Emergency Stabilization: West Seattle High-Rise Bridge

Washington ACI Chapter & SEAW Joint Meeting

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February 16, 2022

City of Seattle

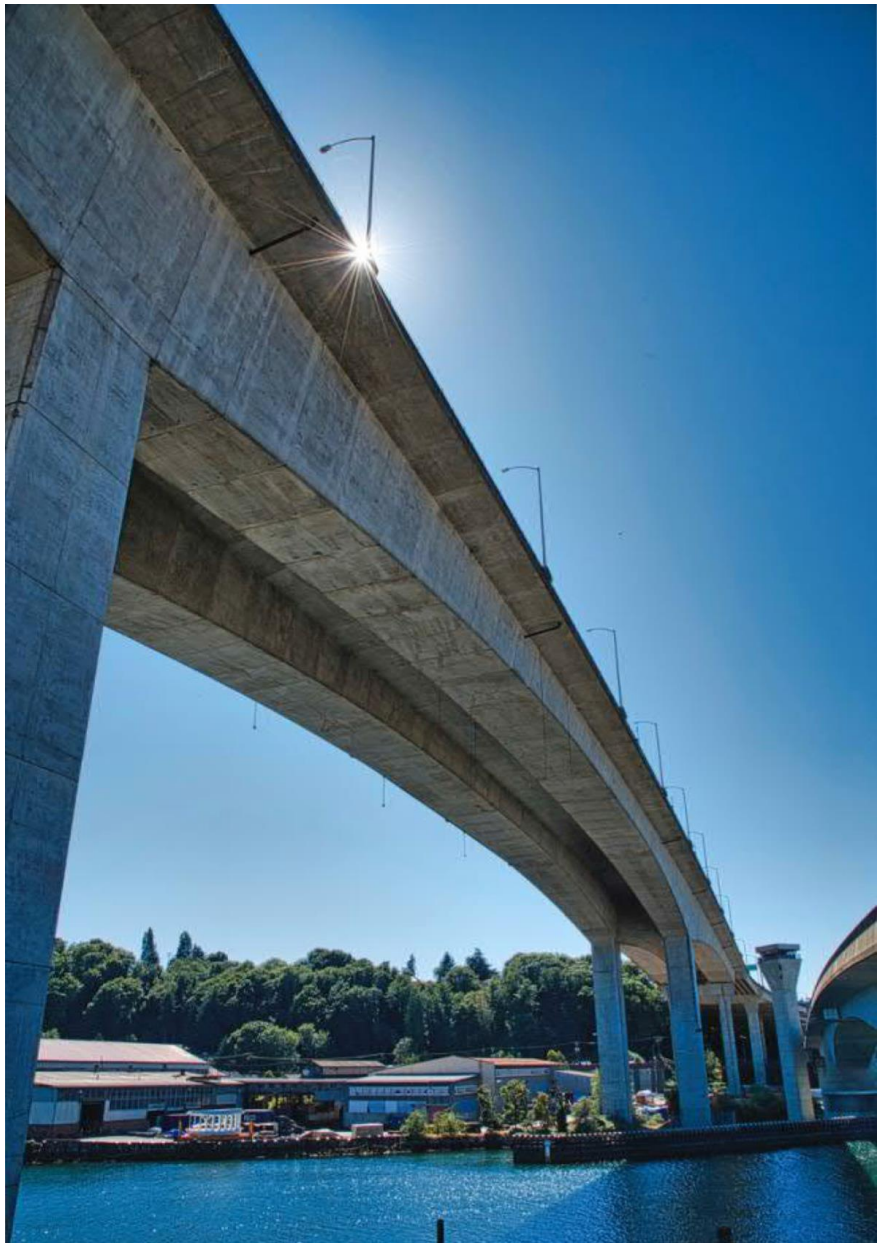
wsp

BDI
RAW DATA. REFINED RESULTS.

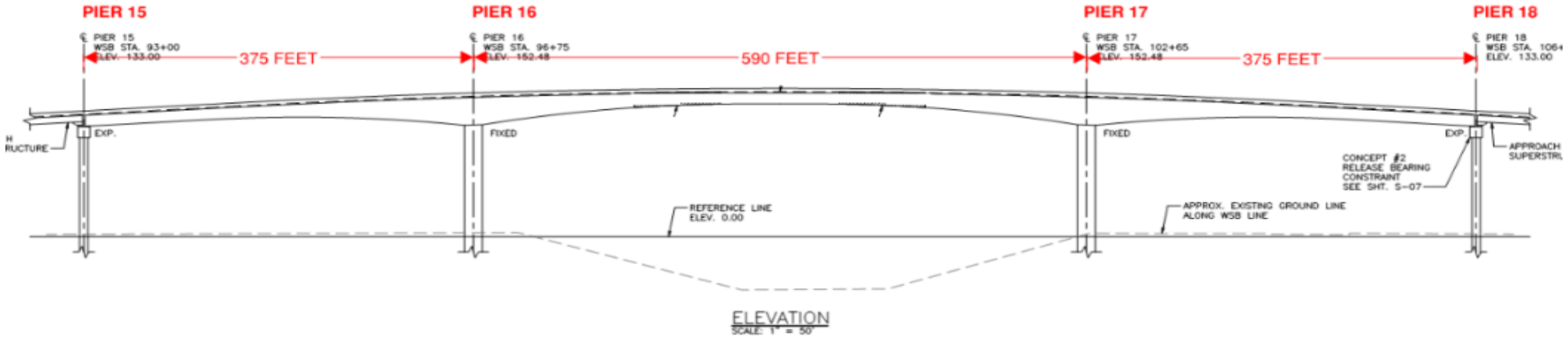
Bridge Overview

- Operational July 14, 1984
- Segmental construction
- Approximately 100,000 ADT
- Cracking prioritized in 2013
- Preventative maintenance and more frequent observations started immediately
- Load rating analysis in 2019

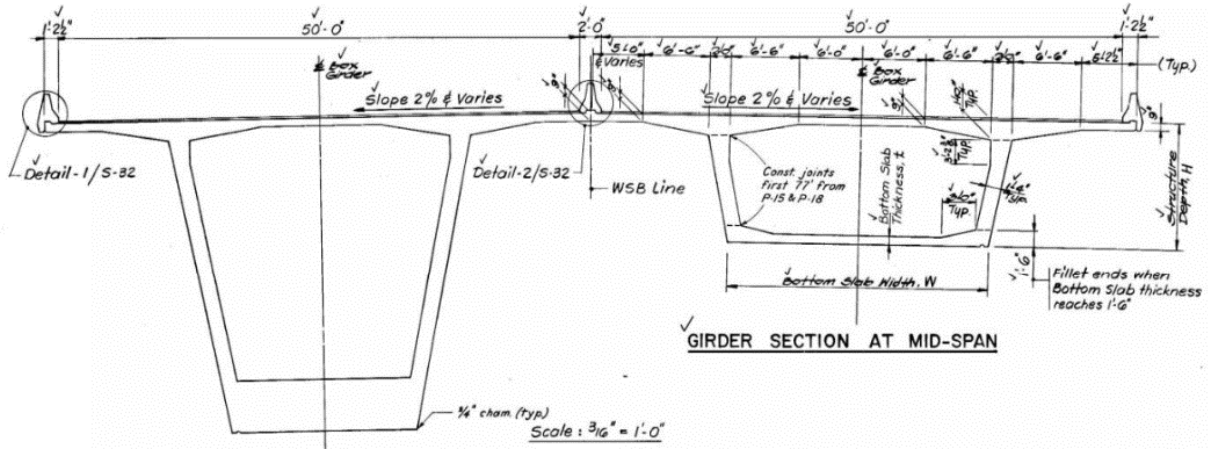
Segmental (CIP balanced cantilever)



Bridge Details



- Elevation (top)
  - Main span 590’
  - Flanking spans 375’
- Section (bottom)
  - Near Pier Table (left) h~30’
  - Near mid-span (right) h~12’



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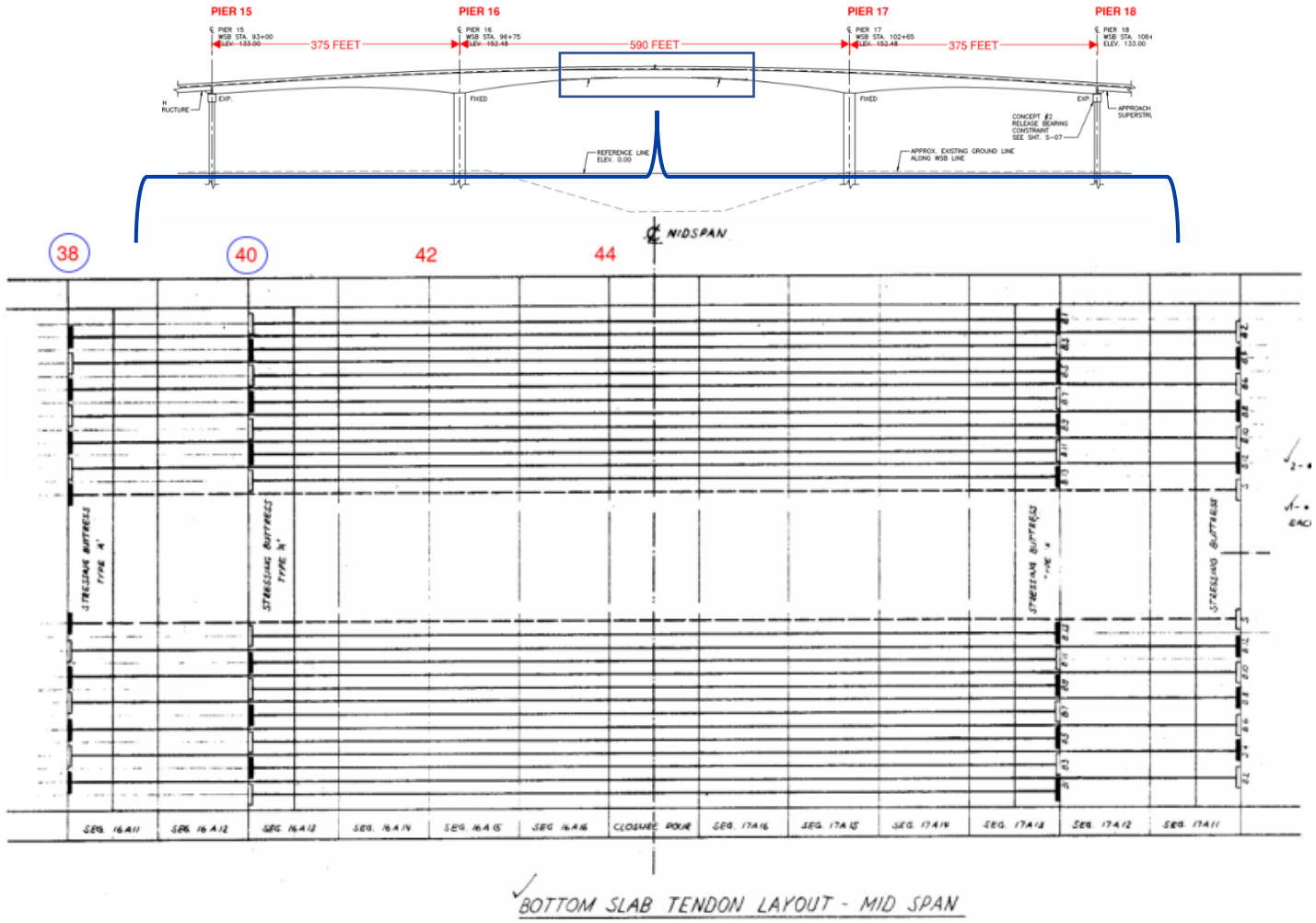
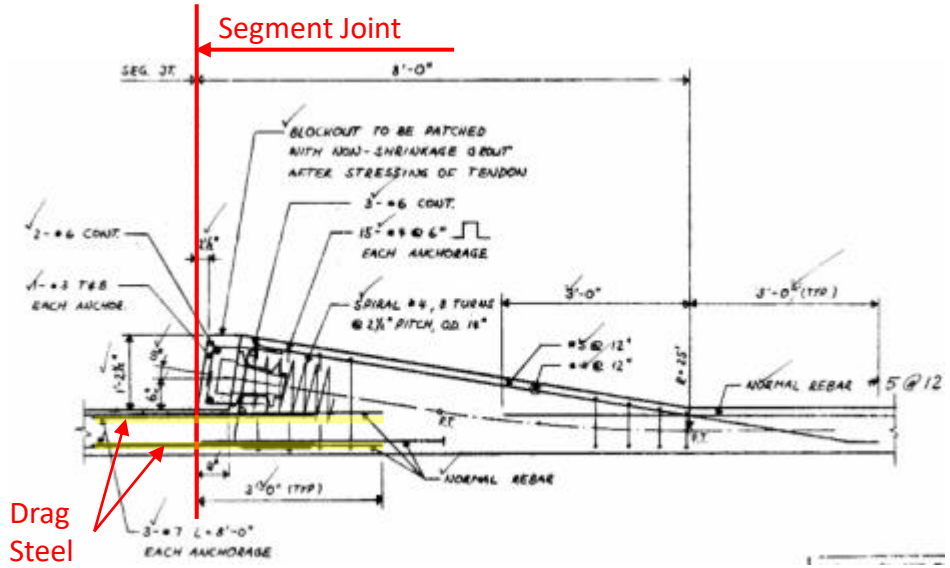
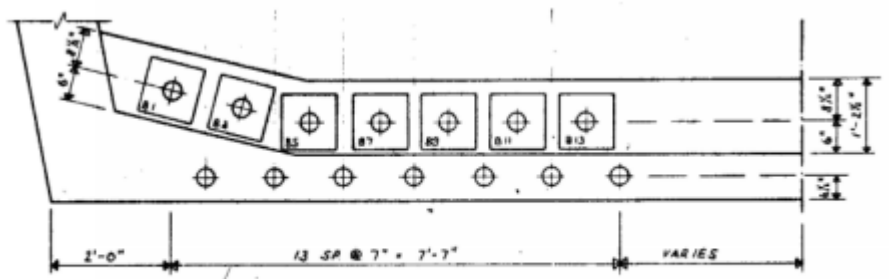


Terminated at discrete bulkheads

- Joints 38 and 40 – main span
- Joints 12 and 14 – end spans



LONGITUDINAL SECTION AT BOTTOM FLANGE PT ANCHORAGE



Bridge Assessment

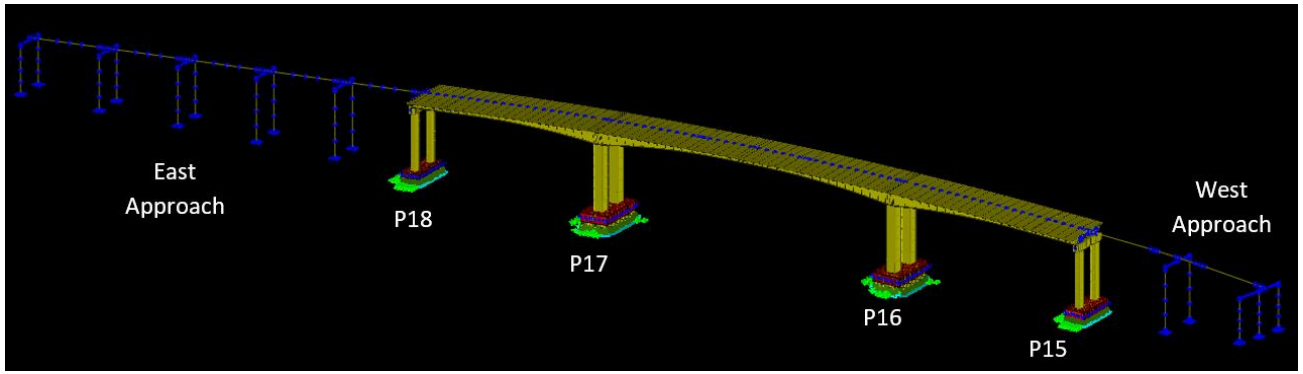
FAST ACT Federal Mandate

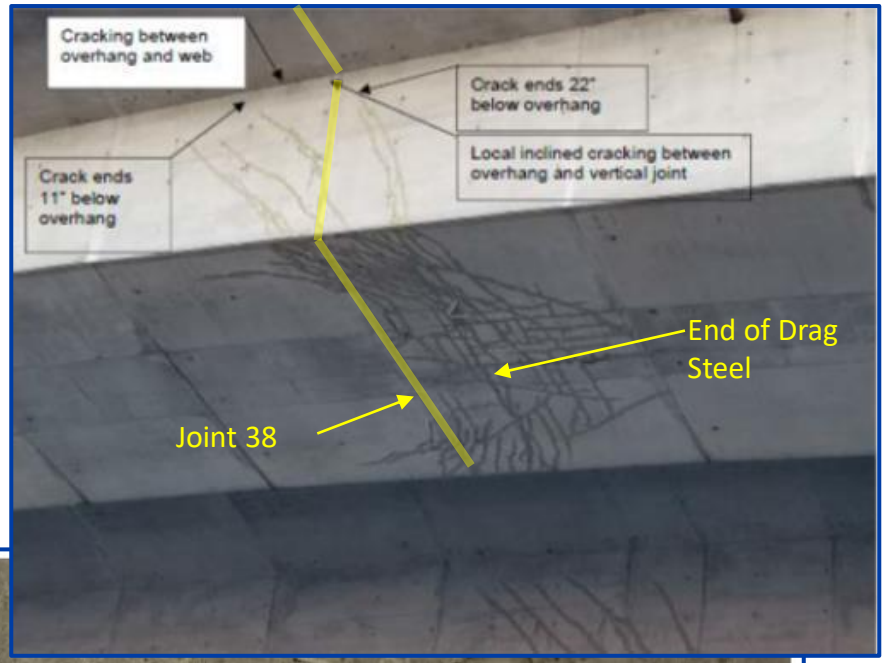
Load Rating

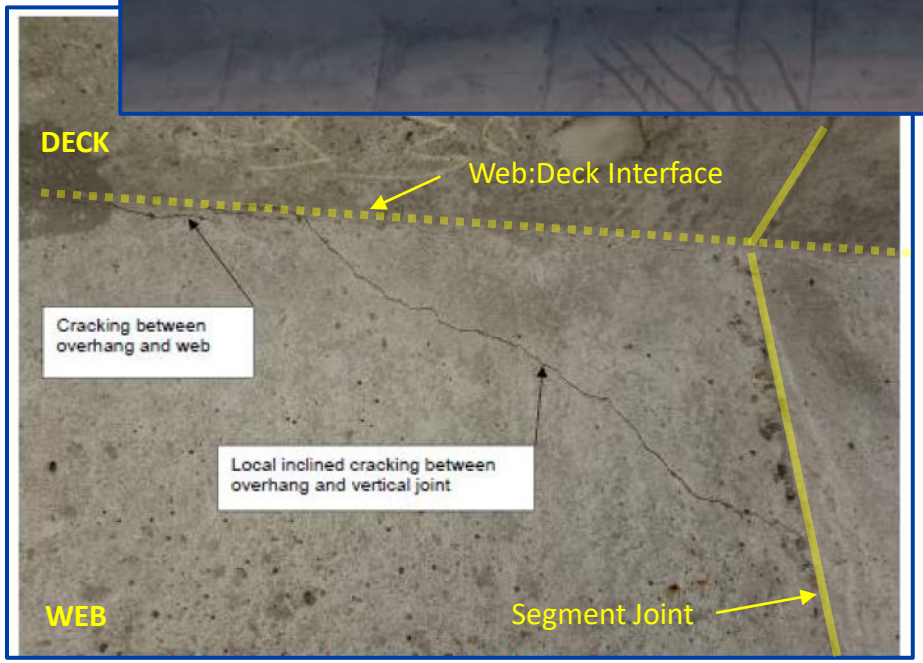
Known Main Span Cracking

Data Gathering

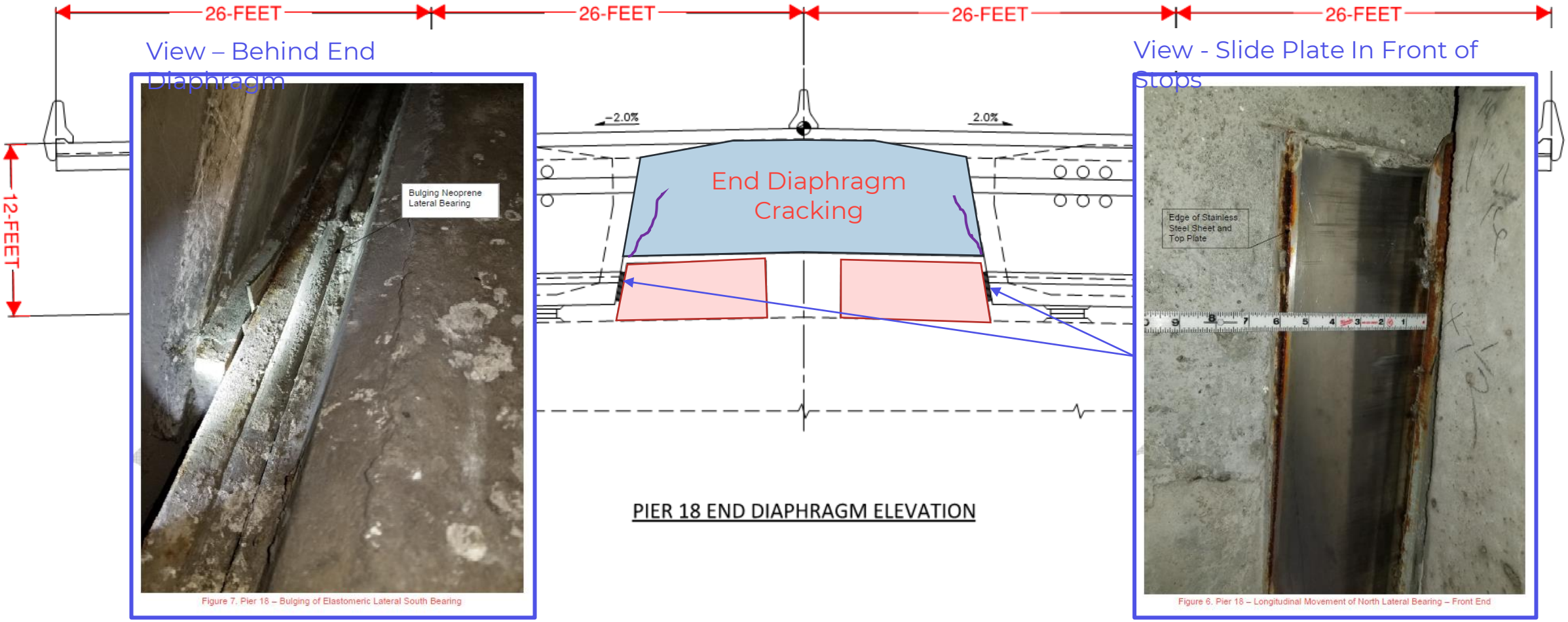
Field Observations







Bridge Assessment



Bridge Assessment

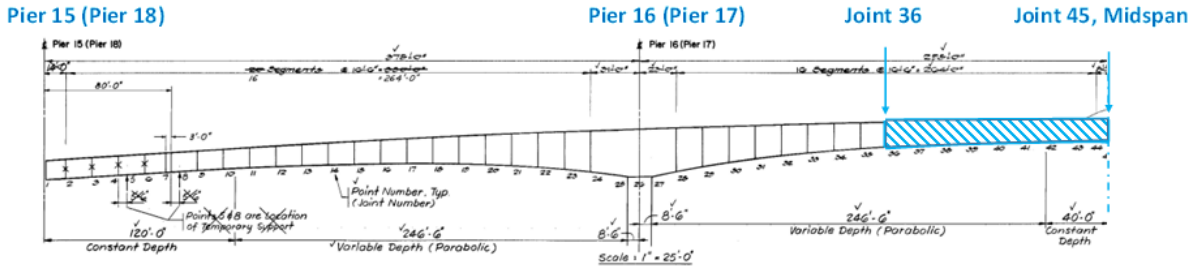


Figure 9: Longitudinal elevation. Pier 15 to the mid-span (the west half).

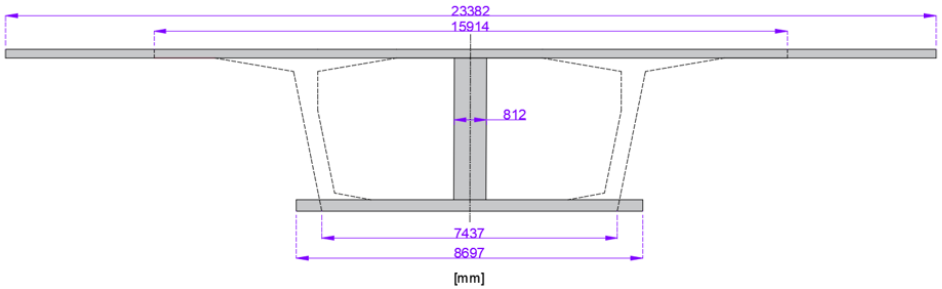


Figure 13: The analyzed I-shape beam cross-section (red) and the original cross-section (dashed line) at segment 12.

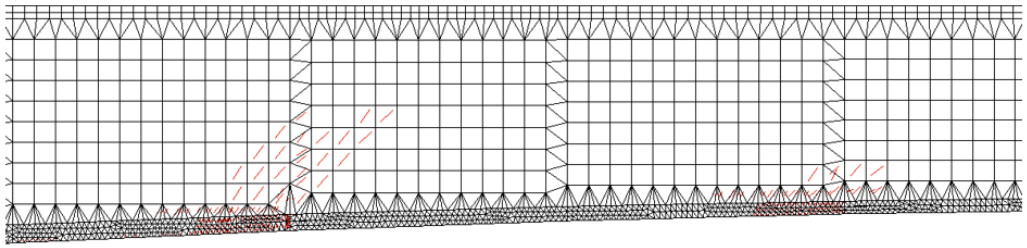


Figure 22: Crack diagram at load factor 0.9 of Phase I.

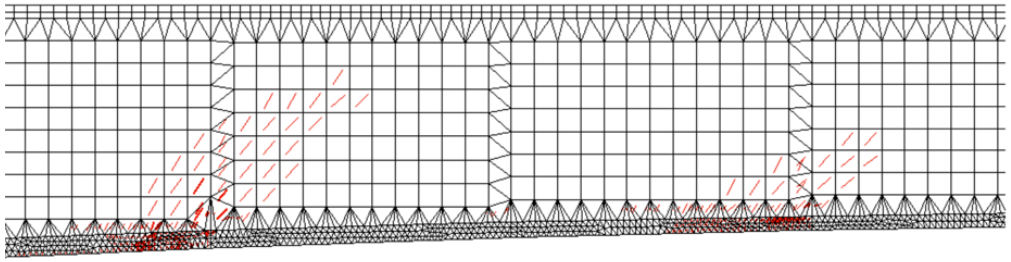
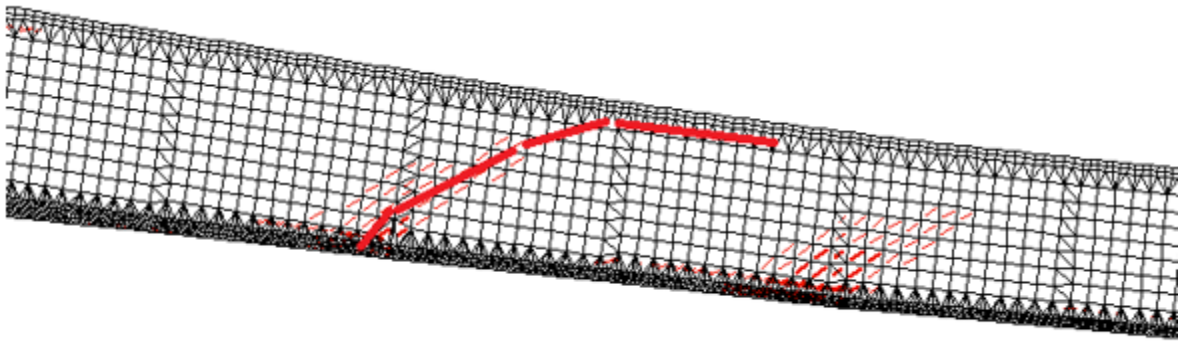
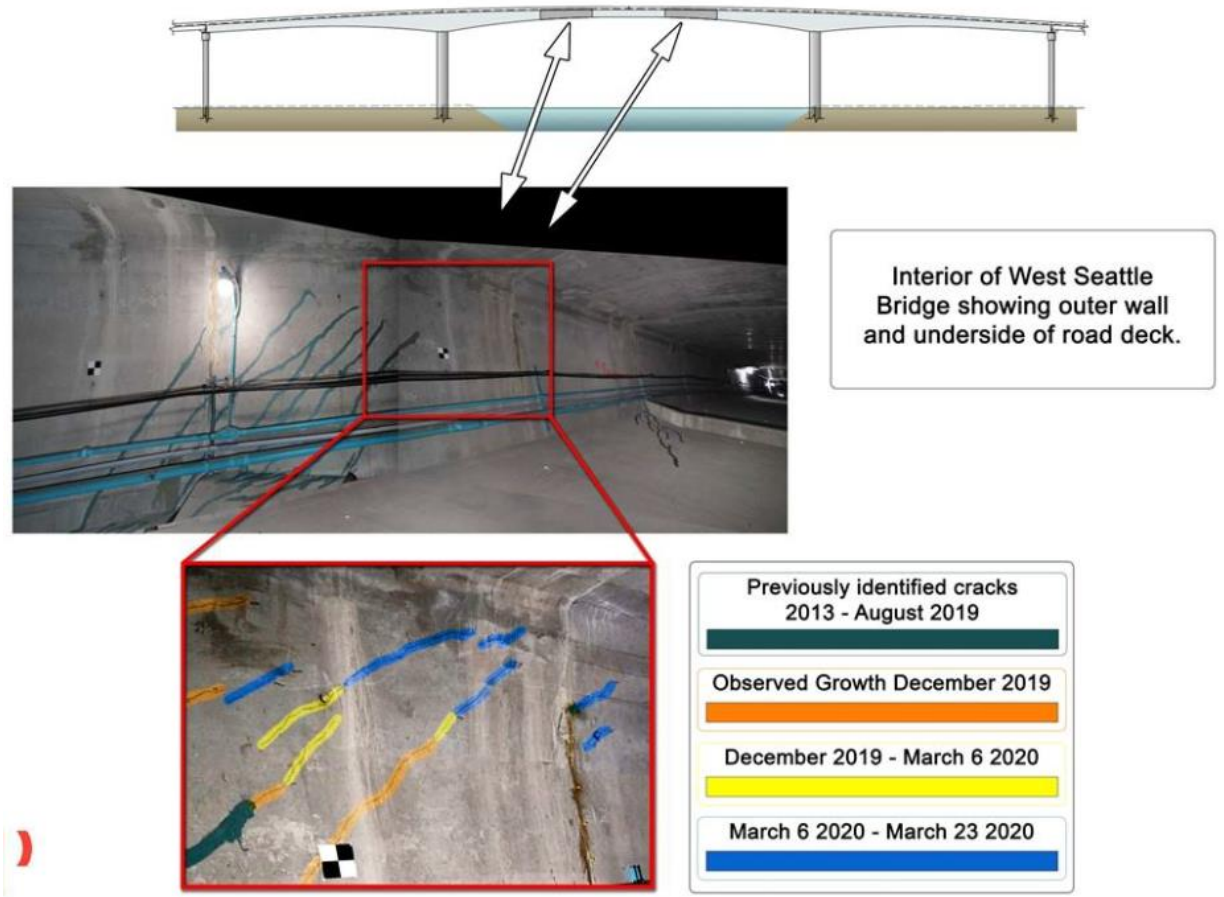


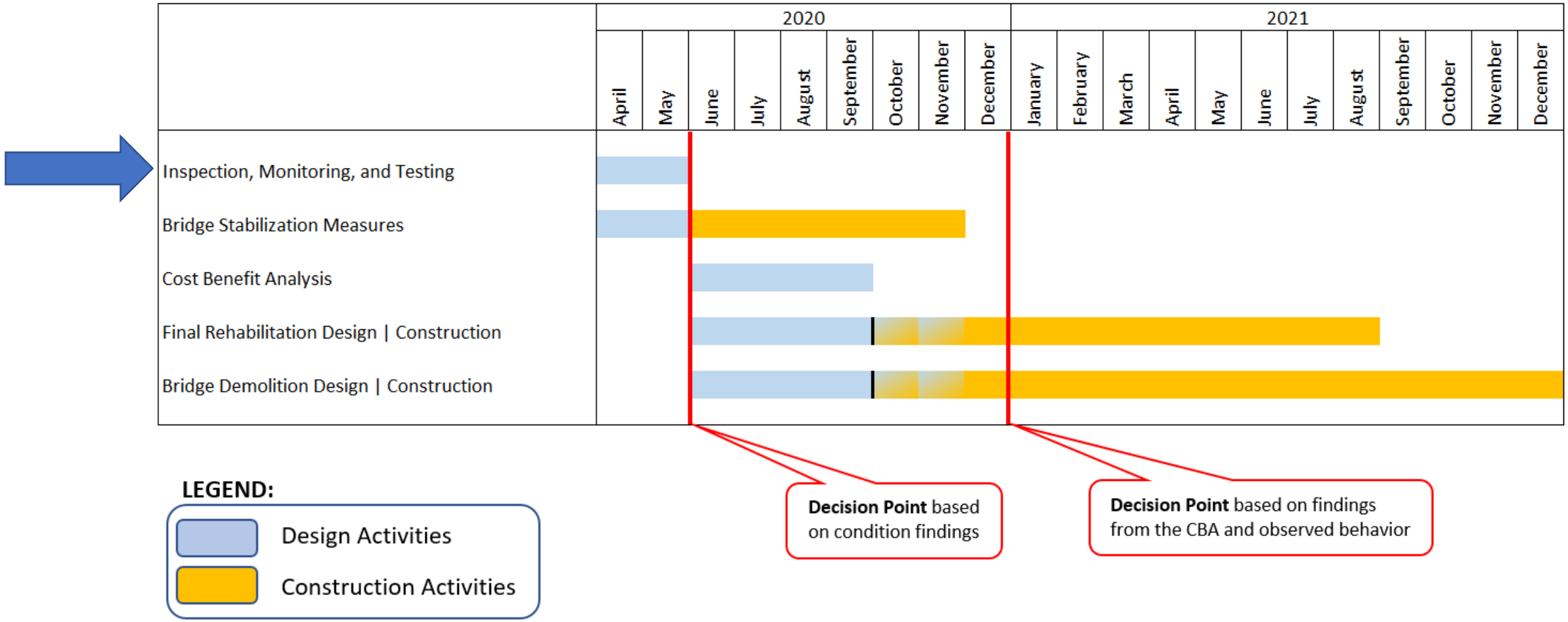
Figure 23: Crack diagram at load factor of 1.0 from a previous analysis



The Emergency



Decision Matrix

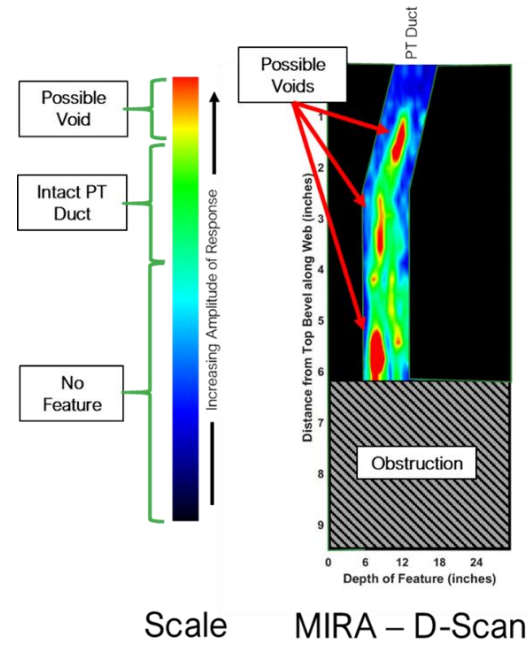


Testing & Monitoring Overview

Providing information for the Decision Matrix

Nondestructive Evaluation (NDE) Testing (Condition)

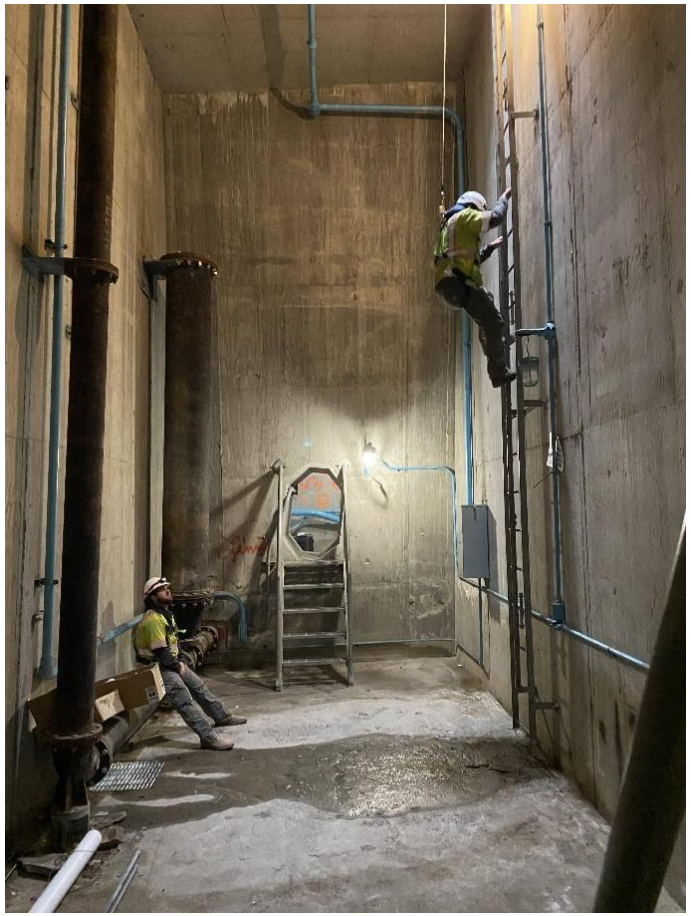
- Examining condition at a material level
- Level of corrosion in mild steel and post-tension steel
- Concrete chemical properties – propensity for corrosion
- Depth of cracks



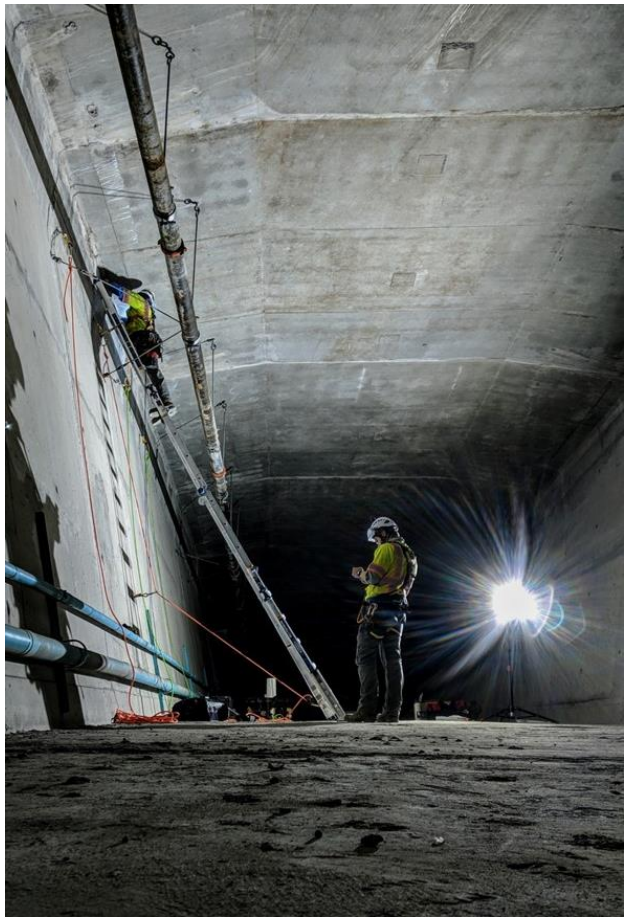
Structural Health Monitoring (Performance)

- Structural movement / deformation
- Change with respect to expectations
- Rate of change
- Safety

Testing & Monitoring



Confined space entry and air monitoring procedures



Ladders , removable bolts and fall protection to perform testing and material sampling (Photo Courtesy WSP)

SPRAT Ropes Access to obtain exterior concrete samples

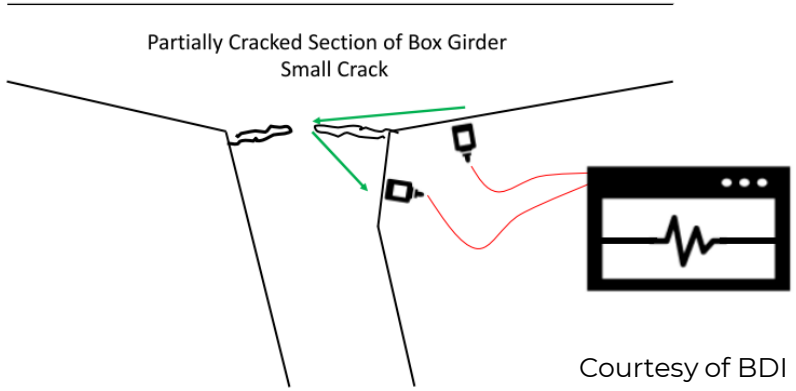
Testing (Crack Depths)

Ultrasonic Pulse Velocity (UPV)

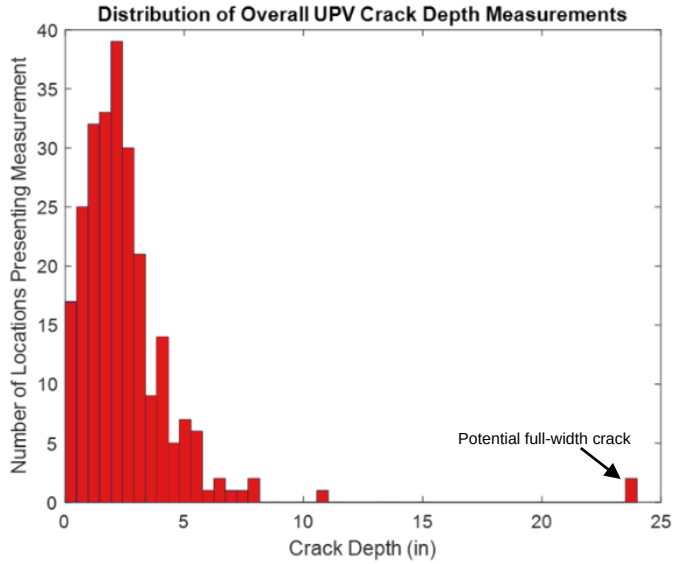
- UT probes above and below web-deck chamfer

Determine:

- Full-depth cracks (no signal)
- Depth of crack (time-of-flight)



Courtesy of BDI



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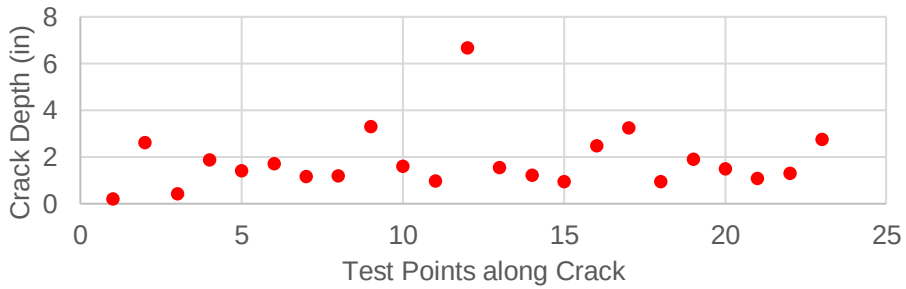
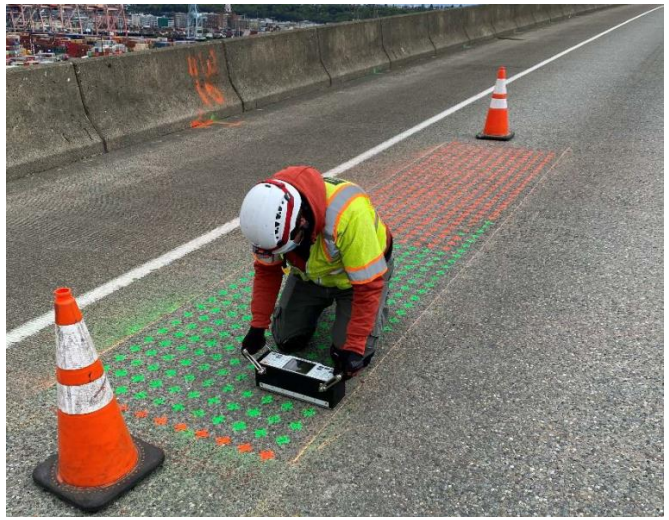


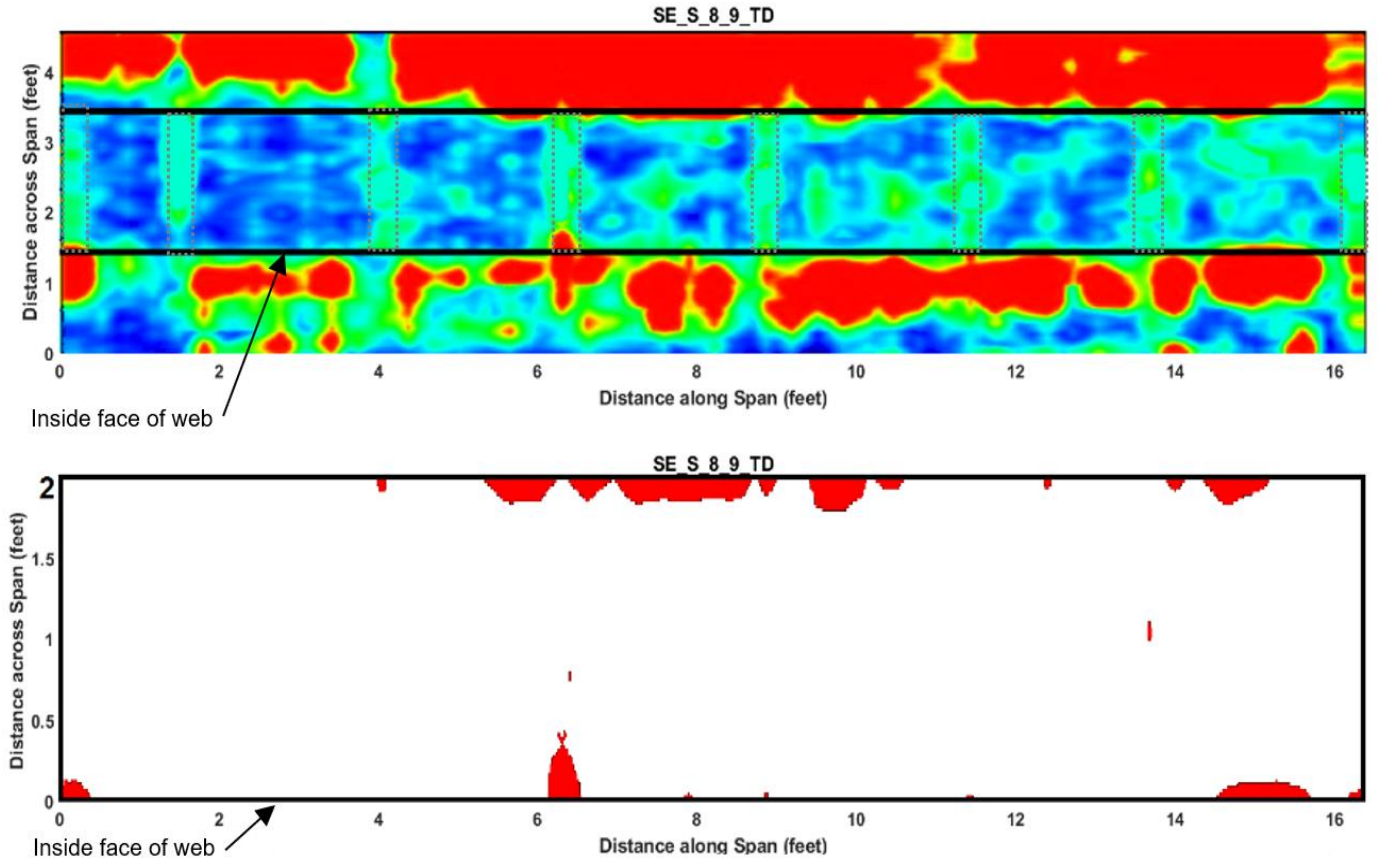
Testing (Crack Depths)

Ultrasonic shear wave tomography

- Scans from top of deck above web
- Assess depth of crack plane
- Compare to UPV results



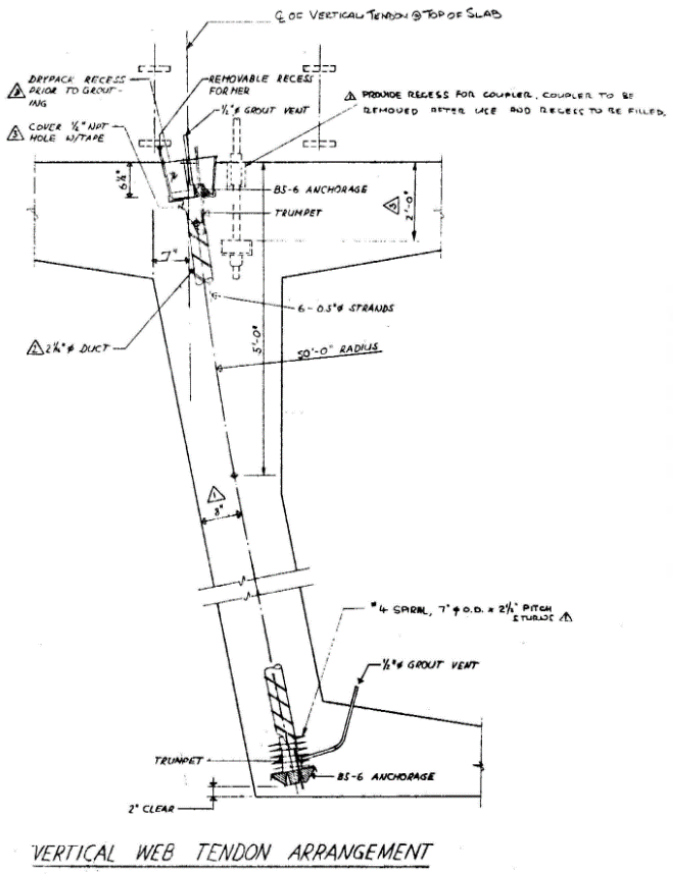
Courtesy of BDI



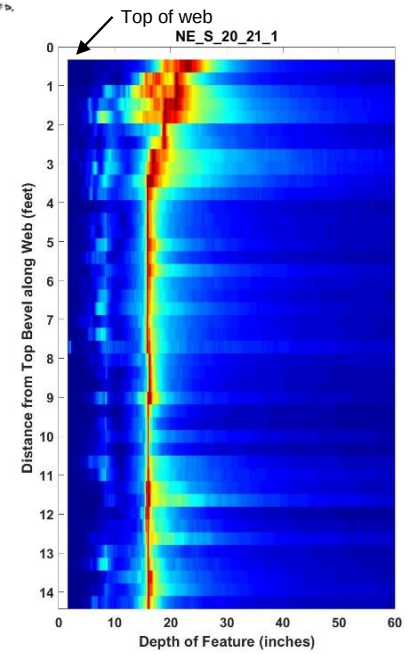
Ultrasonic Tomography Results as a Section Taken at Top of Web.

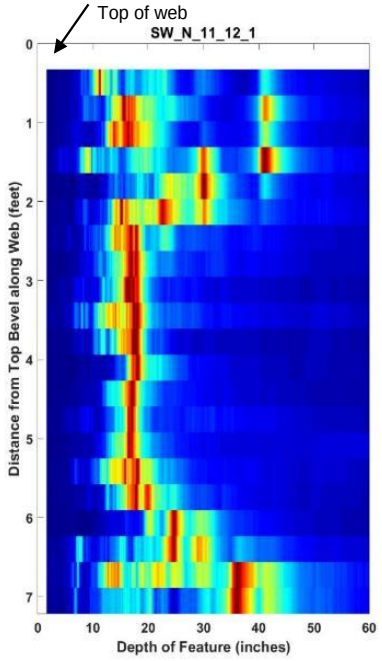
Courtesy of BDI

Testing (Condition of PT Tendons)



Impact echo

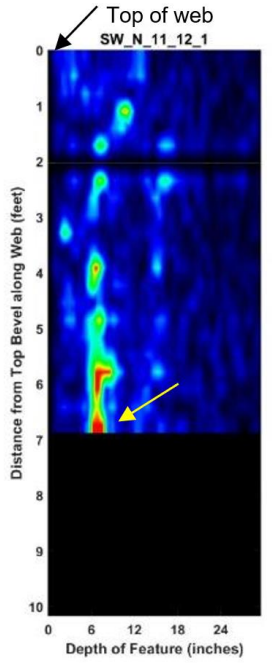




Intact grout

Voids in grout

USW tomography



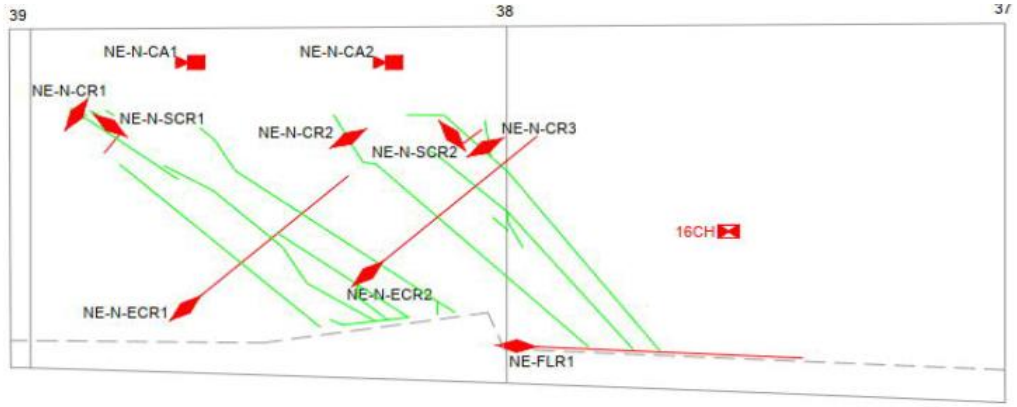
Voids in grout

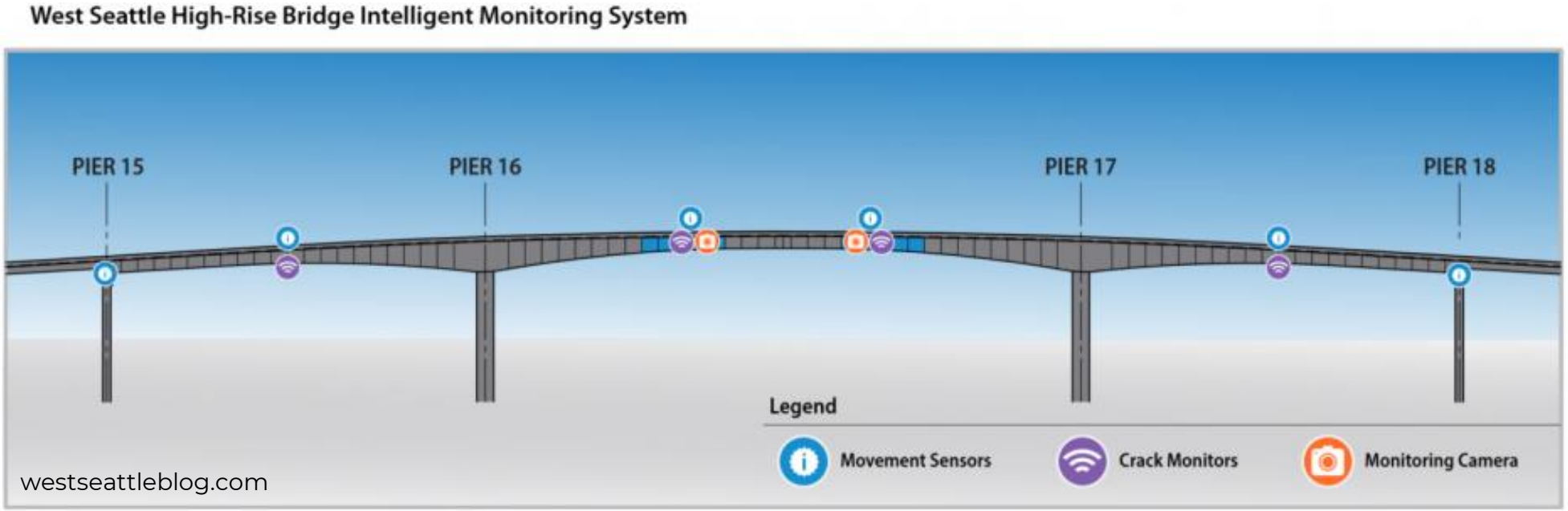
Ground truth

Monitoring

A suite of structural monitoring instrumentation

- Main span deflection– MEMS Shape Array
- Crack growth – vibrating wire crack gages
- End-span displacements – string potentiometers
- High resolution cameras
- Monitoring website with Alarms

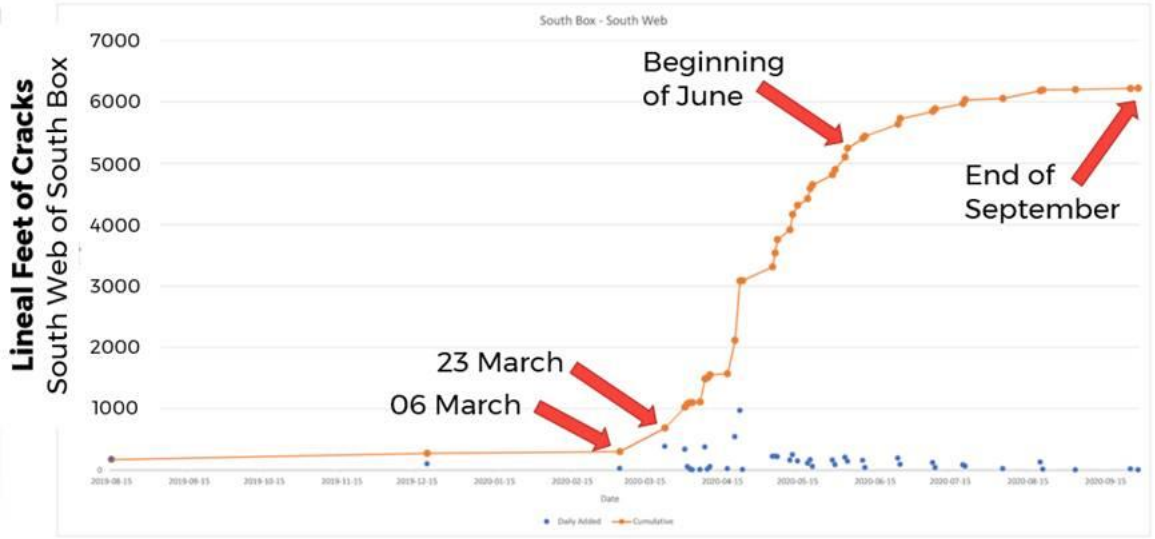


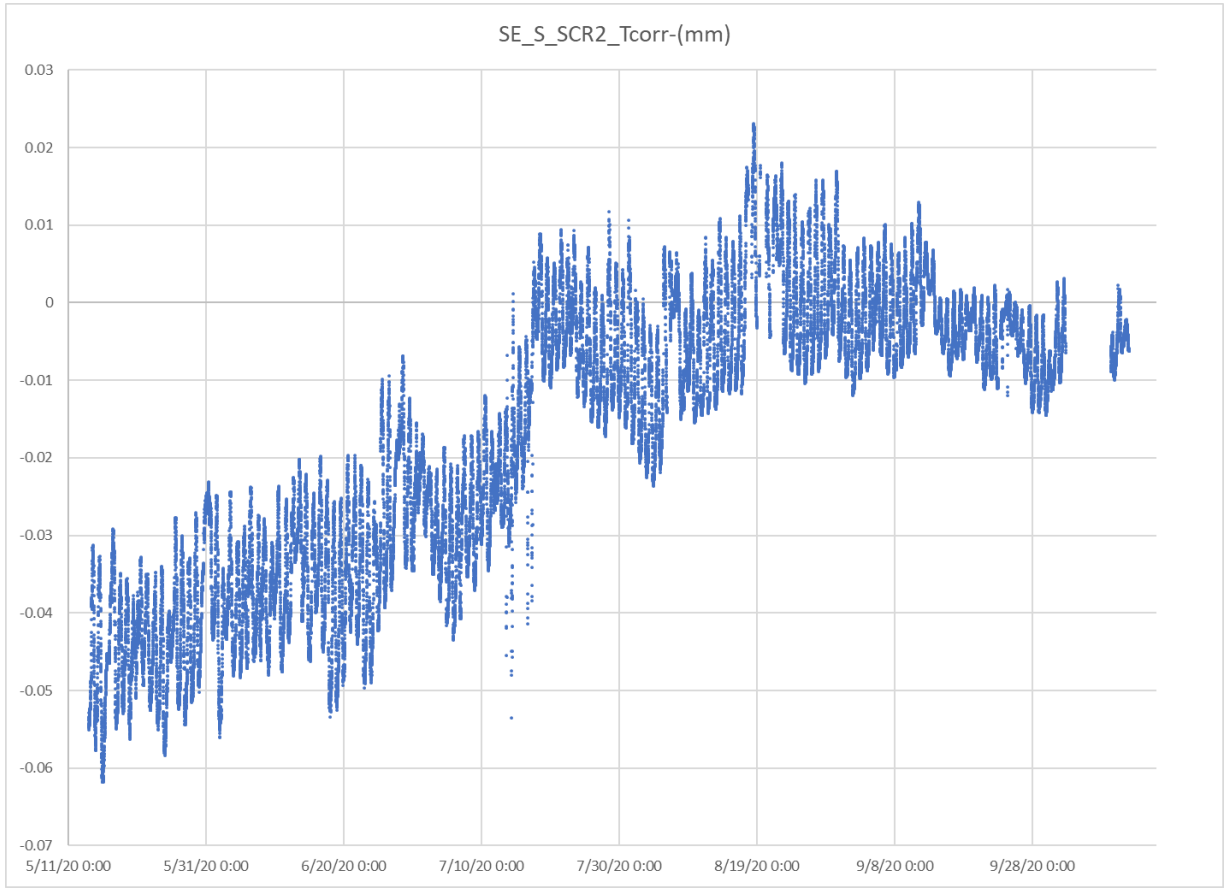


Monitoring

Crack growth has slowed since the spring

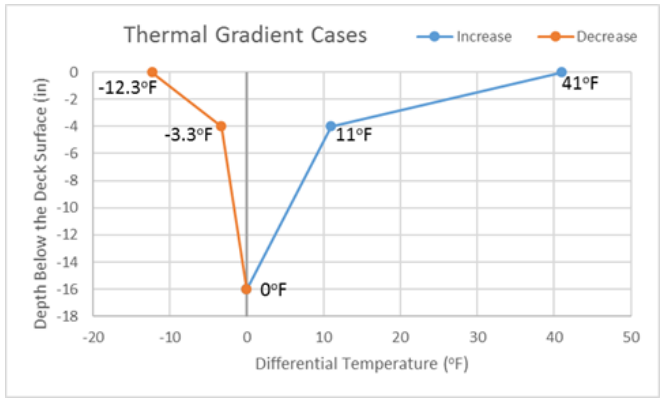
- Manual Measurements of crack length
- Temperature-corrected measure of crack slip

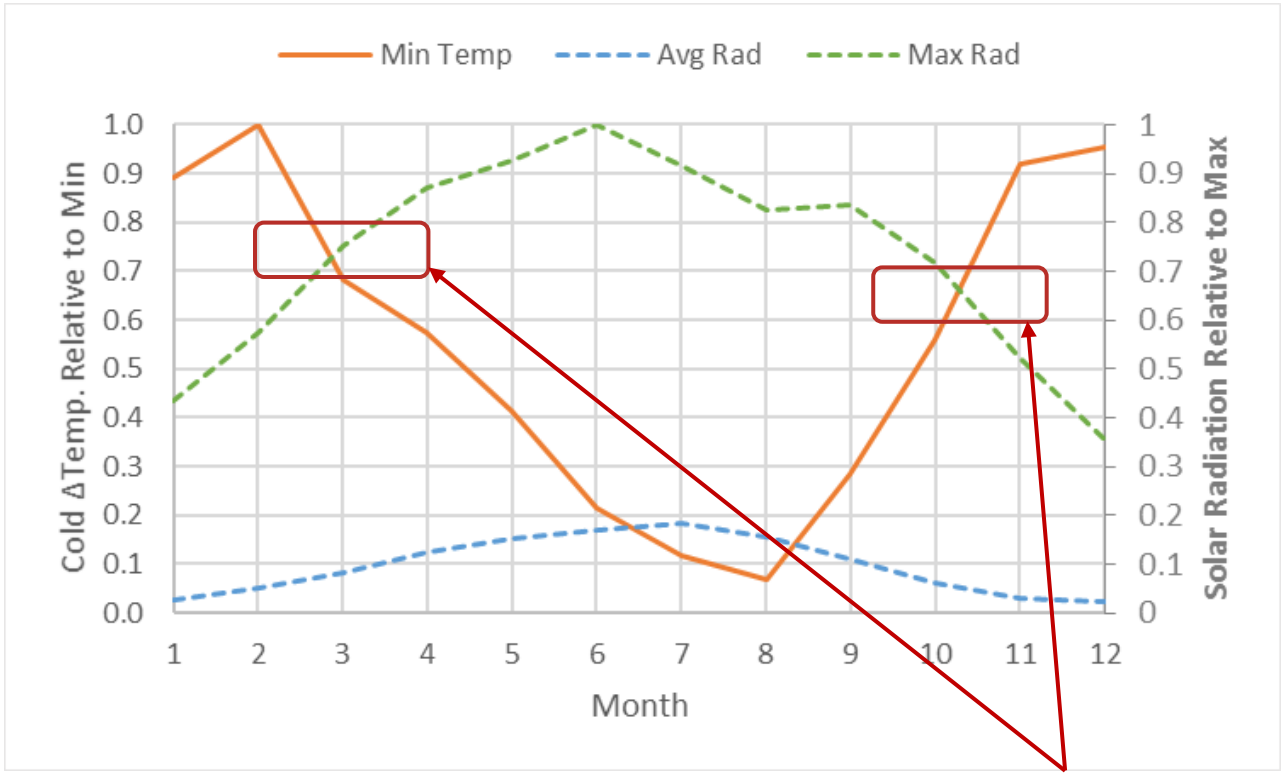




Data Correlations - Predicted vs Actual

	(Deg F)	(W/m^2)	Temperature (Deg F)
	Temperature	Solar Radiation	Relative to Avg
Avg	53.3	129.5	0
Min	16.9	0	-36.4
Max	103	1355	49.7



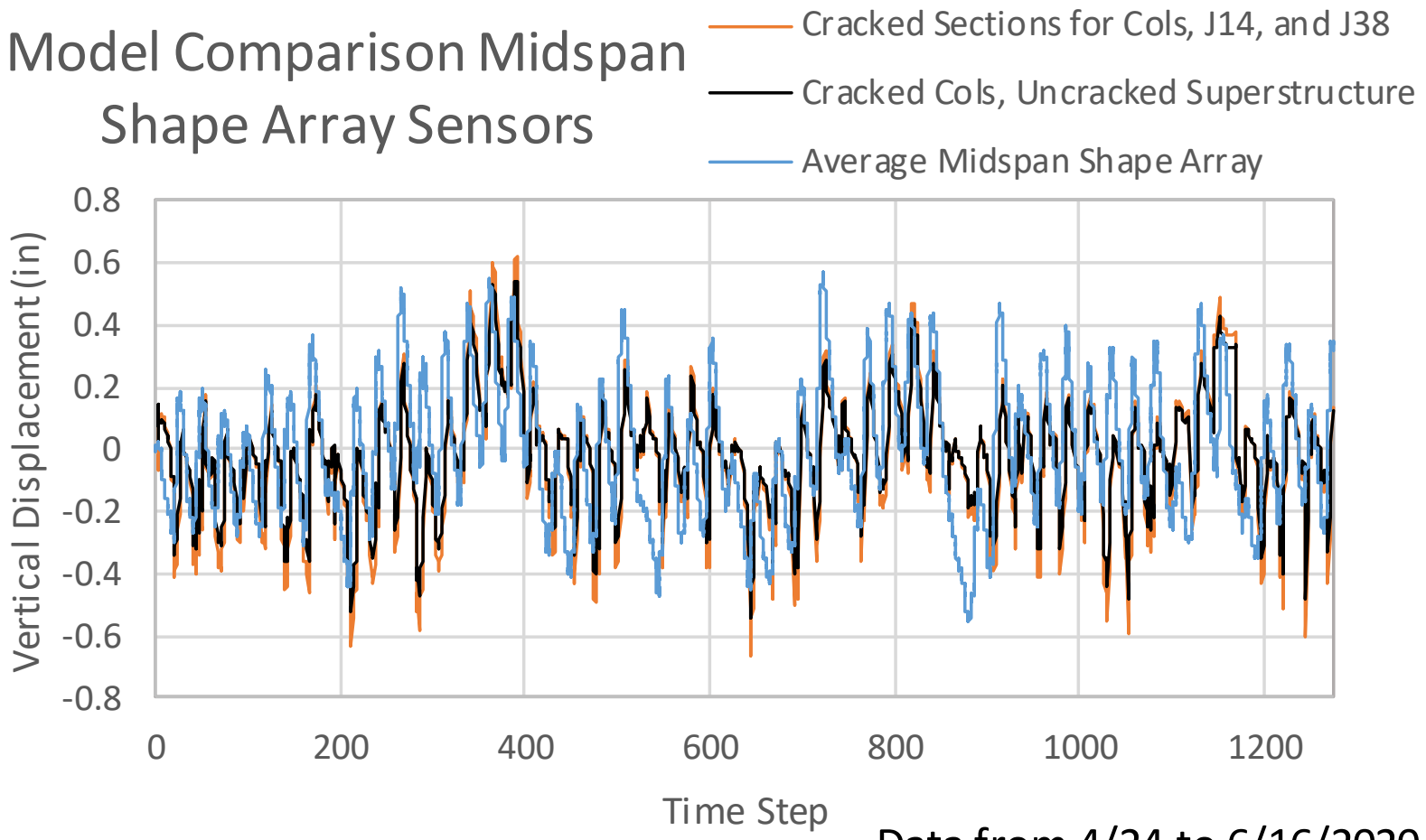


- Predictions made using University of Washington weather station temperature and solar radiation data as input.
- http://www.weatherjon.org/meteo/pages/station/table.php

Worst combination TU + TG is Spring and Fall seasons

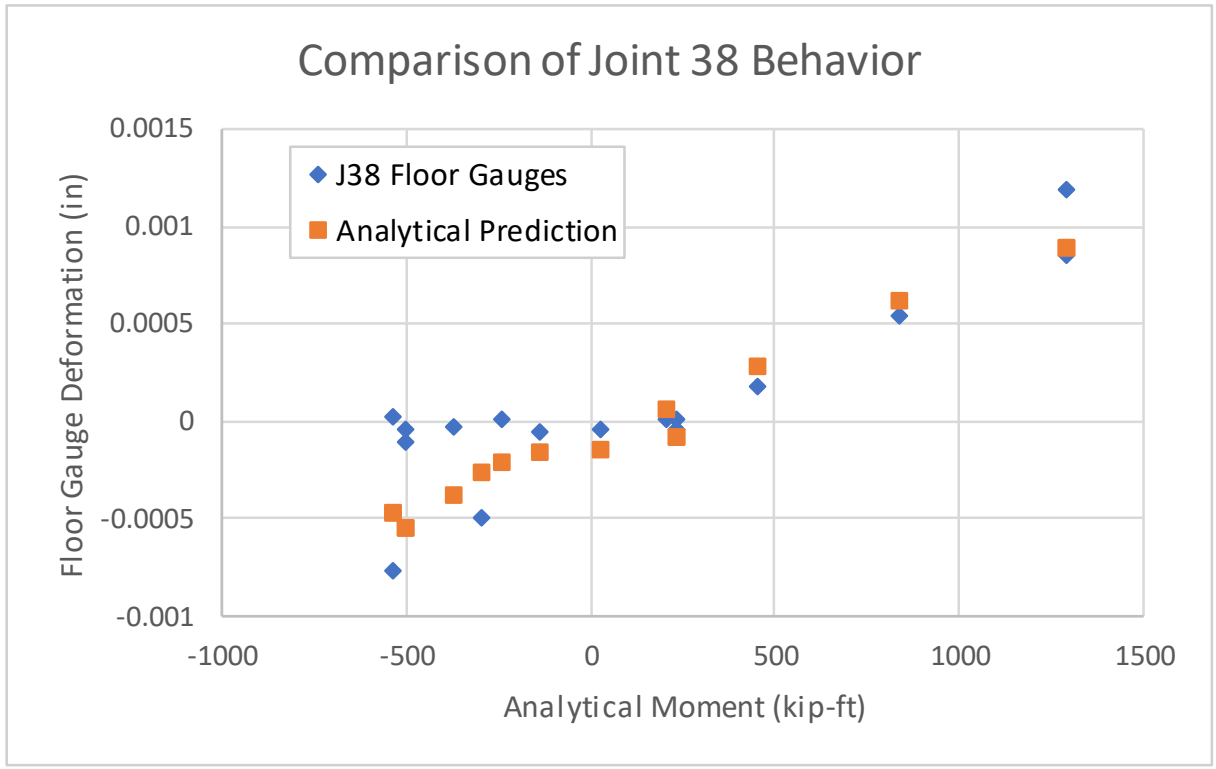
Data Correlations - Predicted vs Actual

- Same process used to scale TU and TG midspan vertical displacements using weather station temperature and solar radiation data.

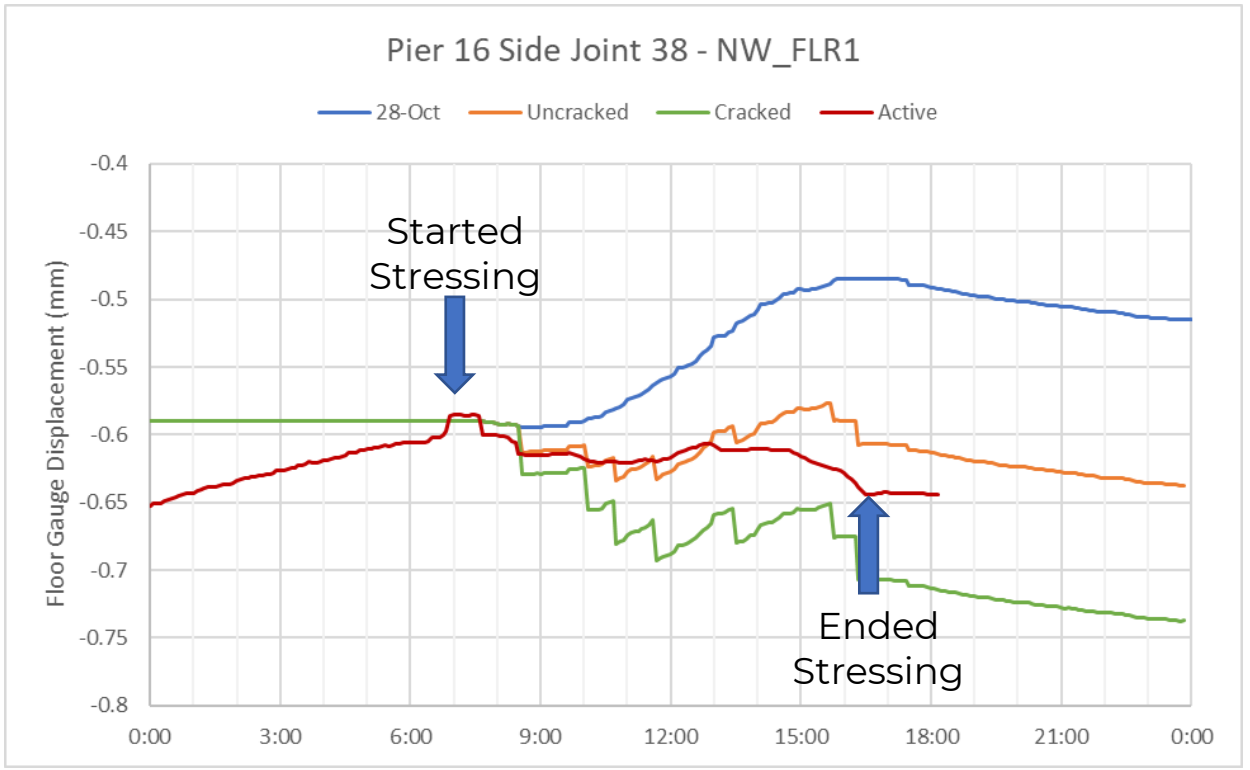


Data from 4/24 to 6/16/2020

Data Correlations - Predicted vs Actual

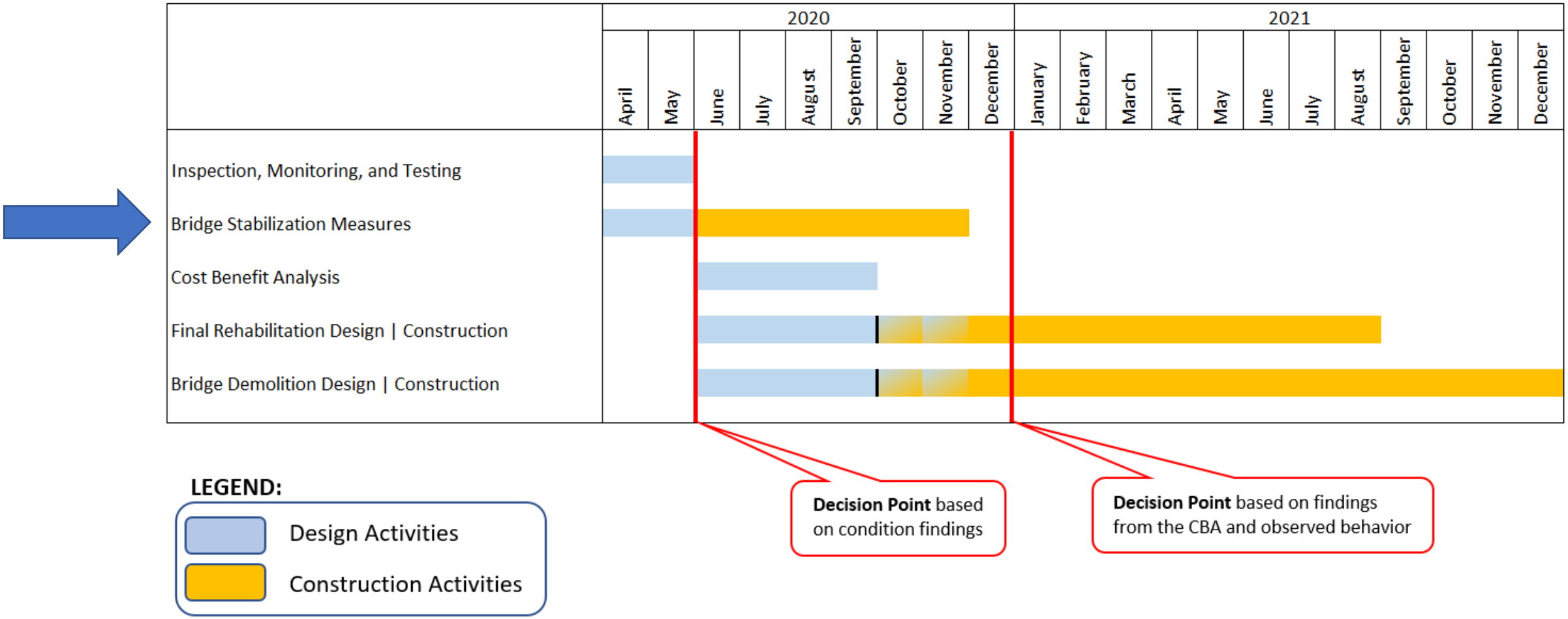


Platform Hoisting

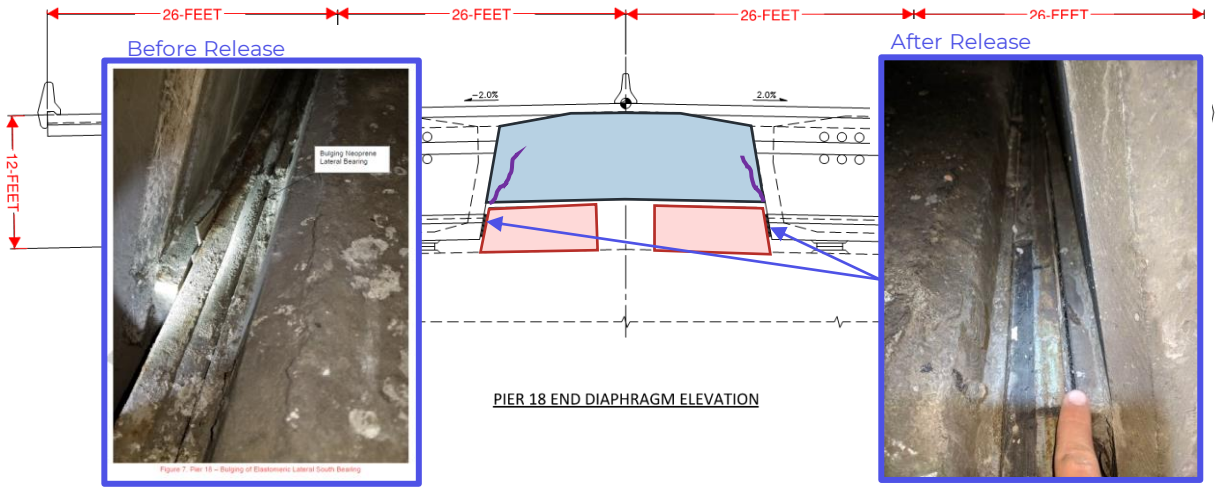


Post-Tensioning

Decision Matrix



Stabilization



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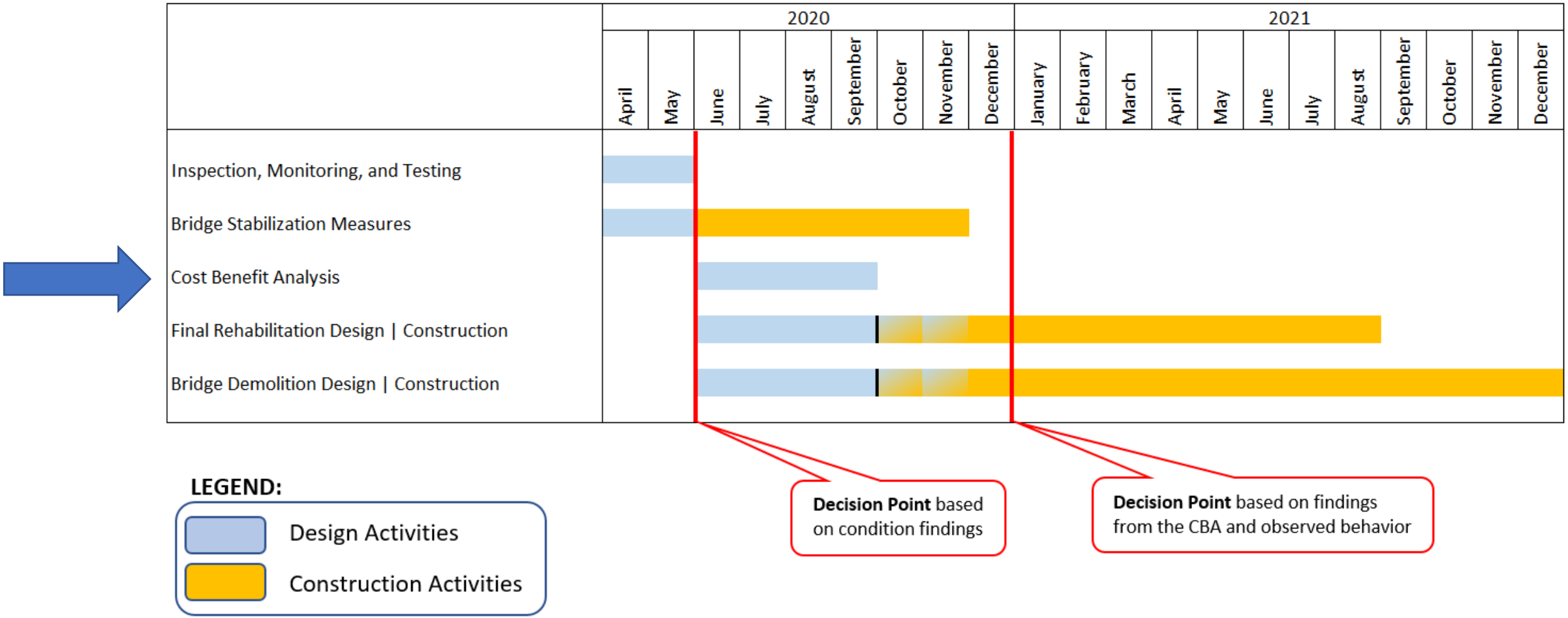
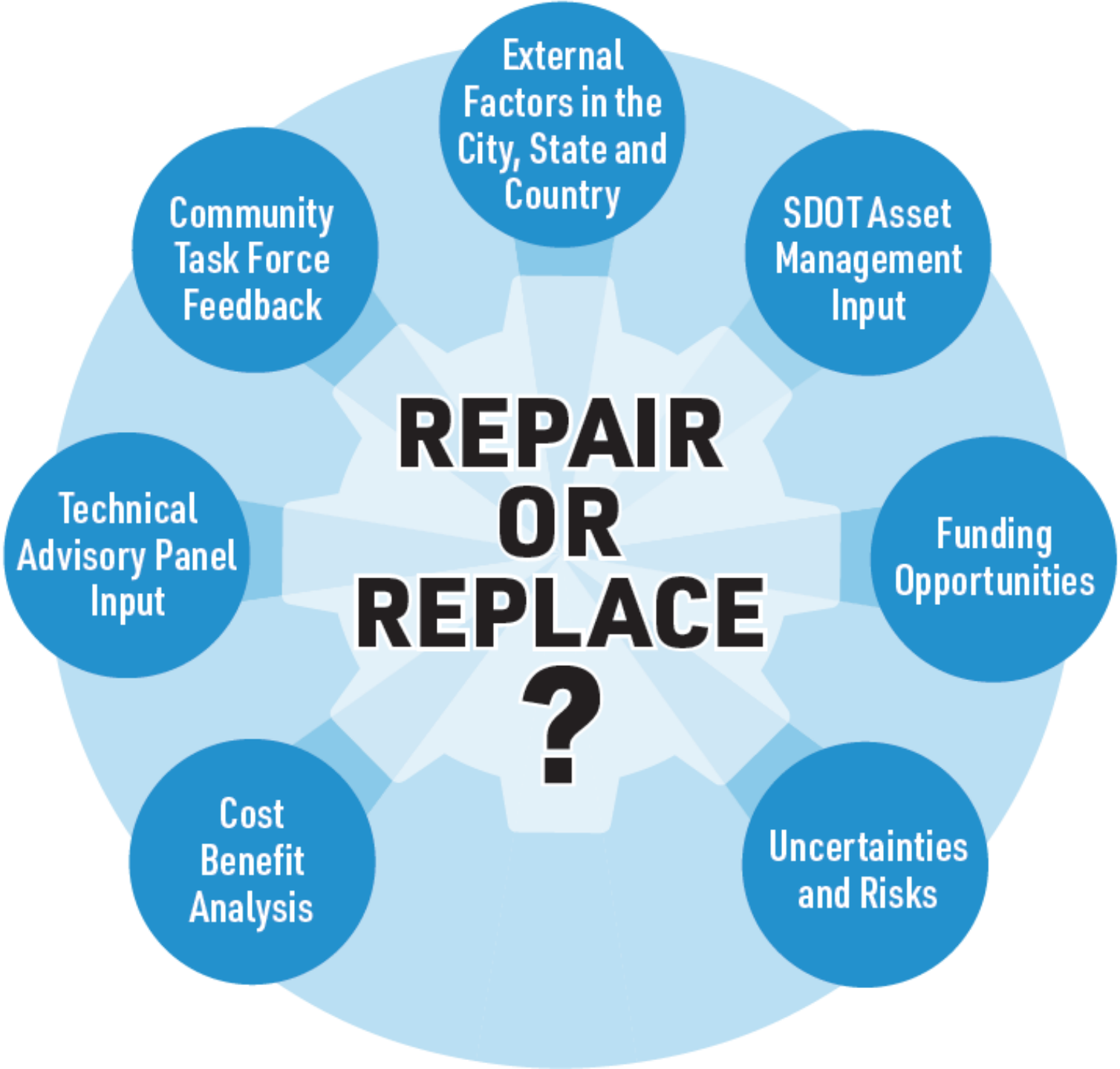


How did we get here?



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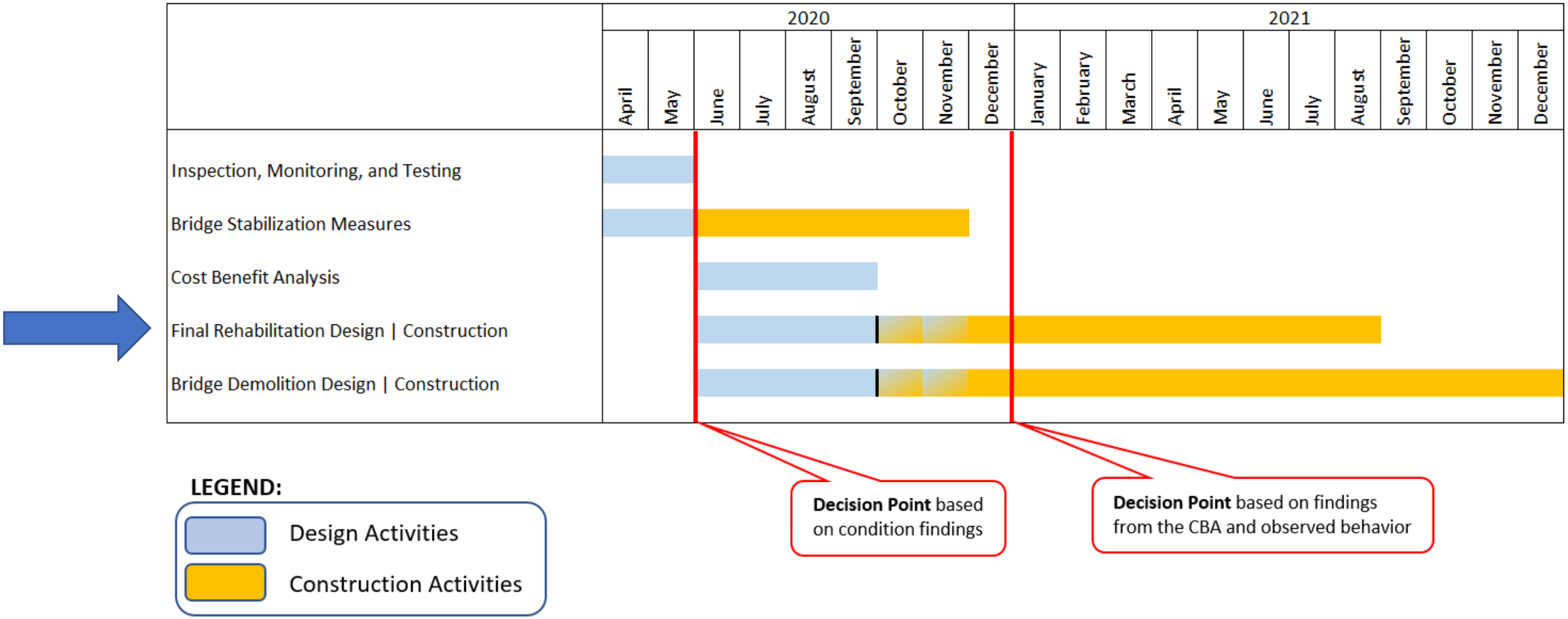
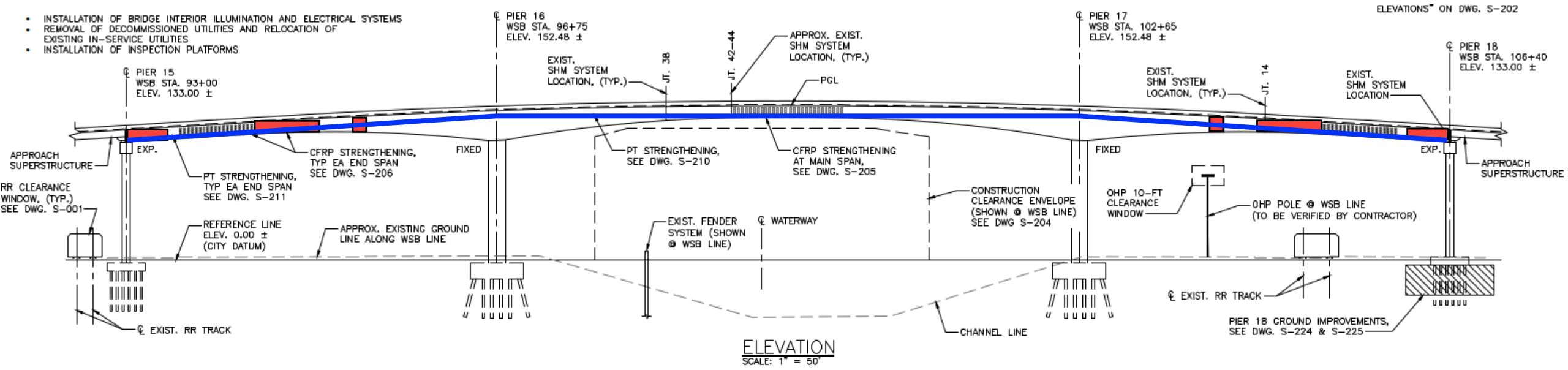


Further Rehabilitation

LEGEND:

- Design Activities
- Construction Activities

Work Activities	2020	2021												2022											
	December	January	February	March	April	May	June	July	August	September	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December
General Contractor/Construction Manager (GC/CM)																									
Design/Construction								Intermediate			Final		5. RFC												
Contractor On-Boarding				1. RFQ			2. SC	3. NTP		CR & Est.			4. MACC												



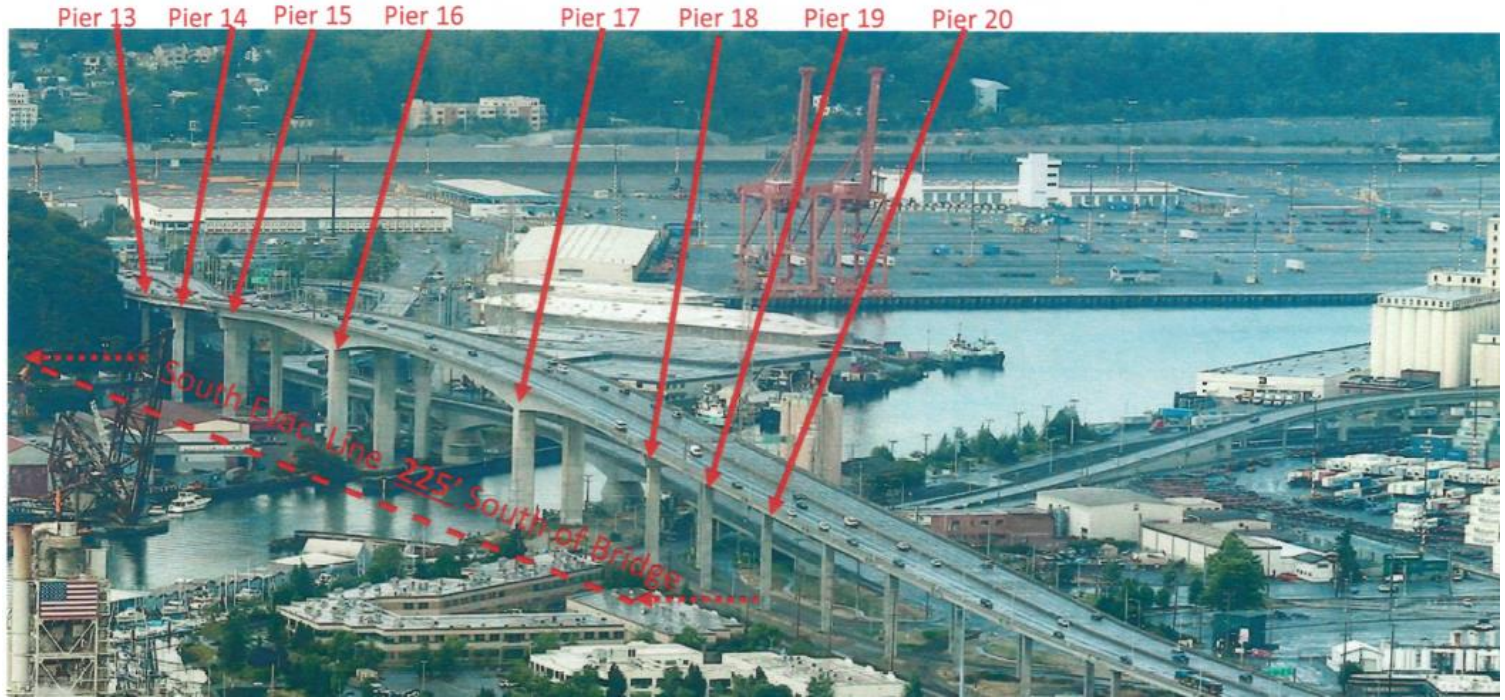
Roadway Structures Division

- Total Division Staff of 63 Permanent Positions
  - 3 Main Groups
    - Movable Bridge Operations
    - Structural Maintenance
    - Structural Engineering
- Work Type Split
  - Operation & Maintenance
  - Capital Programs (Levy/Non-levy)
  - Subject Matter Expertise
  - Emergency Response/Incident Management Team
  - Equity Initiatives
  - Reimbursable Work

Making the Decision to Close

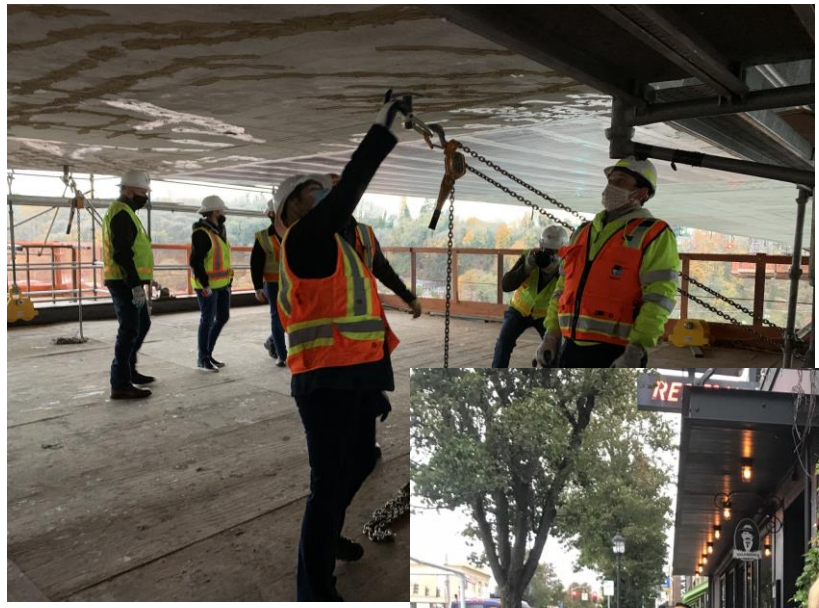
- Bridge closed in March 2020 due to rapid growth of cracks
- Decision Driven By:
  - Public Safety
  - Preserve Integrity of the Bridge
- Growth of cracks continued, confirming immediate removal of traffic was essential
- This was not a maintenance issue

Pivot to ER, NDE & Stabilization



The Importance of Leadership & Community Support

- Mayor Jenny Durkan
- Deputy Mayor Casey Sixkiller
- SDOT Director Sam Zimbabwe
- SDOT Deputy Director Lorelei Williams
- Program Director Heather Marx
- SDOT Roadway Structures Division
- City Budget Office
- Seattle City Council
- Regional Stakeholders
- WSDOT/FHWA
- Community Task Force/Technical Advisory Panel



Reconnect West Seattle

2020 / 2021 Implementation Plan

- 15,000 Surveys and 1,700 meetings
- Online project dashboard
- 55 projects
- Completed 21 projects
- Low bridge access policy

Project Name
Sylvan Way Speed Radar

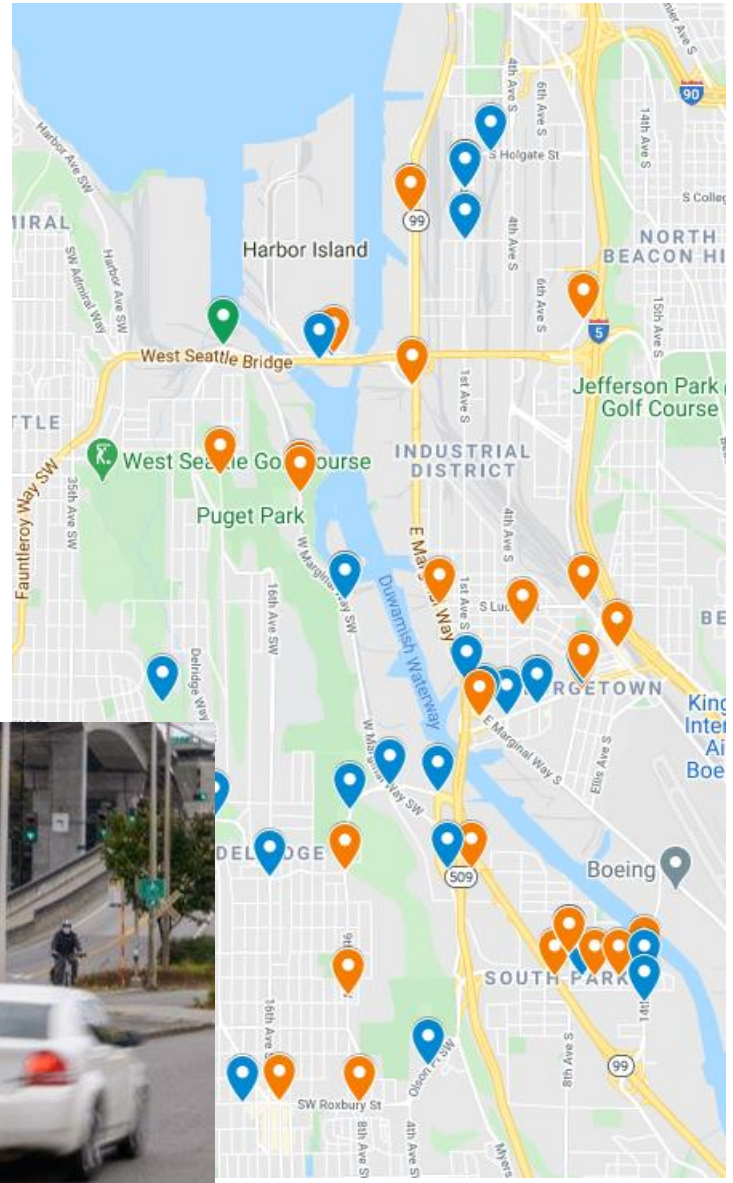
Project Year
2020

Project Description
Radar speed signs on Sylvan Way S

Request Origin
Detour Route Planning

Status
Complete

Project Site or Extents



Learn more:
www.seattle.gov/ReconnectWestSeattle

Planning for the future

Eventual High-Rise Bridge Replacement

- Rapid to 30% Design
- Long-term Off Alignment

Reconnect West Seattle

- Redundant modes of travel
- Increasing bike and transit capacity

High & Low Bridges

- Heavy impact to Budget for Instrumentation, Inspection and Maintenance

Predicting the Future

- Business Practices Upgrades
- Consistent and Clear Communication
- Move from Reactive to Proactive
- Future Levy Focus on Maintenance