NDE and Live Load Testing

Emergency Investigation of AASHTO Girders

Rebecca Nix, SE
Utah DOT

Shane Boone, PhD, PE
BDI

Outline

- Background
- NDE of Prestressed Structures: AASHTO Girders and Ultrasound
- Emergency Investigation
  - Field Observations
  - Phase 1: NDE Investigation
  - Phase 2: Load Testing
- Conclusions – NDE
- Conclusions – Load Testing
- Discussion

Structure Background

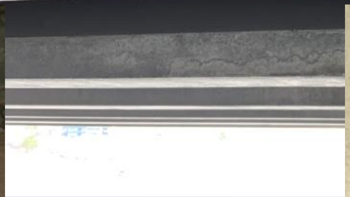
Structure Background

- Location: Pleasant Grove, UT
- Year Built: 2002
- Bridge Width Out to Out: 33’ – 9.5”
- Total Bridge Length: 234’ – 11”
- AASHTO Girders: 28 Type V (14 per span)

Structure Background

Inspection Background

Inspection Background

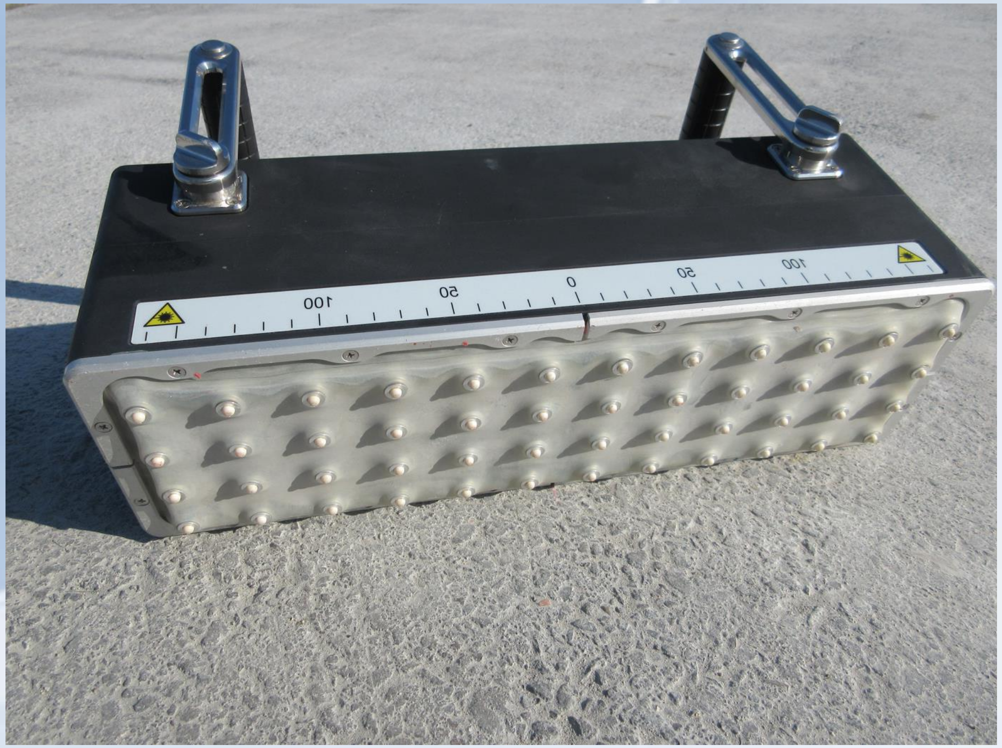


Inspection Background

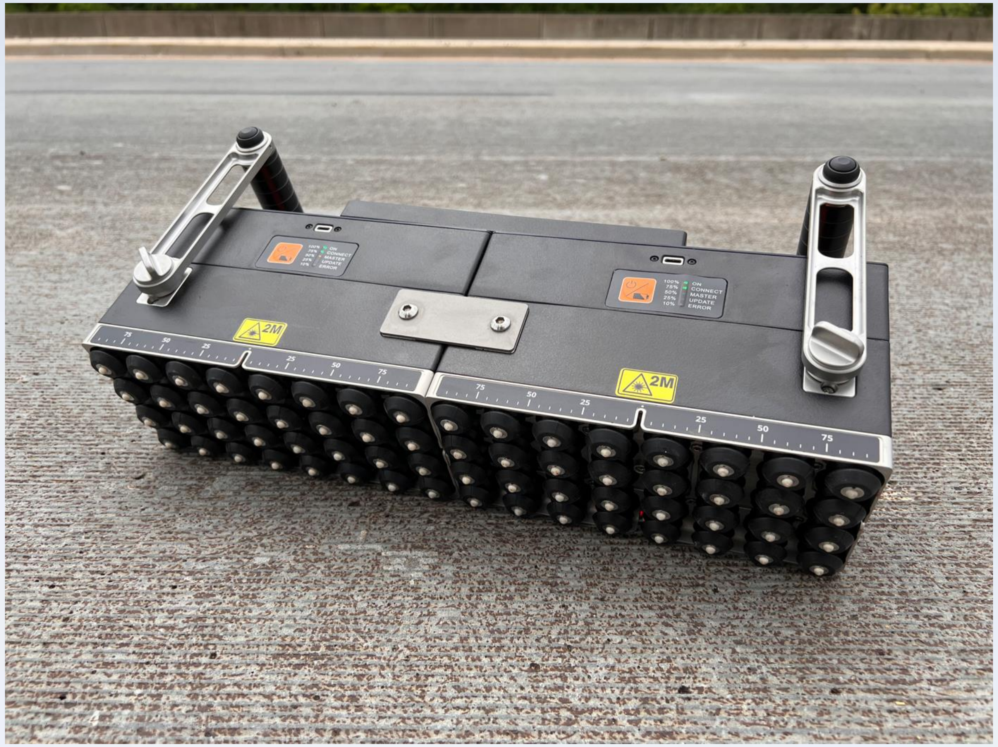
NDE of Prestressed Structures

AASHTO Girders and Ultrasound

Ultrasonic Tomography (MIRA)



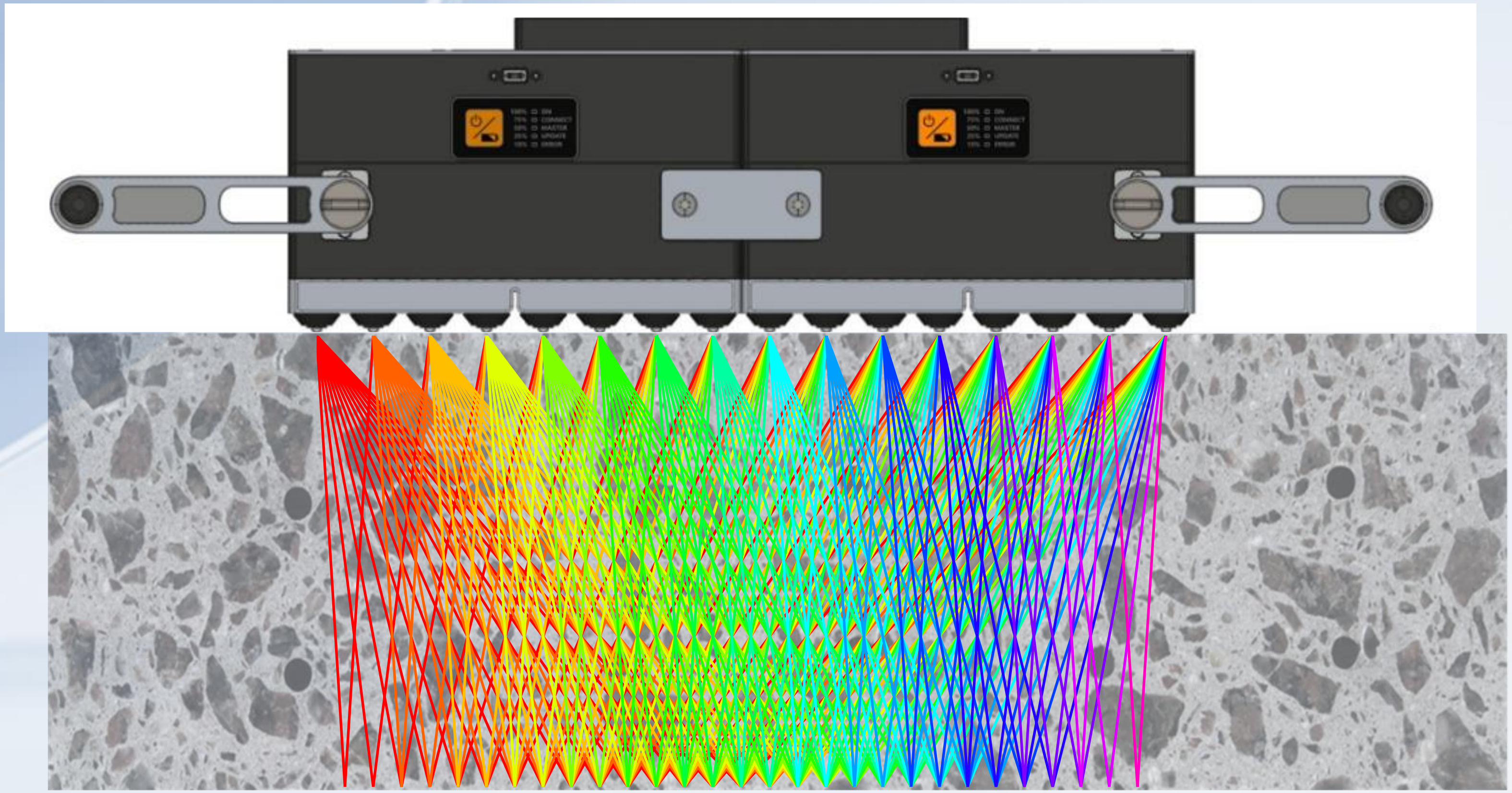
MIRA Gen 3
4 × 12 Dry-Point Contact (DPC) Transducers



MIRA 3D Pro
4 × 16 Dry-Point Contact (DPC) Transducers

Ultrasonic Tomography (MIRA), Cont'd

For 16/64 transducers: 120 or 2016 signals per test point.

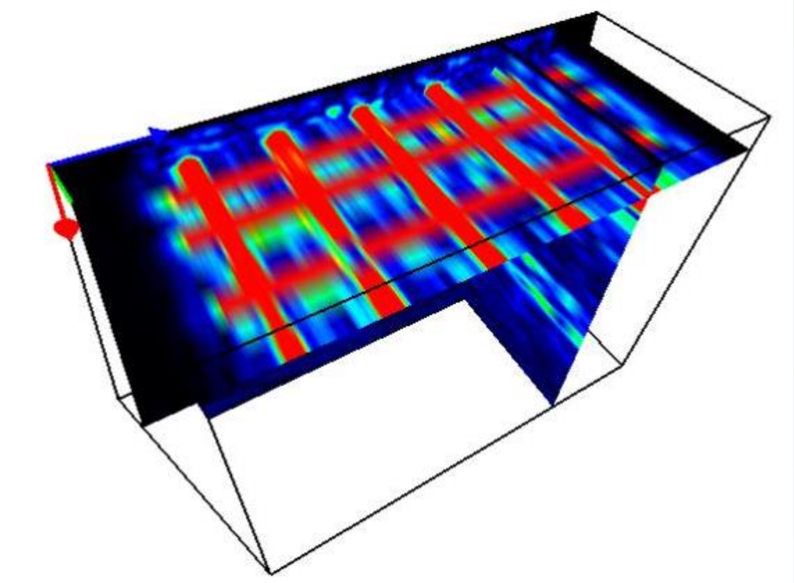


Credit: Herbert Wiggenhauser

Ultrasonic Tomography (MIRA) Application

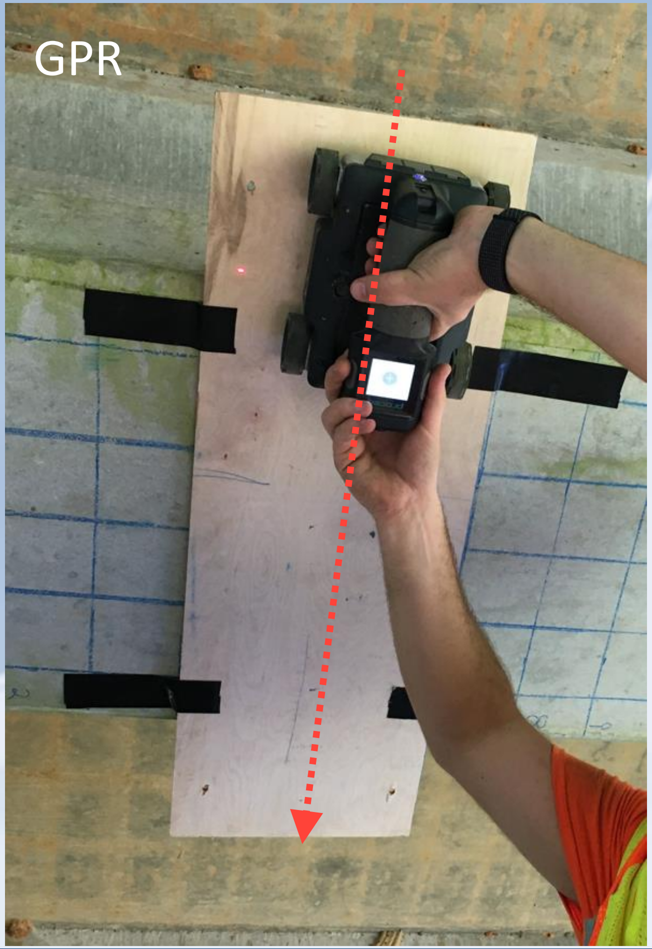
AASHTO Girder

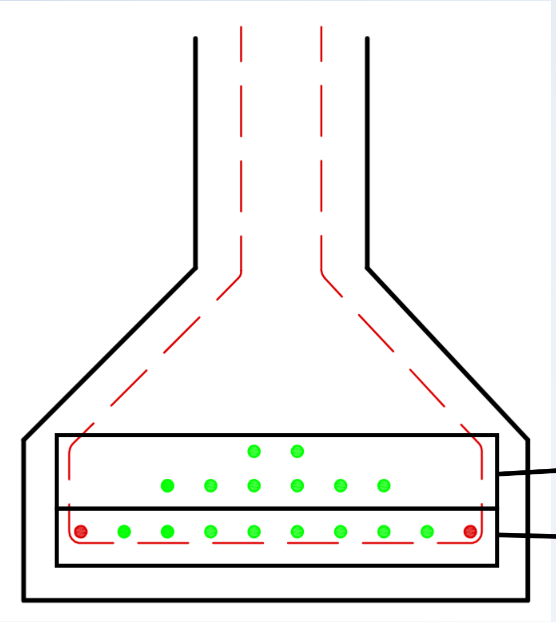
Box Girder PT Duct Investigation

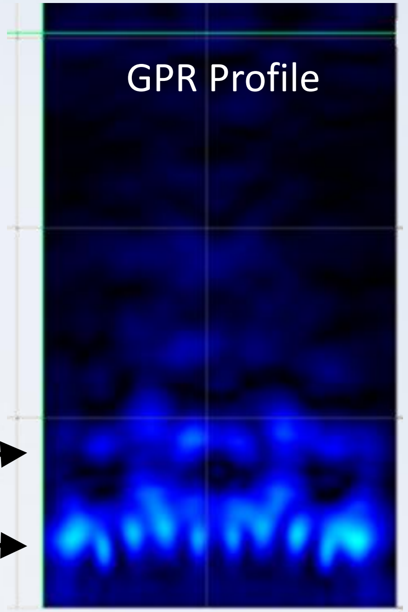


Construction Quality Control

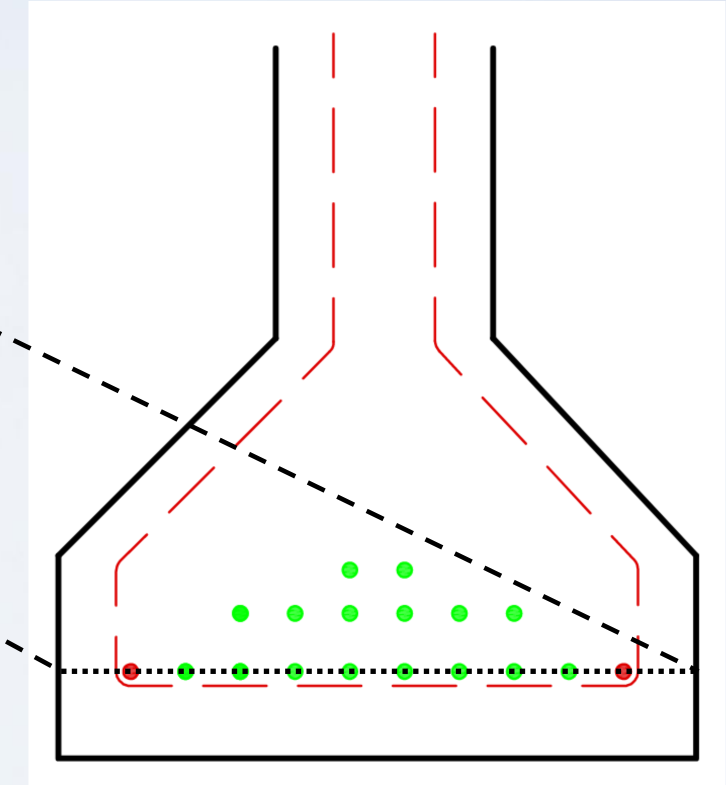
GPR Application for AASHTO Girders



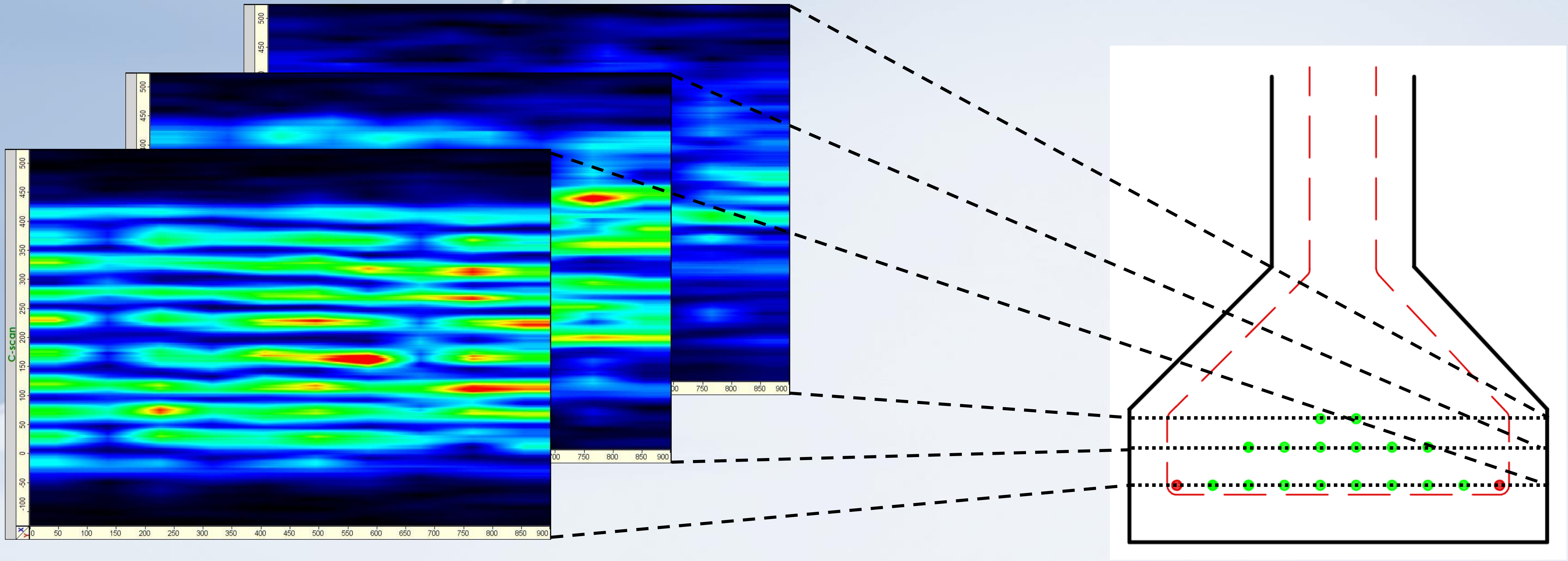




Ultrasound Application for AASHTO Girders

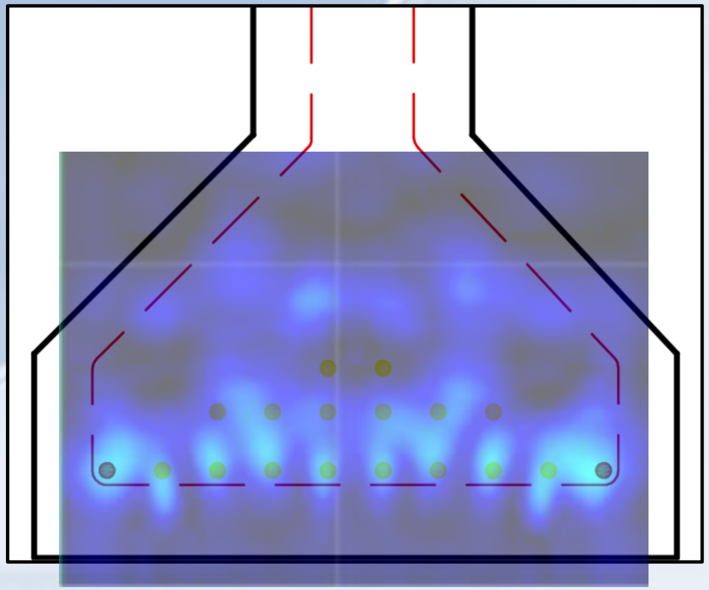


Ultrasound Application for AASHTO Girders, Cont'd

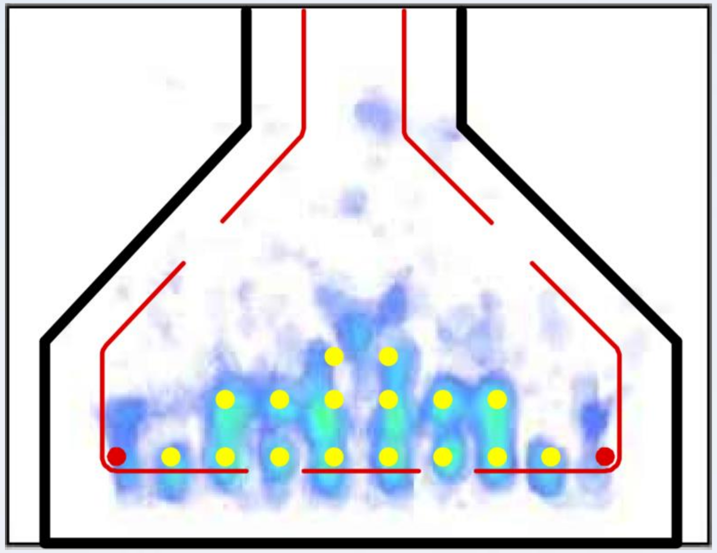


Ultrasound Application for AASHTO Girders, Cont'd

GPR

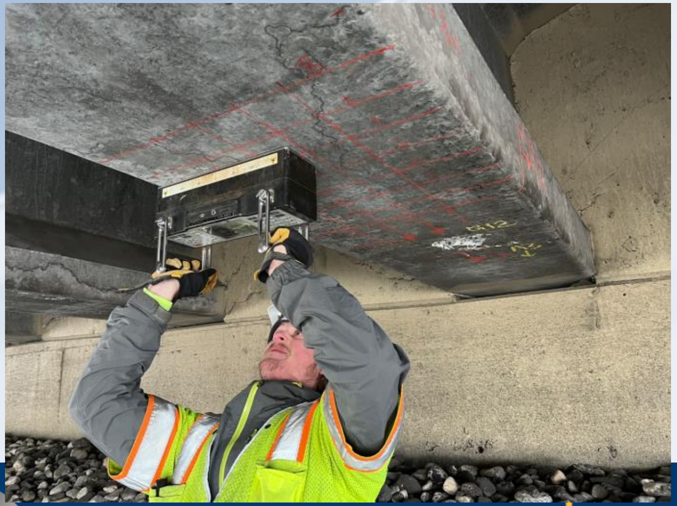


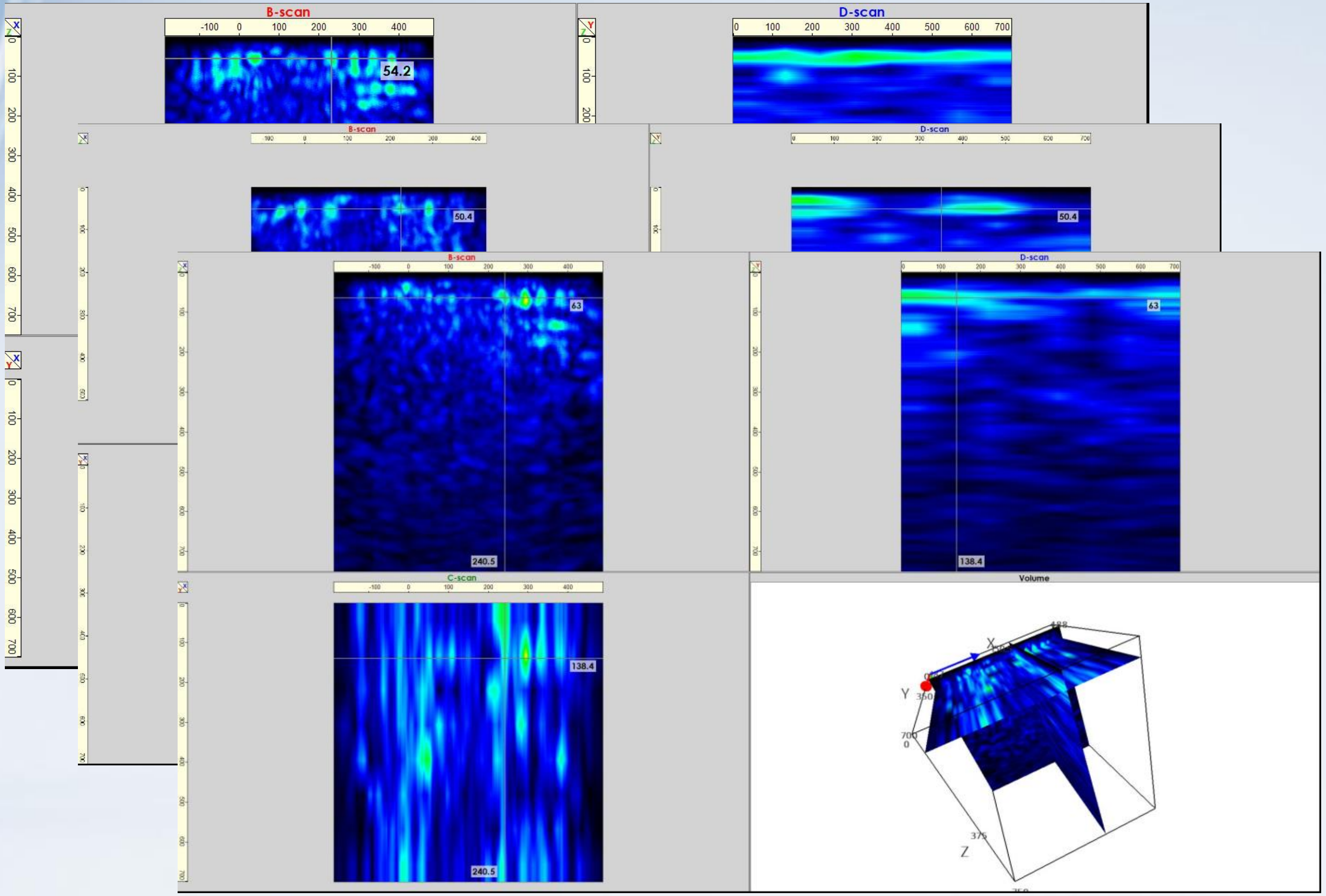
Ultrasound



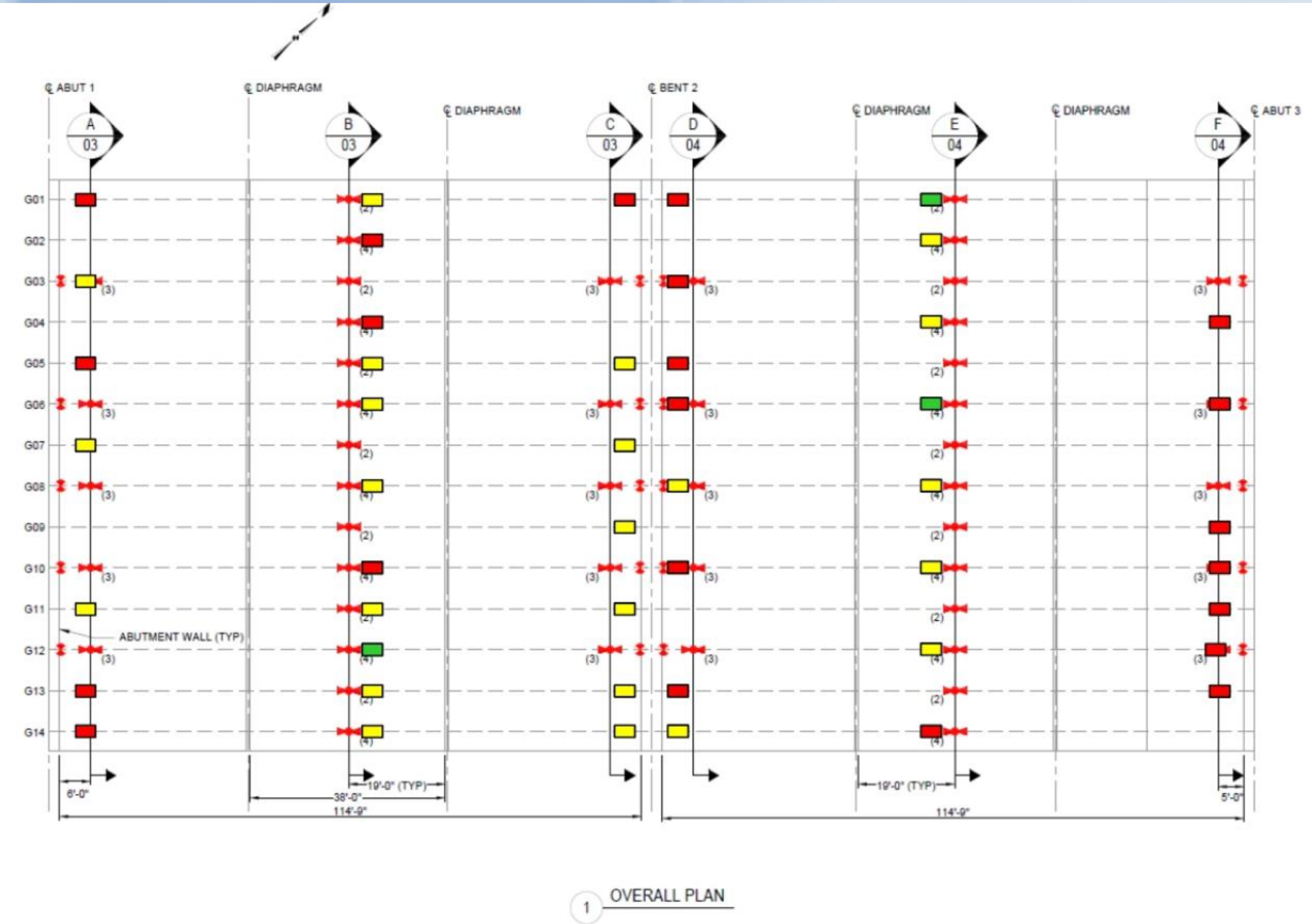
Field Observations and Ultrasound Application

NDE Investigation





NDE Investigation – Deliverable



Total segments tested: 48

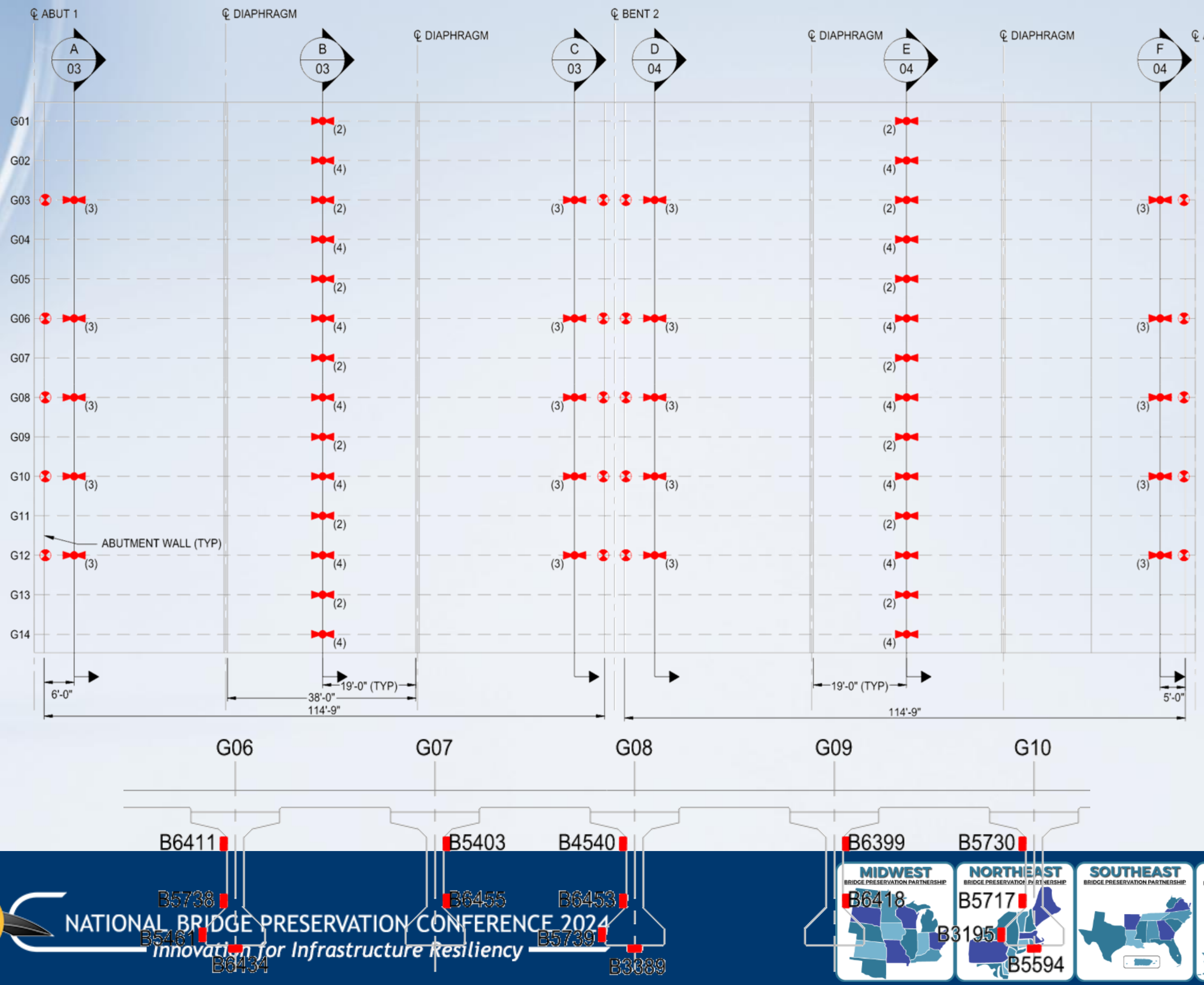
- 21 severe (44%)
- 3 good (6%)
- 24 poor (50%)

Phase 2

Live Load Testing

Load Test – Instrumentation Goals

- Cross-sectional performance
- Load Distribution
- Support Conditions



Strain transducers

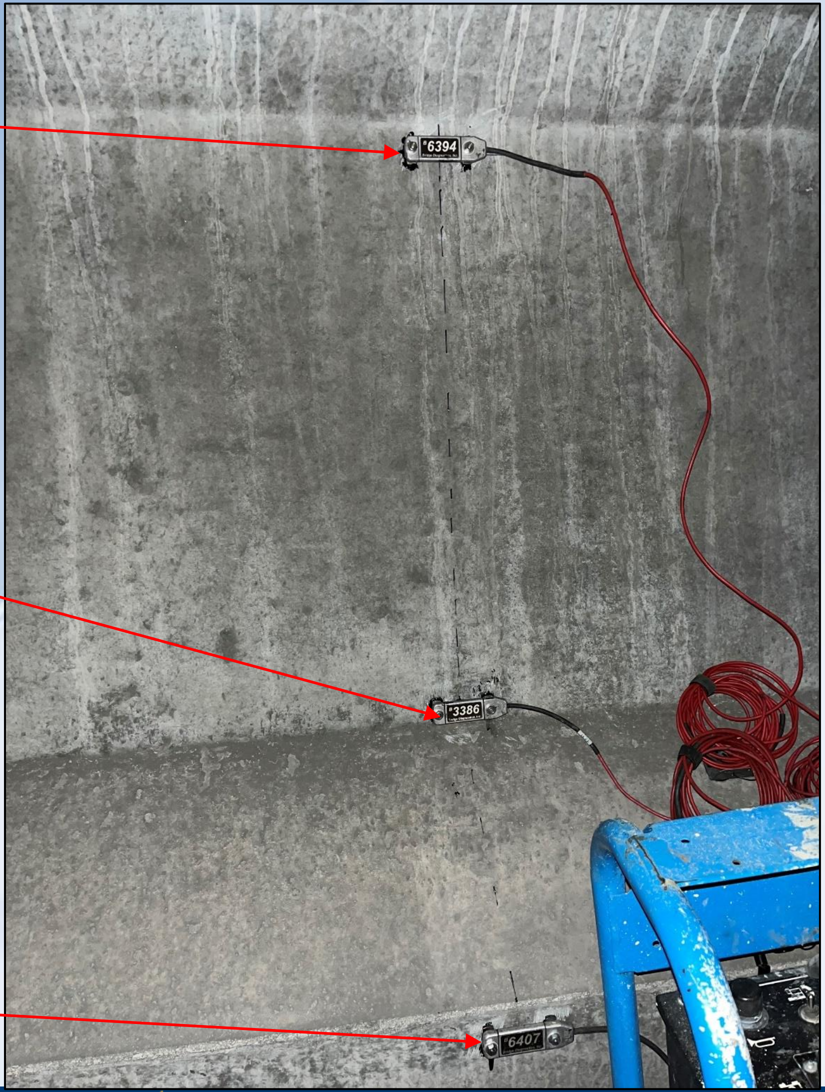
Tilt Sensors

Load Test – Instrumentation

Strain transducer along top of web

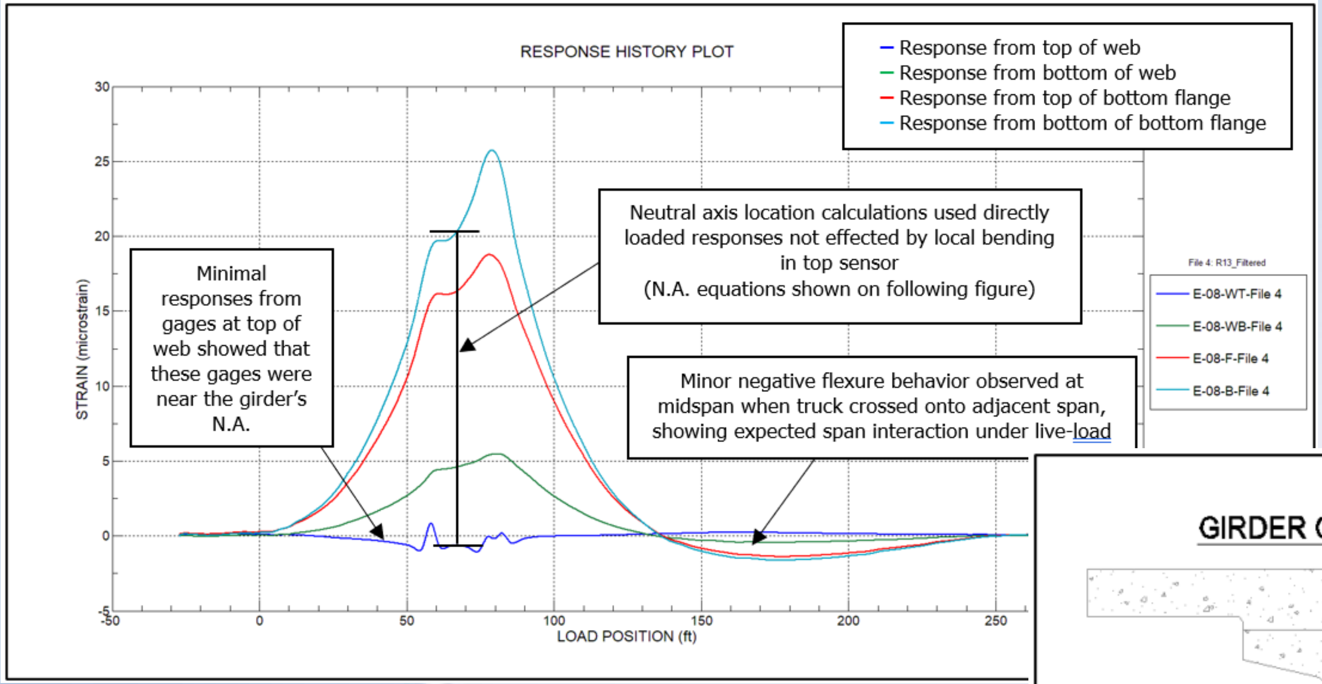
Strain transducer along bottom of web

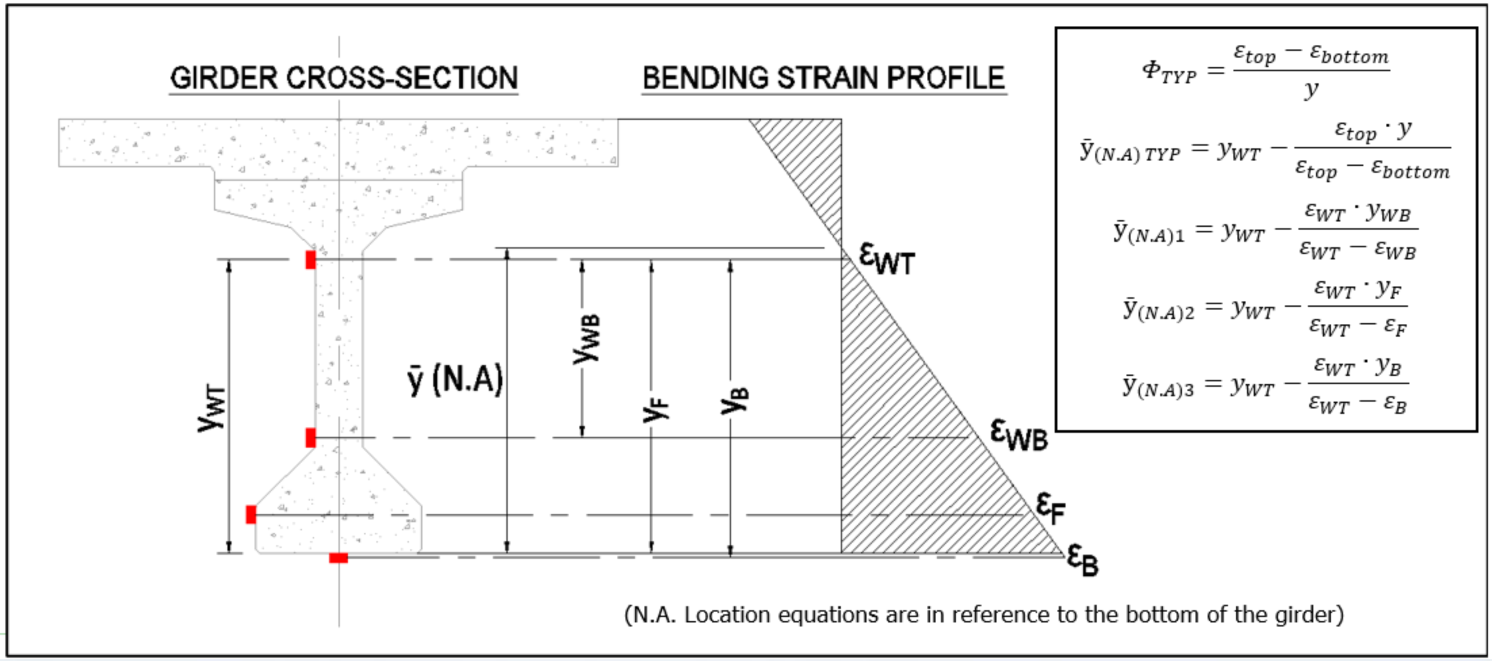
Strain transducer along top of bottom flange



Rotation sensor installed along bottom of girder near supports

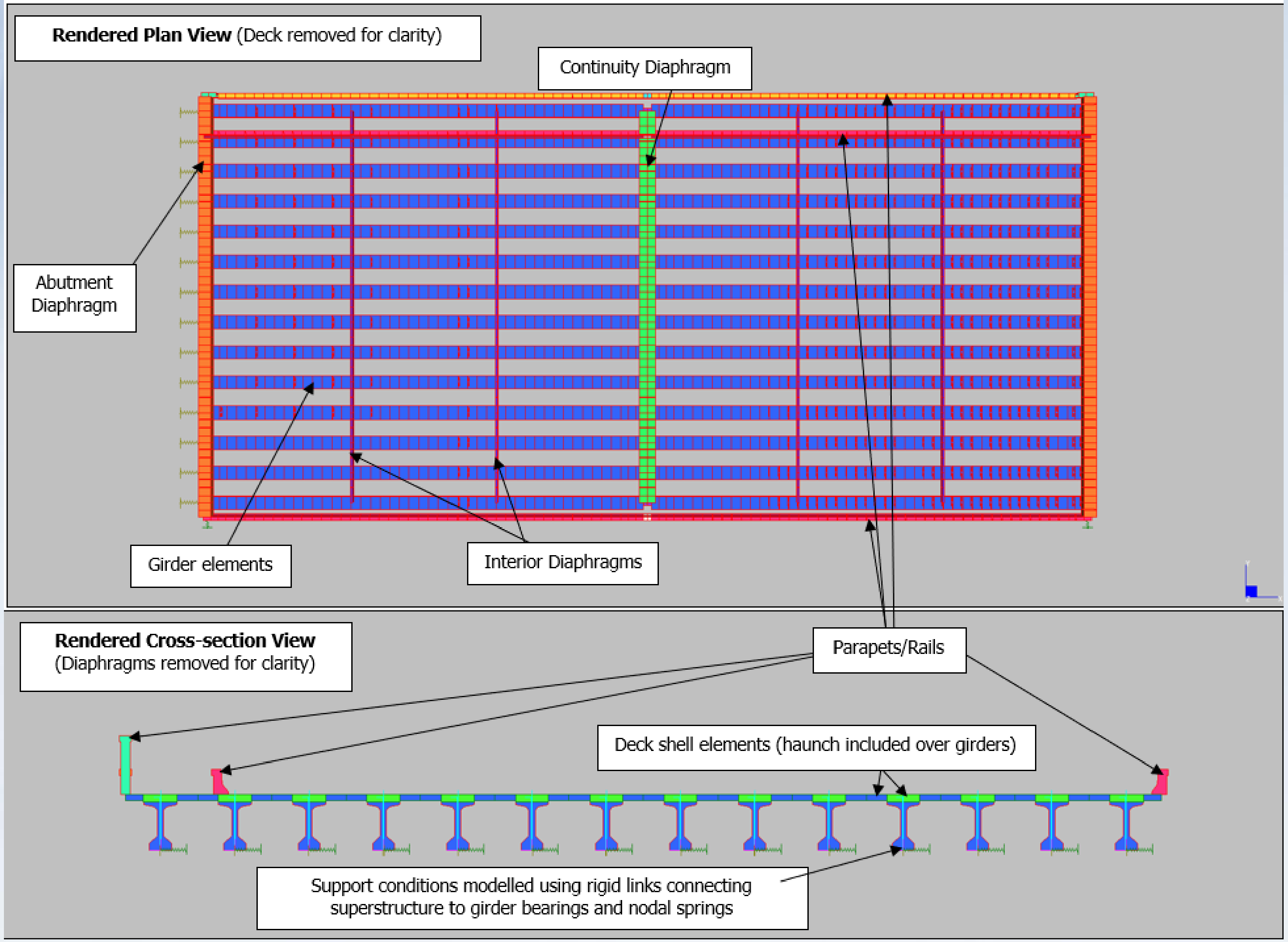
DATA ANALYSIS – GIRDER CROSS-SECTION





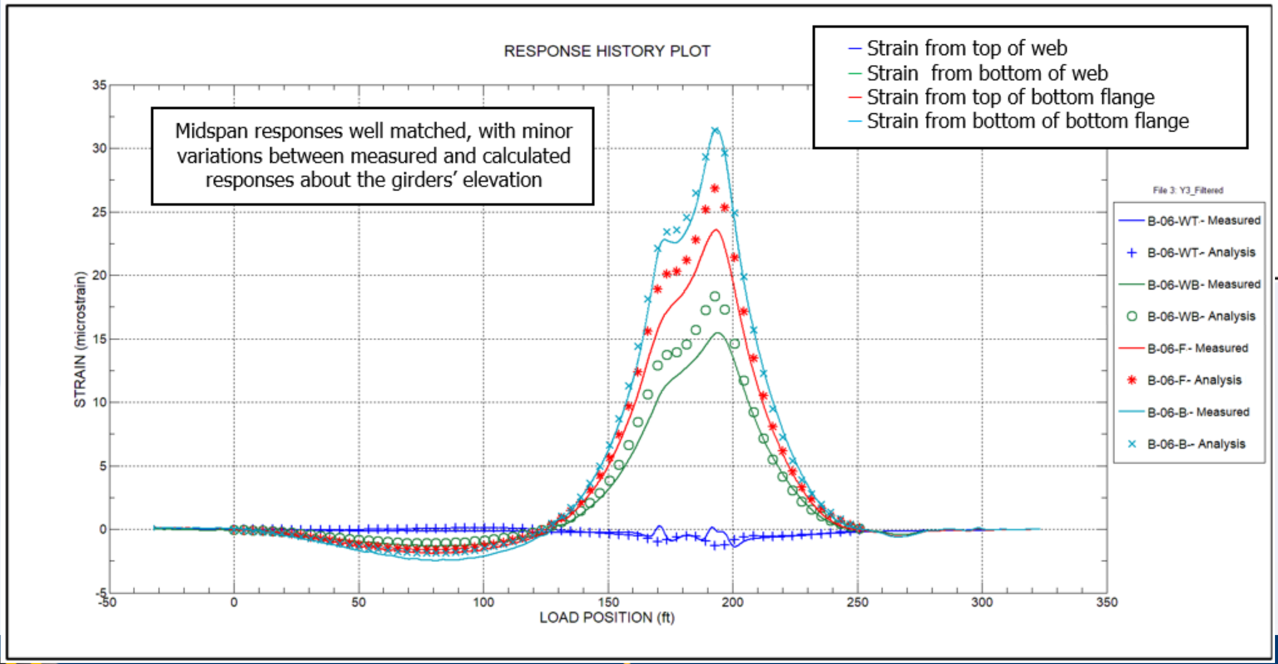
Integrated Approach

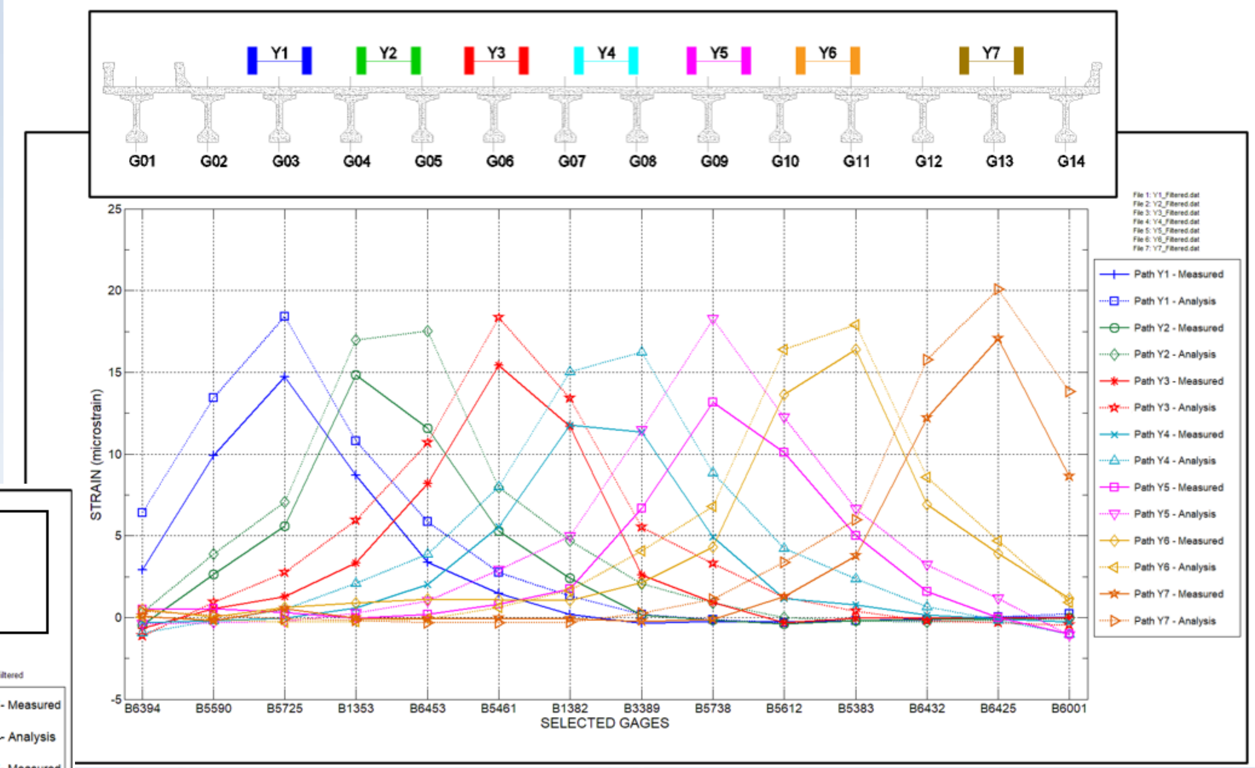
- Generate a field-verified model to quantify:
  - Girder and support stiffness
  - Load distribution
  - Load rating model parameters



Load Test and Model Calibration Results

- Girder stiffness as expected and consistent
- Girder supports nearly fixed with some variation
- Concrete defects not yet influencing load paths
- Does not suggest potential strand bond reduction





- Modeled distribution paths typically align better with response vs. other distribution factor methods.
- Modeled and test response correlate well at this time.

Conclusions – NDE

- Voids in flanges were likely caused by inadequate consolidation and segregation at the time of placement
  - Inadequate vibration/over vibration
  - Stiff concrete mix
  - Delayed placement
- Honeycombing between the prestressing strands may affect the flexural and shear strength along the beam.
- Substandard concrete in thin web precast girders may:
  - Reduce shear strength capacity and thereby reduce the member’s load-carrying capacity.
  - Increase cracking and reduce durability.

Conclusions – Live Load Testing

- At the time of the live load testing, the structure was performing in a stiff and expected manner, with no signs of loss of performance at service level loads.
- The structure is currently performing as expected in terms of load paths.

Is there a discrepancy between the NDE and Load Testing findings?

Discussion

- Although the structure is currently performing as expected from a live load response perspective, the poor concrete condition must be addressed.
- Load Testing determined that the deterioration identified by NDE has not yet influenced girder stiffness or the structure's load paths. However, there is the potential for a decrease in ultimate strength and reduced long-term durability/capacity. The potential for strength reduction is an immediate concern that will be amplified as the deterioration continues.
  - I.e. the bridge is responding well with regards to stiffness and load distribution, but the deterioration may cause a reduced capacity
  - This should be considered during load rating
- Considering that the structure is currently performing as expected, it is worthy of remediation to:
  a. Minimize exposure of strands
  b. Ensure the concrete-strand bond

Next Steps

- Initial Recommendations:
  - Remove poorly consolidated concrete, patch, and fiber wrap
- Final Decision
  - Replace bridge as part of a capacity project

Thank You

Contact Details:

Rebecca Nix
Utah DOT
Bridge Management Engineer
Rnix@Utah.gov

Shane Boone
BDI
Senior Vice President
ShaneB@BDITest.com