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Session TH27
Concrete Degradation Part 1

Structural Performance of NPP Concrete Structures Affected by Alkali-Silica Reaction (ASR)

Long Phan, Ph.D., P.E.
Long.phan@NIST.GOV
Engineering Laboratory
National Institute of Standards and Technology

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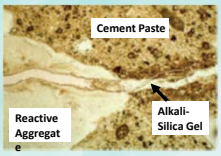
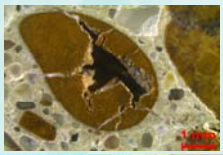
Alkali-Silica Reaction (ASR)

- Chemical reactions between the alkali hydroxides in pore solution of concrete and *metastable* forms of silica in reactive aggregate that forms alkali-silica gel.
- Alkali-silica gel is hygroscopic and will absorb water and expand, resulting in expansive pressure and both micro- and macro-cracking over time.
- Results in reduction of mechanical properties, stiffness, bond strength of concrete, and overall service life in dams, bridges, pavements, power plants, etc.
- Current RC design procedure and practice do not account for effects of ASR





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NIST Study Objectives and Outcome

- Develop **technical basis for regulatory guidance** to evaluate ASR-affected NPP through service life.
- Assess significance and quantify **effects of ASR on structural performance and capability** under design basis static and dynamic loads.

- Identify and describe **characteristics of an aging management program** to adequately monitor and manage aging effects of ASR.
- **Methodology for determining, for an existing ASR-affected structure, in-situ and future structural capacity.**

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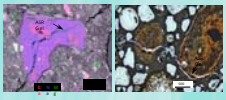
Technical Approach

- **Accelerate ASR** in experiments through mixture proportioning and curing



- Quantify **Degree of Reaction** over time (image analysis to measure volume percent of cracking and dissolution in paste and aggregate that is attributable to ASR).

- **Correlate changes** in microstructural features (microcracking, onset and evolution of ASR gel characteristics) with ASR-induced expansion, surface cracking, degradation of mechanical properties and structural capacities through experiments and modeling
- **Evaluate applicability** of existing RC design standards and methods

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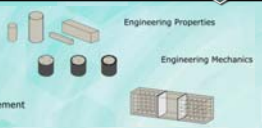
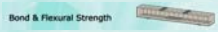
Research Plan: Five Tasks

Task 1: Assessing In-Situ Mechanical Properties



Task 2: Assessing Development and Lap-Splice Lengths of Reinforcing Bars



Task 3: Evaluating Seismic Performance of Structural Members

Task 4: Estimating the Degree of ASR and the Corresponding Expansion

Task 5: Predicting Future and Ultimate ASR Expansion

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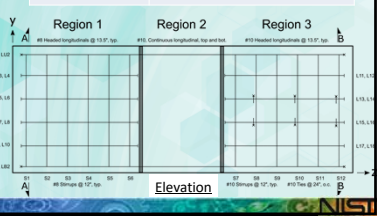
Research Progress: Task 1 – Block Specimens (10 ft × 6 ft × 4 ft)

Specimen Name	Target Free Expansion (ε_{ASR})
ASR 1	0.1%
ASR 2	0.3%
ASR 3	0.5%
Control	0%



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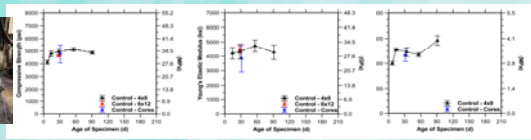
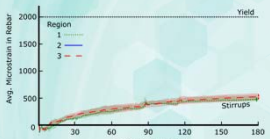
Research Progress: Task 1 – Block Specimens (cont'd)

Mechanical properties versus ages



Strain development versus ages



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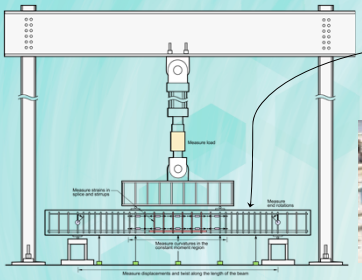
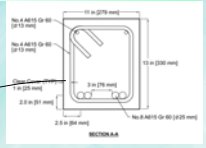
Research Progress: Task 2 – Beams





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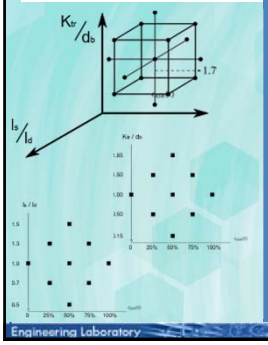
Task 2 – Beams (cont'd)



Specimen #	$\varepsilon_{ASR}(t)$	K_{tr} / d_b	Target l_s / l_d	l_s (in)
1	25%	0.5	0.7	18
2	25%	0.5	1.3	32
3	25%	1.5	0.7	12
4	25%	1.5	1.3	22
5	75%	0.5	0.7	18
6	75%	0.5	1.3	32
7	75%	1.5	0.7	12
8	75%	1.5	1.3	22
9	50%	1.0	1.0	22
10	50%	1.0	N/A	N/A
11	0%	1.0	1.0	22
12	100%	1.0	1.0	22
13	50%	0.0	1.0	32
14	50%	1.8	1.0	18
15	50%	1.0	0.5	10
16	50%	1.0	1.5	32
17	N/A	1.0	1.0	22
18	N/A	1.0	N/A	N/A
19	100%	1.0	1.0	22

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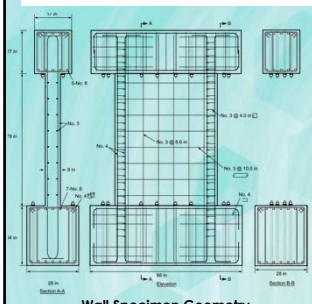
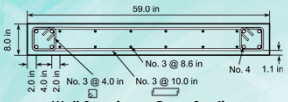
Task 3 – Seismic Performance of Walls



Wall Specimen Geometry

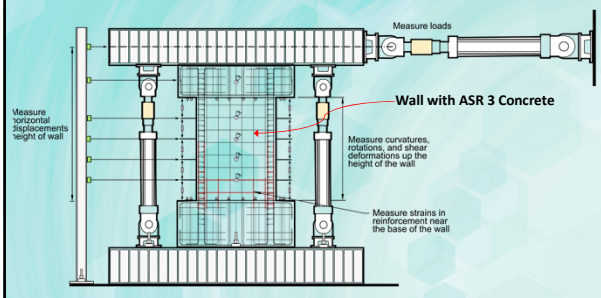


Wall Specimen Cross Section

Specimen No.		Boundary Elements	
	ε_{ASR} (t)	ρ_s (%)	Stirrup Spacing
1	0 %	2 %	4 in
2	50 %	0 %	-
3	100 %	2 %	4 in
4	100 %	0 %	-

Wall Specimen Variables

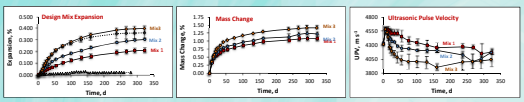
Task 3 – Seismic Performance of Walls (cont'd)



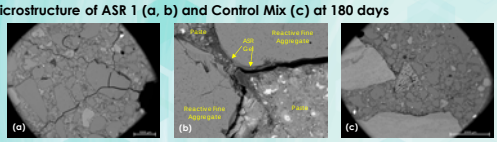
Seismic Lateral Load Test of Wall

Task 4 and Task 5 - Lab Prisms Measurements

1. Selected measurement parameters through ~320 days under ambient conditions



2. Microstructure of ASR 1 (a, b) and Control Mix (c) at 180 days



ASR 1 (0.15 % target), 180 days, 36x mag | ASR 1 (0.15 % target), 180 days, 1050x mag | ASR 4 (Control), 157 days, 36x mag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Thank you! Questions?
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