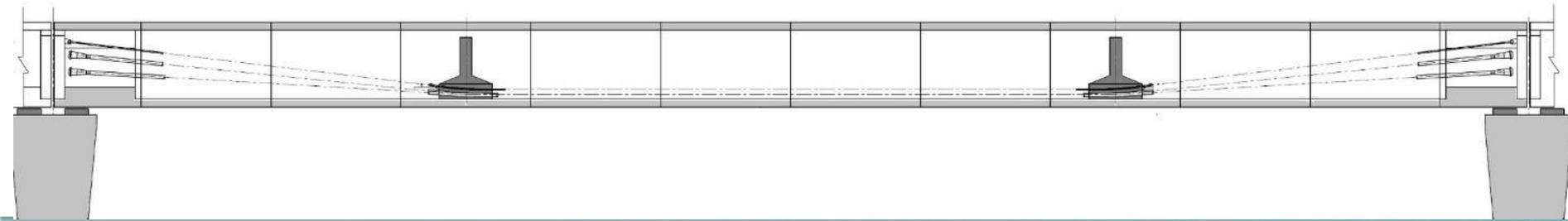
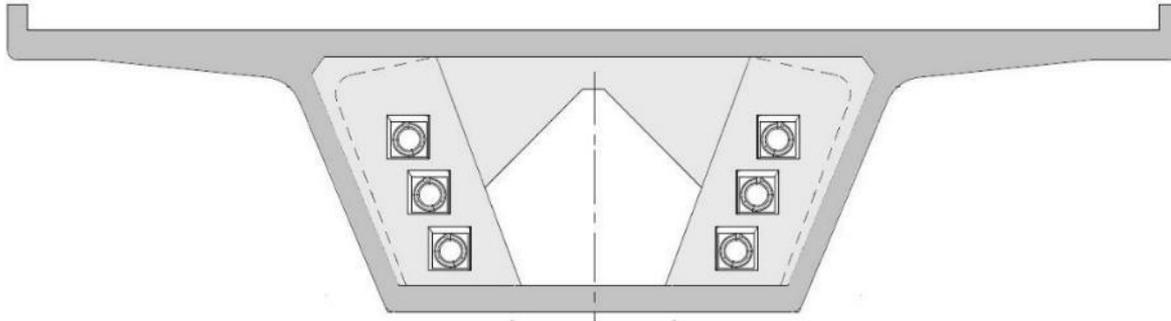


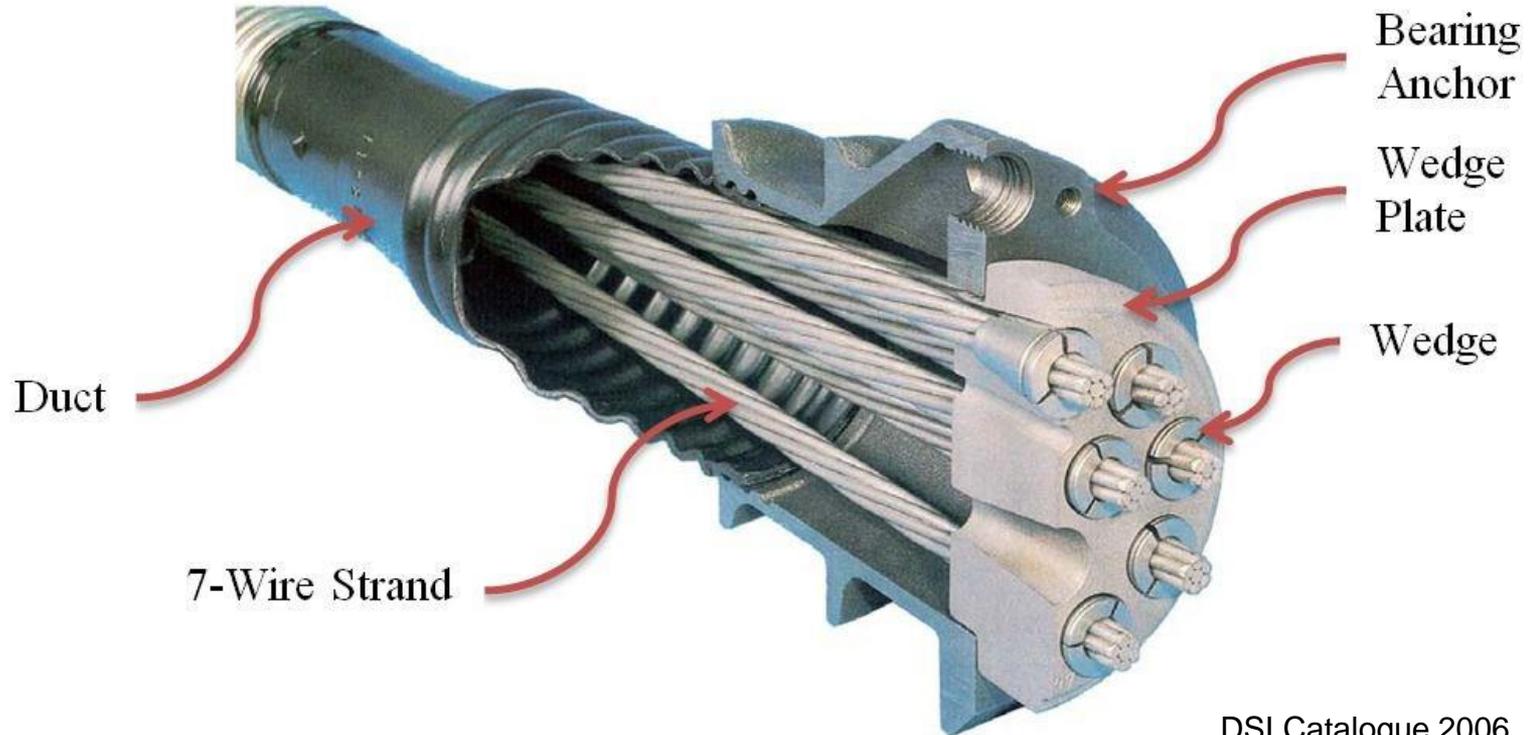


WOFH and KHG Guideway Tendon Issues

Definitions



Definitions



DSI Catalogue 2006

Definitions

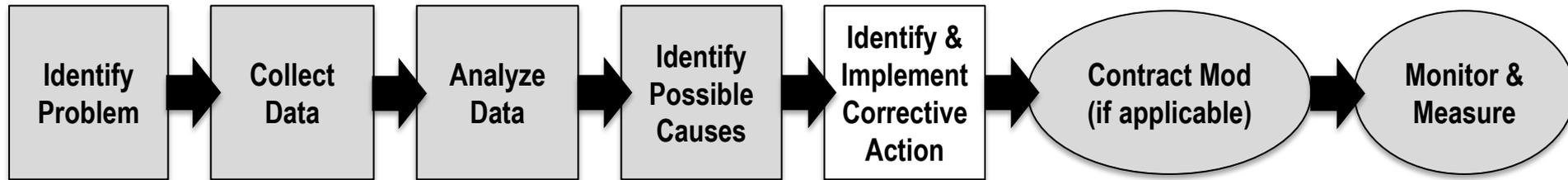
- Tendon protection
 - After tendons are installed, tendons are grouted within 14 days.
 - If not grouted in 14 days, a corrosion inhibiting powder is put in ducts.



Tendon Issue Summary

- 3 of 1586 tendons on WOFH have fractured strands
 - Prevent future fracture issues
 - Replace defective tendons
 - Ensure integrity of remaining installed tendons
- Grout voids & soft grout
 - Fill voids/replace tendons with soft grout
 - Ensure grout integrity in other tendons

Strand Fracture Root Cause Analysis



Timeline – Fractured Strands

- Span 258:

- **1/25/16:** One tendon with fractured strands
- **4/15/16:** Tendon was replaced and grouted

- Span 249:

- **4/1/16:** Two tendons with fractured strands
- **6/14/16:** Both tendons were replaced and grouted



Forensic Engineering Consultants

- Kiewit's consultant: Exponent



- HART's Consultant: Wiss Janney Elstner

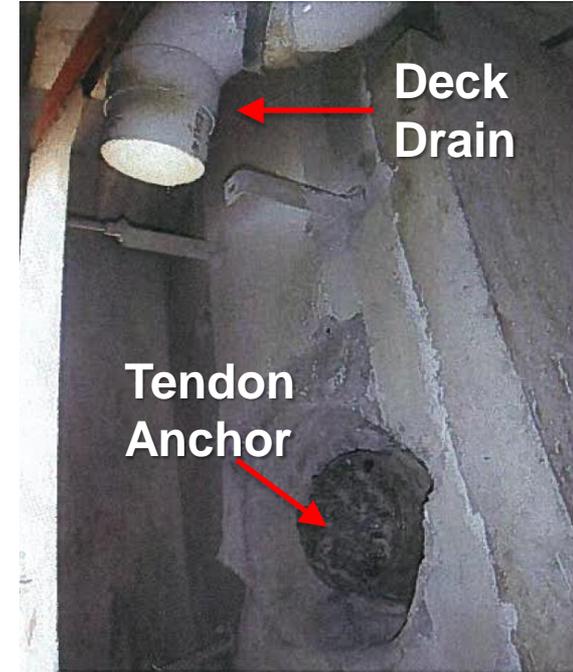


Wiss, Janney, Elstner Associates, Inc.

Fractured Strands

Kiewit's Probable Cause

- Water entered through anchors
- Corrosion inhibitor not effective with water in the duct
- Corrosion & fractures limited to anchor area
- Corrosion leads to fractures



Kiewit's Measures To Avoid Water Infiltration Into Tendons

- Divert drain inlet water away from anchors until permanent downspout is installed
- Pre-grout inspections
 - Visually inspect anchors for corrosion
 - Check low points for water



Investigate Grouted Tendons

- Kiewit chipped out grout to expose anchors
 - **Stage 1:** 26 tendons with water in ducts or exceeding 180 days between stressing and grouting.
 - 2 corroded anchors discovered and replaced.



Investigate Grouted Tendons

- Kiewit chipped out grout to expose anchors
 - **Stage 2:** 6 tendons that had problems with grout quality caused by water in the ducts.
 - 1 corroded anchor discovered and replaced.

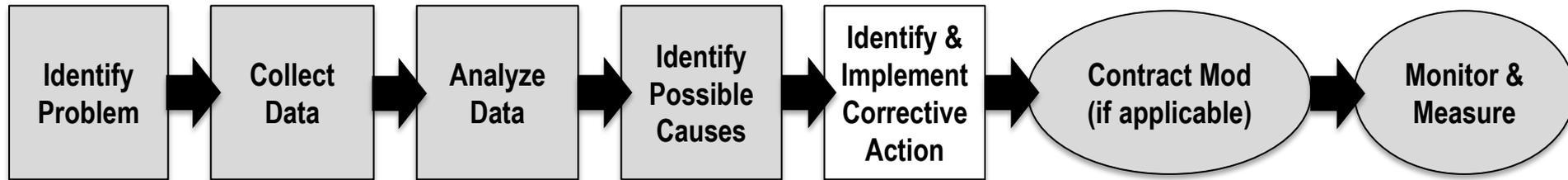


Investigate Grouted Tendons

- Kiewit chipped out grout to expose anchors
 - **Stage 3**: A random sampling of 25 tendons based on statistical analysis.
 - HART evaluating sample size
 - No corroded anchors discovered



Grout Issue Root Cause Analysis



Investigate Tendon Grout Quality

- Kiewit's grout records showed
 - 18 Tendons had grout voids (vacuum grouted per spec)
 - 6 Tendons had soft grout (replaced)
- Kiewit inspected all tendons by sounding with hammers
- Proper grouting halts corrosion



Current Status

- Kiewit has replaced all known problem tendons
 - 3 tendons due to fractured strands
 - 3 tendons due to corroded anchors
 - 6 tendons due to soft grout
- Received Kiewit preliminary report 9/2/16
- Resolving HART comments on anchor investigation
- Holding periodic status meetings with Kiewit

Next Steps

- Receive, review and reach concurrence on Kiewit's final report
- WJE to write summary report of findings

Mahalo!



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