Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

Wednesday February 26, 2014

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Transportation Engineer - Civil
Caltrans
A354 Gr BD Rods & Bolts SAS

- 320 Rods
- 224 Rods
- 96 Rods
- 274 Rods
- 192 Rods
- 25 Rods
- 108 Rods
- 336 Rods
- 96 Rods
- 90 Rods
- 388 Rods
- 36 Rods
- 32 Rods
- 18 Rods
- 24 Rods
- 43 Rods

2/26/2014

SFOBB SAS Contract 04-0120F4

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Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

17 locations/types with 2,306 rods/bolts
- Rods and Bolts (with head)
- 1” to 4” diameter
- 2 inches to 32 feet long
- 0.1 Fu to 0.7 Fu Tension (minimum specified ultimate tensile strength)
- Cut and Rolled Threads
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

1. E2 Shear Key - Connect to Concrete - Above Column, Under OBG [S1, S2]
2. E2 Shear Key - Connect to Concrete - Above Bent Cap, Under Crossbeam [S3, S4]
   E2 Bearing - Connect to Concrete - Under OBG [B1, B2, B3, B4]
3. E2 Shear Key - Connect to OBG [S1, S2] & Connect to Crossbeam [S3, S4]
4. E2 Bearing - Connect to OBG [B1, B2, B3, B4]
5. E2 Bearing Assembly Bolts (Spherical Bushing Halves)
6. E2 Bearing Assembly Bolts (Retaining Rings)
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

1. E2 Shear Key - Connect to Concrete - Above Column, Under OBG [S1, S2]

96 Rods, 3” Diameter, Cut Threads, Tensioned to 0.70 Fu, “2008 Rods”, rods cast in concrete in 2008 but could not tension until 2013 after compression of deck from cable load transfer operation, 32 of 96 rods broke, tension lowered, and then rods replaced by Saddle Design
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

2. E2 Shear Key - Connect to Concrete - Above Bent Cap, Under Crossbeam [S3, S4]
   E2 Bearing - Connect to Concrete - Under OBG [B1, B2, B3, B4]
192 Rods, 3” Diameter, Cut Threads, Tensioned to 0.70 Fu, “2010 Rods”, manufactured differently than “2008 Rods” – vacuum degassed and MT inspected
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

3. E2 Shear Key - Connect to OBG [S1, S2]
   E2 Shear Key - Connect to Crossbeam [S3, S4]

320 Rods, 3” Diameter, Cut Threads, Fully Threaded, Tensioned to 0.70 Fu,
Same Heat (material fabrication) as “2010 Rods”
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

4. E2 Bearing - Connect to OBG [B1, B2, B3, B4]
224 Rods, 2” Diameter, Rolled Threads, Fully Threaded, Tensioned to 0.70 Fu
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

5. E2 Bearing Assembly Bolts (Spherical Bushing Halves)
96 Rods, 1” Diameter, Cut Threads, Tensioned to 0.7 $F_y = 0.61 F_u$, ASTM A143 IHE Test (48-hr. ASTM F606 wedge tensile test) Performed, Material Only Exposed in Shop Environment

24 Rods in Each Bearing -> Total 96 Rods -> Not Accessible after Bearing Assembly
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

6. E2 Bearing Assembly Bolts (Retaining Rings)

336 Socket Head Cap Screws, 1” Diameter, Cut Threads, Tightened to Snug + ¼ turn ~ 0.4 Fu, Mechanically Galvanized (not Hot Dip Galvanized)

42 Bolts in Each Retaining Ring -> 2 Rings per Bearing & 4 Bearings -> Total 336 Bolts
Most Not Accessible after Bearing Assembly -> 32 of 336 Bolts Accessible

The retaining rings (2 per bearing) are bolted to the bearing bottom housing by Hochang

The retaining rings are covered by the bearing top housing by Hochang

The bearings are installed in the field at Pier E2 by ABF

Some of the bolts in the retaining ring are clear of the bearing top housing making them accessible

The bearing top housing covers most of the retaining ring on the bearing bottom housing

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7. PWS Anchor Rods - PWS Socket to Anchorage
7. PWS Anchor Rods - PWS Socket to Anchorage

274 Rods, 3½” Diameter, 20% Rods with Cut Threads & 80% Rods with Rolled Threads; installation involved only enough tension to align cable strands, then eventually reached 0.32 Fu Sustained load at bridge opening, and peak load of 0.35 Fu from Seismic; Dehumidified (<40% RH)
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

8. Tower Saddle Tie Rods
9. Turned Rods at Tower Saddle Segment Splices
10. Tower Saddle to Grillage Anchor Bolts
11. Tower Outrigger Boom (for Maintenance) at Top of Tower
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

8. Tower Saddle Tie Rods

25 Rods, 4” Diameter, Rolled Threads, Fully Threaded, Tensioned to 0.5 $F_y = 0.41\, Fu$, then reach 0.68 $F_u$ Sustained load at bridge opening, Dehumidified (<40% RH)
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

9. Turned Rods at Tower Saddle Segment Splices

108 Rods, 3” Diameter at Threads with 3-1/16” Diameter Shank, Cut Threads, 100 Rods Tensioned to 0.45 Fu & 8 Rods Snug Tightened to ~0.1 Fu (no tensioning access), 8 Rods have slightly larger shanks with tighter tolerances to be alignment pins and came from same heat as the tower saddle tie rods, Dehumidified (<40% RH)
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

10. Tower Saddle to Grillage Anchor Bolts

90 Hex Head Bolts, 3" Diameter, Cut Threads, Snug Tightened to ~0.1 Fu, Partially Dehumidified (heads in <40% RH dehumidified Tower Head, nuts inside non-dehumidified Tower Grillage)
11. Tower Outrigger Boom (for Maintenance) at Top of Tower

4 Hex Head Bolts, 3” Diameter, Cut Threads, 2 Snug Tightened to ~0.1 Fu and 2 currently under no tension and will be Snug Tightened to ~0.1 Fu in the future when swing out maintenance boom
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

12. Tower Anchor Rods - Tower at Footing (3" Dia)

13. Tower Anchor Rods - Tower at Footing (4" Dia)
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

12. Tower Anchor Rods - Tower at Footing (3" Dia), 388 Rods, Tensioned to 0.48 Fu
13. Tower Anchor Rods - Tower at Footing (4" Dia), 36 Rods, Tensioned to 0.37 Fu

Manufactured by Vulcan Threaded Products, Cut Threads, Partially Dehumidified (top in <40% RH dehumidified Tower Skirt, bottom in grout & concrete inside steel footing box)
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

14. East Saddle Anchor Rods

15. East Saddle Tie Rods
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

14. East Saddle Anchor Rods

36 Rods, 2” Diameter, Cut Threads, Snug Tightened to ~0.1 Fu, Dehumidified (<40% RH)
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

15. East Saddle Tie Rods

18 Hex Head Bolts, 3” Diameter, Cut Threads, Snug Tightened to ~0.1 Fu, then reach 0.2 Fu as load bridge, Dehumidified (<40% RH)
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

16. B14 Cable Bands - Cable Brackets (East End) - Strongback Anchor Rods

[Diagram of the San Francisco-Oakland Bay Bridge with annotations and references to cable bands, cable brackets, and strongback anchor rods.]
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

16. B14 Cable Bands - Cable Brackets (East End) - Strongback Anchor Rods
24 Rods, 3” Diameter, Rolled Threads, Tensioned to 0.16 Fu, Pre-Compress Neoprene, Machined Down from Extra 3½” Diameter PWS Anchor Rods Material
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

17. W2 Bikepath Anchor Rods
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17. W2 Bikepath Anchor Rods

43 Rods, Metric M30 (~1-1/4”), an architectural enhancement to the bikepath results in redesigned connections that abandon these rods.
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17 locations/types with 2,306 rods/bolts
Locations and Tensioning of ASTM A354 Grade BD Rods and Bolts on the San Francisco-Oakland Bay Bridge Self-Anchored Suspension Span

<table>
<thead>
<tr>
<th>ID</th>
<th>Structural Component</th>
<th>Year</th>
<th>Nominal Bolt Number of Bolts</th>
<th>Diameter [in]</th>
<th>Bolt Tension @ Service % Fu (UTS)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Shear Key Anchor Bolts — Bottom (S1/S2)</td>
<td>2008</td>
<td>96</td>
<td>3</td>
<td>0.70</td>
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<tr>
<td>2</td>
<td>Shear Key Anchor Bolts — Bottom (S3/S4)</td>
<td>2010</td>
<td>96</td>
<td>3</td>
<td>0.70</td>
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<tr>
<td></td>
<td>Pier E2 Bearing Bolts — Bottom Housing (B1, B2, B3, B4)</td>
<td>2010</td>
<td>96</td>
<td>3</td>
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<td>3</td>
<td>Shear Key Anchor Bolts — Top (S1/S2)</td>
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<td>160</td>
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<td>Shear Key Anchor Bolts — Top (S3/S4)</td>
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<td>160</td>
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<td>4</td>
<td>Pier E2 Bearing Bolts — Top Housing</td>
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<td>5</td>
<td>Spherical Bearing Bushing Assembly Bolts</td>
<td>2010</td>
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<td>6</td>
<td>Bearing Retainer Ring Plate Assembly Bolts</td>
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<td>336</td>
<td>1</td>
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<td>7</td>
<td>PWS Strand Anchor Rods (Main Cable)</td>
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<td>3-1/2</td>
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<td>8</td>
<td>Tower Saddle Tie Rods</td>
<td>2010</td>
<td>25</td>
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<td>9</td>
<td>Tower Saddle Turned Rods (@ Splices)</td>
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<td>100</td>
<td>3</td>
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<td>8</td>
<td>3</td>
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<td>Tower Saddle Grillage Bolts</td>
<td>2010</td>
<td>90</td>
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<td>Tower Outrigger</td>
<td>2010</td>
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<td>12</td>
<td>Tower Anchorage Anchor Bolts (75 Dia. Anchor Bolts)</td>
<td>2006</td>
<td>388</td>
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<td>13</td>
<td>Tower Anchorage Anchor Bolts (100 Dia. Anchor Bolts)</td>
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<td>36</td>
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<td>14</td>
<td>East Saddle Anchor Rods</td>
<td>2010</td>
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<td>2</td>
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<td>15</td>
<td>East Saddle Tie Rods</td>
<td>2010</td>
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<td>0.20</td>
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<tr>
<td>16</td>
<td>Cable Bracket Anchor Rods</td>
<td>2010</td>
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<td>17</td>
<td>Bikepath Anchor Bolts at Pier W2</td>
<td>2010</td>
<td>43</td>
<td>1-1/4</td>
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</tbody>
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Fu (Tensile Strength) per ASTM A354-11  

Total: 2,308