Load Test of a Precast Concrete Tub Stadium Riser and Bond Testing of #20 Bar

Presented by

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The Project

- Expansion at a collegiate football stadium
- Mezzanine club level in endzone
  - Cantilevering precast concrete tub riser
  - Supported by steel truss
Concrete Tub Riser
Plan View

• Which direction controls?

\[
\frac{l_{\text{long}}}{d} = \frac{28\text{ ft}}{2\text{ ft}} = 14 \\
\frac{l_{\text{tran}}}{d} = \frac{2 \times 48\text{ in}}{5.5\text{ in}} = 17
\]
Distress
Cracking in non-cantilever portion

- Consistent for bottom-most mezzanine concrete tub risers
Retrofit and Load Test

- Bending response
  - Longitudinal
  - Transverse cantilever
  - Torsional
Load Test per ACI 318-11

• Load cantilever portion
• Design live load = 100 psf
• Total test load = 150 psf
• Use industrial totes for loading
  – 30 inches of water

• Load
  – Four equal increments with 24-hr hold
  – Measure deflection with string potentiometer
  – Measure crack width
Instrumentation Locations
First Loading Increment

0.02"

0.07"

0.07"

0.07"

0.06"
Second Loading Increment
Last Loading Increment

Predicted Truss Deflection: 0.08"
Predicted Tub Deflection (relative): 0.15
Last Loading Increment and 24-hr Hold

- Last Loading Increment: 0.12" (~20%)
- 24-hr Hold: 0.12" (~30%)
- ~30% at various points
Fully Unloaded
Fully Unloaded and 24-hr period

Absolute change of 0-0.06″

~0%

~60%

~30%

~10%

~30%
Deflections with Loading

![Graph showing deflections with loading](graph.png)
Relative Deflection

<table>
<thead>
<tr>
<th>Location</th>
<th>Max (in.)</th>
<th>Final (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue</td>
<td>0.20”</td>
<td>0.08”</td>
</tr>
<tr>
<td>Yellow</td>
<td>0.24”</td>
<td>0.12”</td>
</tr>
<tr>
<td>Green</td>
<td>0.23”</td>
<td>0.12”</td>
</tr>
</tbody>
</table>

Graph showing the relationship between Applied Load (psf) and Measured Deflection (in.).
## Crack Width: West End

<table>
<thead>
<tr>
<th>Description</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to test</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Half Load</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Full Load</td>
<td>35</td>
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</tr>
<tr>
<td>Full Load + 24-hr hold</td>
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<th>F</th>
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<tr>
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<td>15</td>
<td>35</td>
</tr>
<tr>
<td>Half Load</td>
<td>20</td>
<td>40</td>
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<tr>
<td>Full Load</td>
<td>20</td>
<td>45</td>
</tr>
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<td>40</td>
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Acceptance Criteria

- Maximum deflection (Eq. 20-1)
  \[ -\Delta \leq \frac{i_t^2}{20,000h} = \frac{(2\times48\text{in})^2}{20,000(5.5\text{in})} = 0.084\text{in} \]

- Residual deflection (Eq. 20-2)
  \[ -\Delta_r \leq \frac{\Delta_1}{4} \]

Criteria not satisfied
Discussion

- Dominated by cantilever bending
- Next steps
  - Retest?
  - Perform cyclic test?
  - Detailed analysis?
  - Retrofit?
- Other influences
  - Temperature on ≈20’ cable
Corpus Christi Harbor Bridge Project

Main span: 1,661 ft (longest in US)
Confirm Development Length

• Develop yield strength of #20 (grade 75)
  – Diameter = 2.5”
  – Min. yield strength = 368 kips
• Supplied by Williams Form Engineering
  – All-thread bars
  – Threaded terminator
• Footings

#20 ~ 16#5s
Fabricated Beams

- 6’-0” deep, 4’-0” wide, 15’-6.5” long
- Development length: 4’-8”

2#20s  1#5 (Grade 100)  14#5  2#6 @ 6” O.C.  #4 @ 9” O.C.  PVC tube
Two Tests at Once
Instrumentation Plan

• Internal strain gages
  – Vibrating wire gages (#5 bar)
  – Foil strain gages (#20 bar)
• External strain gages
• Slip at ends of #20 bars
• Deflection
• Pressure

Two on single bar and install PVC bar over it
Two on each #20
Acceptance Criteria

• Reach 75 ksi in #20 bars  
  – (2800 microstrain)
• Slip < 0.04”
• No evidence of bond failure

• 50’ safety buffer

Expected load...  
1.25-1.5M pounds
Strain in #20 Bars

Start loading | Loud bang | Continue loading, another bang | Continue loading | Unload
Slip at Ends

Graph showing the relationship between Applied Load (kips) and End Slip (in.) for Bottom and Top Beam.
Condition of Beam

Residual Strain (external): 1,000 με
0.04” crack / 38” gage = 1,052 με

Residual Strain (external): 1,200 με
0.05” crack / 38.125” gage = 1,300 με
Discussion

• Met acceptance criteria
• Idealized behavior

• Important to measure right component
• Redundancy
  – Gages
  – Equipment
Questions?