



American Concrete Institute®
Advancing concrete knowledge

Architectural Concrete in Hot Weather

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ACI WEB SESSIONS

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RAFAEL HERNANDEZ AIRPORT AIRCRAFT FIREFIGHTING STATION

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Project Basics

- **Aircraft Firefighting and Rescue Station:**
 - Serves the Rafael Hernandez Airport, Aguadilla, Puerto Rico
 - Owned by the Puerto Rico Ports Authority
 - Designed by:
 - CDM Smith
 - JR Technical and Development (Subconsultant)
 - Federally Funded Project
 - Part of General Master Plan for Airport
 - \$4.3M construction project
 - Largest Runway on the Island (11,702ft)
 - Replaces existing AFRS built in the 1940's
 - National Fire Protection Academy – Category 6
- **Applicable Codes:**
 - Uniform Building Code 1997 with PR-99 Amendments
 - FAA Advisory Circular AC 150/5210-15A
 - ACI-318
 - ACI 305R (Hot Weather Concreting)



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Project Basics

- **The Structure:**
 - 2 Story structure
 - 1,693 s.m.
 - Designed with typical 16 ft x 16 ft grid for modularity and construction speed
 - Oriented towards sustainability:
 - Cast in Place
 - Exposed Architectural Concrete Structure
 - No exterior paint
 - Ramp access to second floor (no elevators)
 - 3 Apparatus Bays for firefighting vehicles

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Key Constraints and Challenges

- Puerto Rico Climate:
 - Hot Weather Concreting (Usually between 90 to 95 degree weather)
 - Heavy rains during the afternoons
- High seismicity zone:
 - Zone 3 (UBC-97)
 - Adjacent to location of largest earthquake/Tsunami in history in Puerto Rico (Mayaguez-1918)
- Coastal Region Issues:
 - Proximity to coast
 - Less than 1 mile from the coast
 - Higher propensity to corrosion issues
- Sustainability
 - Reduced lifecycle costs

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Specification/Notes Basics

- Architectural Notes:
 - Exposed concrete walls must have a dense and smooth-as-glass finish with an even concrete color. The Formworks must have a stable surface such as "Finn-Form" Panels that meet a no deflection requirement.
- 03301-Reinforced Concrete
 - w/c = .5 required
 - $F'c = 4,000$ psi (min)
 - Slump range provided: 4 in – 8 in
- 03360-Concrete Finishes
 - Rubbed finish
 - Cleaned with 1 part white portland cement/1.5 parts sand with water-Consistency of thick paint

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During Execution

- Batch plant issues:
 - Poor quality control
 - Reports of some trucks delivering material after the maximum times required by the specifications. Specs provided for a maximum of 1.5 hours after cement is added.
 - Some evidence of aggregates from several quarries used in same batch
- Casting issues:
 - Evidence elements were improperly vibrated
 - No chutes were used as specified in the specification
 - Improper care was taken for compaction in high steel areas such as boundary elements
 - Hammer impacts were used instead of external vibrators


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During Execution

- Resistance issues:
 - 95% of first 400 cu yds cast were below specified compressive strength
- Appearance:
 - High level of segregation was observed specially around high reinforcement areas and the bottom of vertical elements

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Deficiencies



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During Construction

□ We were looking for this:



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During Construction

□ We got this:



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During Construction

□ We were looking for this:



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During Construction

□ We got this:



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Troubleshooting

□ Concrete Engineering

- Review of mix designs by batch plant to produce concrete well suited for an exposed finish under hot weather conditions
- Review of casting operation
- Review of quality control review before mixing, arrival or truck, during placing

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Challenges

□ Architectural:

- High Expectations – Mock up
- Over Confidence – Take for granted
- Available Materials – Regardless
- Special Forms
- Advanced Placing Techniques
- Strict Planning
- Special Inspection Controls
- First Shot - No Forgiveness

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Challenges

- Hot Weather
 - Mix Proportioning Considerations
 - Initial Temperature
 - Travel Time
 - Slump Loss / Retention
 - Plastic / Drying Shrinkage
 - Water Addition at Job Site
 - Re-tempering vs. Design Water at the Field
 - Testing and Inspection

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Forms



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Reinforcement



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Wall Finish



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Wall Finish



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Mix Requirements

- Fresh Stage:
 - Workability
 - Placeability
 - Effective Consolidation
 - Pumpability
 - Slump Retention
 - Moderate temperature
 - Cohesion
 - Uniformity

Constructability

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Mix Proportioning

- Mix Proportions
 - ▣ Aggregate total gradation
 - ▣ Unit water content reduction
 - ▣ Increase slump from 6 to 8 inches.
 - ▣ Hydration control admixture
 - ▣ Potable water

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Mix Proportions

Total Combined Gradation- Individual Percentage Retained on Each Sieve

Sieve Size	Mix 1 (%)	Mix 2 (%)
25	0.0%	0.0%
19	8.4%	6.5%
12.5	19.0%	14.7%
9.5	10.9%	8.8%
4.75	3.9%	10.1%
2.36	9.6%	11.6%
1.18	15.4%	15.0%
0.60	10.3%	10.3%
0.30	9.3%	9.3%
0.15	6.7%	6.7%
0.075	3.6%	3.6%

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Concrete

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The Results

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Testing and Inspection

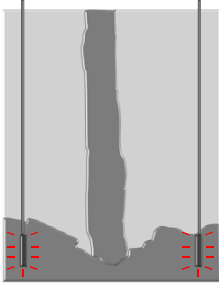
- ▣ Concrete Batch Plant:
 - Visual inspection of aggregates and conditioning
 - Batch weights within tolerances
 - Actual water demand / real water to be added at job site
- ▣ Job Site:
 - Allow permitted (design) water addition per ASTM C94 at jobsite
 - Verify slump more than once along the pour
 - Superplasticizer at job-site for further slump adjustments
 - Enforcement and consistency during the Inspection process

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Consolidation

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Consolidation



The diagram shows a cross-section of a concrete wall. Two vertical lines represent consolidation rods. At the base of the wall, red arrows point upwards, indicating the direction of vibration or consolidation. The concrete below the rods is shown in a darker, more textured state, representing the consolidation process.

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The Results



A photograph showing a concrete structure, likely a wall or column, with a large opening. The structure is made of light-colored concrete. The background is dark, suggesting an interior or shaded area.

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A photograph of a construction site. It shows a concrete structure under construction, with scaffolding and other construction equipment visible. The sky is blue.

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A 3D architectural rendering of a modern airport building. The building has a long, low profile with a glass facade and a green roof. It is situated on a paved area with a green lawn in front.

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