Constructability of a High Temperature Concrete Pad

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BUILDING STRONG®

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Presentation Outline

- Background
  - Issue
  - Objective
- Construction details
  - Pad design
  - Construction materials
- Approach
  - Small scale demonstrations
  - Medium scale demonstrations
  - Full scale construction
- Conclusions & Recommendations

Issue

- Short take-off and vertical landing (STOVL) aircraft have high exhaust temperatures
  - Ex: F-35B Joint Strike Fighter (JSF), V-22 Osprey, AV-8B Harrier
- Put extreme short term thermal load on airfield pavements during vertical landings (VL)
- Thermal load greater than conventional portland cement concrete (PCC) can withstand
- Explosive spalling = high foreign object damage (FOD) potential
- Tri-service effort to design & construct PCC STOVL pads to withstand multiple landings
  - NAVFAC: Geometric & PCC mixture
  - USACE & Air Force: Construction

Objective

Program

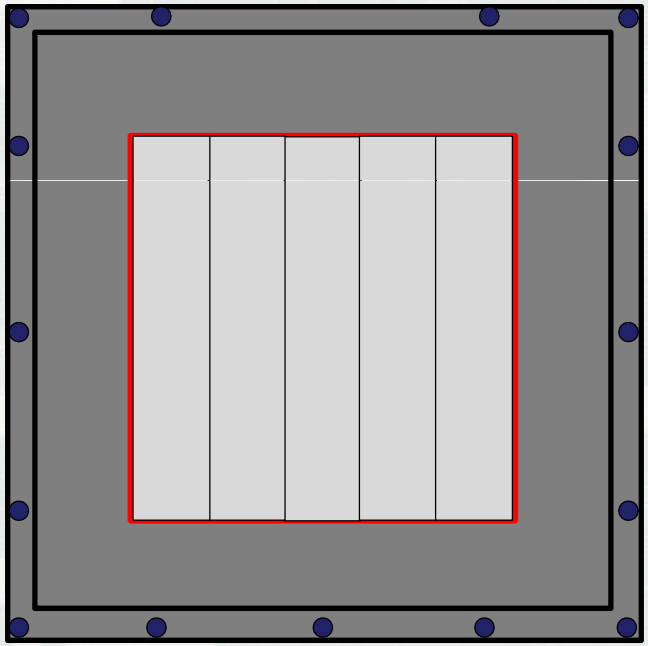
- Develop & validate heat resistant STOVL pad geotechnical & structural design for the JSF

ERDC

- Evaluate heat resistant material constructability
  - Verify full scale PCC mixture proportioning
  - Identify construction limitations
  - Revision of in-place documents
    - Geometric design - ETL 10-04: Joint Strike Fighter (JSF) F35-B Vertical Landing (VL) Pad Design
    - Construction specification - UFGS 32-13-99: High Temperature Concrete for Airfields
      - "Living" document

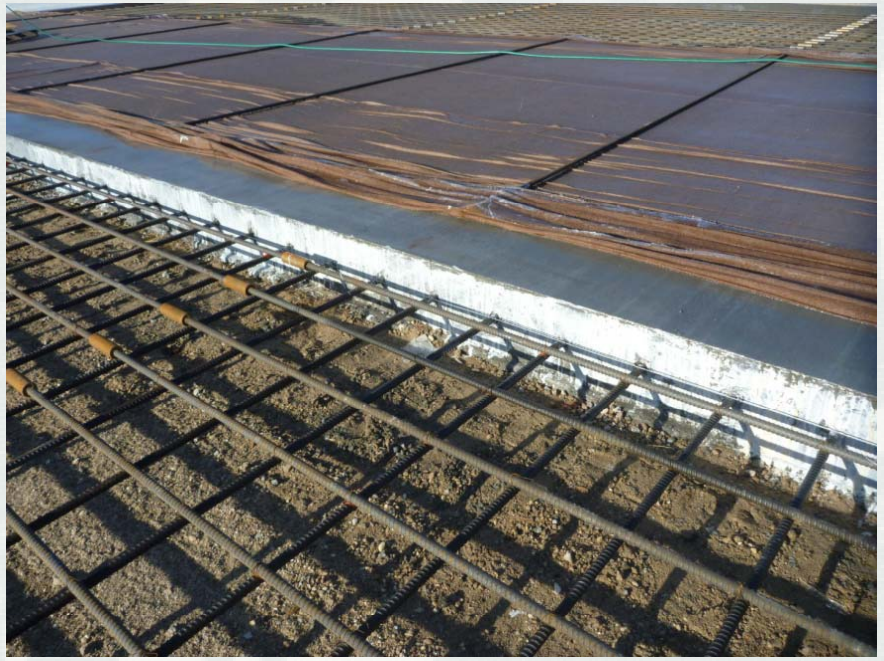
Pad Design

- First pads built at Eglin AFB, FL
  - First F-35B flight training base
- Dimensions
  - 12 in.-thick center landing zone: 100 ft x 100 ft
    - Continuously reinforced pavement
    - Optimized NAVFAC lightweight PCC
    - Focus of ERDC work
  - 12 in.-thick safety zone: 50 ft outside of landing zone
    - Jointed plain pavement
    - 650 psi flexural strength conventional PCC
  - 8 in.-thick shoulder: 10 ft outside landing zone
    - Jointed plain pavement
    - 650 psi flexural strength conventional PCC
  - Allows for 2-in. max surface grinding over lifecycle



Construction Materials

- 5 - 20 ft x 100 ft paving lanes
- #8 A722 Grade 120 rebar at 12 in. spacing
  - Dywidag thread bar
- Mechanical coupler bar splice
- 5.5 in.-high steel high chairs
  - Maintains rebar just below mid-depth
- Epoxy filler between construction joints
- 14 day wet cure after all concrete poured
  - Burlap and soaker hose/ponding
- Sodium silicate densifier applied to surface
  - 90 days after final placement

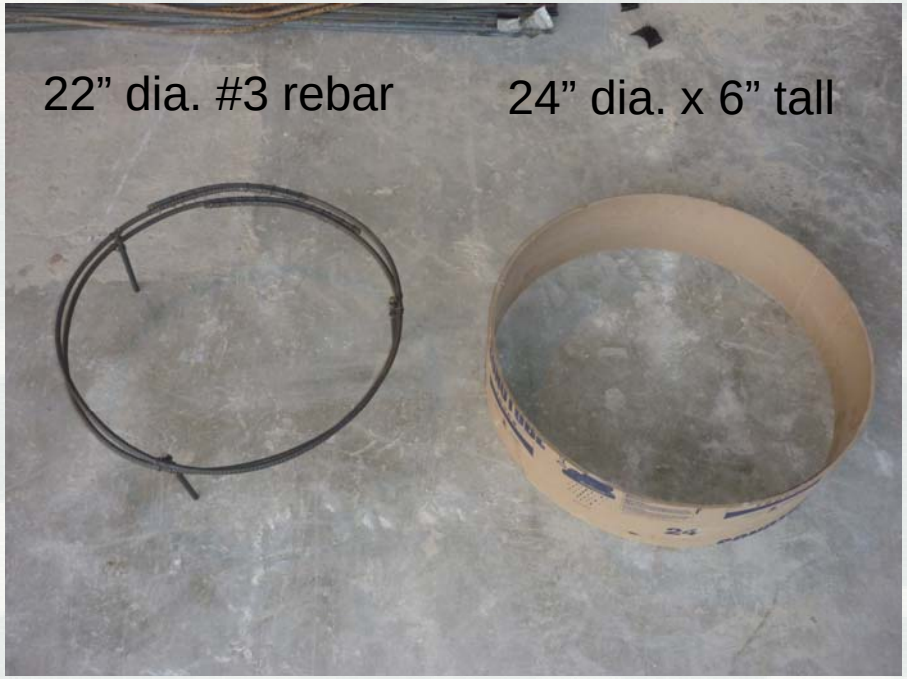


Construction Materials

- NAVFAC designed lightweight PCC mixture
  - Materials
    - Expanded slate aggregates
    - Type I/II portland cement
    - Class F fly ash
    - Air entraining admixture
    - Low & medium range water reducers
    - Polypropylene fibers
  - Target fresh properties
    - 3 ± 1 in. slump
    - 6 ± 1.5 % total air content
      - 3 - 4 % air loss during delivery
      - ASTM C173 measured
    - 100 - 105 lb/ft^3 unit weight
  - Target hardened properties
    - 550 psi flexural strength

Construction Materials

- NAVFAC heat resistant PCC verification testing



Disk sample materials

NAVFAC jet blast simulator

Approach

- Small scale construction demonstration (Vicksburg, MS)
  - July 2010 - Mixture design for contractors
  - August 2010 - High temperature joint sealant (ERDC & NAVFAC)
- Medium scale test section construction
  - 3 mix design verification demonstrations at the ready mix plant (Ft. Walton Beach, FL)
  - 2 test sections constructed by contractors (Eglin AFB, FL)
- Full scale STOVL pad construction
  - November 2010 to January 2011 - 2 STOVL pads (Eglin AFB, FL)

Small Scale Construction Demo

- First NAVFAC mixture batched greater than 6 ft^3
- Test panels cast to show contractors mixture
- Took input from contractors present to optimize mixture design for job

- <u>Lessons Learned</u>
  - Lightweight aggregates must be presoaked to control water demand
  - Aggregate properties vary more than expected
  - Slump, WR, and w/c ratio increased for fluidity
  - Mixture is deficient in available paste
  - Expected surface will not look “pretty”
  - Good fiber dispersion and consolidation

Small Scale Construction Demo

- Verify the NAVFAC sealant material application
- Test high temperature joint sealant on mixture
- Develop sodium silicate application method

- <u>Lessons Learned</u>
  - Apply sealant to dry-to-touch joint surface
  - Good sealant bond to NAVFAC mixture
  - Use shielding tape to achieve a clean surface
  - Hand spraying + brooming puddles effective for applying sodium silicate

Medium Scale Plant Batching Demo

- Verify that larger batches of NAVFAC mixture could be made with full scale production equipment
  - Larger test panels made at plant
  - Simulated transport time used
  - Jet blast samples made & sent to NAVFAC

- <u>Lessons Learned</u>
  - Cementitous content increased for more paste
  - Aggregate moisture must be carefully controlled
  - Aggregate contamination in stockpiles
  - Watch the plant production
    - ACI batching tolerances not applied
    - Equipment breakdowns
  - Required admixture rates are highly temperature dependent

Medium Scale Plant Batching Demo

- Verify that the NAVFAC mixture could be placed with full scale placement equipment
  - Full paving lane used for test section
  - Evaluate contractor's procedures & workmanship

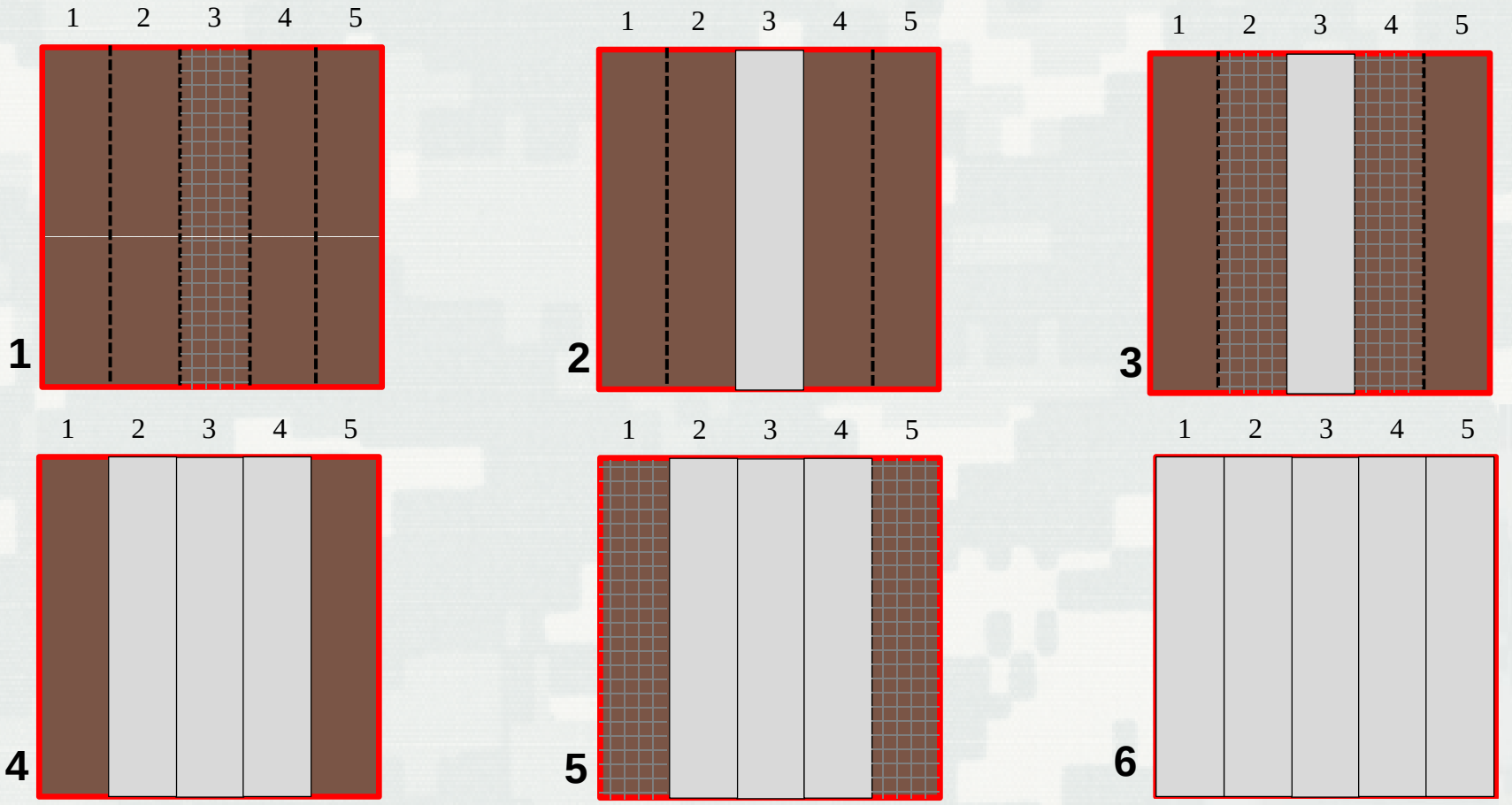
- <u>Lessons Learned</u>
  - Mixture modification too great to allow use of pump trucks following specification
  - Contractors needed to work on concrete work fundamentals
  - Good bond between rebar and concrete
  - Ensure aggregates are tested as delivered to modify mix design

Full Scale Construction

- Phasing
  - Safety Zone → Landing Area → Shoulder
  - Landing zone construction
    - Work from inside out → Efficient reinforcement placement
    - Alternate rebar placement and PCC pours per lane per pad → Speedy construction times
    - Minimum PCC construction window required: 9 days

Full Scale Construction

- Landing zone construction phasing



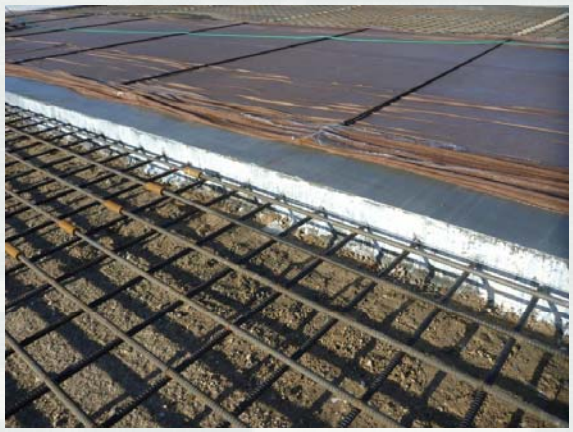
Full Scale Construction

Rebar placement of interior lane

Full Scale Construction







Rebar placement of exterior lanes

Full Scale Construction





Concrete placement – telescopic conveyor truck

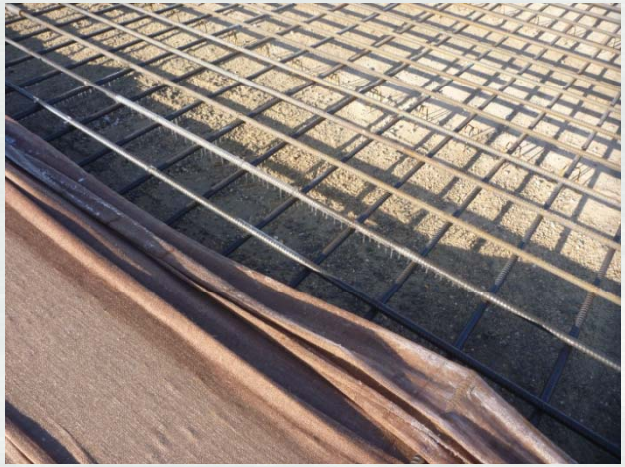
Full Scale Construction

Concrete placement – emergency tailgating interior lane

Full Scale Construction

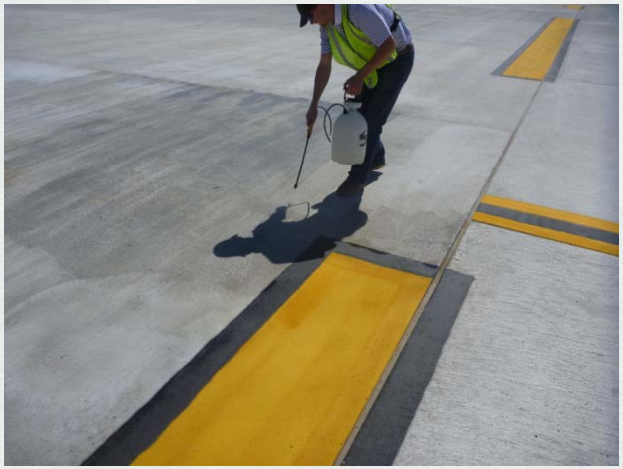
Concrete placement – tailgated

Full Scale Construction



Curing

Full Scale Construction



Sodium silicate application

Full Scale Construction

Final Product

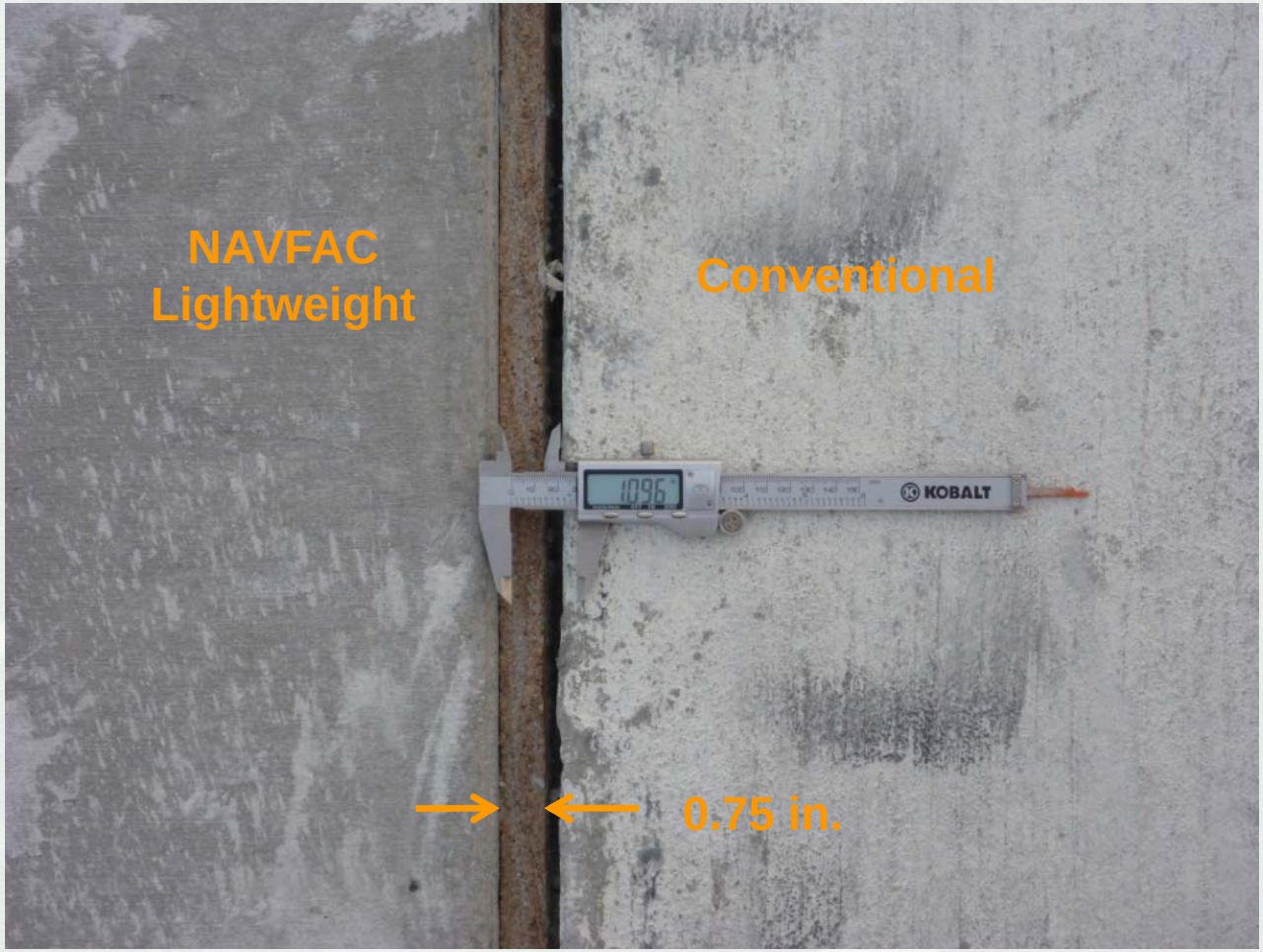
Full Scale Production

Tight shrinkage cracking as expected

Full Scale Production

Texture scaling

Full Scale Production

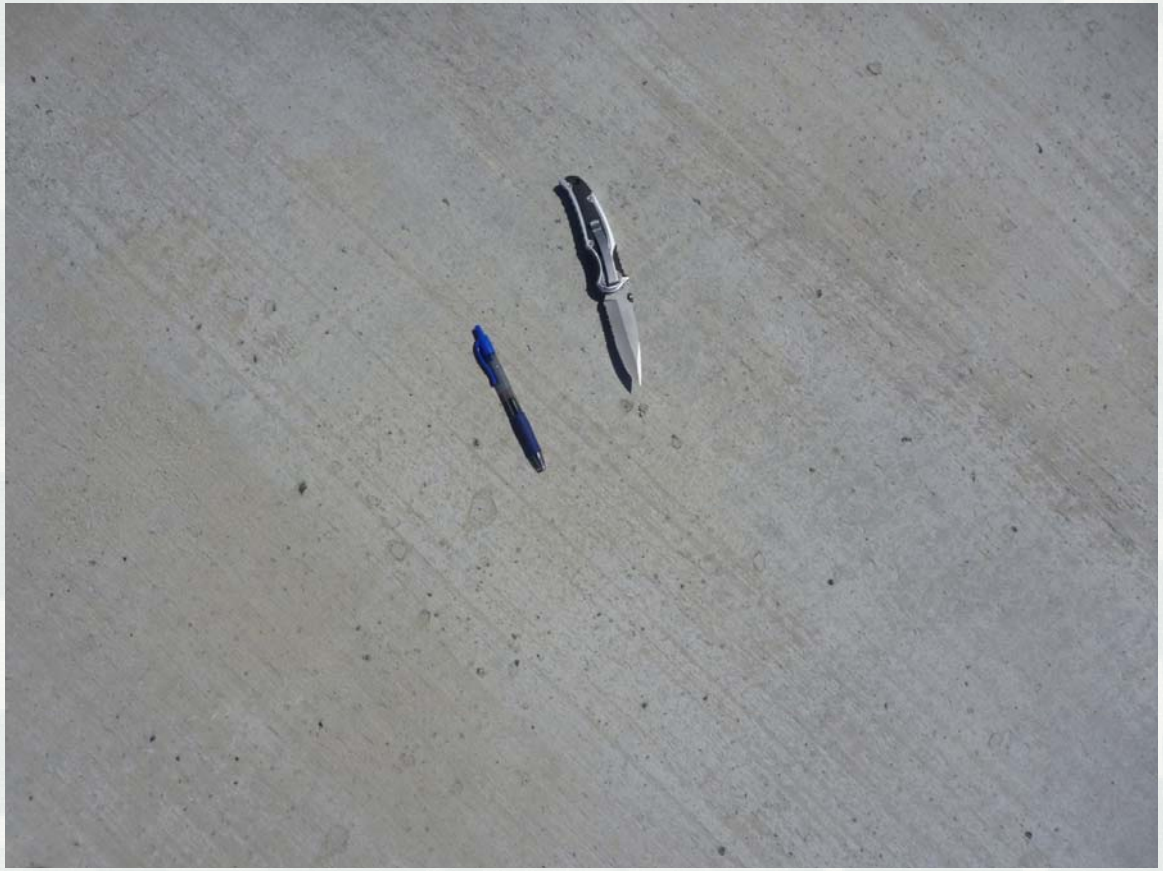


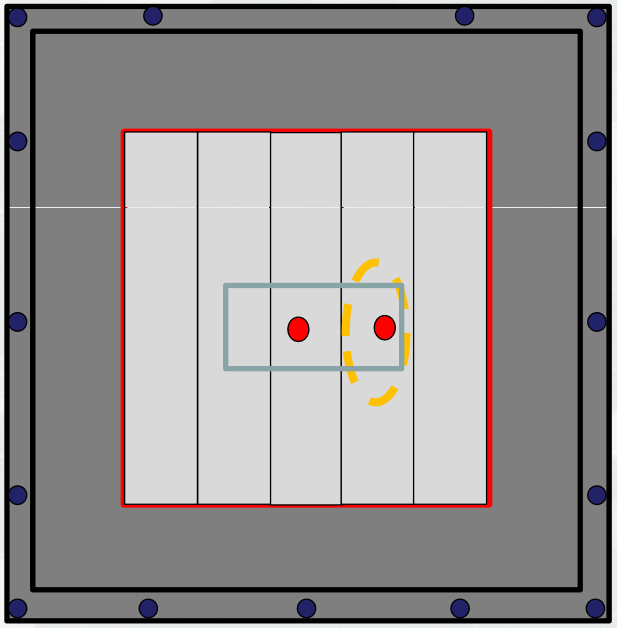
Large amount of dry shrinkage observed

Full Scale Production

Field molded silicone joint sealant used on all safety zone joints

Full Scale Production



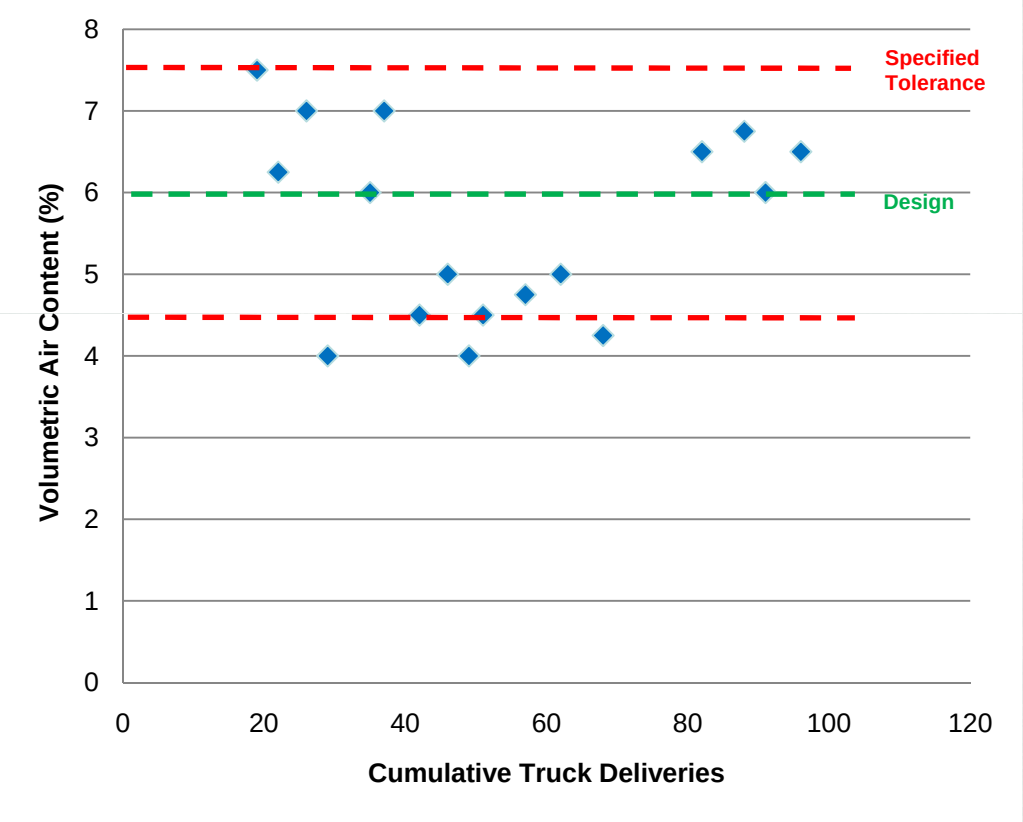


Mysterious Popouts on North Pad

Conclusions & Recommendations

- More paste should be available to apply appropriate texture or other measures should be taken
- Ensure correct materials and specifications are being followed
  - High chairs
  - Air entrainer dosages
  - Concrete material property testing & modifying mixture design
  - Aggregate moisture contents & control of water in PCC production critical
- Placement equipment requirements expanded to include tailgating
- Unsure of aggregate contamination effects on thermal performance at surface
- Use of specified fine sand gradation should be changed to a coarser gradation
- Rebar configuration used worked well & other options should be removed
- Entire pad should be sprayed with 9%$_m$ Sodium silicate solution
- Better methods for applying sodium silicate evenly should be used
- Performance not verified since no aircraft have used pads yet
  - Shrinkage cracking held tight together

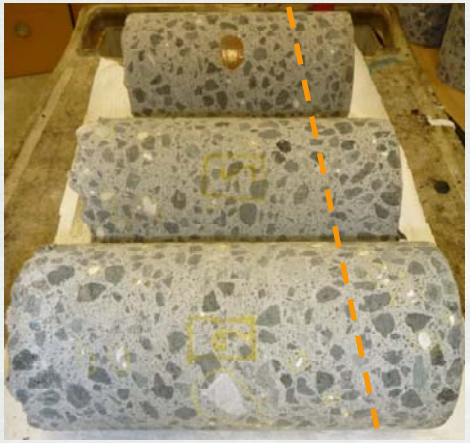
Conclusions & Recommendations



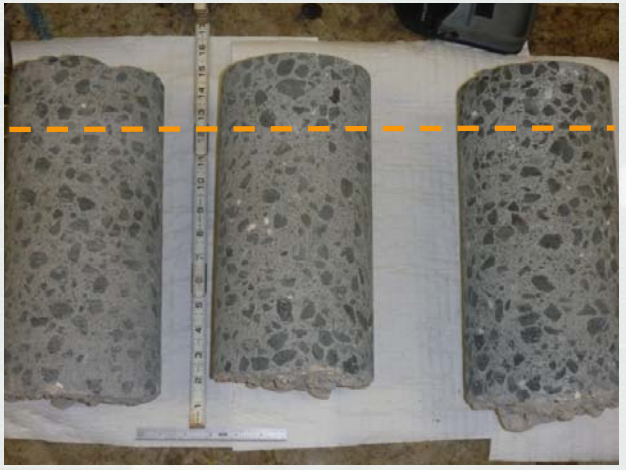
UFGS 32-13-11 Specification		
Take Action at		Action
Level	Value (%)	
Individual test control chart		
Watch	± 1.0	adjust AEA, retest
Warning	± 1.5	halt operations, repair, retest
Range between 2 consecutive tests		
Watch	2.0	recalibrate AEA dispenser
Warning	3.0	halt operations, repair, retest

Ensure correct materials and specifications are being followed – Air content

Conclusions & Recommendations



FOD Hazard?



Aggregate contamination

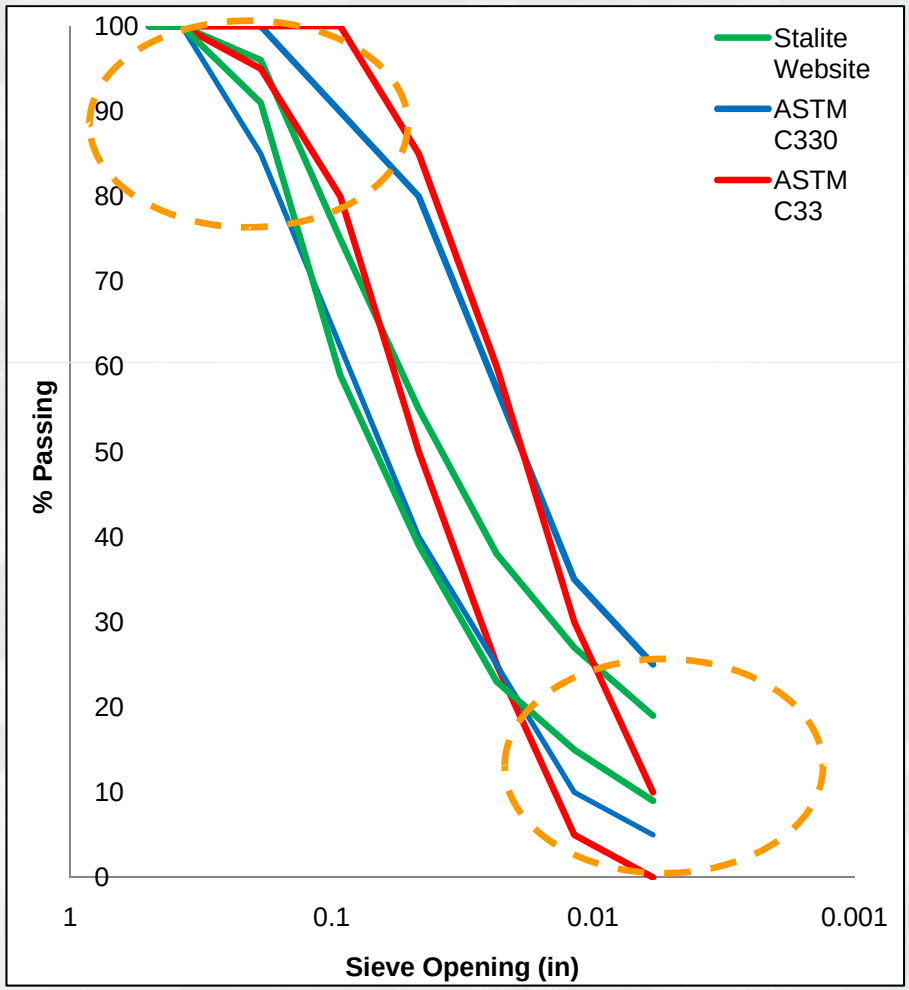
Conclusions & Recommendations

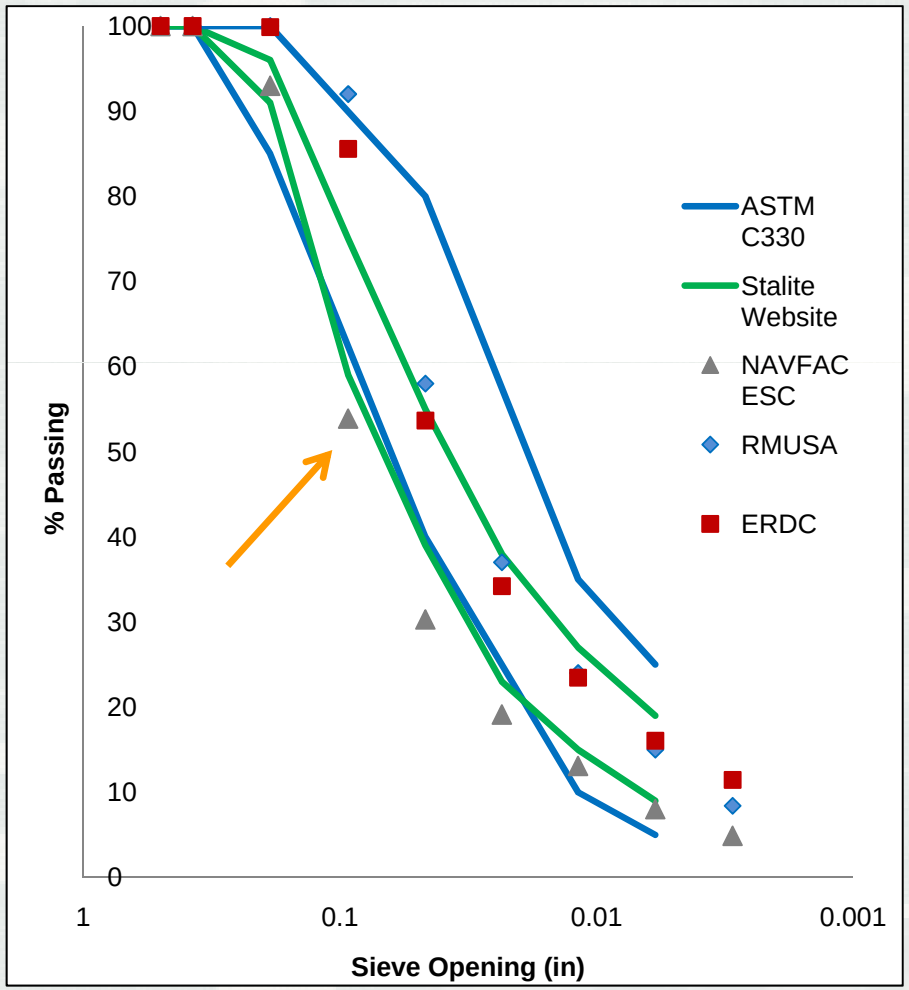
Aggregate Size	Comparison of Measured Laboratory Physical Properties by Organization					
	Property	**Stalite**	**NAVFAC**	**ERDC**	**RMUSA**	**ERDC**
0.75”	BSG	1.52 [1.47-1.54]	1.54	1.52[a]	1.50	1.50
	ABS	6.0	NA	10.1[a]	3.8	4.2
	Gradation	ASTM C330 for 1.5-in max	Fails ASTM C330	-	Passes ASTM C330	Passes ASTM C330
0.375”	BSG	1.60 [1.57-1.64]	1.55	1.52[a]	1.53	1.61
	ABS	6.0	NA	10.1[a]	4.6	6.6
	Gradation	ASTM C330 for 0.5-in max	Fails ASTM C330	-	Passes ASTM C330	Passes ASTM C330
Fine	BSG	1.75 [1.70-1.80]	1.79	1.95	2.01	1.93
	ABS	6.0	NA	3.0	4.6	3.5
	Gradation	Not ASTM C33 Within ASTM C330	Fails Stalite Fails ASTM C330	Fails Stalite Passes ASTM C330	Fails Stalite Passes ASTM C330	Passes Stalite Passes ASTM C330
Date Tested		Website (typical)	March 2010	June 2010	July 2010	November 2010

[a]Blended

Ensure correct materials and specifications are being followed – aggregate properties

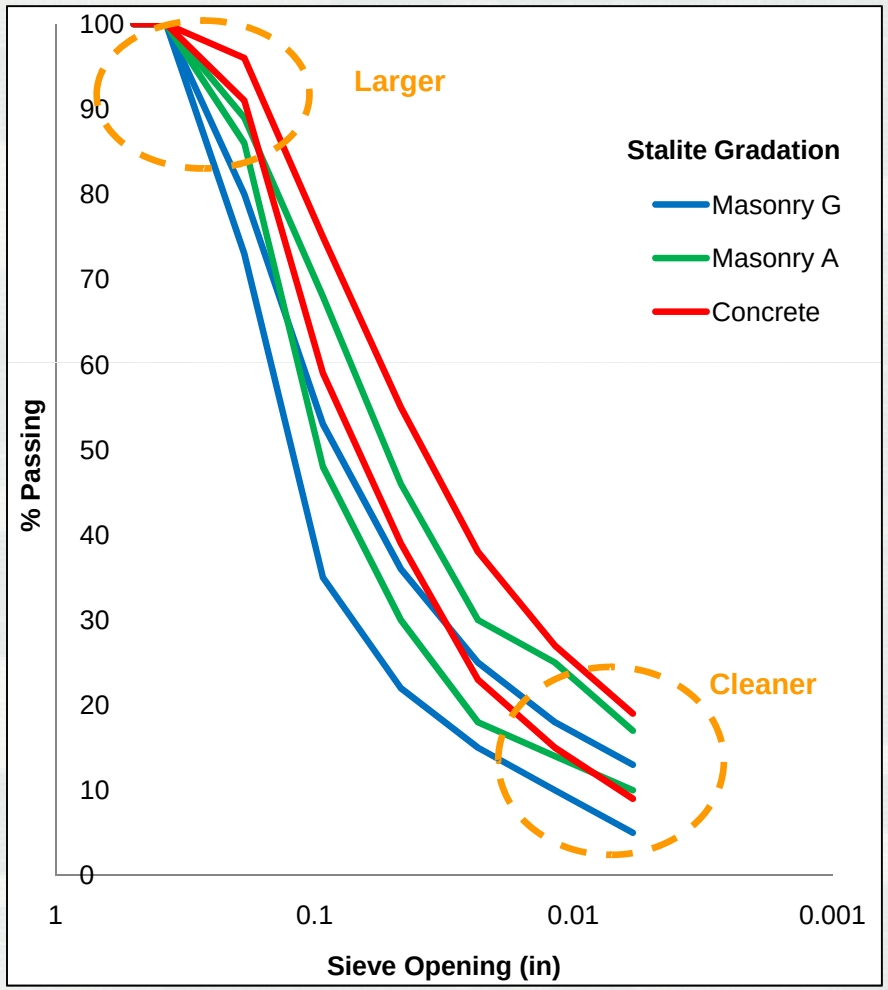
Conclusions & Recommendations

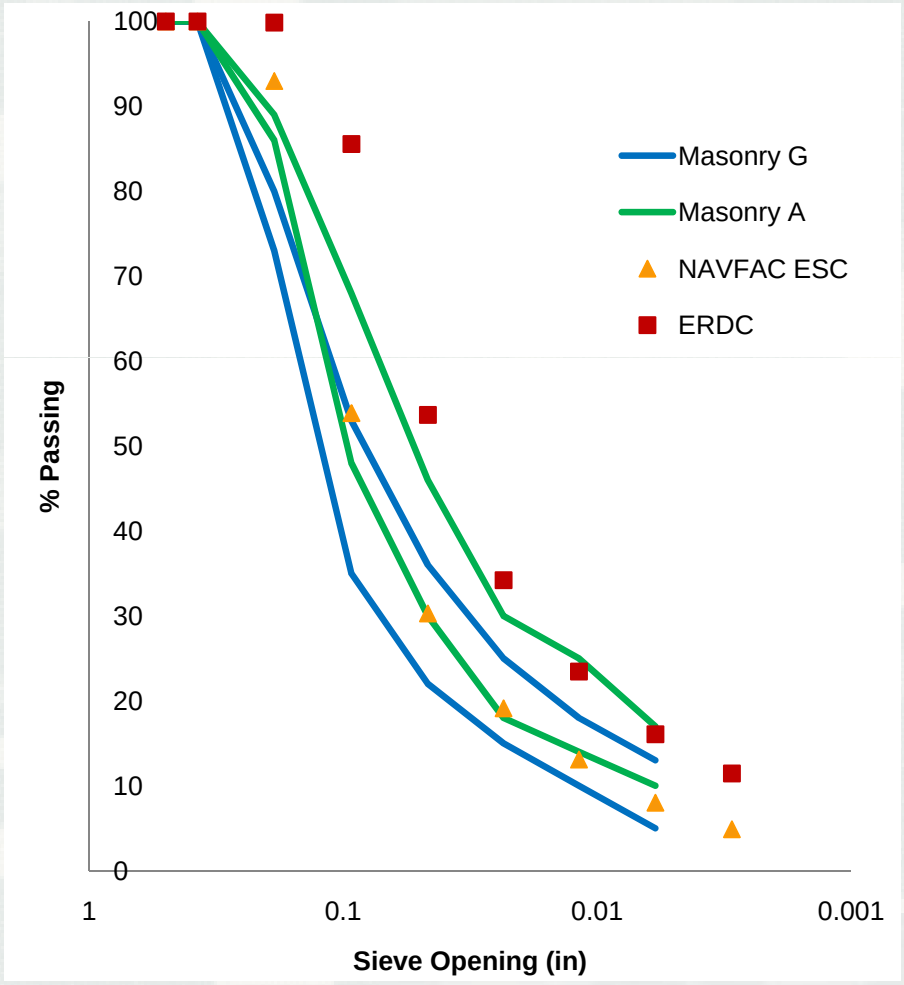




Paste loss & sand gradation changed from laboratory studies

Conclusions & Recommendations





Determination of NAVFAC laboratory gradation

Questions?