	2.3×10^{-9}
3.0 - 2	44.5	107.5	74.4	2.0×10^{-9}
3.0 - 3	44.4	108.7	75.3	1.4×10^{-9}
6.0 - 1	44.1	105.8	73.4	5.9×10^{-11}
6.0 - 2	43.4	107.2	74.8	1.6×10^{-9}
6.0 - 3	44.0	107.0	74.3	2.6×10^{-10}

Table 1: Hydraulic Conductivity Results for Specific Samples

LEACH TESTING:

The Leach Testing method is used to determine what kind of affect the Saltstone grout mixture will have after it has stabilized the cesium located in the waste tanks. The samples will be determined using a chromium sample in the laboratories to simulate the effects that can be done to the environment around the Savannah River Site. This test method can be used to:

- Compare releases of waste components from various types of solidification agents and formulations.
- Determine diffusion coefficients for the release of waste components from waste forms at any specific temps.
- Promote extents of reaction than can be achieved under expected service conditions within a lab time-frame
- Determine the dependence of time for diffusive release.

Two tables with the results for each of the leach test samples will be provided as shown:

Leachate Exchange	Date/Time	6.0 - 4	6.0 - 5	6.0 - 6	Blank
	30s	56.4	67.8	50.5	1.07
1	2 hour	176.2	197.5	168.0	1.03
2	7 hour	340	342	211.5	0.99
3	24 hour	543	544	236.0	1.12
4	2 day	236.5	426	223.3	1.23
5	3 day	200.0	317	182.3	1.22
6	4 day	199.3	280.8	129.7	1.26
7	5 Day	269.9	223.0	229.7	0.99

Table 1: Electric Conductivity Results

Leachate Exchange	Date/Time	6.0 - 4	6.0 - 5	6.0 - 6	Blank
	30 sec	9.07	9.16	8.54	8.47
1	2 hour	10.09	10.13	9.99	7.50
2	7 hour	10.35	10.33	10.08	8.25
3	24 hour	10.55	10.60	10.22	8.50
4	2 day	10.16	10.48	10.21	8.60
5	3 day	10.16	10.34	10.14	8.77
6	4 day	10.44	10.60	10.27	8.04
7	5 Day	10.48	10.38	10.35	8.96

Table 2: pH Results

Image 6: Containers w/ Leachate Water

Image 7: Leaching Containers w/ Samples

Image 8: Leach Cylinder (3" x 6" Sample)

CONCLUSION:

The Saltstone mixture was put on rigorous experiments including Concrete Compression in which the 1 layer cylinder performed the best with an average stress level of 1717.33 lb/in² meanwhile all of the other samples gave similar results that lingered around 1350 lb/in² until failure. Results from the Leaching Tests also yielded pH levels of an average of 10 which meets EPA standards to be able to pour down regular septic tank drains. Maintaining a safe environment for the future generations is a major goal of the Department of Energy's Office of Environmental Management mission. The Saltstone grout mixture project significantly is making progress in the process and safe storage of low level radioactive waste at Savannah River site. The enclosure of the tank farms at SRNL by using the Saltstone approach will be something that will be mimicked by other nuclear facilities because this breakthrough process not only encloses the vault itself, but it absorbs some of the damaging chemicals that can potentially be transported offsite and contaminate the environment.

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