

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



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Touchdown I&II (Cast-in-place on falsework) –
Longitudinal PT / Transverse PT (bents)
1,000,000 lbs of PT



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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

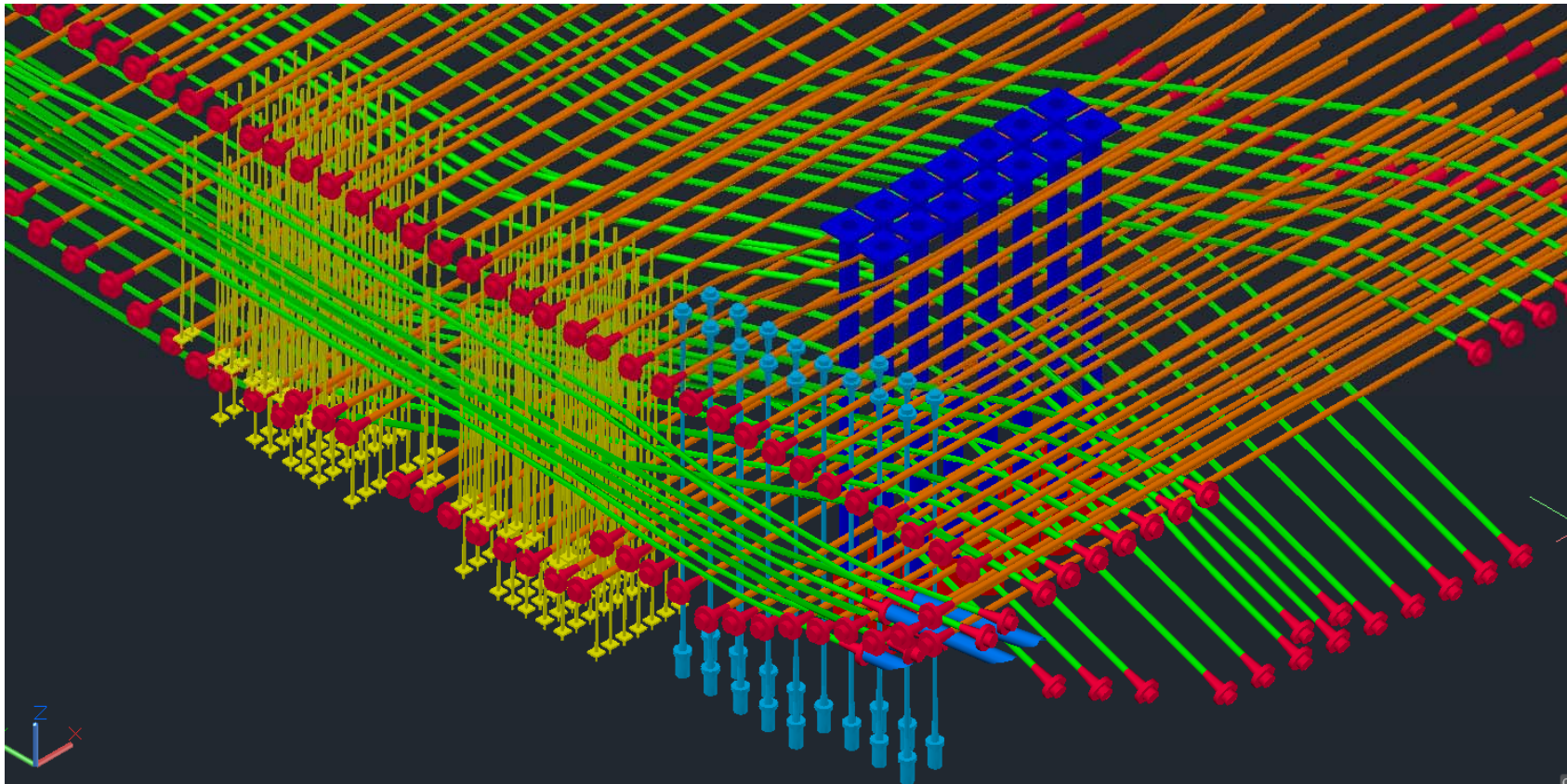


San Francisco-Oakland Bay Bridge



SAS (Steel self-anchored-suspension) -

Multidirectional bent cap PT / Vertical PT tie-downs
800,000 lbs of PT



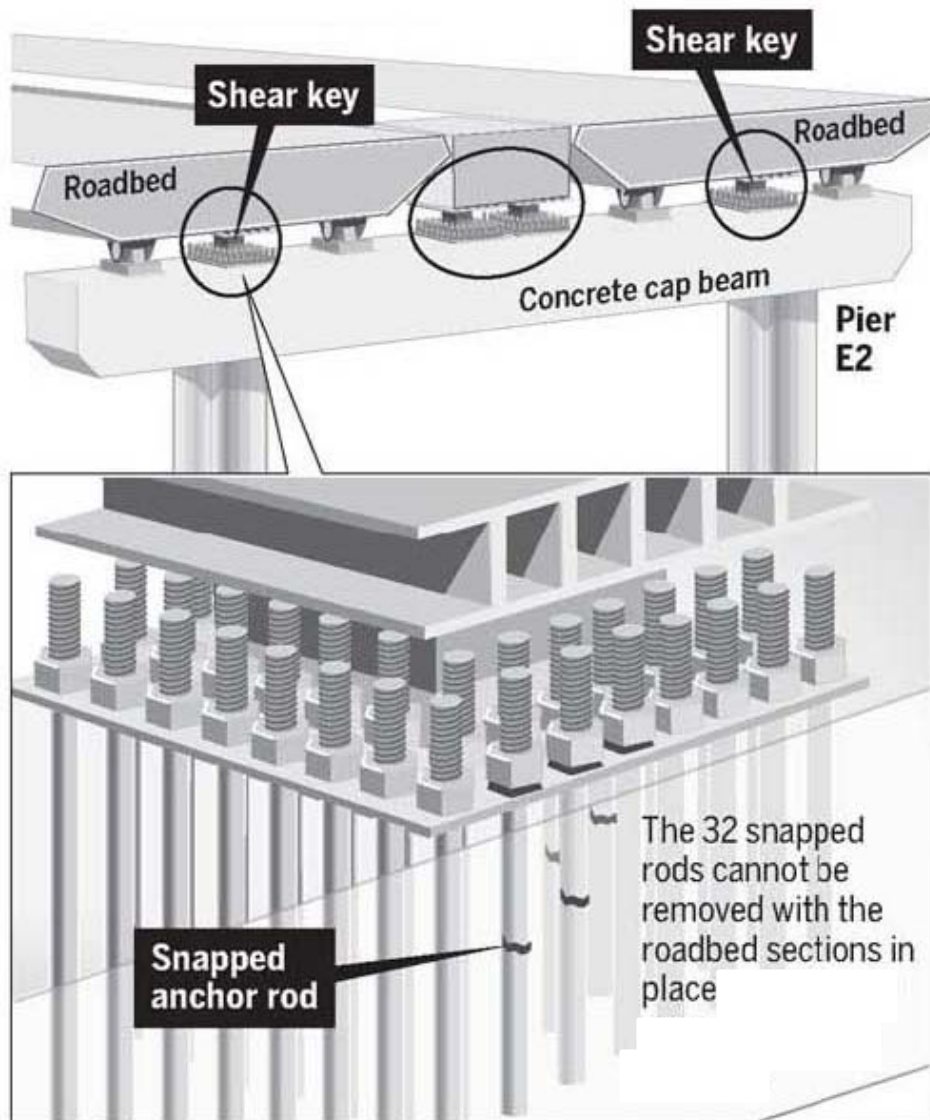
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E2 Bar Quantity Summary

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

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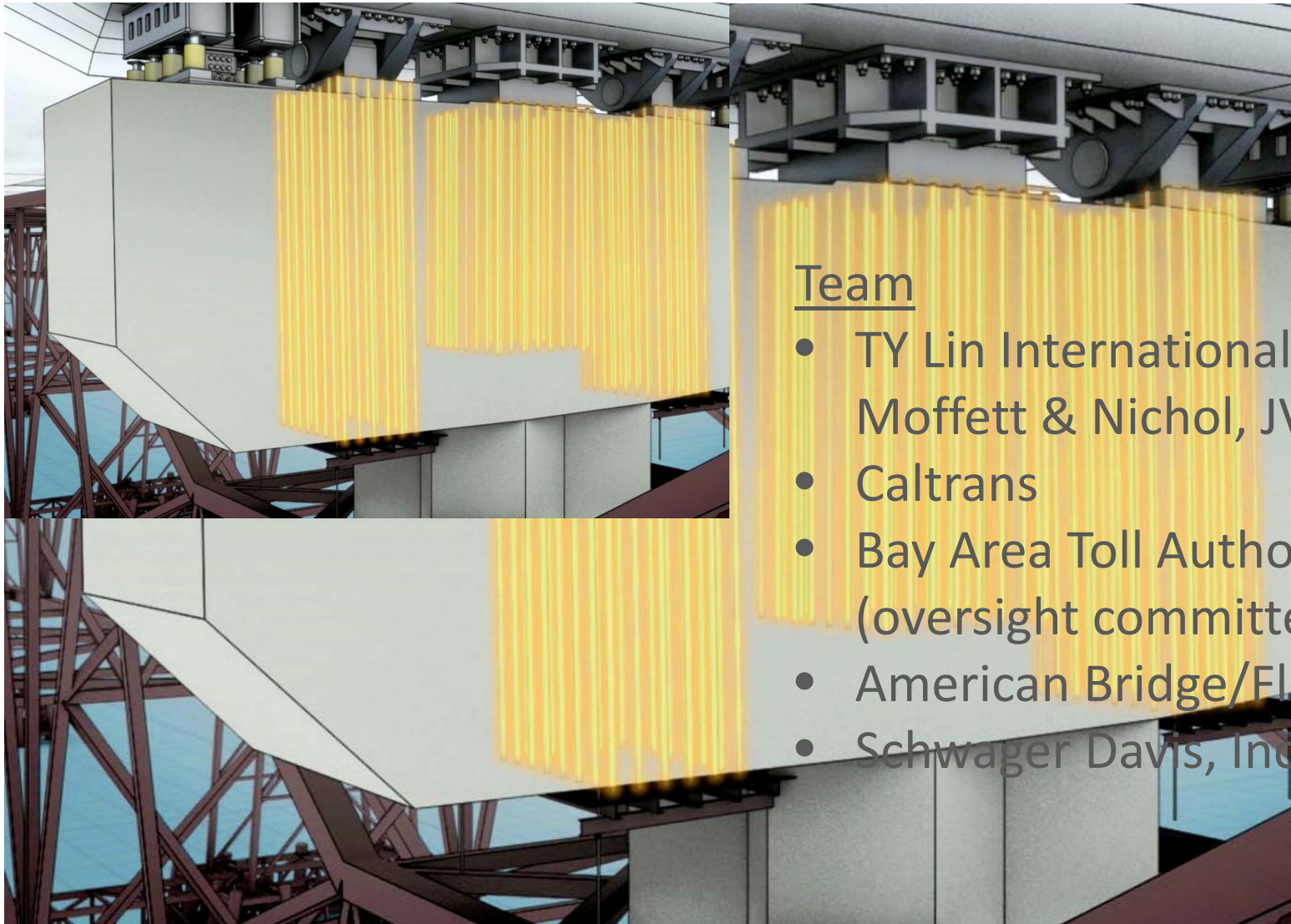
Broken rods

“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.”

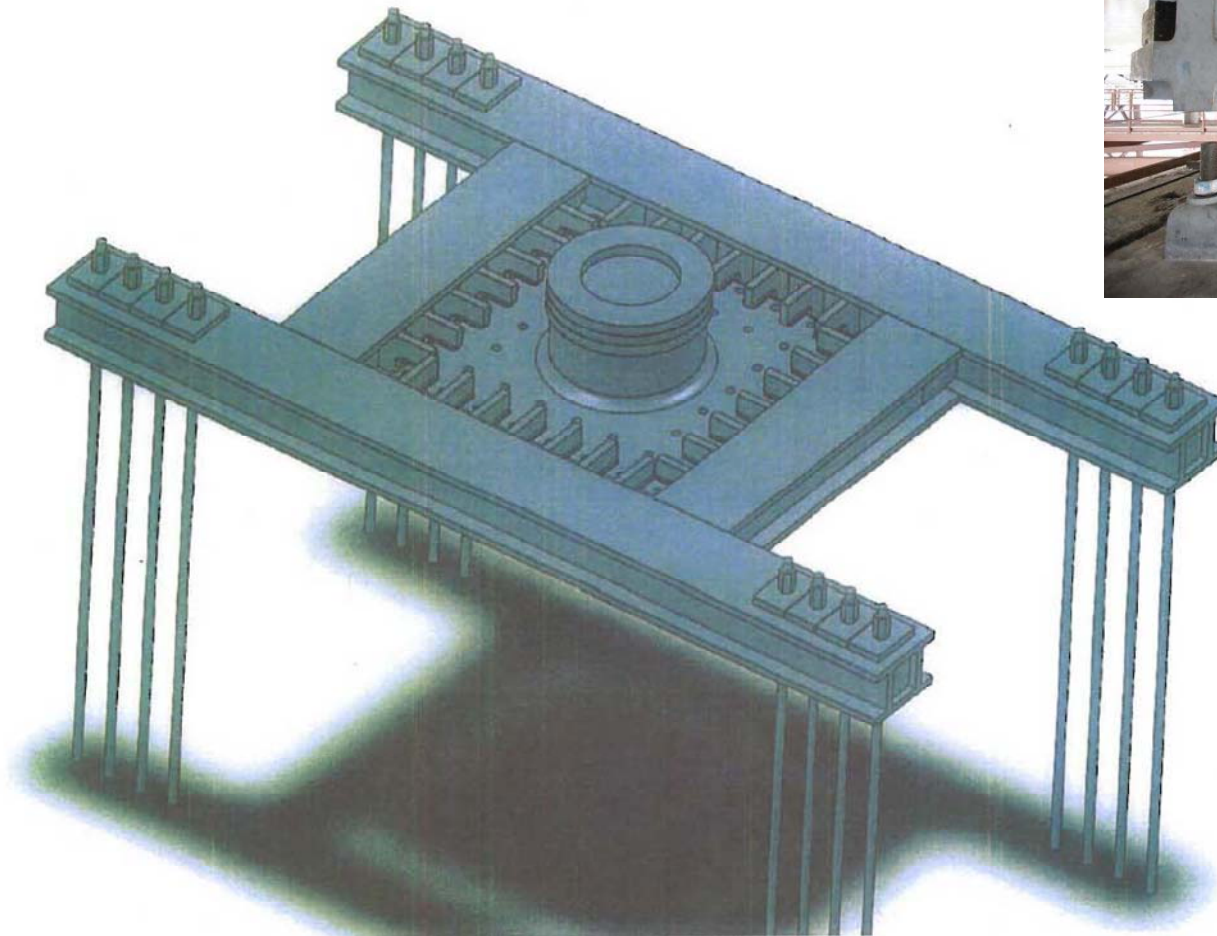
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Team

- TY Lin International / Moffett & Nichol, JV
- Caltrans
- Bay Area Toll Authority (oversight committee)
- American Bridge/Fluor, JV
- Schwager Davis, Inc.

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142 Tendons

Loop Tendons

40 each 26-0.6"

Through Tendons

22 each 12-0.6"

Draped Tendons

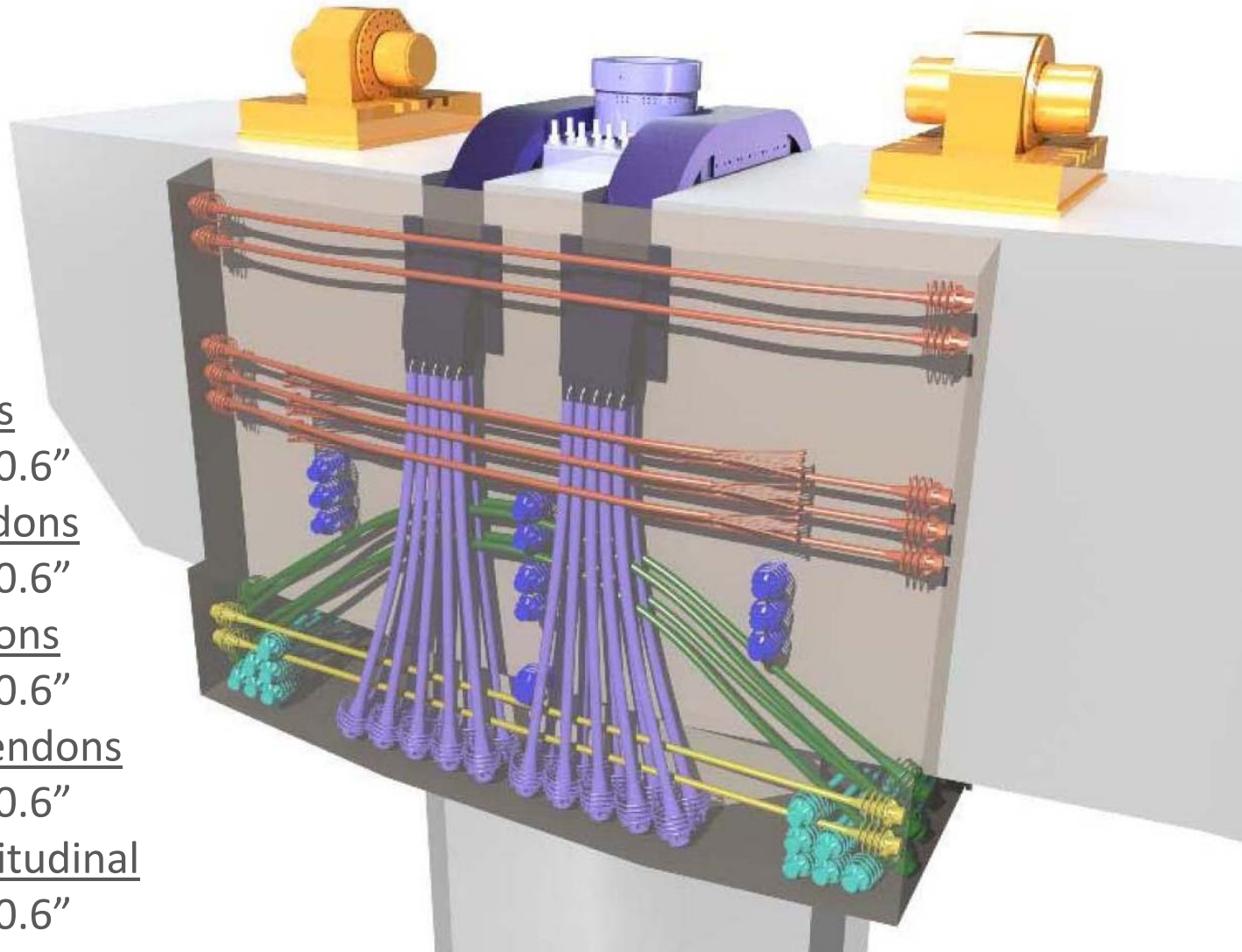
16 each 19-0.6"

Transverse Tendons

40 each 12-0.6"

Bottom Longitudinal

24 each 12-0.6"



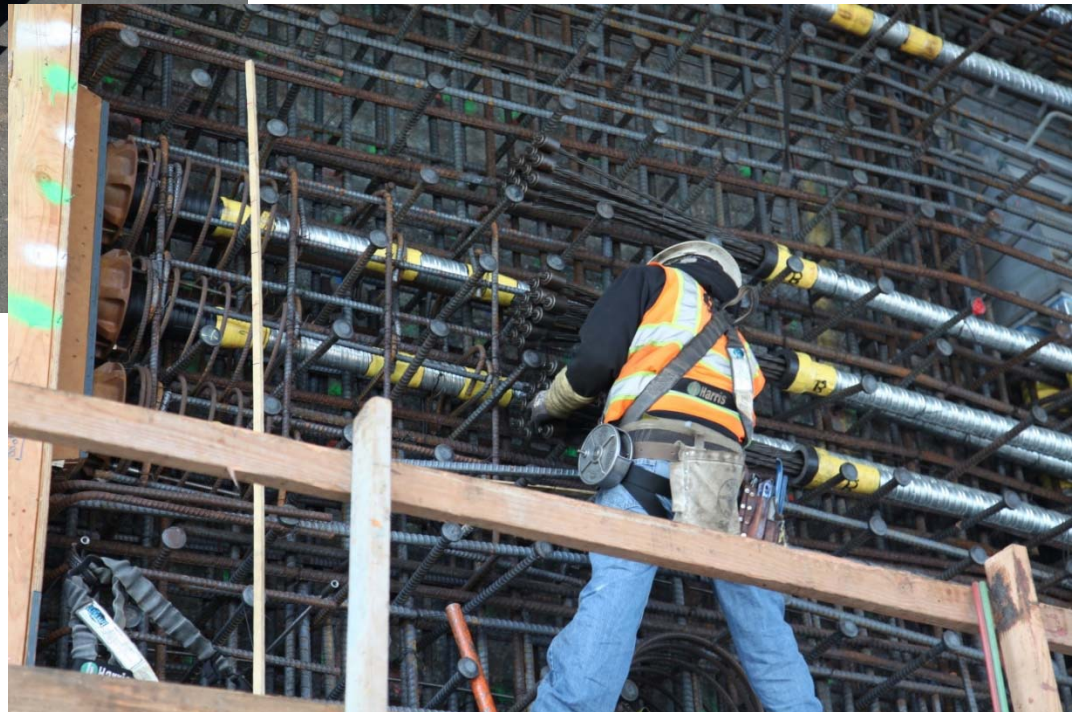
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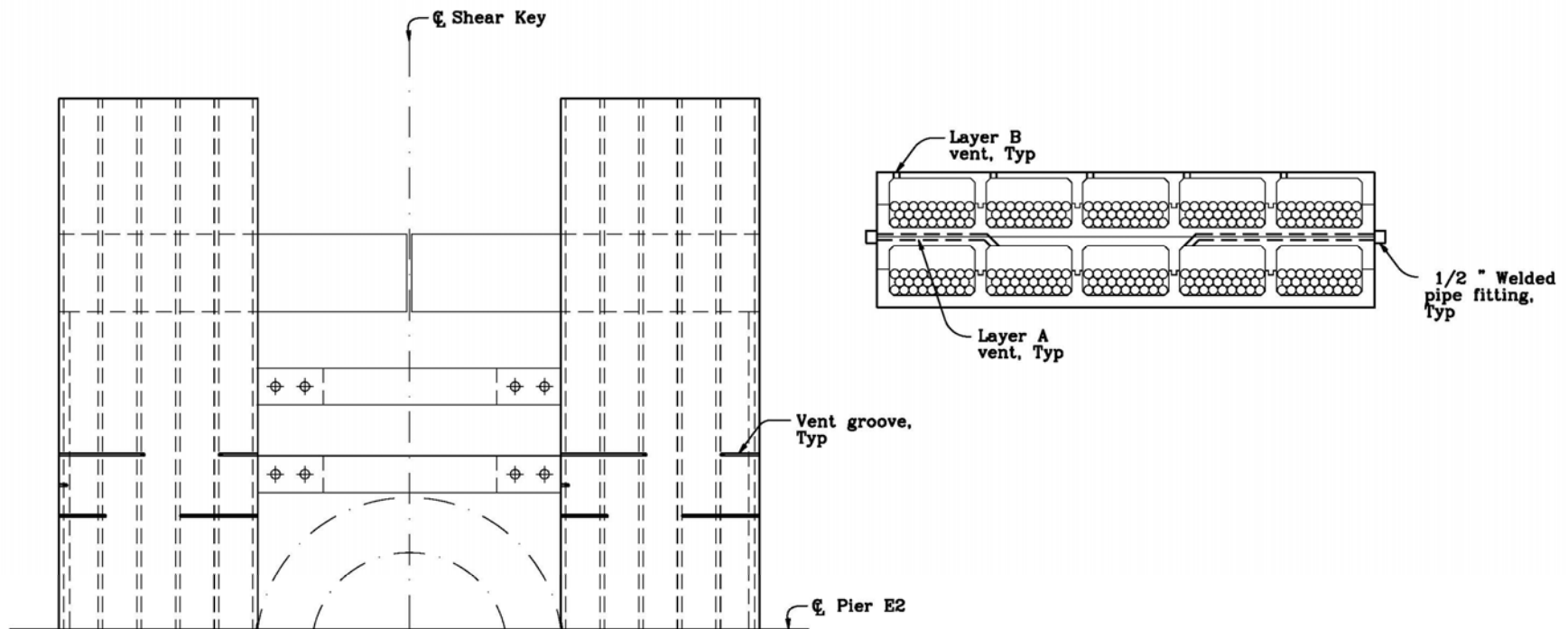
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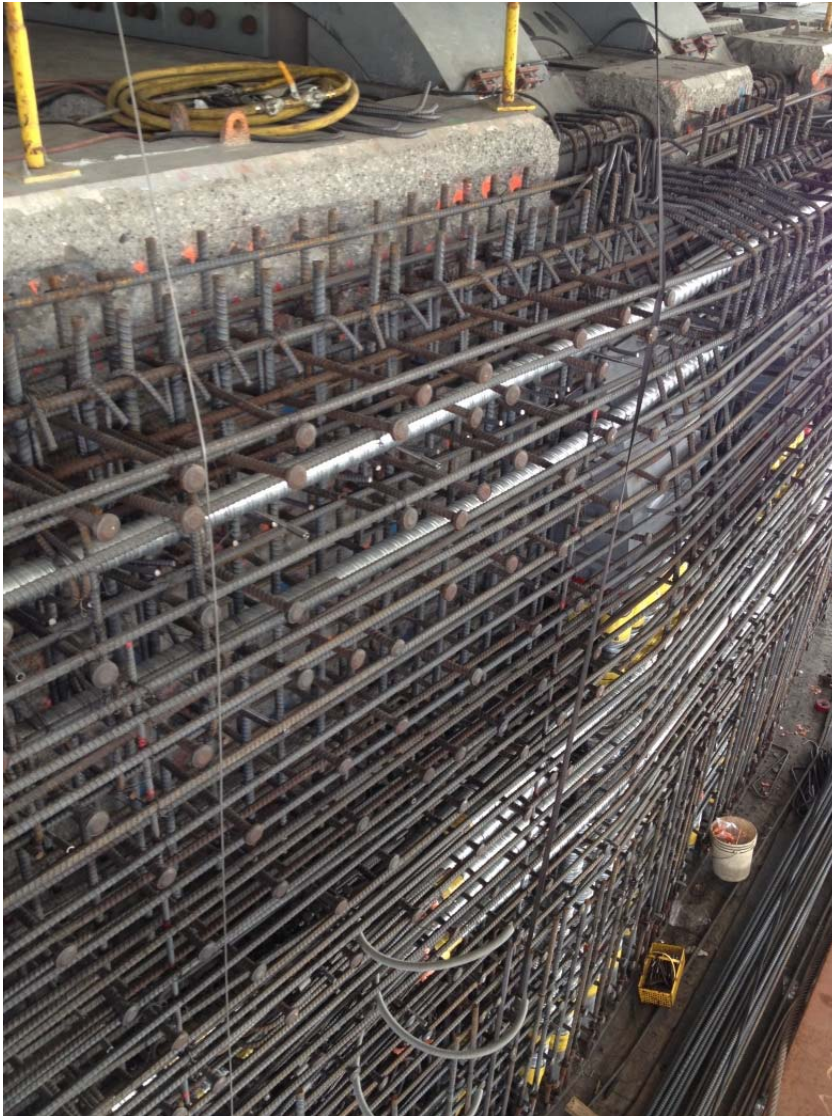
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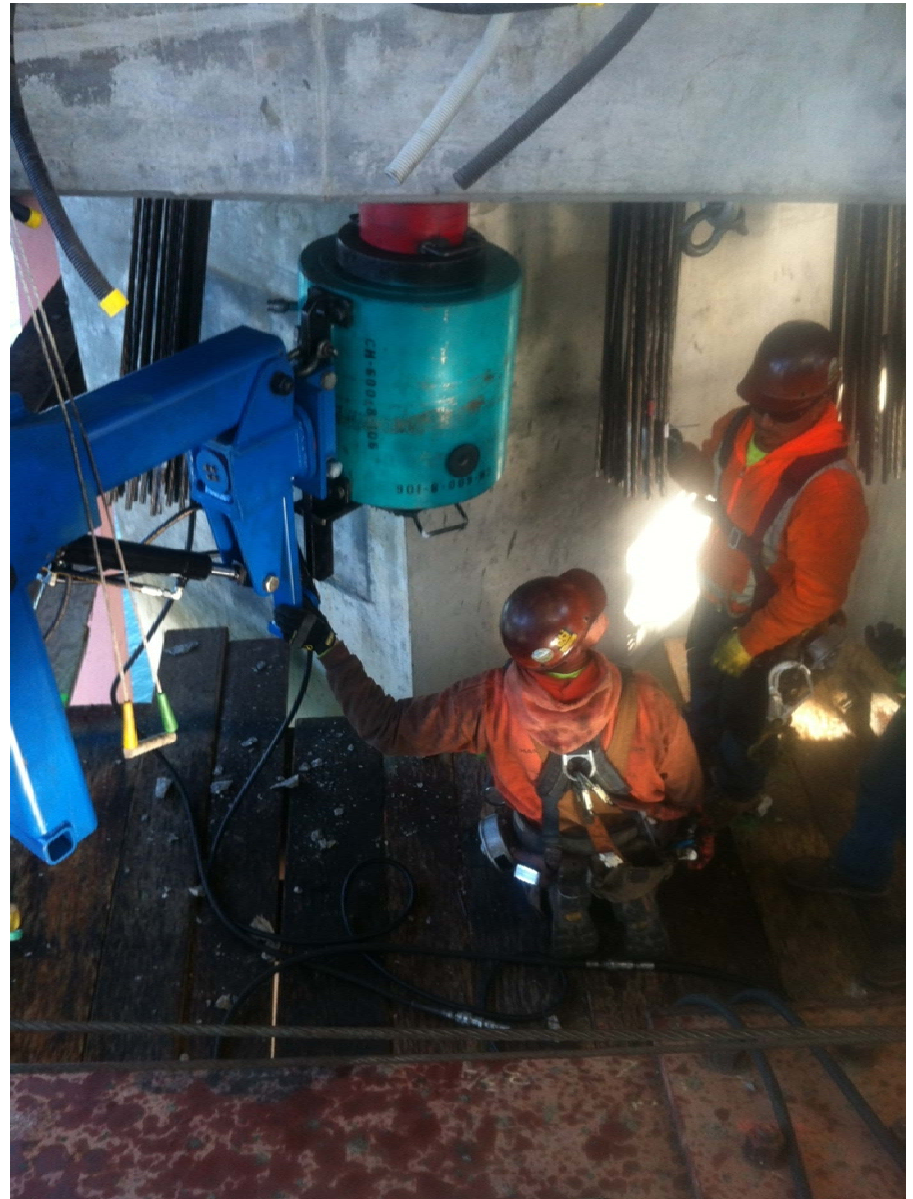
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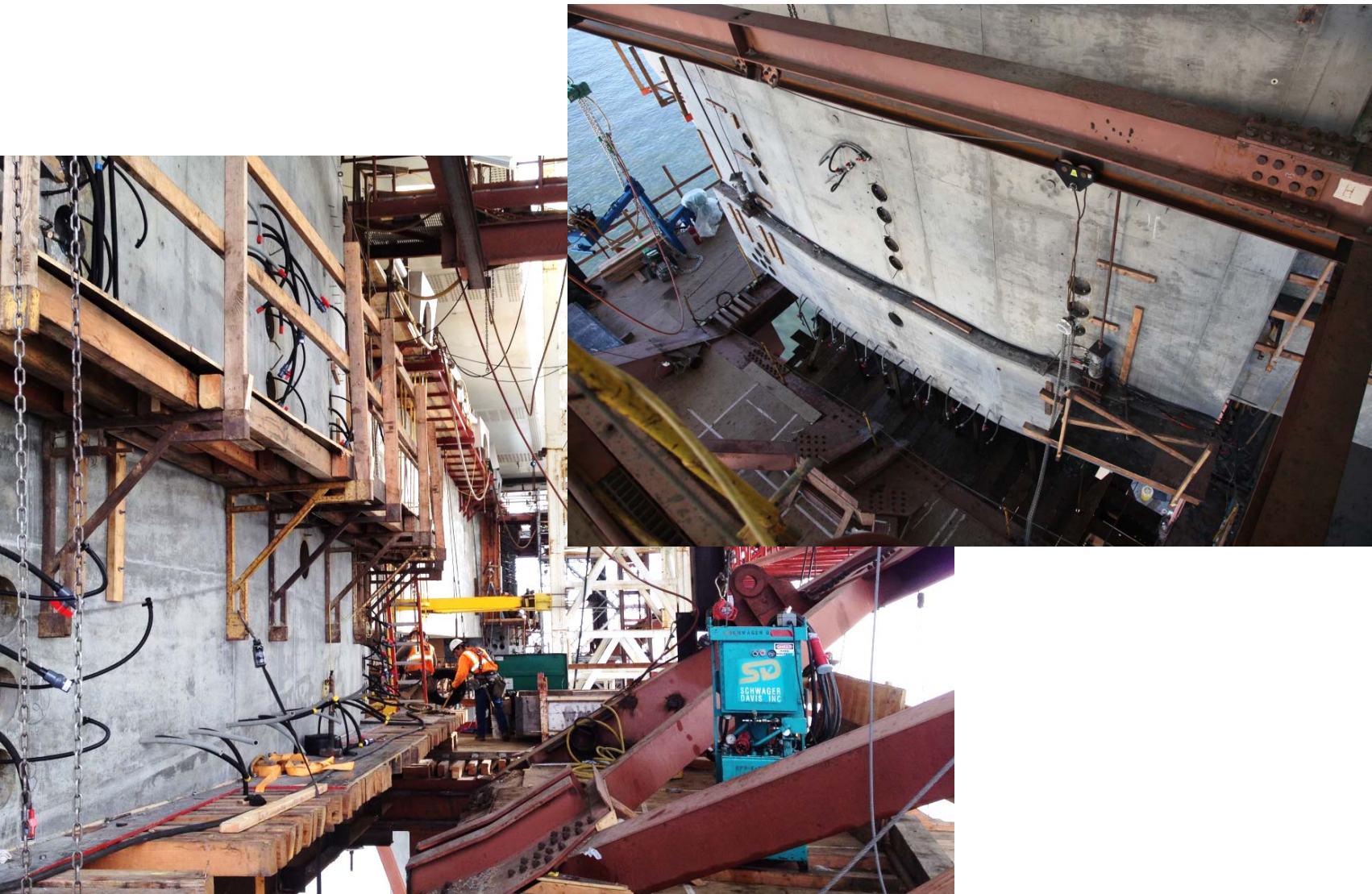
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