San Francisco-Oakland Bay Bridge: Post-Tensioned solution for retrofit of broken bolts

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Presentation outline

1. Introduction
2. Bridge phase summary
3. Cause and location of bolt failure
4. Proposed solutions
5. Approved solution
6. Post-tensioning details
7. Post-tensioning challenges
San Francisco-Oakland Bay Bridge
San Francisco-Oakland Bay Bridge
1989 Loma Prieta Earthquake
SF-Oakland Bay Bridge – Shear key retrofit
San Francisco-Oakland Bay Bridge
San Francisco-Oakland Bay Bridge

Skyway Structure (Precast Segmental / Balanced Cantilever) -
Longitudinal PT / Transverse PT / Vertical PT
21,000,000 lbs of PT
San Francisco-Oakland Bay Bridge

**Touchdown I&II (Cast-in-place on falsework)** –
Longitudinal PT / Transverse PT (bents)
1,000,000 lbs of PT
San Francisco-Oakland Bay Bridge

YBI Transition Structure (Cast-in-place on falsework) -
Longitudinal PT / Transverse PT (bents)
4,000,000 lbs of PT
San Francisco-Oakland Bay Bridge

SAS (Steel self-anchored-suspension) -
Multidirectional bent cap PT / Vertical PT tie-downs
800,000 lbs of PT
San Francisco-Oakland Bay Bridge

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  Multidirectional bent cap PT / Vertical PT tie-downs
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**E2 Bar Quantity Summary**

- 24 bars per bearing
- 48 bars per shear key
- 288 total bars
- 32 fractured bars

The 32 snapped rods cannot be removed with the roadbed sections in place.
**Broken rods**

“On March 1, workers began stressing the 96 rods fabricated in 2008 for the two shear keys; between March 8 and March 15, 32 fractured rods were discovered.

Engineers and metallurgists have determined that the bolts broke due to hydrogen embrittlement, which requires a source of excess hydrogen, susceptible material and tension. Ongoing metallurgical analysis revealed that the bolts were susceptible due to the steel being harder on the outside than in the middle, or a lack of uniformity in the steel’s microstructure. The steel also showed low toughness and marginal ductility (the ability to stretch).

The excess hydrogen caused the threaded areas to become brittle and fracture under high tension when the bolts were tightened. An ongoing investigation is looking into the source of the excess hydrogen, which may have been both internal (i.e. residual from production) and/or external.”
SF-Oakland Bay Bridge – Shear key retrofit

Team
- TY Lin International / Moffett & Nichol, JV
- Caltrans
- Bay Area Toll Authority (oversight committee)
- American Bridge/Fluor, JV
- Schwager Davis, Inc.
SF-Oakland Bay Bridge – Shear key retrofit
142 Tendons

Loop Tendons
40 each 26-0.6”
Through Tendons
22 each 12-0.6”
Draped Tendons
16 each 19-0.6”
Transverse Tendons
40 each 12-0.6”
Bottom Longitudinal
24 each 12-0.6”
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