Western Bridge Engineers' Seminar

9/27/2011

Phoenix, AZ

FPR Deck Structural Evaluation for the Morrison Bridge

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of Transportation

Oregon Department of Transportation

Connecting Commerce and Community
MULTNOMAH COUNTY BRIDGES

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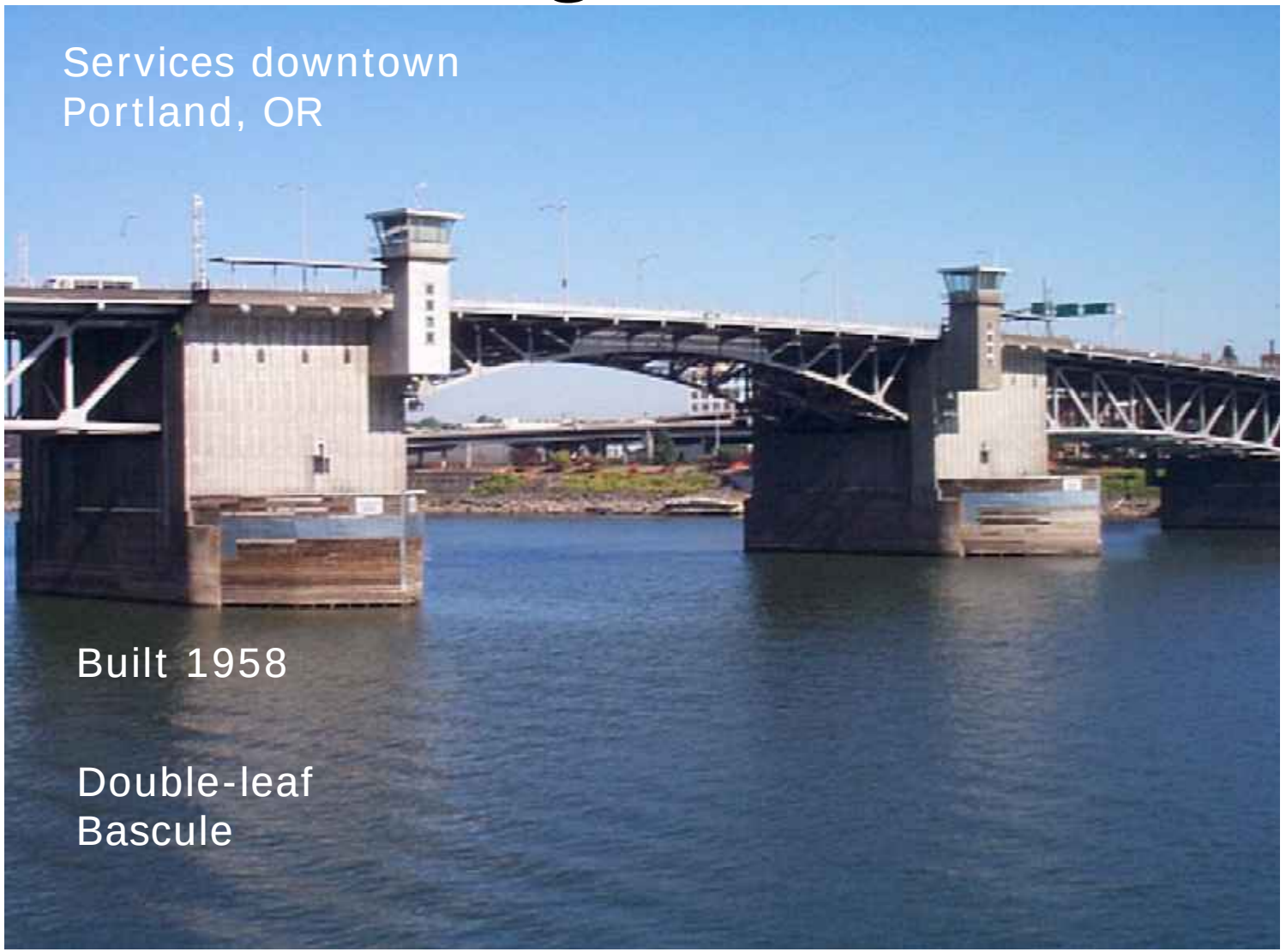
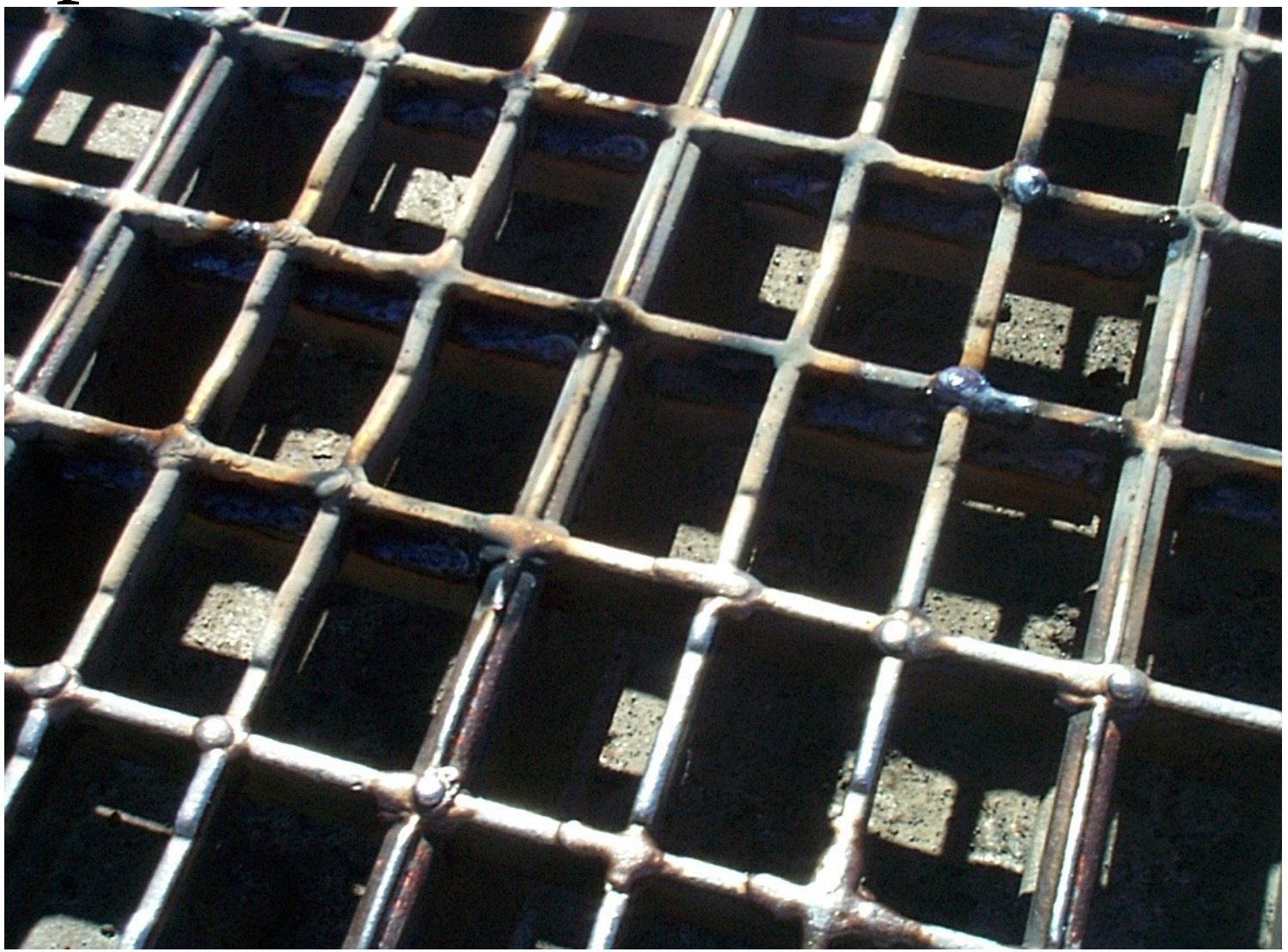
Morrison Bridge



Existing Bridge Deck

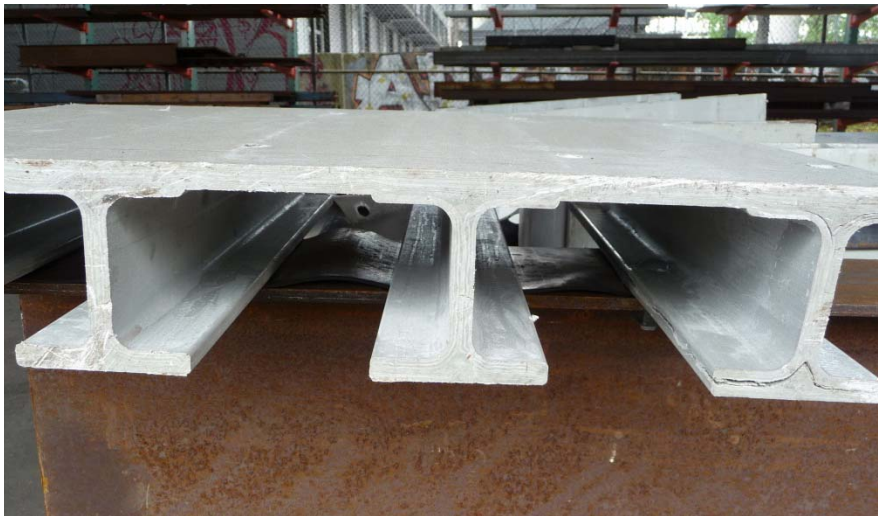
Replacement Need - Maintenance



Replacement Need - Safety

Replacement Need - Environmental

Composite Decks



Structural Evaluation Objectives

FRP deck panels:

- strength and stiffness
- failure modes
- fatigue characteristics

Panel to stringer bolted connection:

- strength
- failure modes

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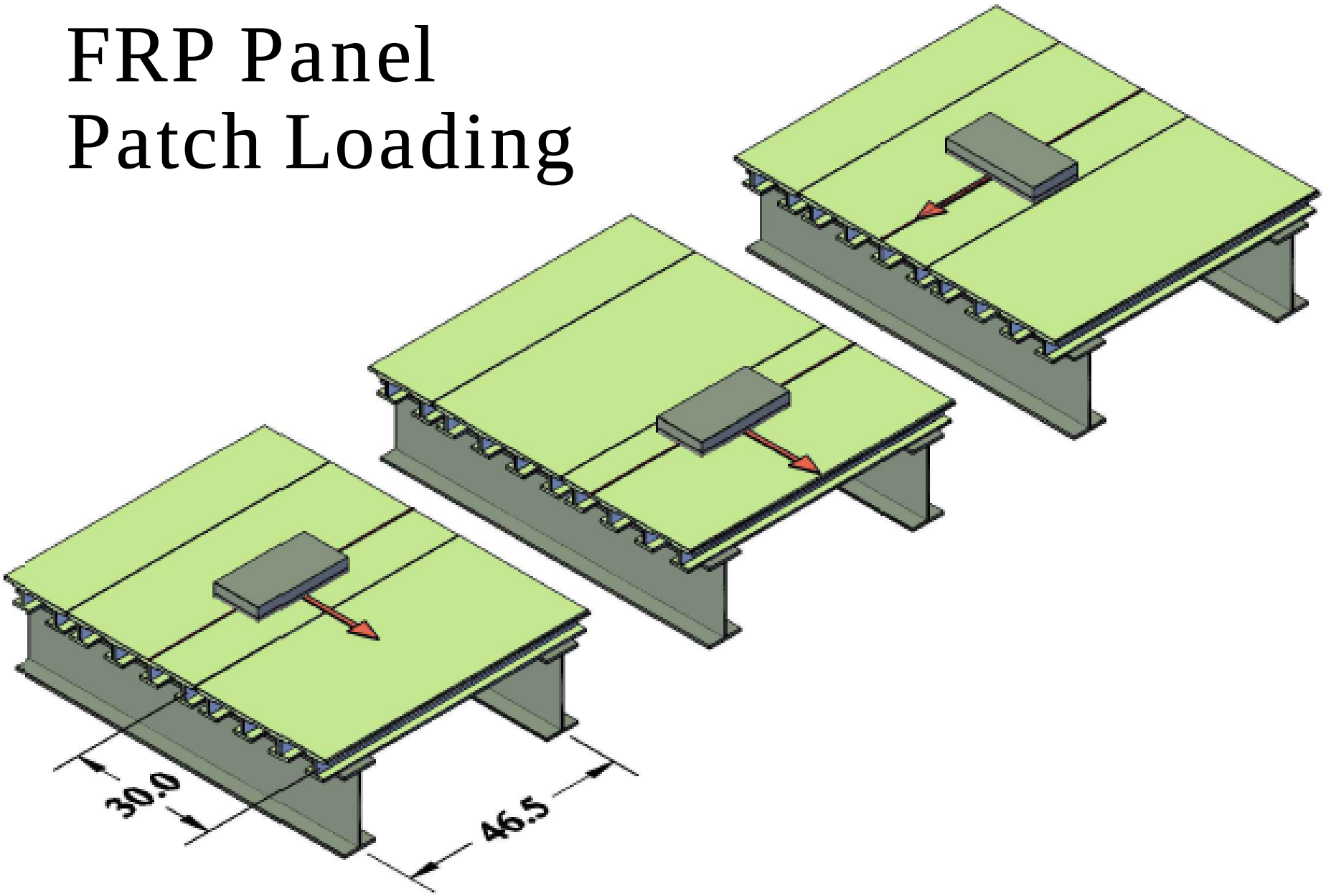
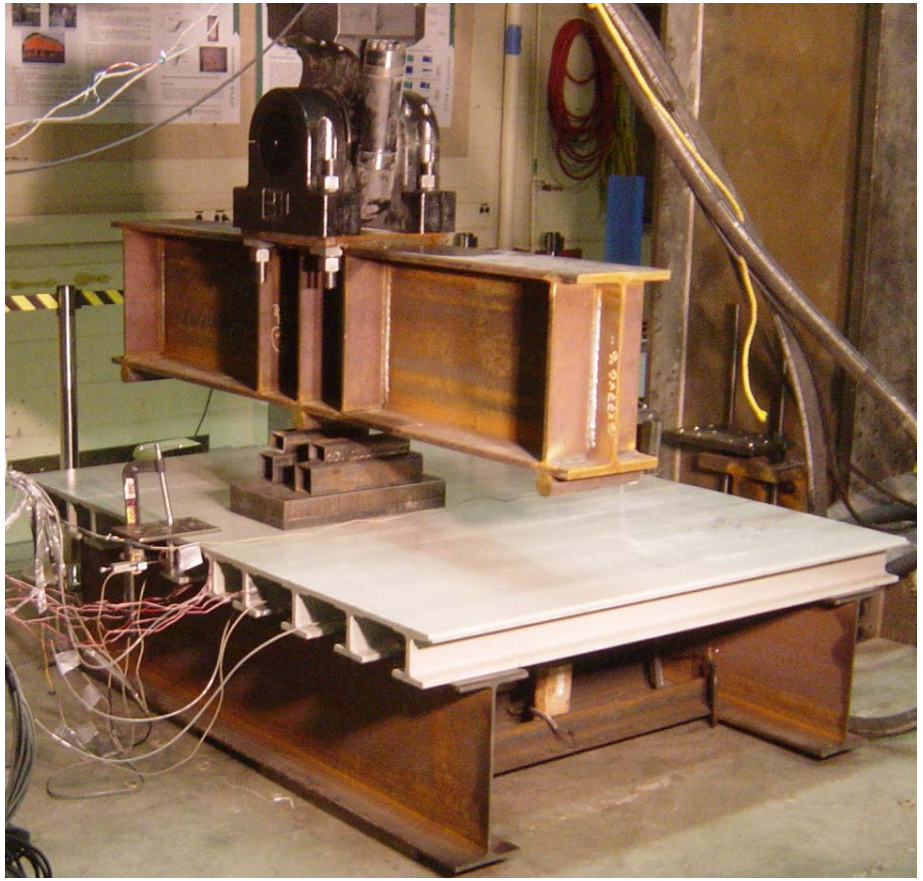
FRP Panel Patch Loading

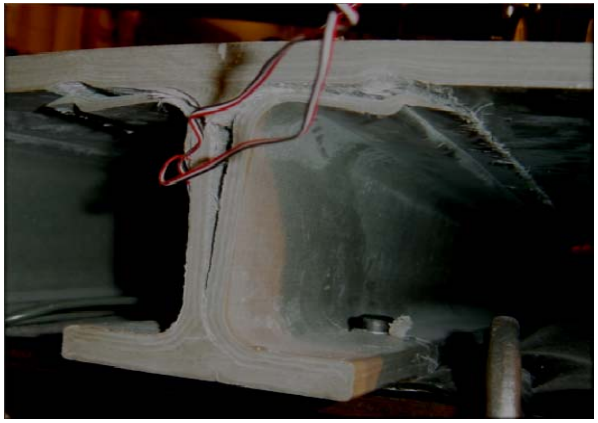


FRP Panel Strength Evaluation



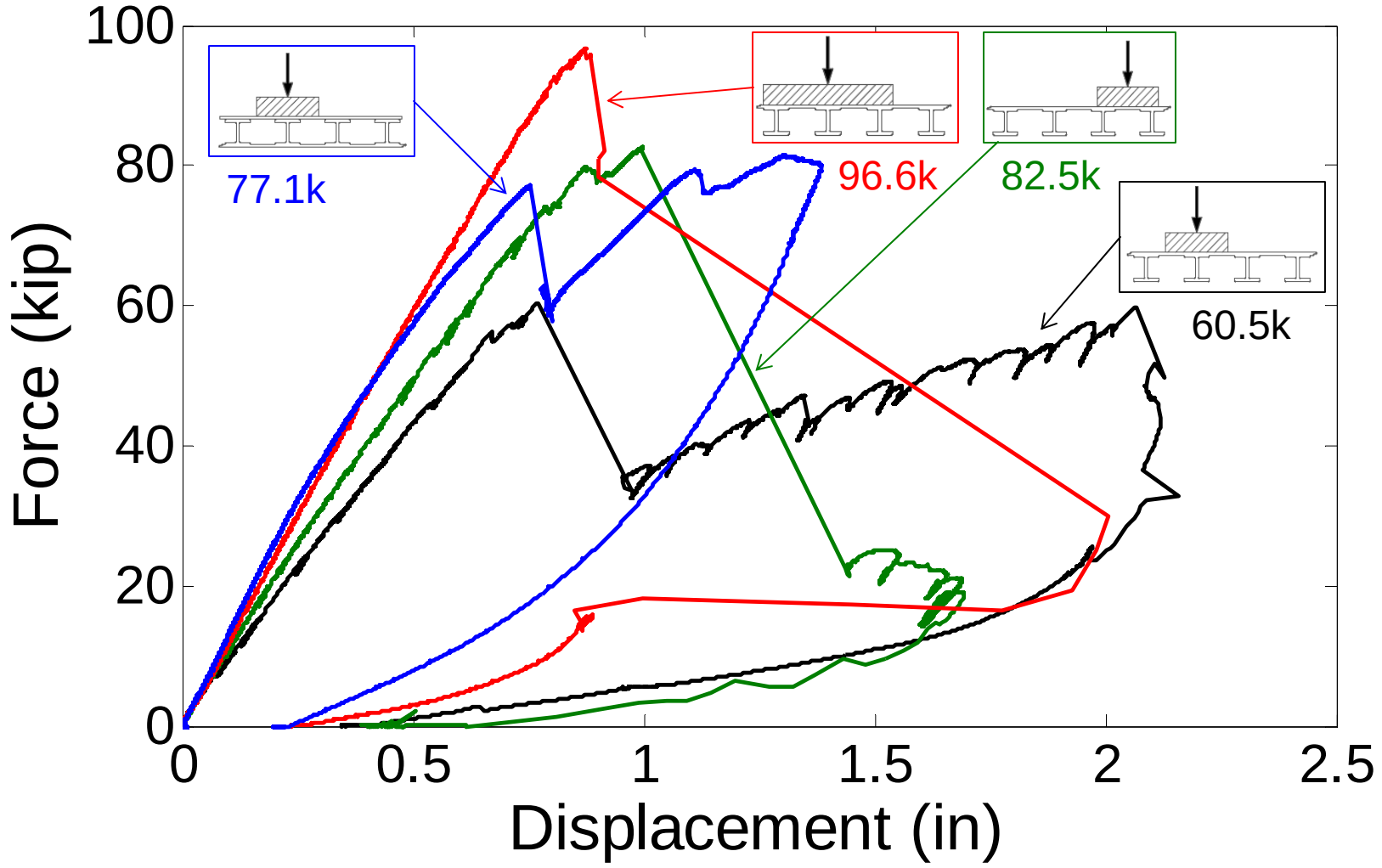
Flexural Failure Modes

1. Delamination

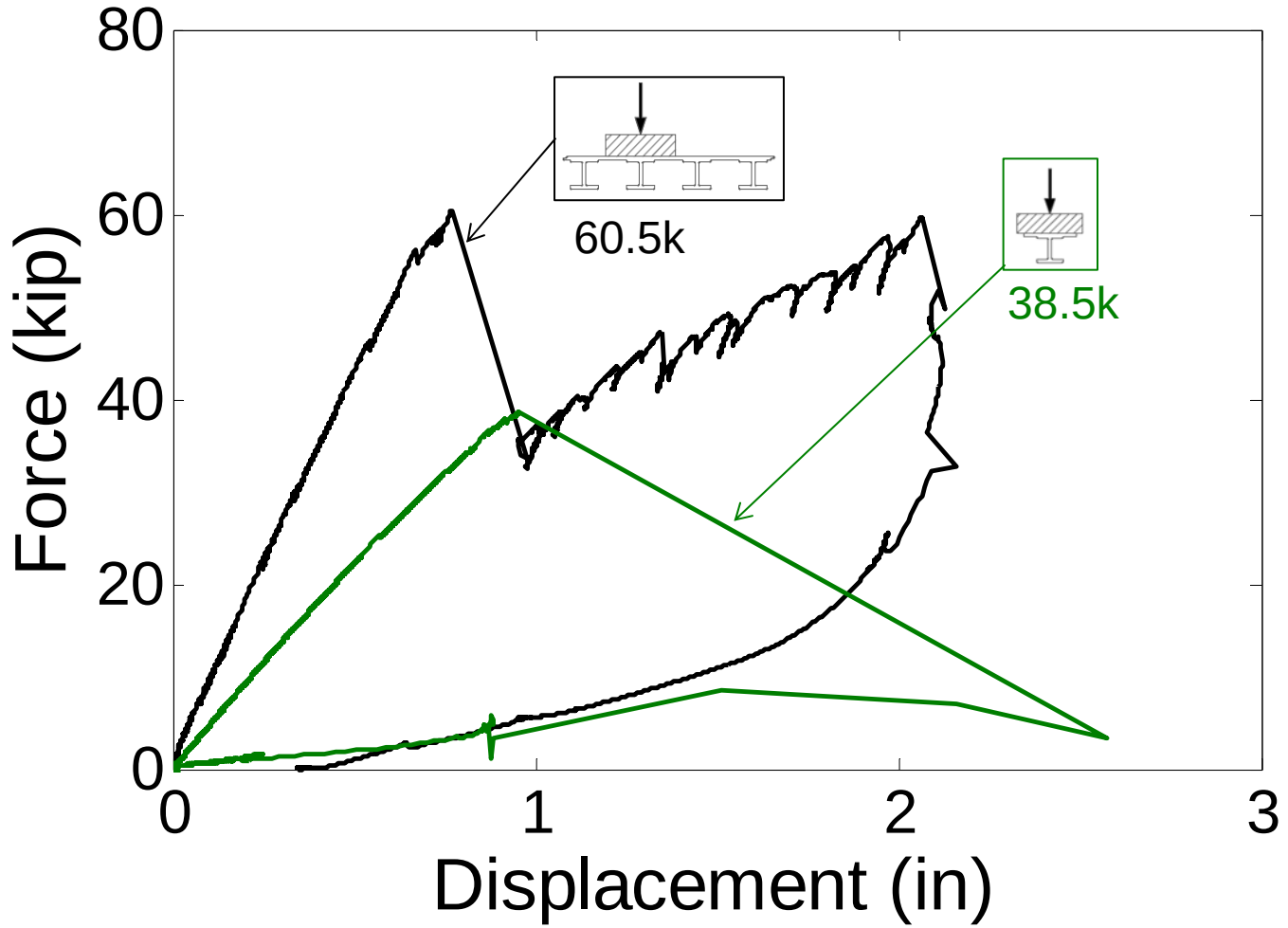


2. Web Crushing

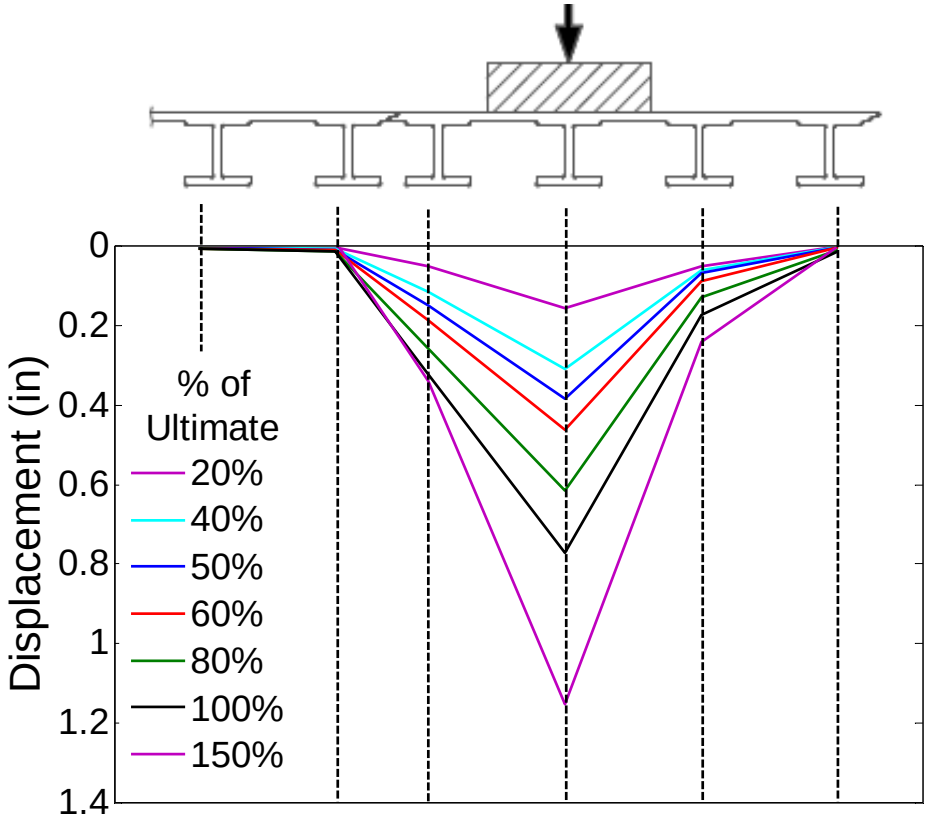
Flexural Behavior

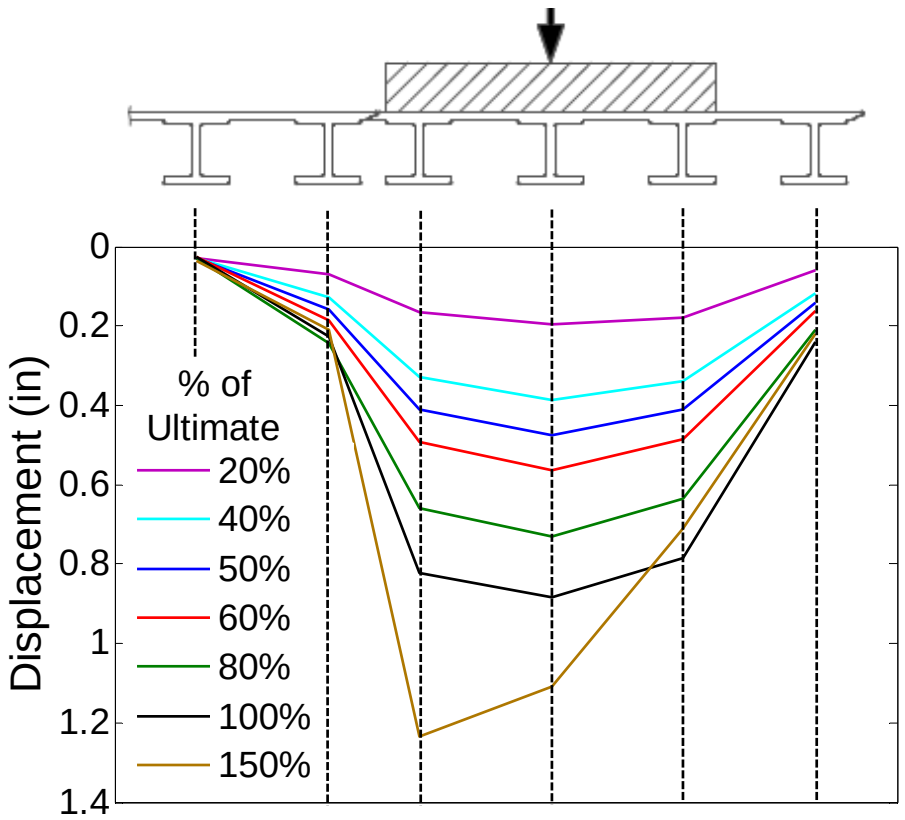


Beam to Panel Sharing

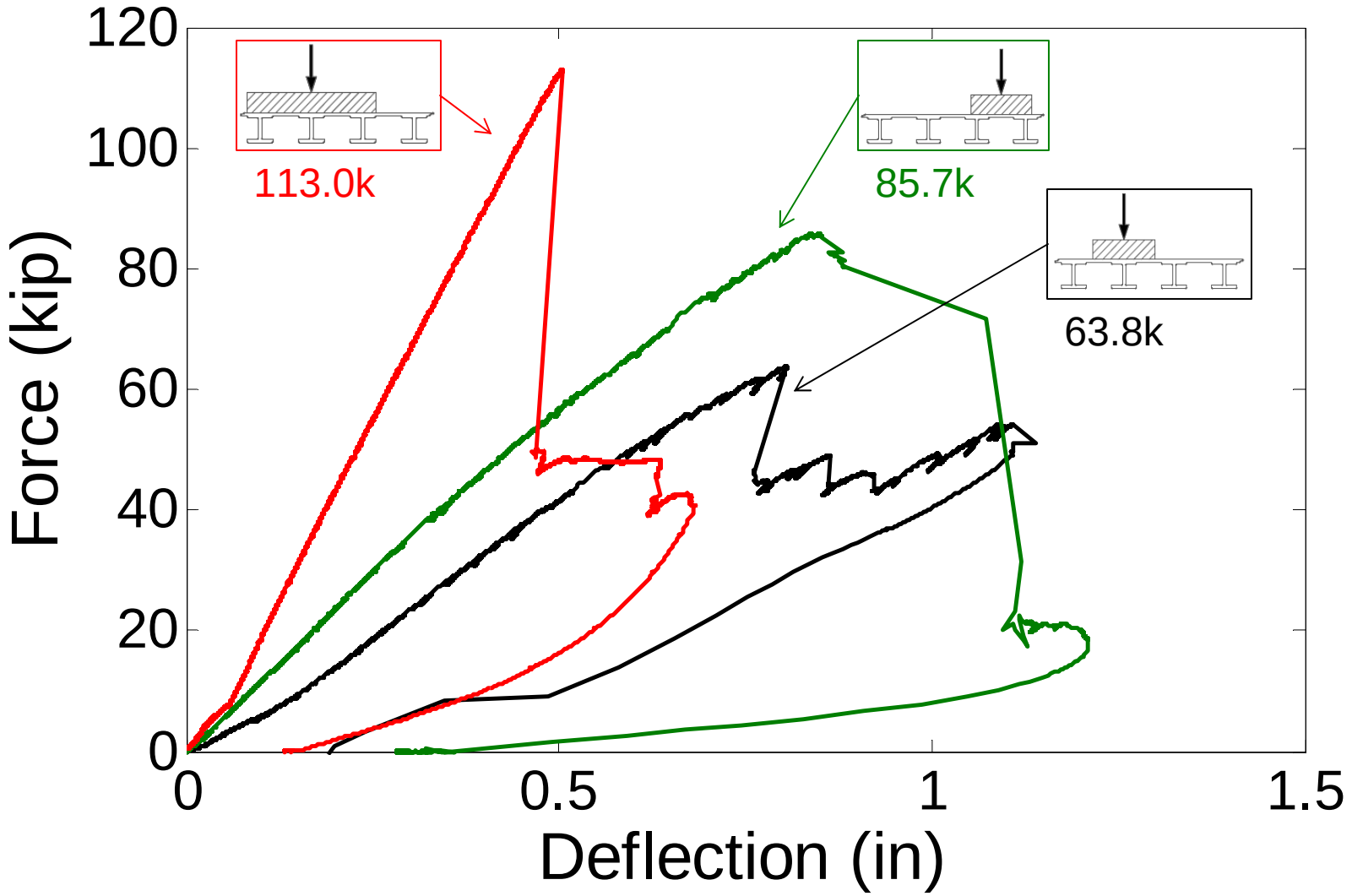


Flexural Distribution in Beams





Shear Behavior



Shear – Failure Modes

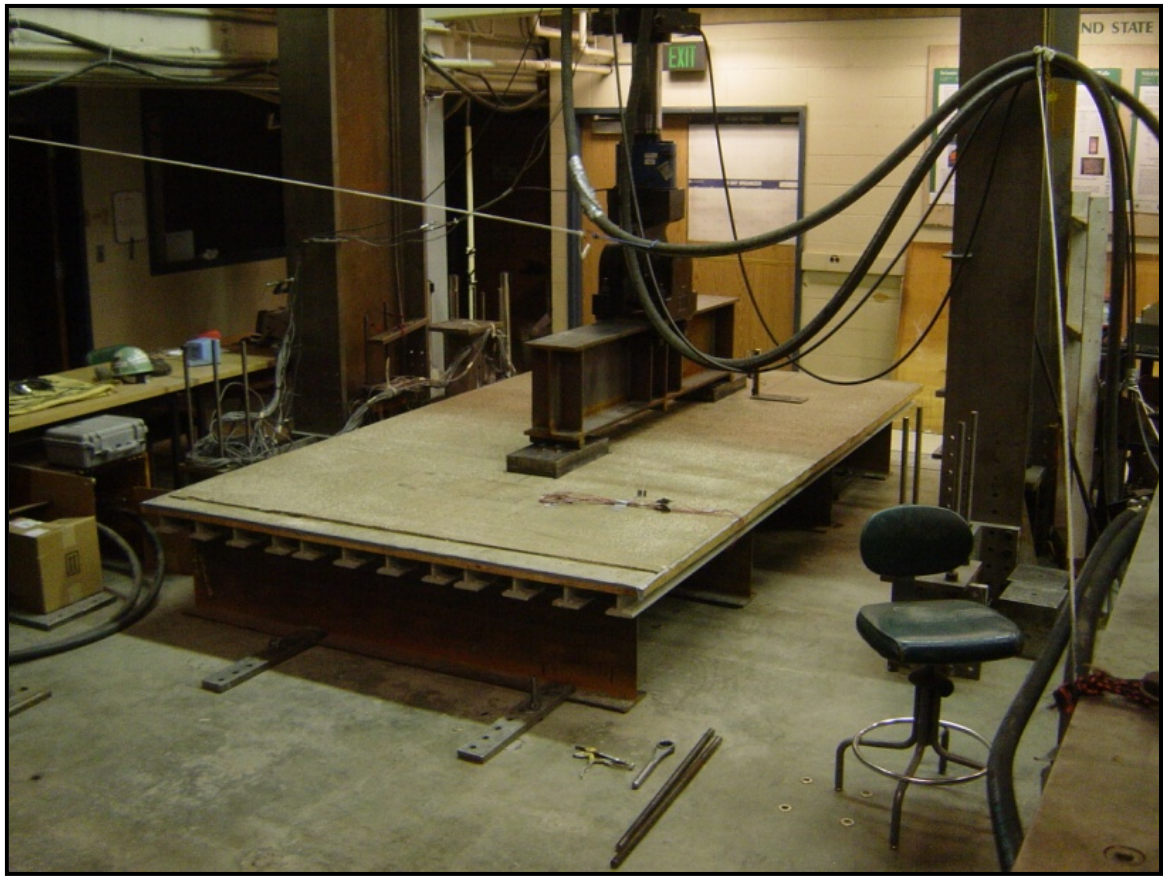
1. Delamination
2. Web Crushing

Fatigue Evaluation Approach

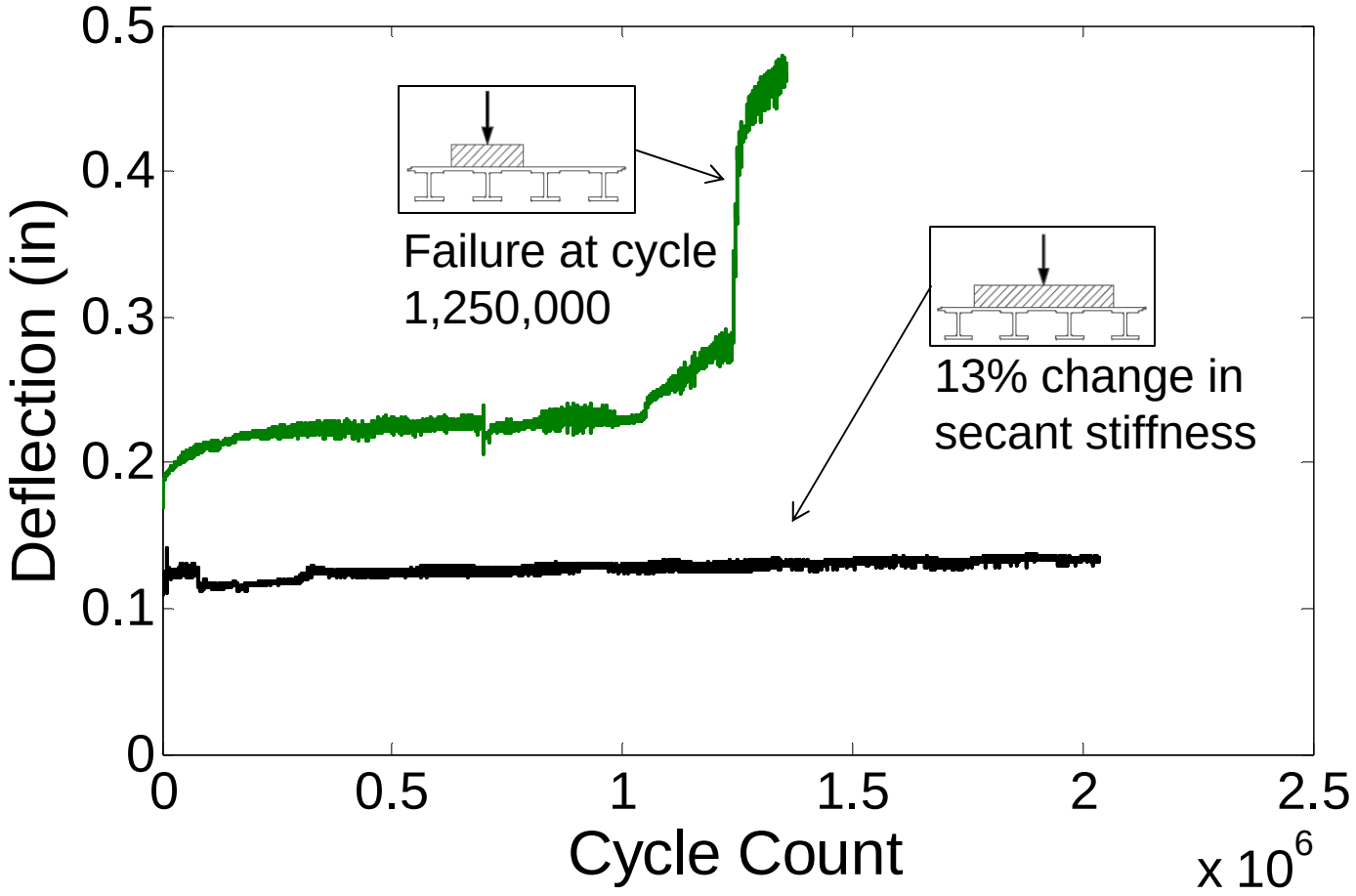
- HITEC approach
  - Load @ 1.5 times the wheel load (24kip)
  - Cycles @ 2 million cycles

- FHWA approach
  - Load @ AASHTO fatigue limit state (13.8kip)
  - Cycles @ Based on traffic demand (6.16 million cycles)

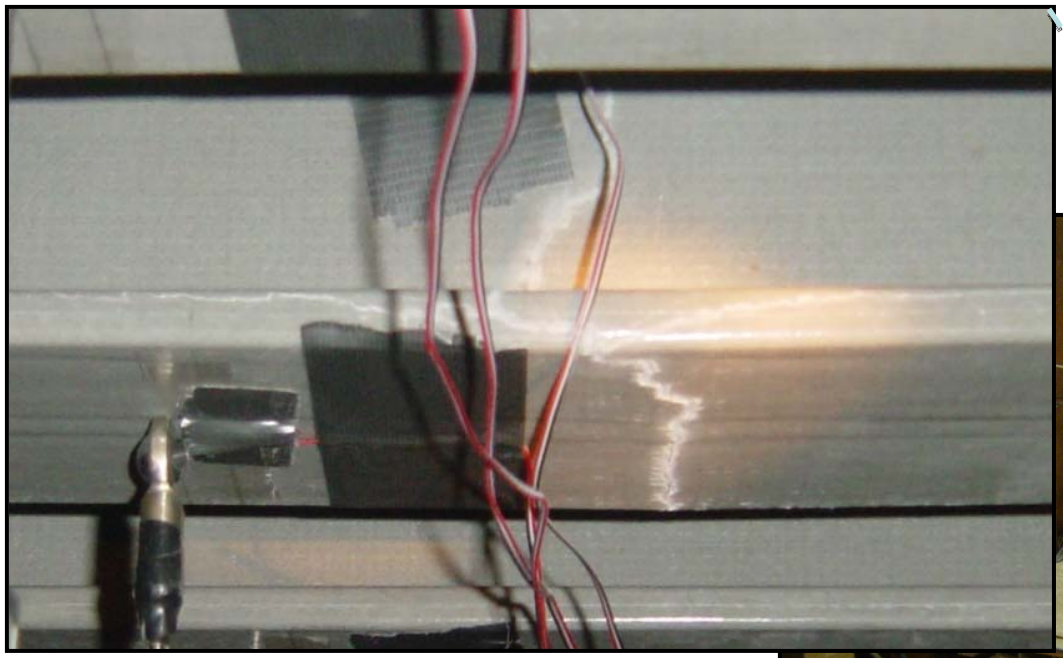
Fatigue – Axle Load Test Setup

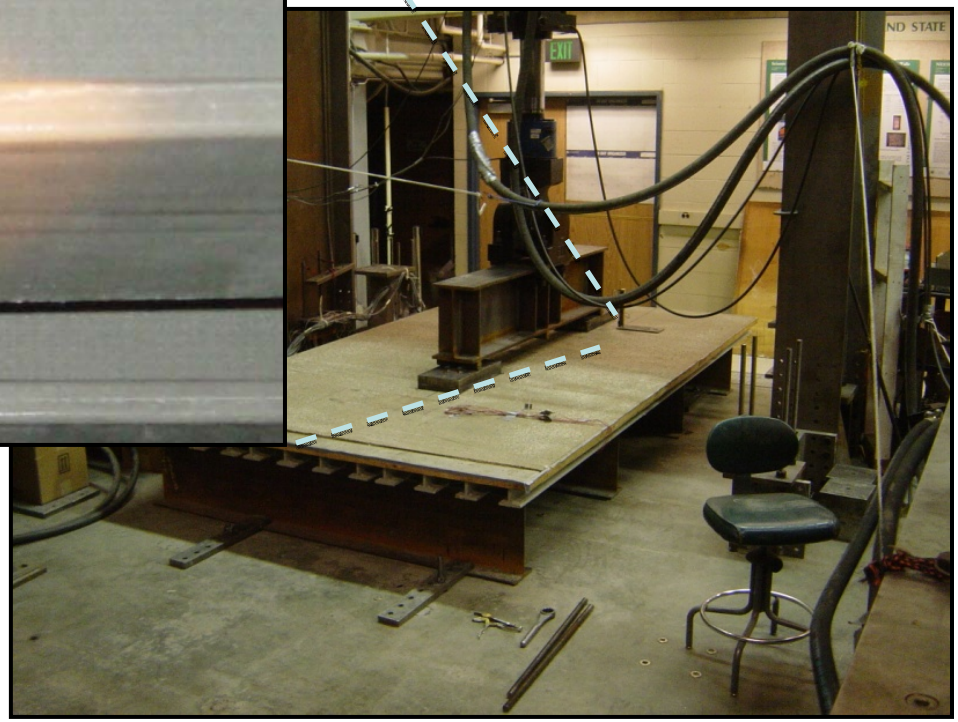


HITEC – Inverted T-beam Deck

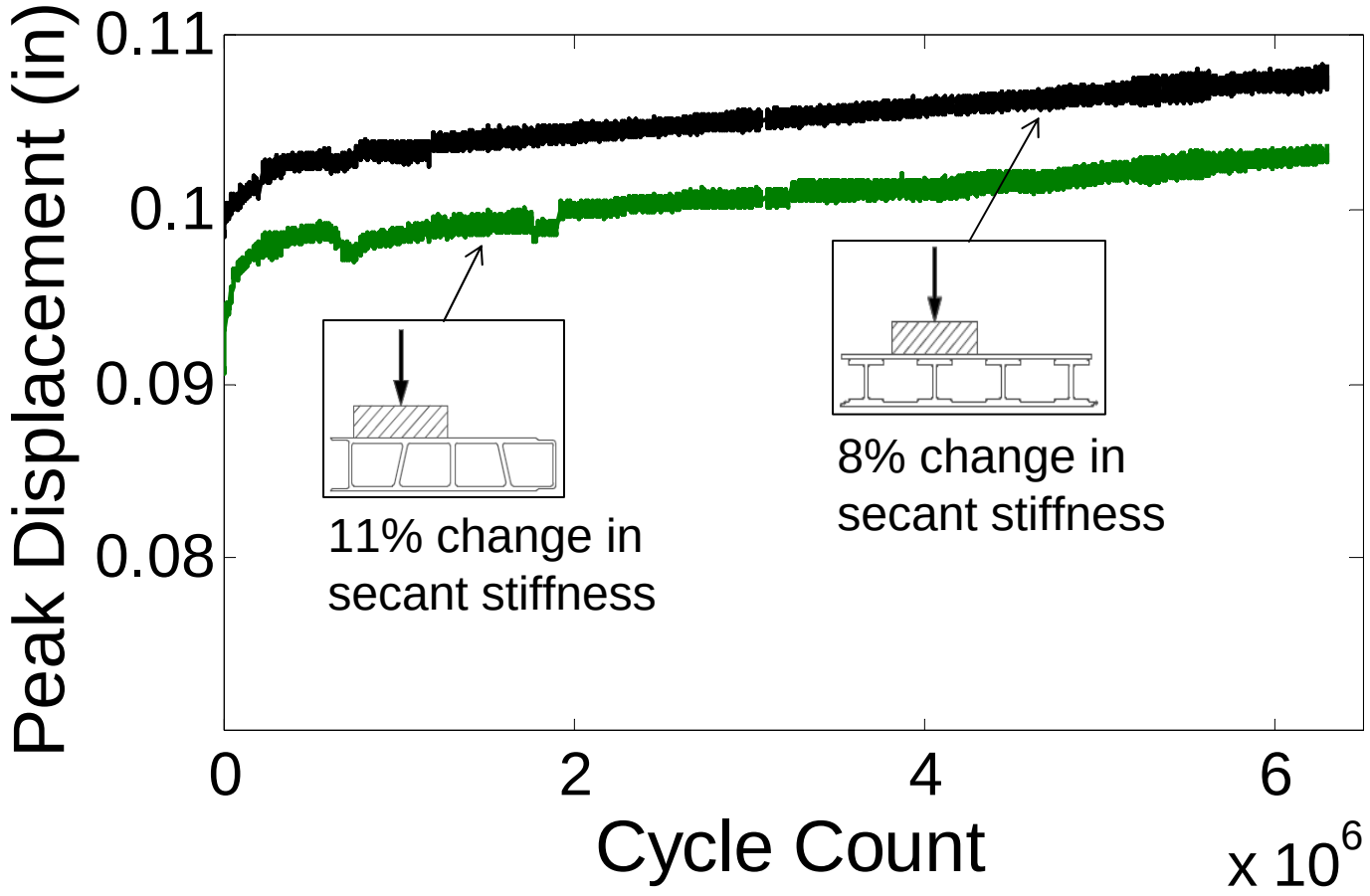


Fatigue Failure Mode

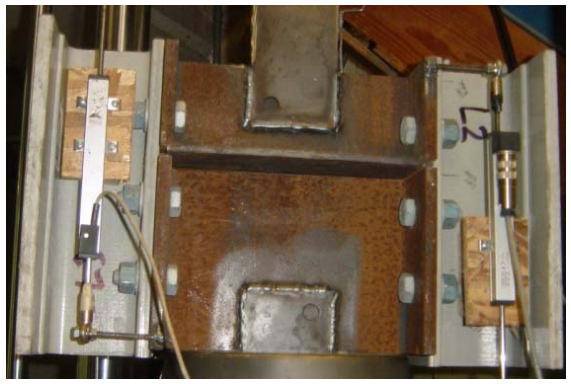




FHWA – Closed Box Decks



Bolted Connections

	Pull	Shear Perpendicular to Fibers	Shear Parallel to Fibers
Martin Marietta			
Zellcomp			

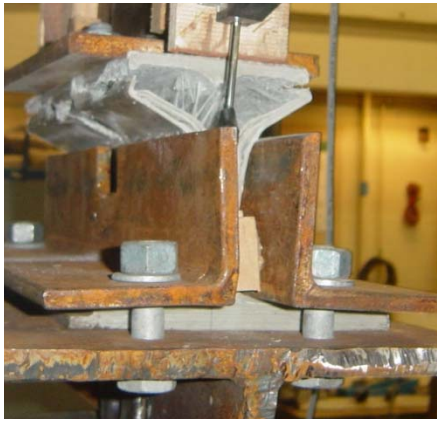
Pull Test

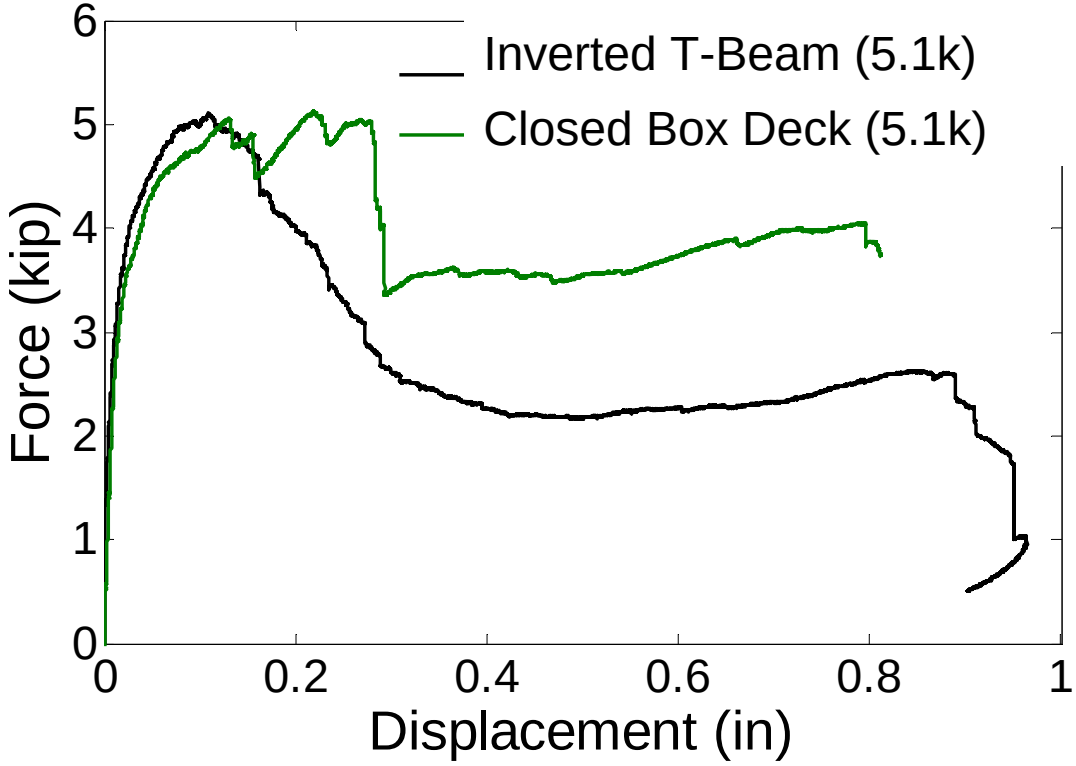
Closed Box (section)

Failure Mode:
Delamination of web

Inverted T-beam

Failure Mode:
Delamination of web

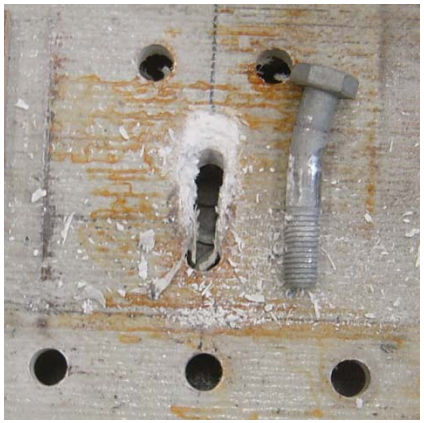




Shear Perpendicular to Fibers

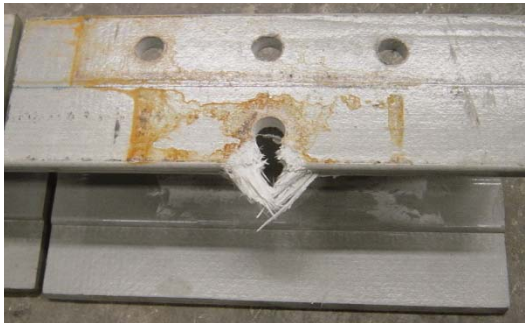
Closed Box (section)

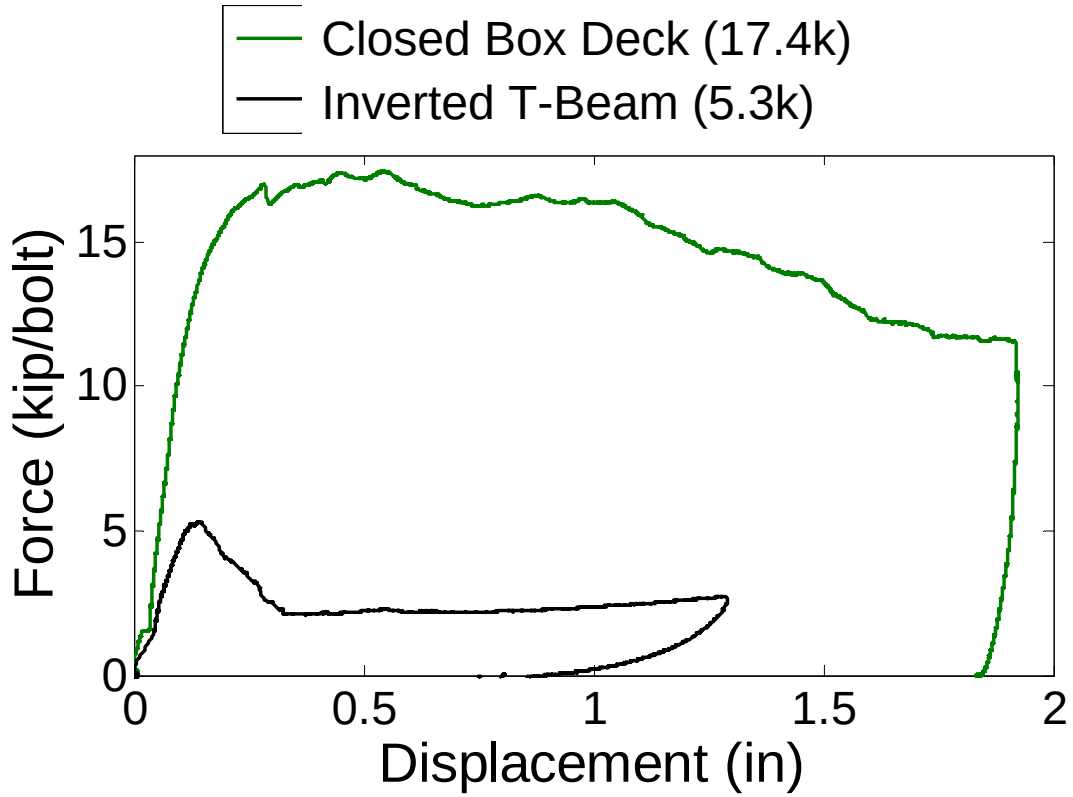
Failure Mode:
Bolt Bearing



Inverted T-beam

Failure Mode:
Bolt Bearing

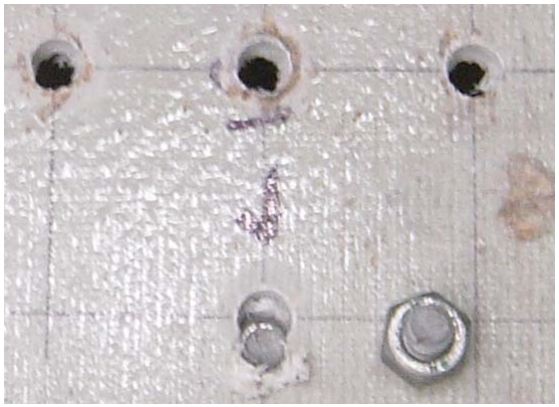




Shear Parallel to Fibers

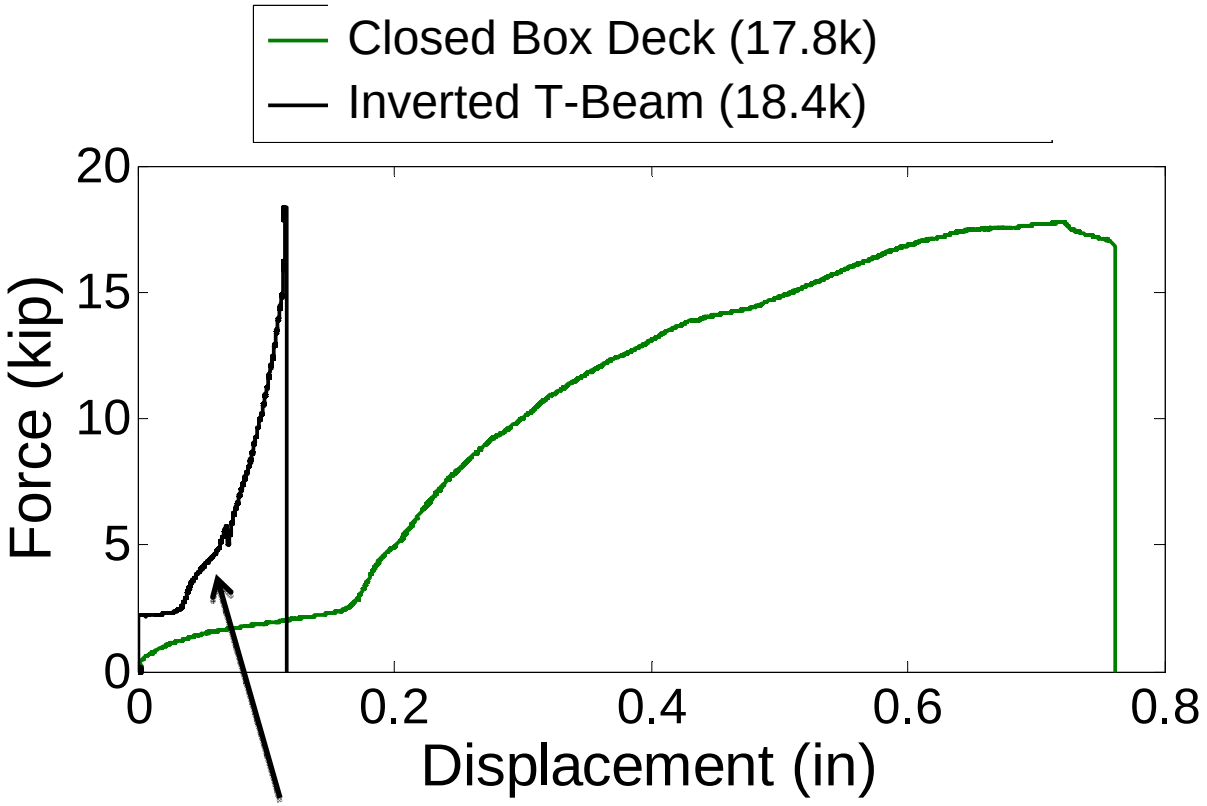
Closed Box (section)

Failure Mode: Bolt shear (threads not excluded)



Failure Mode: Flange Delamination

Inverted T-beam



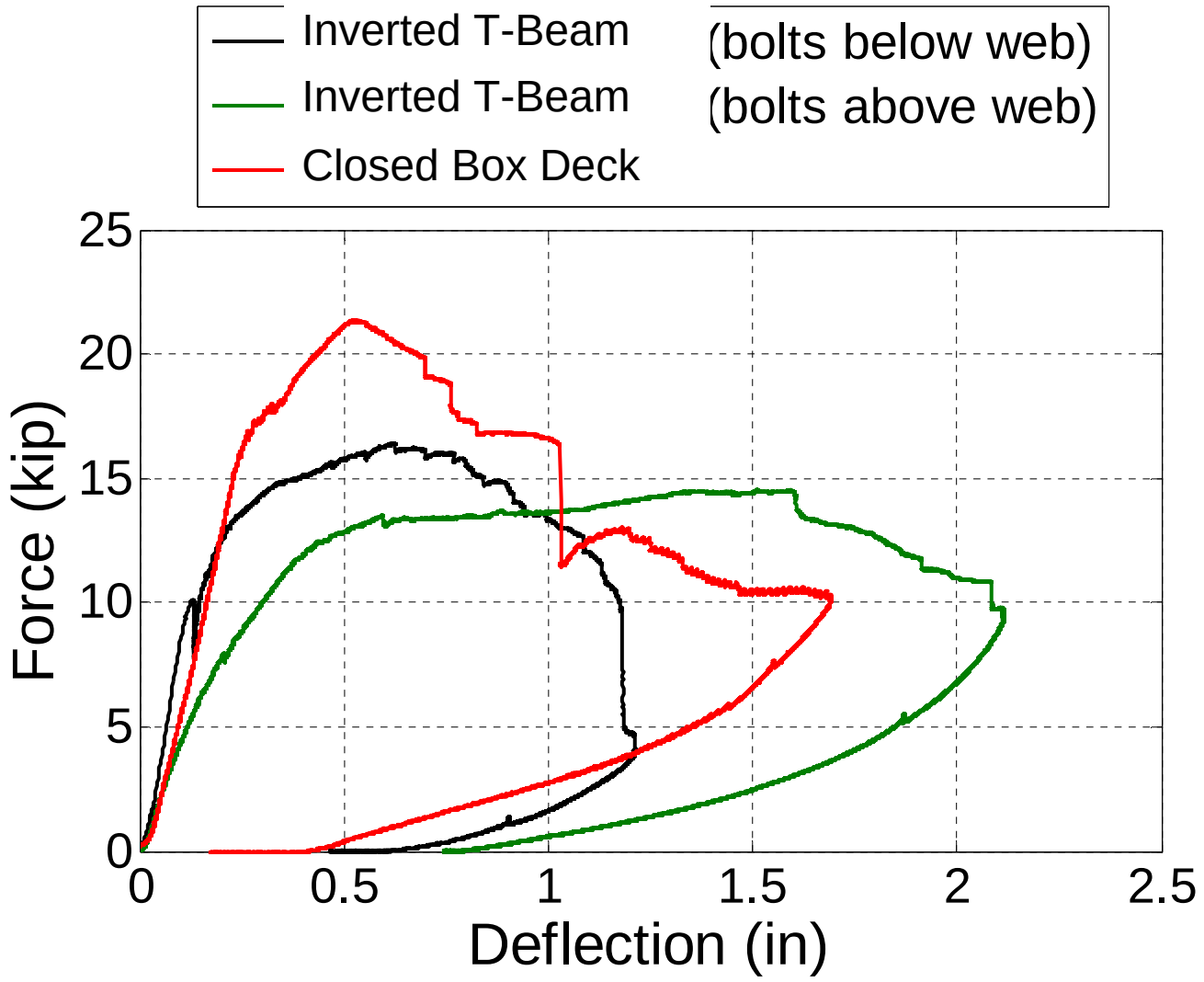
Note: bolt closer to and engaging web, resulting in smaller displacements.

Deck to Girder Strength - Specimens

Inverted T-Beam Deck

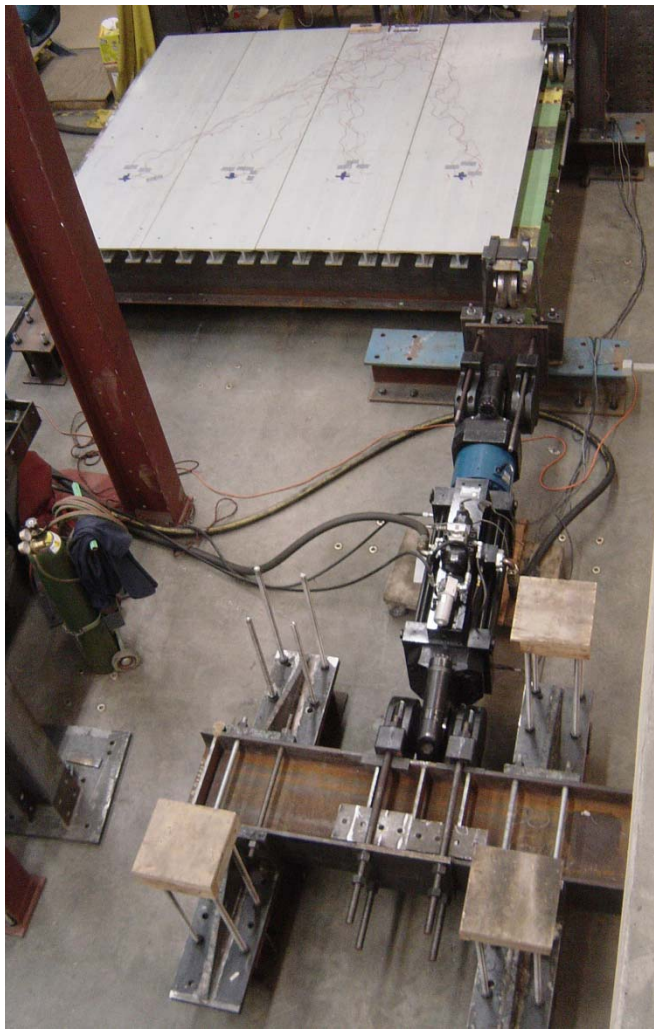
Closed Box Deck

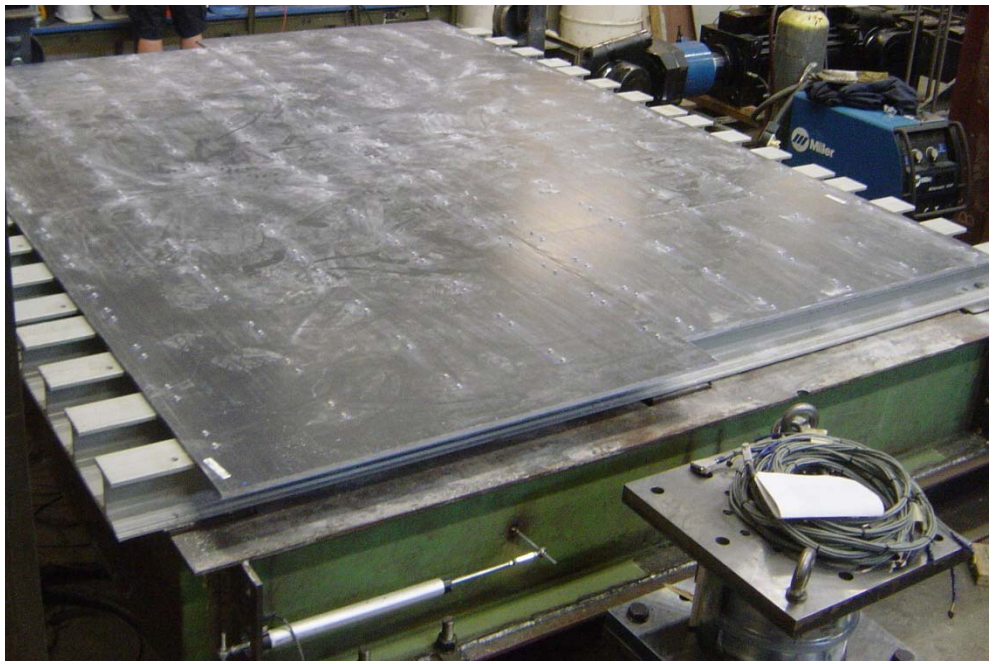
Deck to Girder Test Results



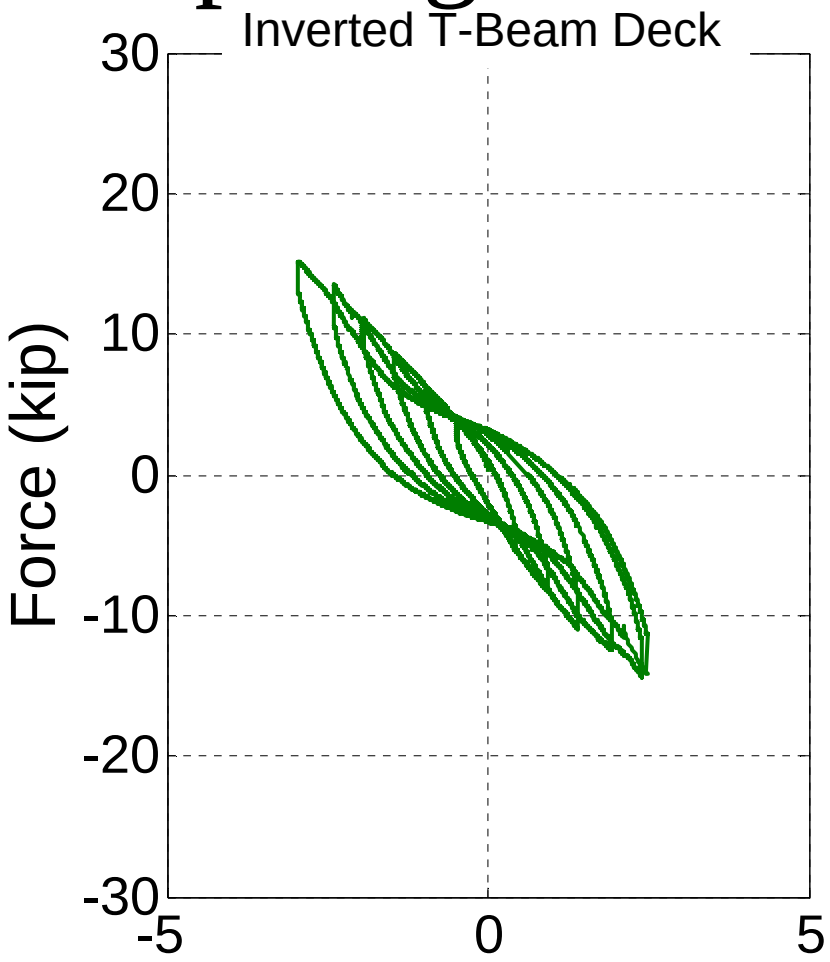
Deck to Girder Failure Modes

Diaphragm Test Setup

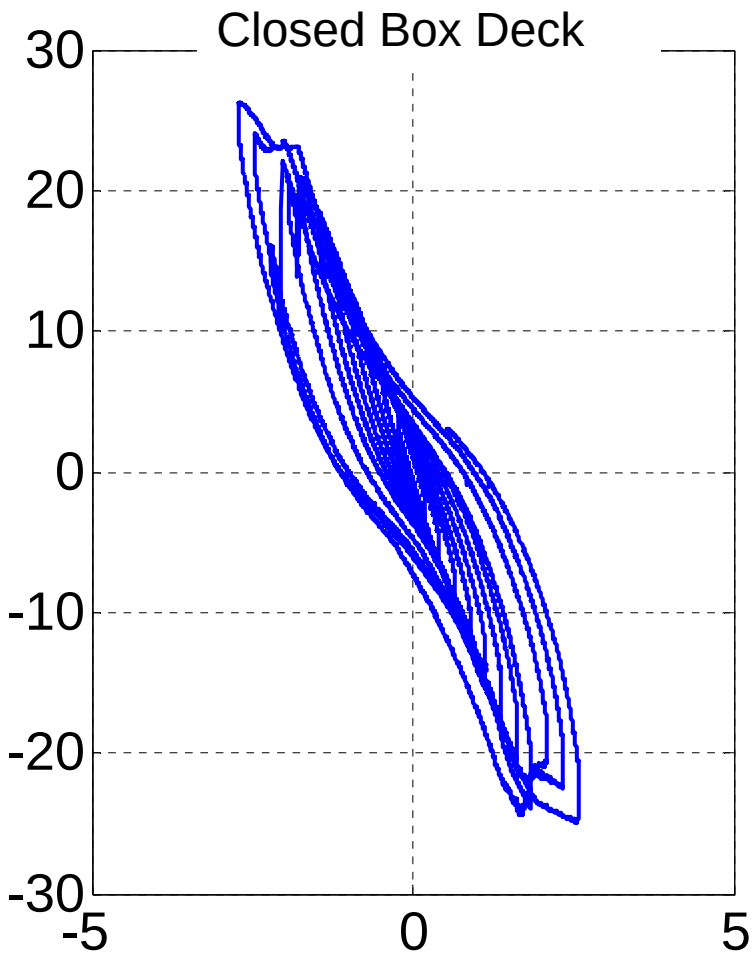




Diaphragm Test Results



Completed cycles to ±2.5in
Stiffness of approx. 6kip/in



Completed cycles to ±2.5in
Stiffness of approx. 12.6kip/in

Summary of Structural Evaluation

Monotonic Strength

- ultimate strength well above wheel load demands
- flexure and shear load failure mode via web/flange shear flow
- load sharing between panel beams distributes after initial failure
- minimal post failure residual displacement (maintenance?)

Fatigue

- HITEC evaluation approach unrealistic for high volume bridges such as the Morrison Bridge, use FHWA
- failure mode of monotonic to fatigue can change
- approximately 10% reduction in stiffness over life of Morrison Bridge deck

Bolted Connections

- FRP strength (local) controlled, not bolt
- direction dependent

Deck diaphragm stiffness doubles with closed deck


HYUNDAI
HYUNDAI
CONWAY