Architectural Concrete in Hot Weather

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RAFAEL HERNANDEZ AIRPORT
AIRCRAFT FIREFIGHTING STATION

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)

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
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

Specification/Notes Basics

- Architectural Notes: Exposed concrete walls must have a dense and smooth-as-glass finish with and 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

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

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

Deficiencies

- High Surface Porosity
- Segregation
During Construction

- We were looking for this:

- We got this:

During Construction

- We were looking for this:

- We got this:

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

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
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

Forms

Reinforcement

Wall Finish

Wall Finish

Mix Requirements

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

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

Mix Proportions

Concrete

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

Consolidation
Consolidation

The Results

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