Repair of Steel Beam/Girder Ends with Ultra High-Performance Concrete

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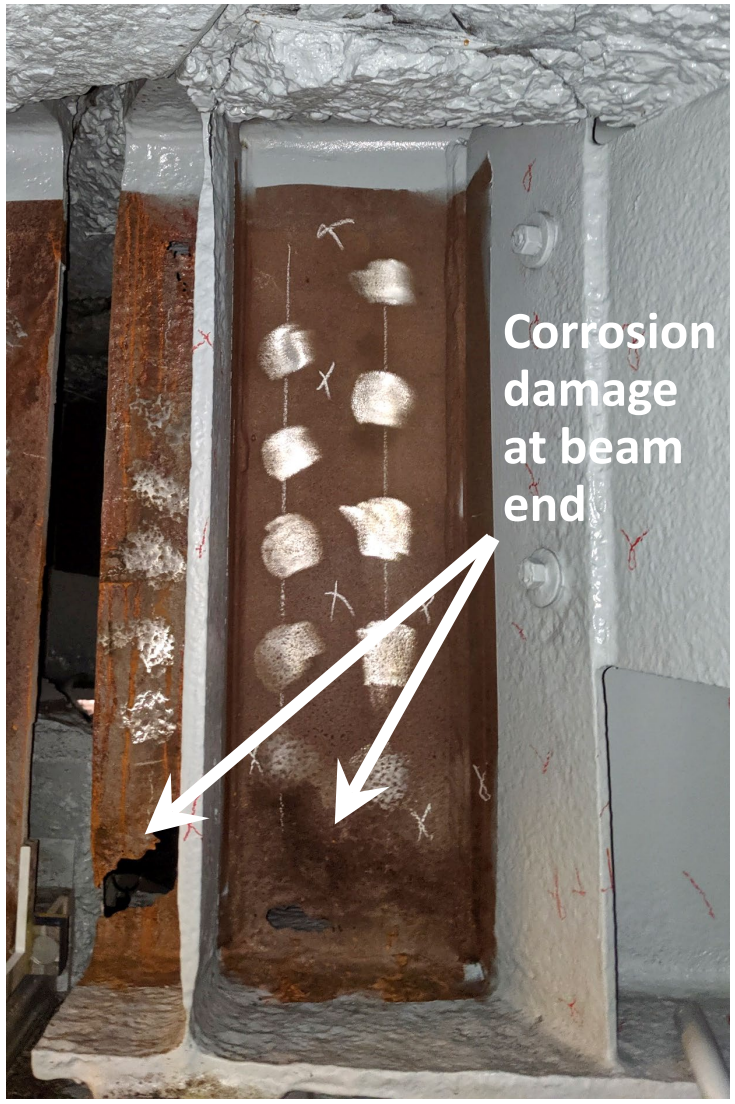
Overview

- Background on Repair
- Overview of Implementations
  - Full-Height Repair
  - Partial-Height Repair
- Key Findings
- Acknowledgements

Background – Corrosion of Beam Ends

- Extensive corrosion of beams occurs beneath leaking joints
- Corrosion can significantly reduce bearing capacity
- US spends **$8.3 billion annually** to repair or replace corrosion damaged bridges

Background – UHPC Beam End Repair



Background – Previous Research

Phase 1
2013-2015

- **Proof-of-concept experiments on third-scale girder specimens**
- **Developed finite element models to identify design parameters**

Phase 2
2015-2018

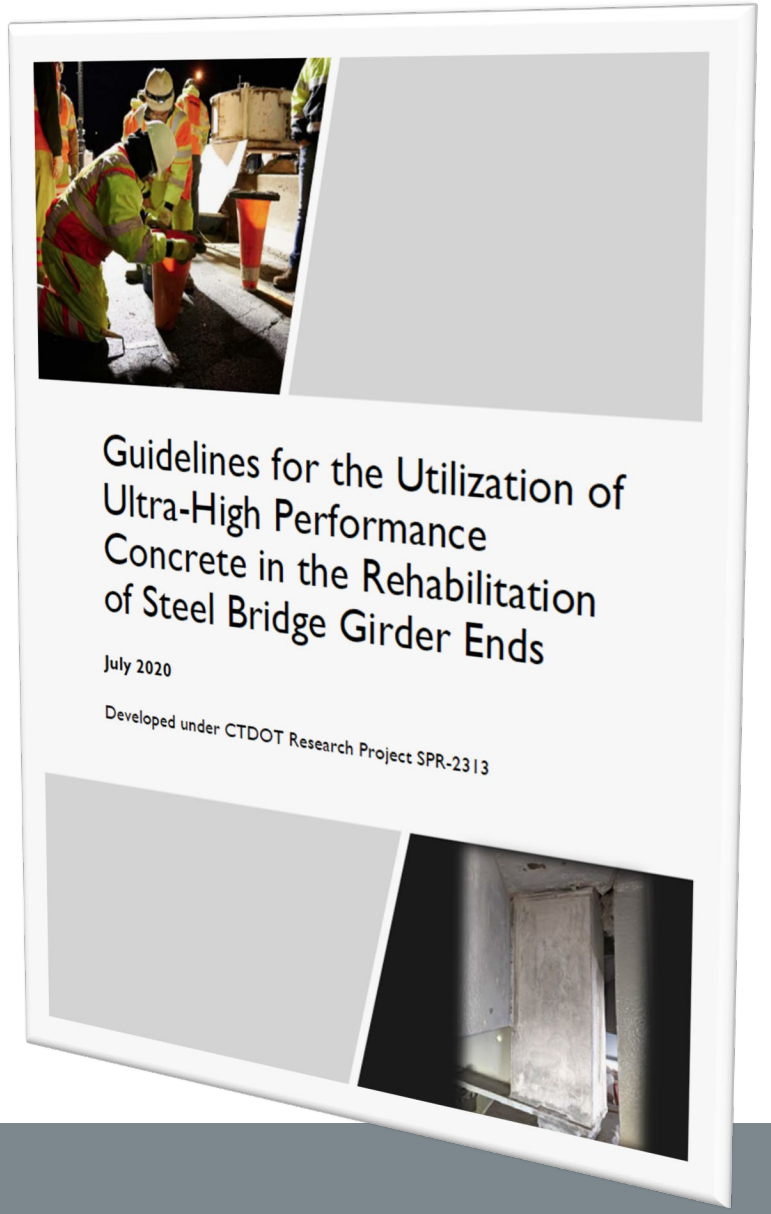
- **Investigation of stud capacity embedded in UHPC**
- **Experimental study on 3 full-scale plate girder repairs**

Background – Previous Research

Phase 3
2018-Present

- **Develop tools that can be used by CTDOT to quickly design repairs**
- **Test an alternative shear connector for repair**
- **Support design, construction and inspection processes as well as instrument and monitor field implementations of the repair.**

Every Day Counts
Innovation for a Nation on the Move



Field Implementations in CT

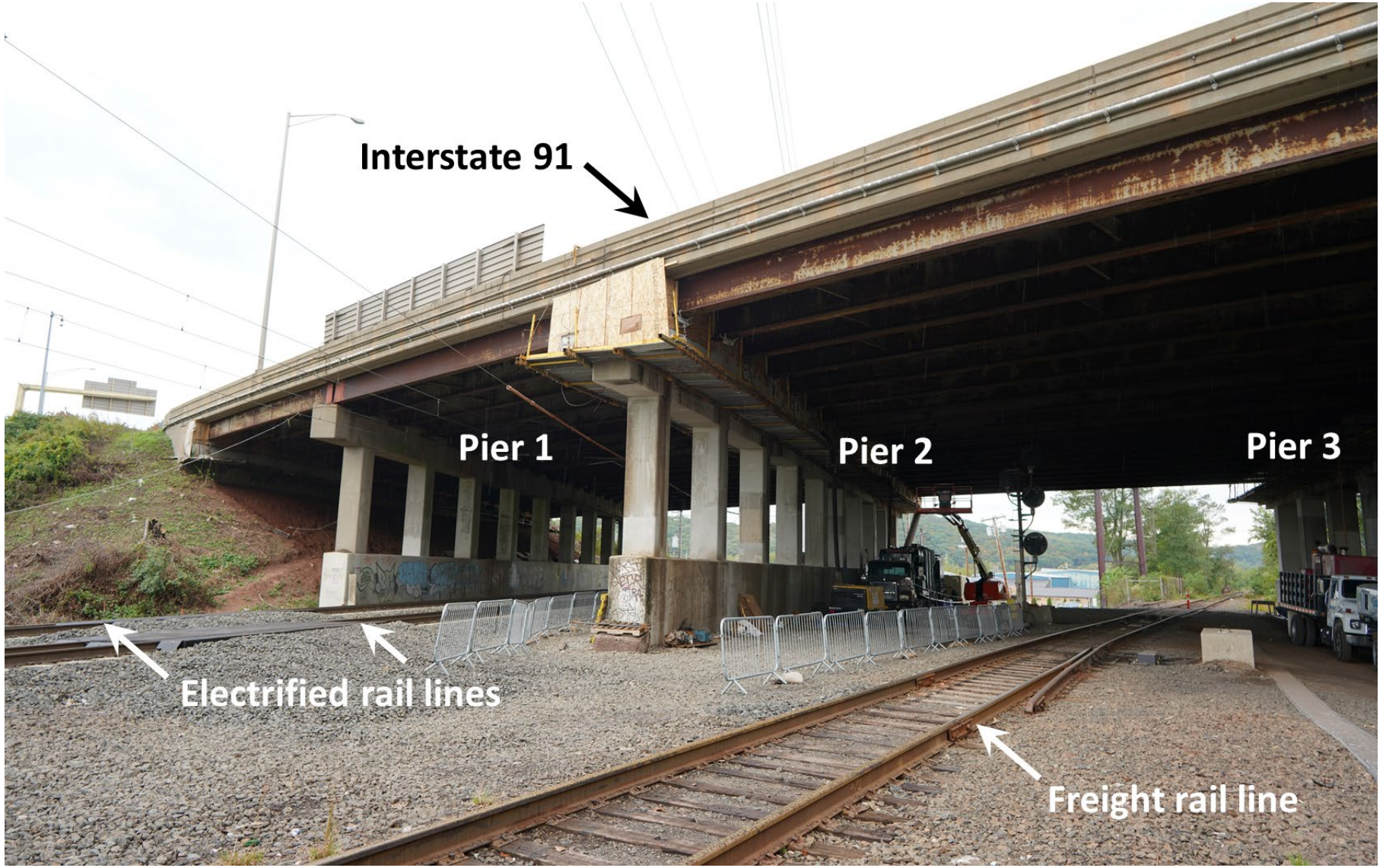
Implementation 1

- Rolled beam bridge
- Built in 1965
- Full-height repair
- Plain carbon steel
- Casting October 2019-May 2020
- Cast from top of deck
- Consultant-led design

Implementation 2

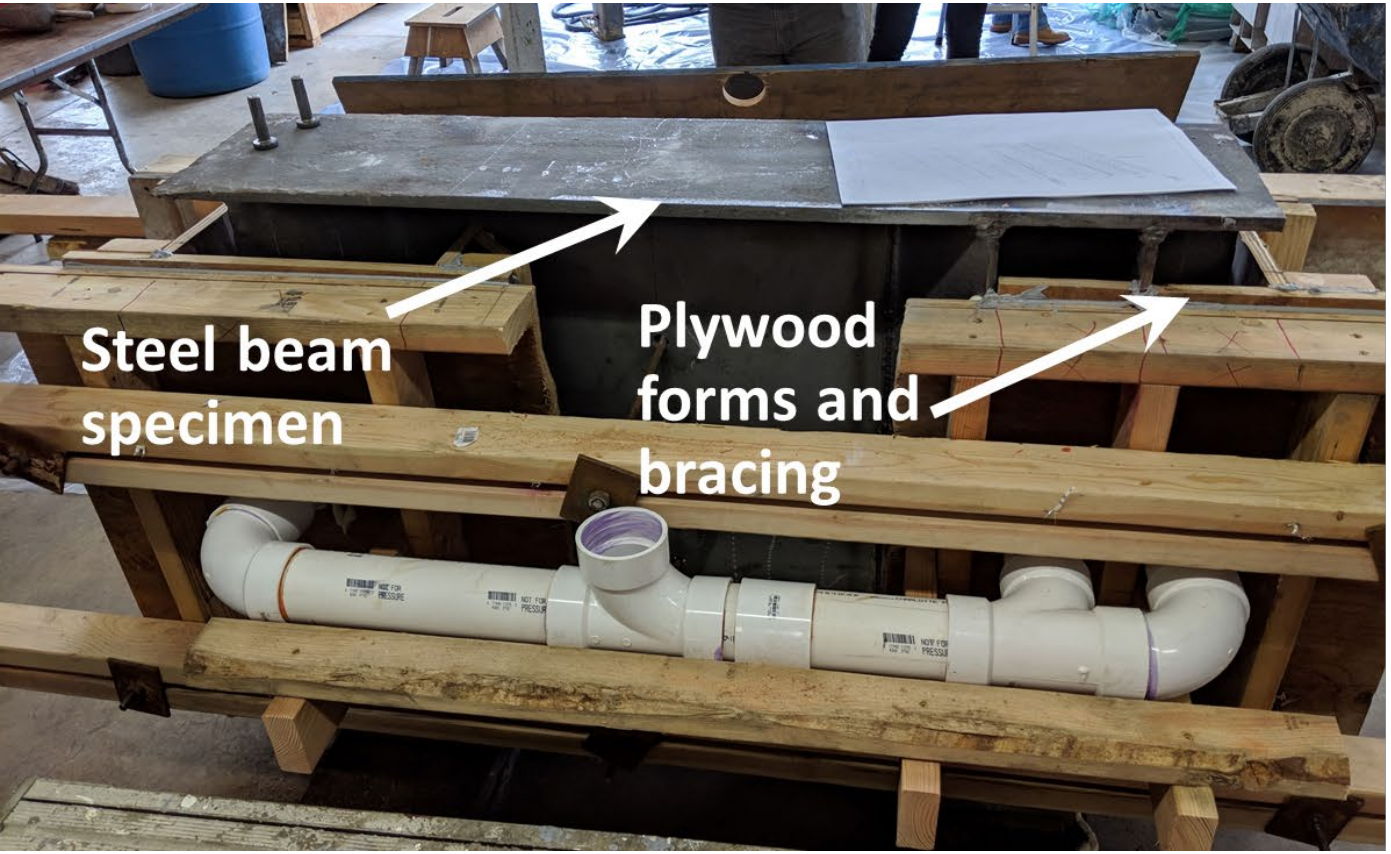
- Plate girder bridge
- Built in 1983
- Partial-height repair
- Weathering steel
- Casting October 2021
- Cast from below deck
- CTDOT In-house design

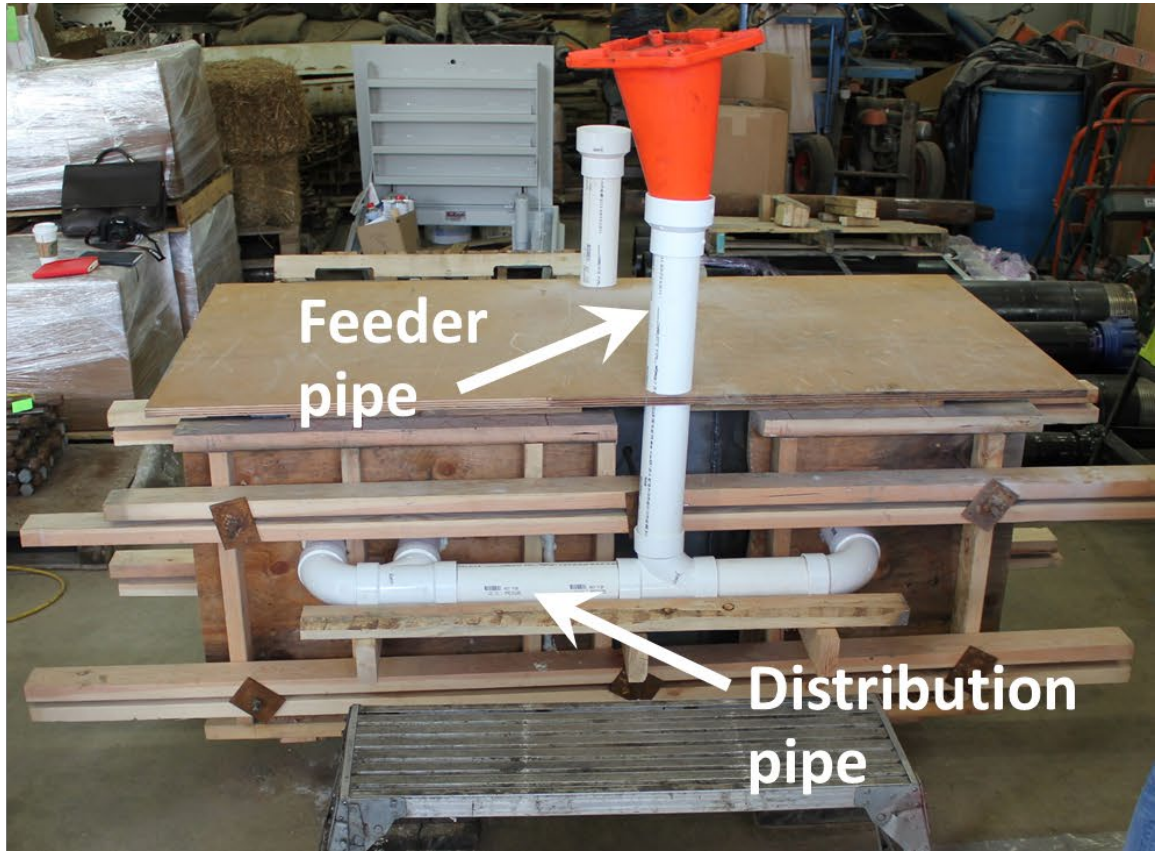
Implementation 1 – New Haven, CT



- 45 beam-ends repaired
- Ranging skews 25° - 35°
- Variable beam depths and end conditions
- Required pre-bid presentation

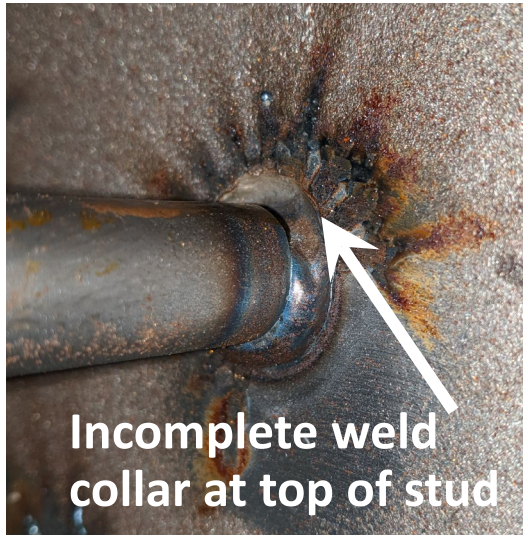
Implementation 1 – Mock-up



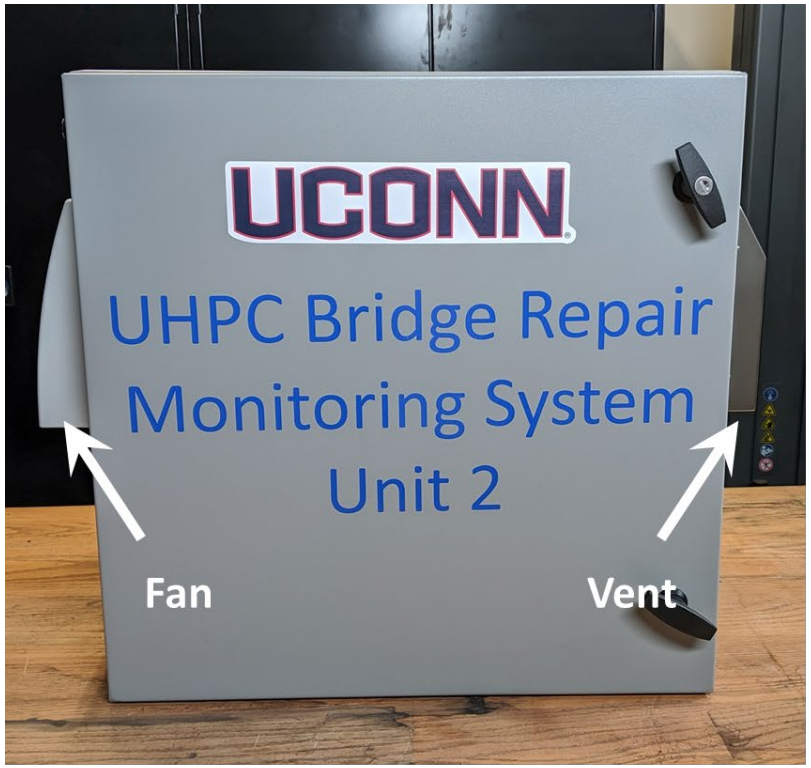


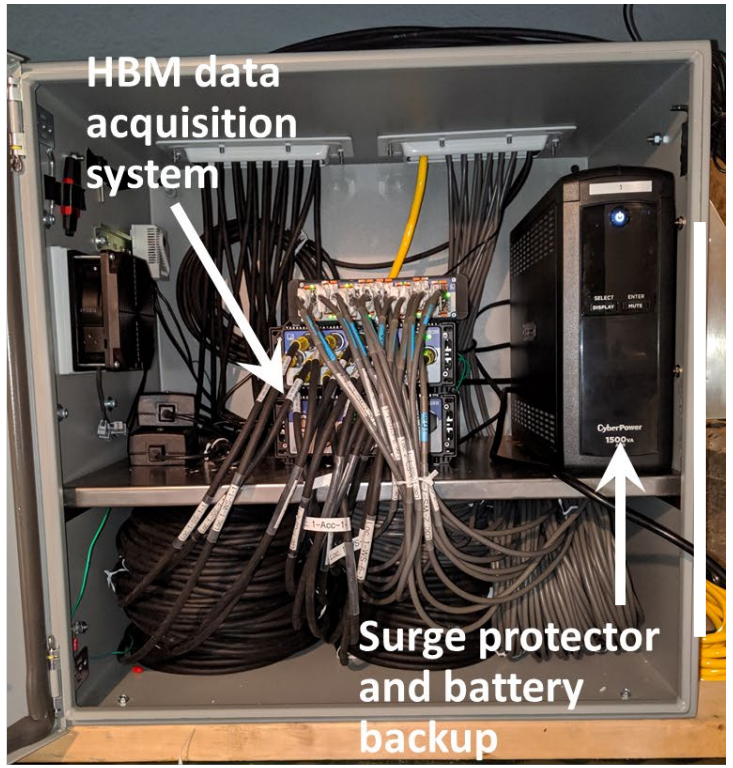
Implementation 1 – Mock-up

Implementation 1 – Stud Welding

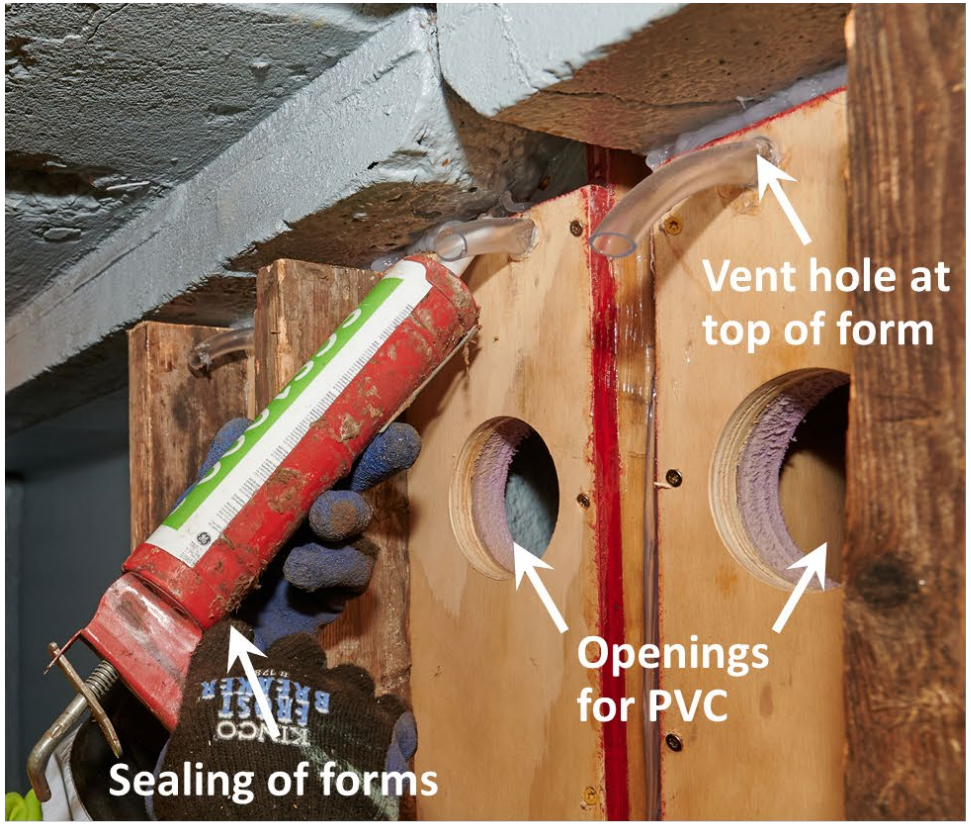


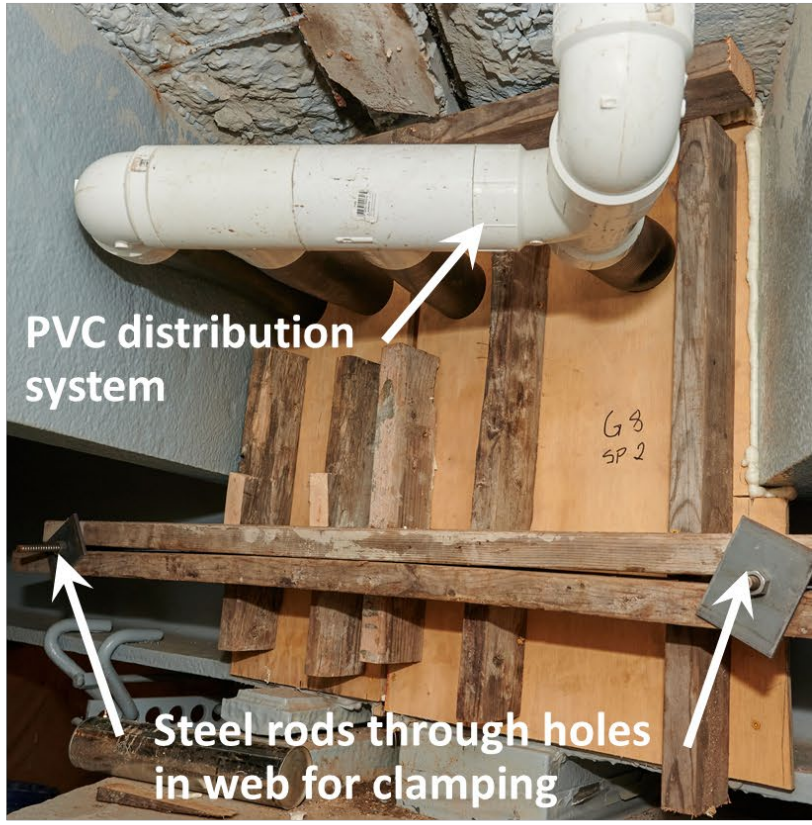
Implementation 1 – Monitoring



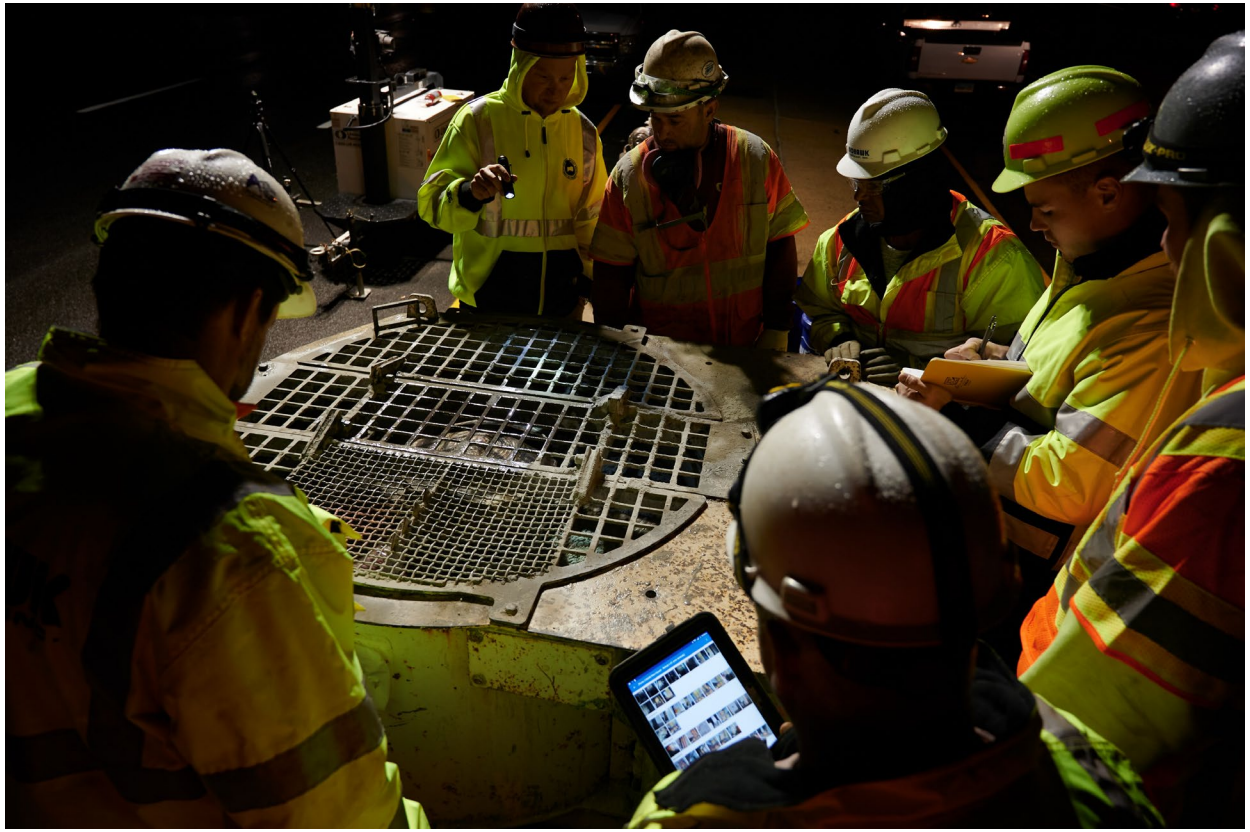


Implementation 1 – Forming





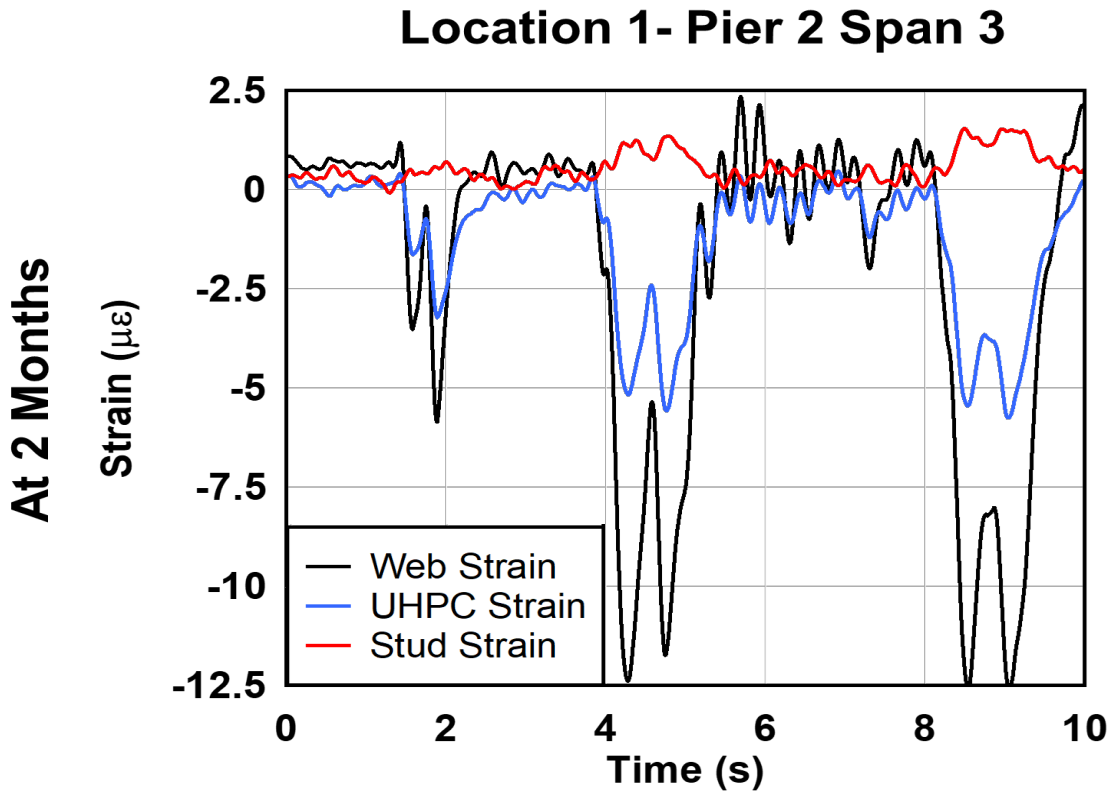
Implementation 1 – Mixing and Casting



Implementation 1 – Cured Beam Ends

Data Collection on Repaired Beam Ends

- Magnitude of web strain under live load events decreased after repair.
- Strains on web, studs, and concrete strain gauges confirmed repair was engaged.



Implementation 2 – East Haven, CT

- 49 beam-ends repaired
- Both simple and continuous spans
- 12 spans
- Required pre-bid video presentation

Implementation 2 – Mock-up

Implementation 2 – Stud Welding

- This repair design was unique in that studs were welded to the bottom flange to carry shear between the web and bottom flange.
- Design varied by based on number of studs on the bottom flange.
- Two standard designs

Implementation 2 – Monitoring

- Monitoring was based on learnings from previous implementation.
- Capturing accelerations, temperature during curing, and strains on web, studs and in UHPC panels.

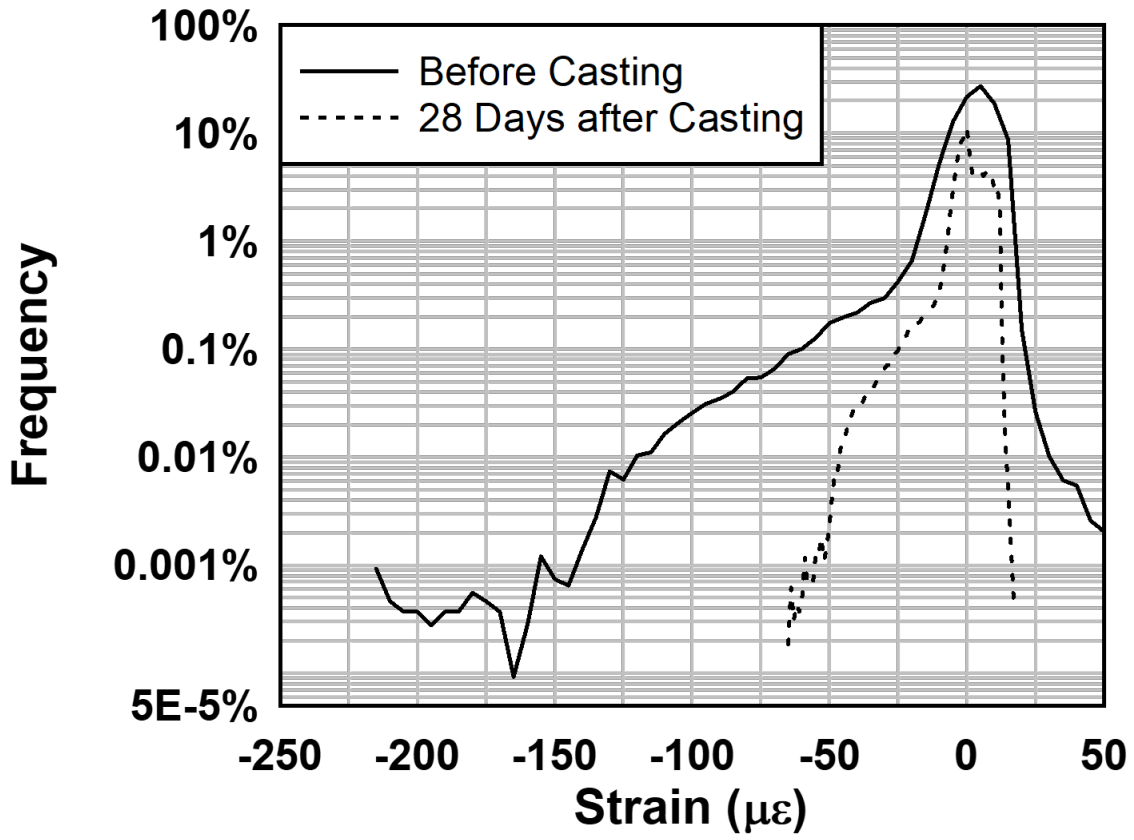
Implementation 2 – Forming

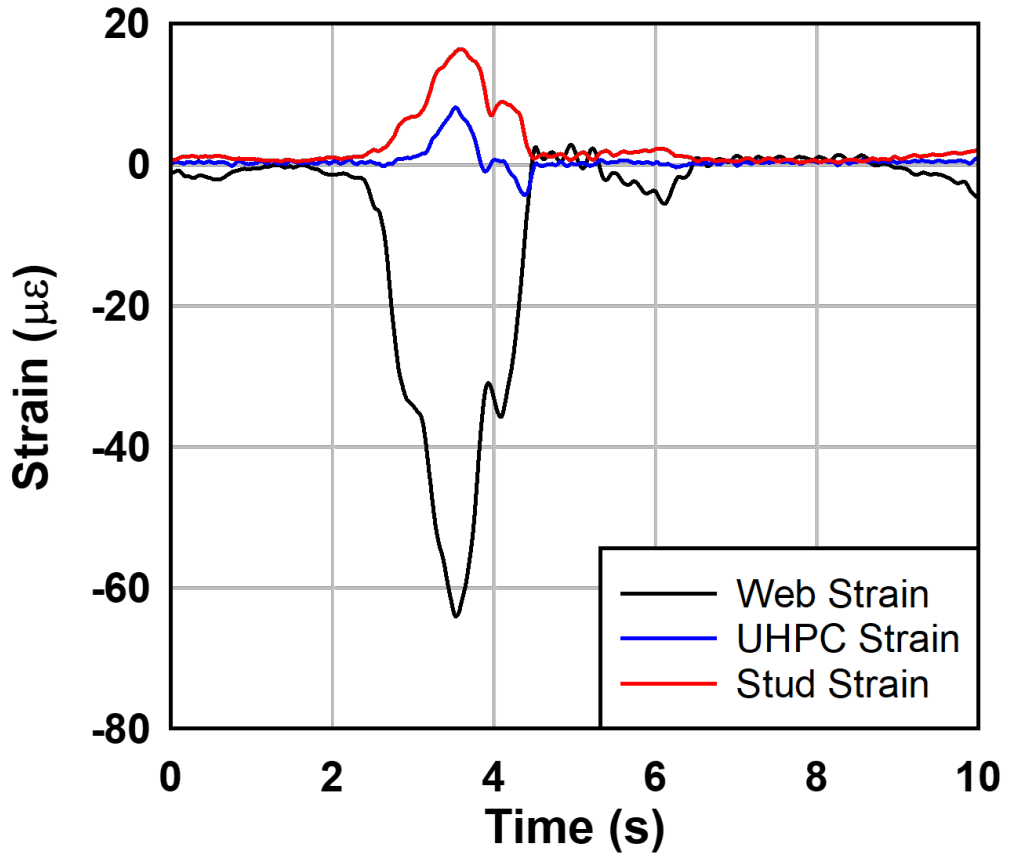
Implementation 2 – Mixing

Implementation 2 – Casting

Implementation 2 – Cured Beam Ends

Data Collection on Repaired Beam Ends





Summary & Key Learnings

- A novel repair procedure for corroded steel beam ends using UHPC was implemented on two bridges in Connecticut.
- The involvement of the research team during design and construction ensured a smooth transition from research to practice.
- It is critical that the owner, contractor, and inspector understand the structural performance of repair and material specific properties for UHPC prior to implementation.
- The two repairs used different designs, UHPC mixes, and casting procedures showcasing the flexibility of the repair.

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MOHAWK NORTHEAST, INC. GM2 CHA CONNECTICUT DEPARTMENT OF TRANSPORTATION NE UCONN SCHOOL OF ENGINEERING

Thanks! Questions?

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RAC Region 1 Meeting
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