MIAMI SCIENCE MUSEUM - BONDED POST-TENSIONING OF GULF STREAM TANK

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Outline of Presentation

- Overview of Tank
- Post-Tensioning and Constructability Details
- Design Criteria
- Loading Scheme
- Modeling
- Analysis & Results
Overview

- 600,000 Gallons Capacity
- Tilted Conical Shape
- Approx. 120 ft. diameter at the top and 27 ft. in height
- 30 ft. Diameter Oculus at the bottom of the cone
- Concrete design as opposed to Structural Steel to dampen the interference with shark’s sensory system
PT Considerations

Considerations:

- P/A requirements.
- 28” thick Tank Wall (Main Tank) and 18” Thick slab (Acclimation Tank)
- VSL ECI 6-12 System with 12 ea. 0.6” dia. low-relaxation strands for main tank and VSlab 6-4 system for acclimation tank/main tank interface
Proposed Tendon layout

- Complex Tendon Layout
- Acceptable locations for stressing pockets
Design Criteria

- Stresses below $6\sqrt{f'c}$ per ACI318.
- Minimum pre-compression of 200psi.
- Concrete strength:
  - At 28 days: 5,000psi
  - At stressing: 3,500psi
- Post-tensioning systems:
  - ECI6-12 with an effective force of 420 kips in the Gulf Stream tank.
  - Vslab6-4 with an effective force of 140 kips in the Acclimation tank.
- Mild steel reinforcement is added as needed to meet strength requirements.
Design Criteria

Load Combinations:
A. Service Load Combinations:
   A.1 Sustained Loads: 1SW + 0.3LL + 1PT
   A.2 Total Load: 1SW + 1LL + 1PT
B. Strength Load Combinations:
   B.1 1.4SW
   B.2 1.2SW + 1.6LL

Where:
- SW: Self-weight
- LL: Live load (water pressure)
- PT: Load due to pre-stress
Loading Scheme

- Water pressure is determined at 5 different water levels:

$$WP1 = 62.43 \, \text{lb/ft}^3 \times 28\, \text{ft} = 1748.4\, \text{lb/ft}^2 = 12.13 \, \text{psi}$$
Loading Scheme

WP1 (12.13 psi)
WP2 (9.71 psi)
WP3 (7.28 psi)
WP4 (4.85 psi)
WP5 (2.13 psi)
WP6 (3.50 psi)
Modeling - Geometry

- The tank is modeled using SAP2000.
Modeling – Tendon layout

Considerations:
• Meet P/A requirements:
  \[ 420 \text{ kips} / (28'' \times S) = 0.200 \text{ksi} \rightarrow 75'' \]
• Achieve even prestress distribution throughout the tank.
Modeling-Tendon Profile

- The typical CGS of the tendons is at mid-depth of the tank wall.
Modeling - Connections

1. Acrylic Panel & Circular Beam:

Link: It is a zero length non-linear link that transfers only x, y and z translation reactions from panel to beam.
Modeling - Connections

2. Gulf Stream Tank & Level 4 slab:

A 1” gap is assigned between both structural elements, thus there is no connection between them.
Modeling - Connections

3. Gulf Stream Tank & Level 4 slab & Acclimation Tank:

There is continuity between all these elements at this side of the Gulf Stream tank only.
Analysis & Results

1. Top Stress Diagram – Load Combination: DL + LL

Allowable stresses: 424psi
Analysis & Results

2. Bottom Stress Diagram – Load Combination: DL + LL

Allowable stresses: 424psi
Analysis & Results

3. Top Stress Diagram – Load Combination: DL + PT

Allowable stresses: 424psi
Analysis & Results

4. Bottom Stress Diagram – Load Combination: DL + PT

Allowable stresses: 424psi
Analysis & Results

5. Top Stress Diagram – Load Combination: DL+ LL + PT

Allowable stresses: 424psi
Analysis & Results

**S11 SHELL LOCAL AXIS STRESSES:**

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<th>Shell</th>
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<th>W (in)</th>
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**AVERAGE STRESS (psi)**

367.86
Analysis & Results

S22 SHELL LOCAL AXIS STRESSES:
Analysis & Results

6. Bottom Stress Diagram – Load Combination: DL+ LL + PT

Allowable stresses: 424psi
Deformation
Challenges

• Map post-tensioning tendons on tank wall.
• Assign the corresponding PT profile to each tendon element.
• Limited capability of the software to generate hyperstatic forces and moments.
Thank you!