APRIL 13, 2022

CTR SYMPOSIUM 2022

TxDOT PROJECT 0-7012
DEVELOPMENT OF NON-FRACTURE CRITICAL STEEL BOX STRADDLE CAPS

Esteban Zecchin
Graduate Research Assistant, PhD Candidate
Ferguson Structural Engineering Laboratory
The University of Texas at Austin

TEAM ACKNOWLEDGEMENTS

- ***Student Researchers***
  - Emma Williams (MS), Sonita Mansoori (UG), Esteban Zecchin (PhD)
- ***Visiting Scholars***
  - Chen Liang (Tongji University, China)
- ***Post-Doctoral Researchers***
  - Dr. Matt Reichenbach, Dr. Sunghyun Park
- ***Principal Investigators***
  - Dr. Todd Helwig, Dr. Michael Engelhardt, Dr. Eric Williamson, & Dr. Matthew Hebdon
- ***Industry Advisory Group***
  - TxDOT PMC: Jamie Farris, Tom Fan, David Fish, Wanching Huang, Moheb Labib, Yongqian Lin, & Paul Rollins
  - Dennis Noernberg (WW AFCO), Dr. Karl Frank, Dr. Jason Lloyd (NSBA-AISC), Randy Rogers (Williams Brothers), & Ronnie Medlock (High Steel)

WHAT ARE STRADDLE CAPS USED FOR?

Straddle caps are commonly utilized in congested urban environments when intersecting roads do not permit the use of conventional piers.

Box straddle cap supporting twin tub girders on I35N & US290 (Google Maps)

ADVANTAGES

- ✓ High strength-to-weight ratio
- ✓ Ease of erection, no shoring required

FRACTURE CRITICAL MEMBERS

- ✓ Stringent fabrication/material requirements
- ✓ Biennial hands-on inspections

RESEARCH MOTIVATION

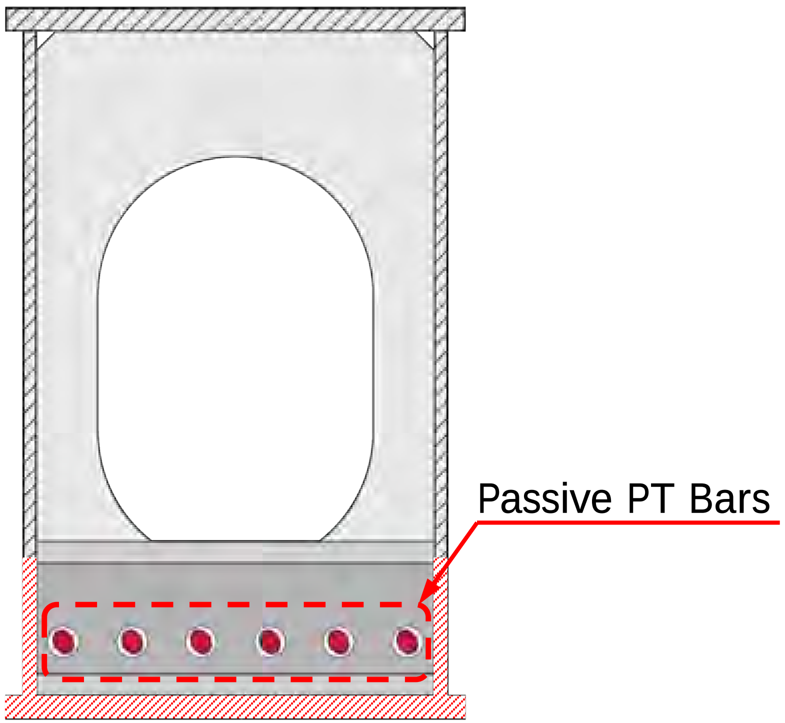
Develop details that allow steel box straddle caps to be classified as internally redundant, thus removing the Fracture Critical designation, providing added safety, and producing significant savings in their life-cycle economy and long-term performance

SELECTED APPROACHES FOR IR STRADDLE CAPS

Developed in conjunction with TxDOT PMC and Industry Advisory Group

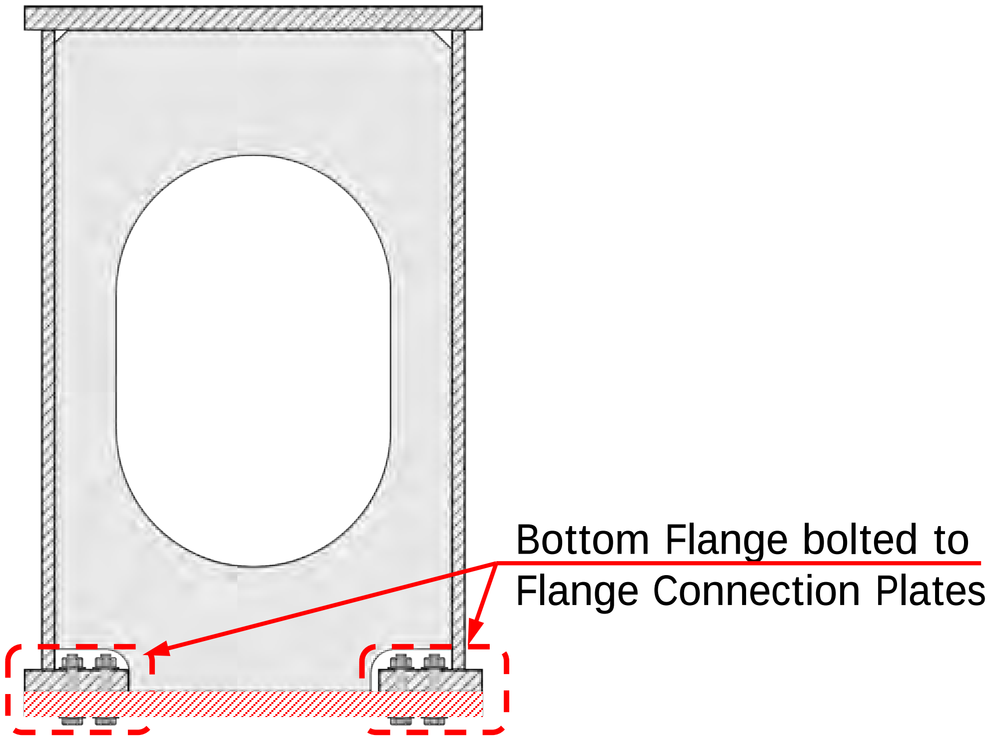
DESIGN CONCEPT A

- Install high-strength bars as ***secondary load path***, engaged in case of fracture of bottom flange

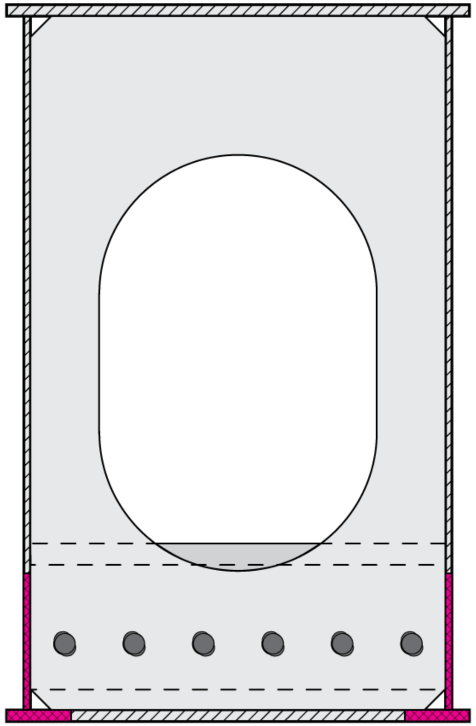


DESIGN CONCEPT B1

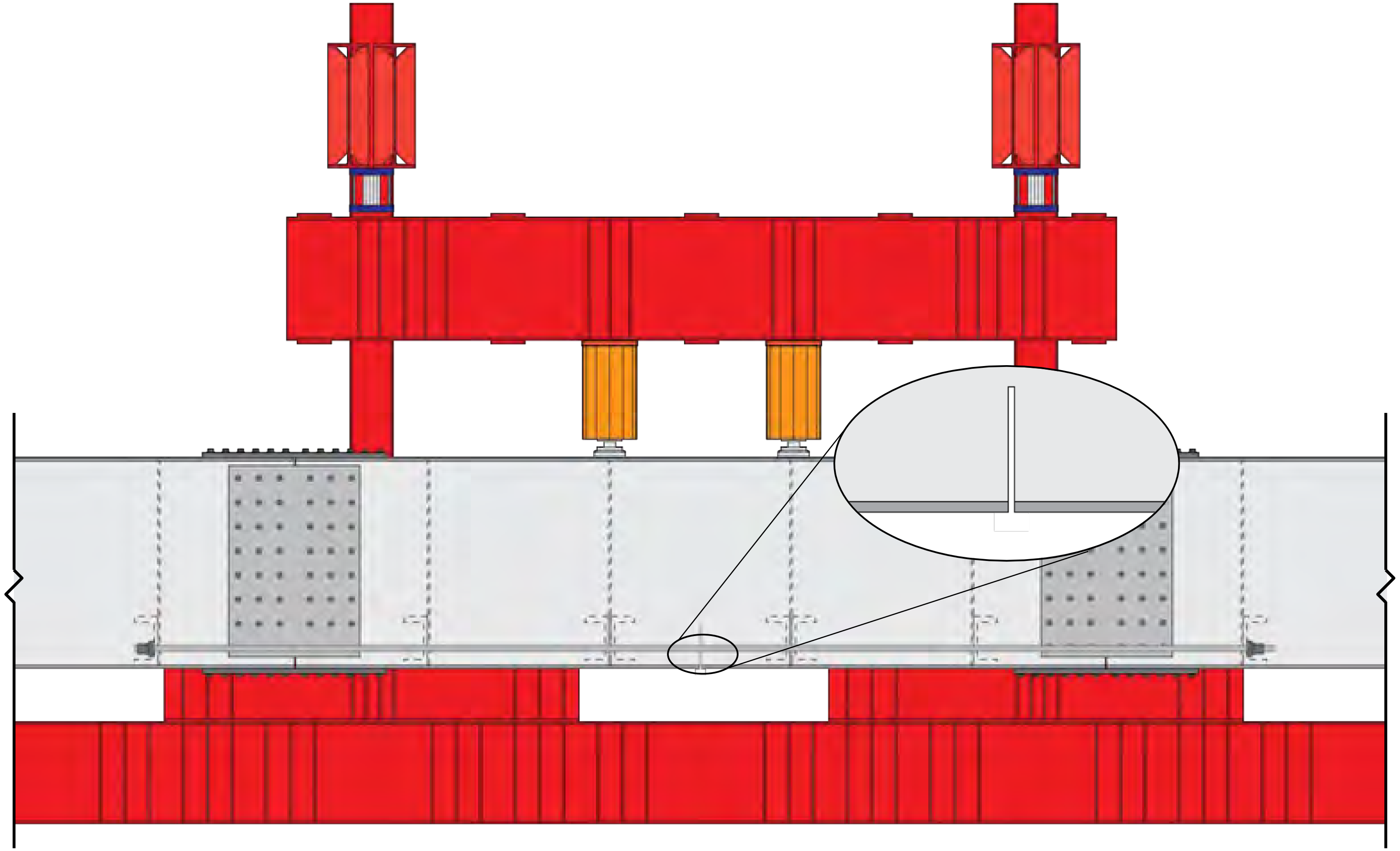
- Utilize bolted connections between components in tension, thus rendering ***cross-boundary separation***



DESIGN CONCEPT A – EXPECTED BEHAVIOR

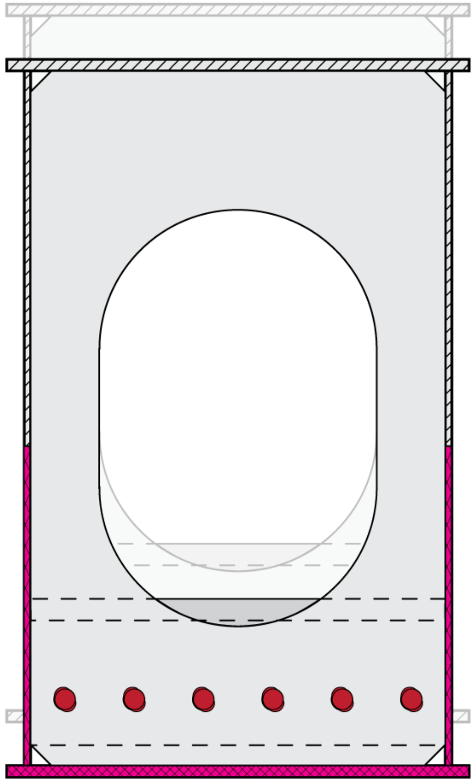


Specimen A Cross-Section

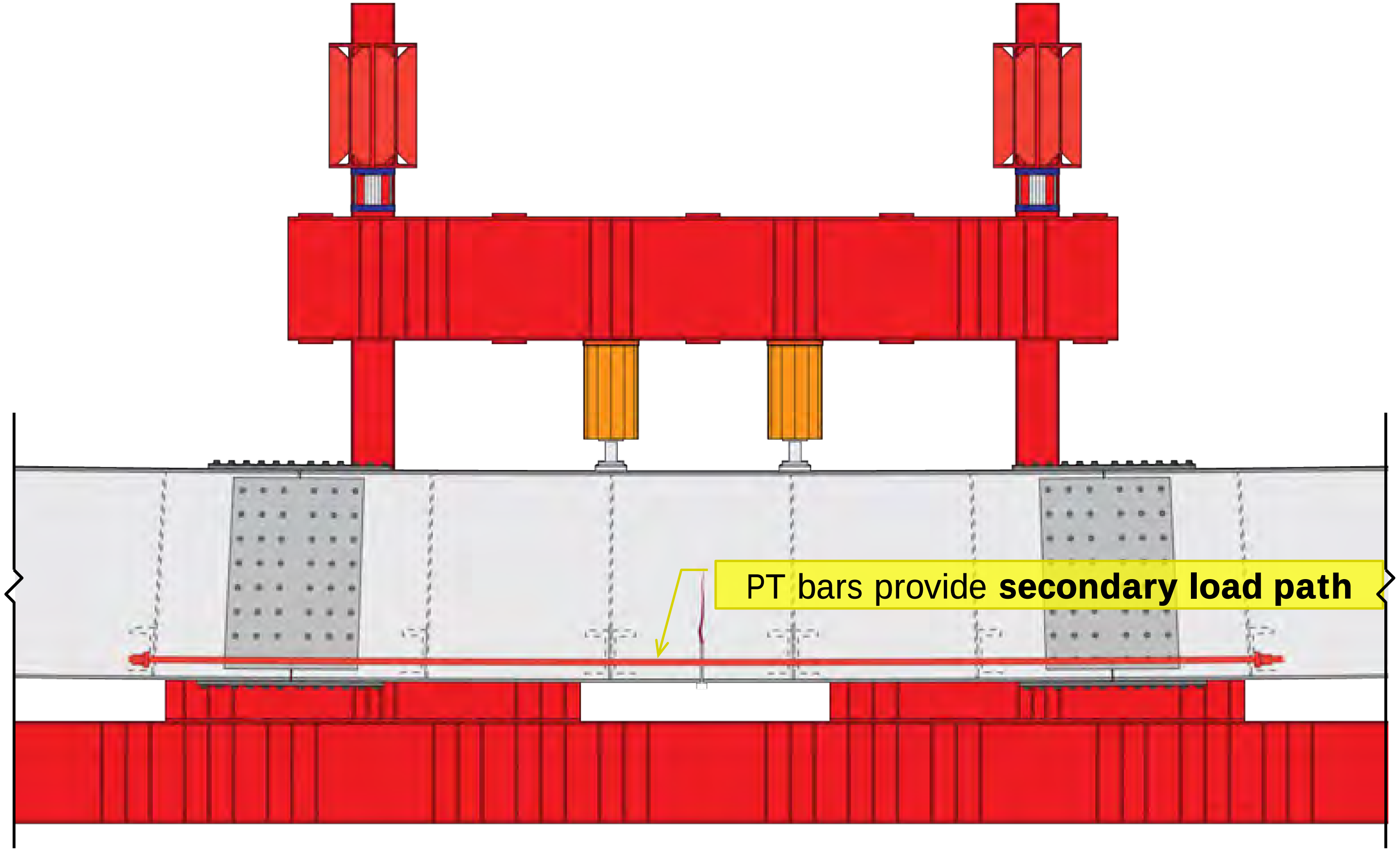


Test Setup Elevation

DESIGN CONCEPT A – EXPECTED BEHAVIOR

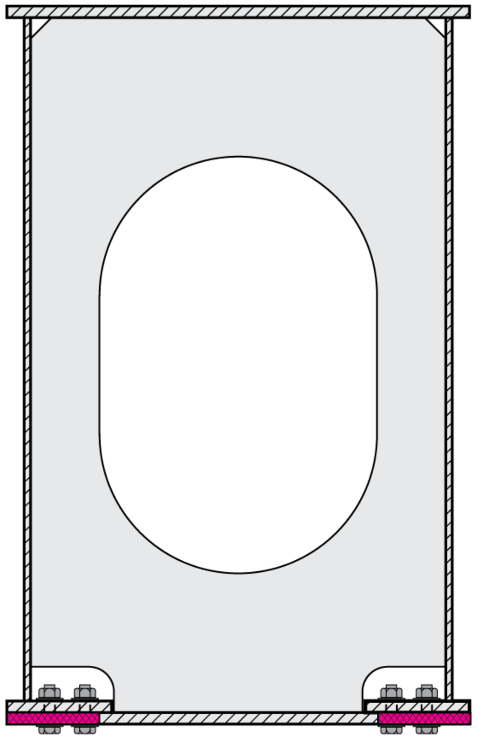


Specimen A Cross-Section

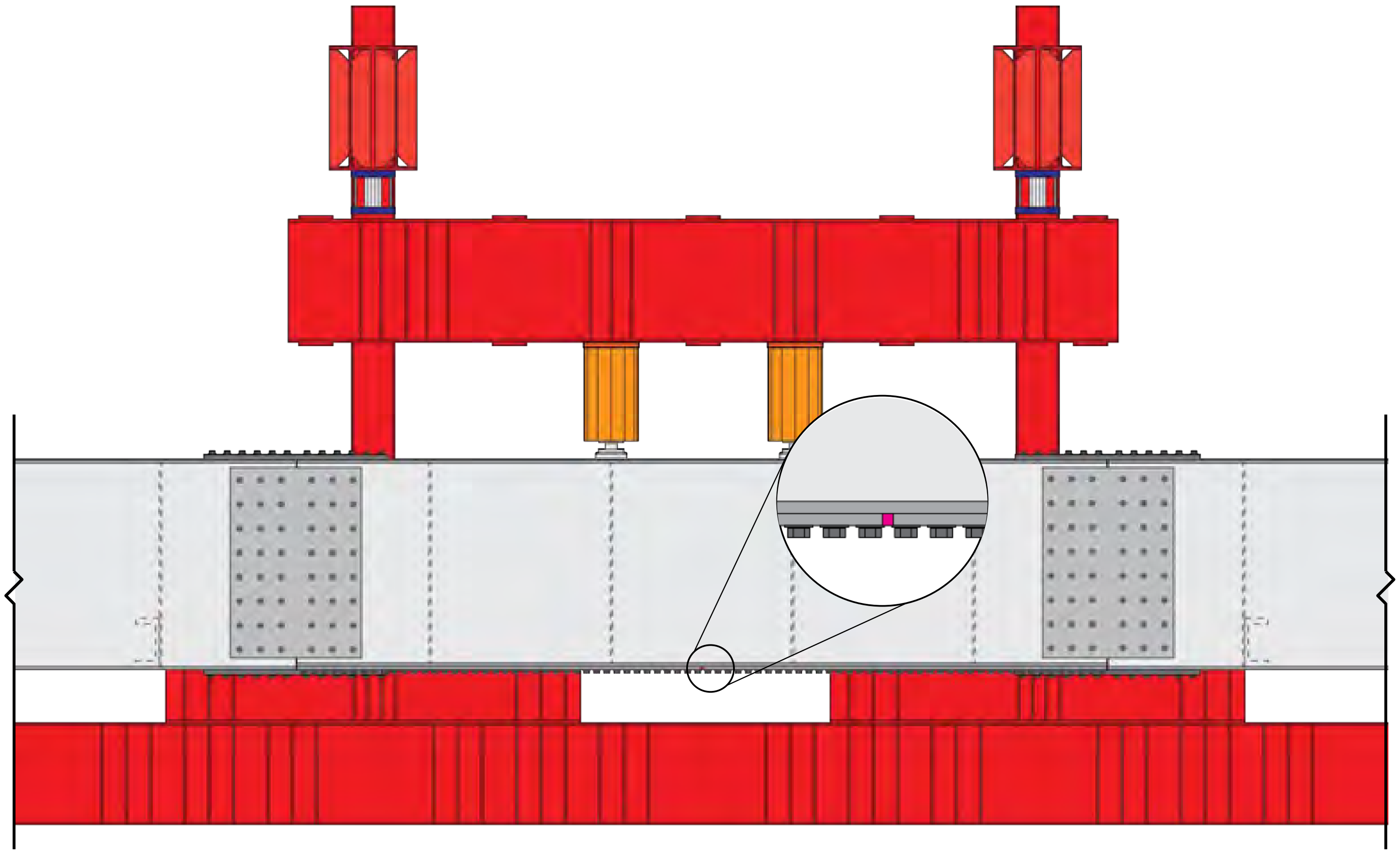


Test Setup Elevation

DESIGN CONCEPT B1 – EXPECTED BEHAVIOR



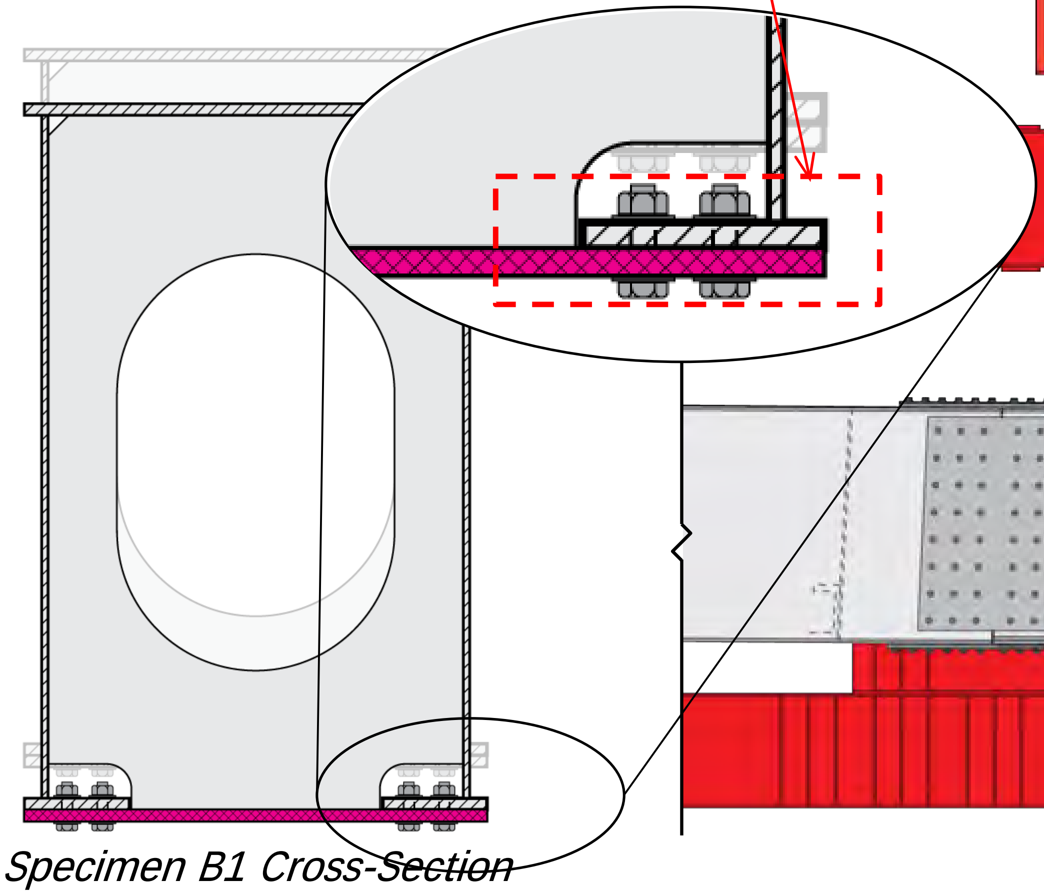
Specimen B1 Cross-Section



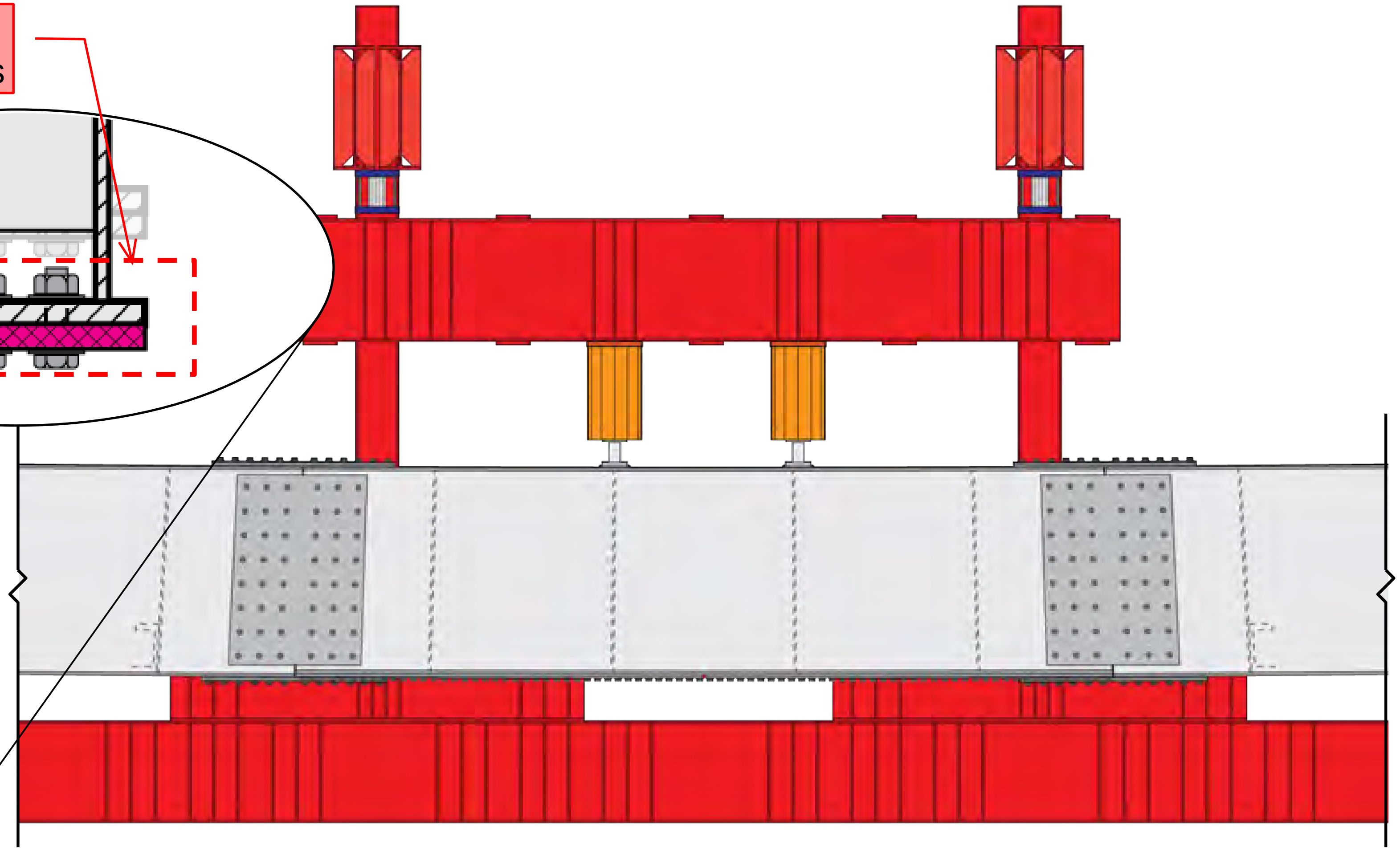
Test Setup Elevation

DESIGN CONCEPT B1 – EXPECTED BEHAVIOR

Cross-boundary separation between bottom flange and flange connection plates



Specimen B1 Cross-Section



Test Setup Elevation

TEST PROTOCOL

A. FRACTURE TEST

Objective: evaluate crack arrest capacity of IR approaches

1. NOTCH SPECIMEN
2. FATIGUE LOADING
3. COOL USING LN2
4. LOAD TO FRACTURE

B. POST-FRACTURE TEST

Objective: assess specimen capacity with a fractured component

1. LOADING AT ROOM TEMPERATURE
2. LOADING AT LOWER-SHELF TEMPERATURE

SPECIMEN ASSEMBLY

SPECIMEN ASSEMBLY

SPECIMEN B1 TESTING

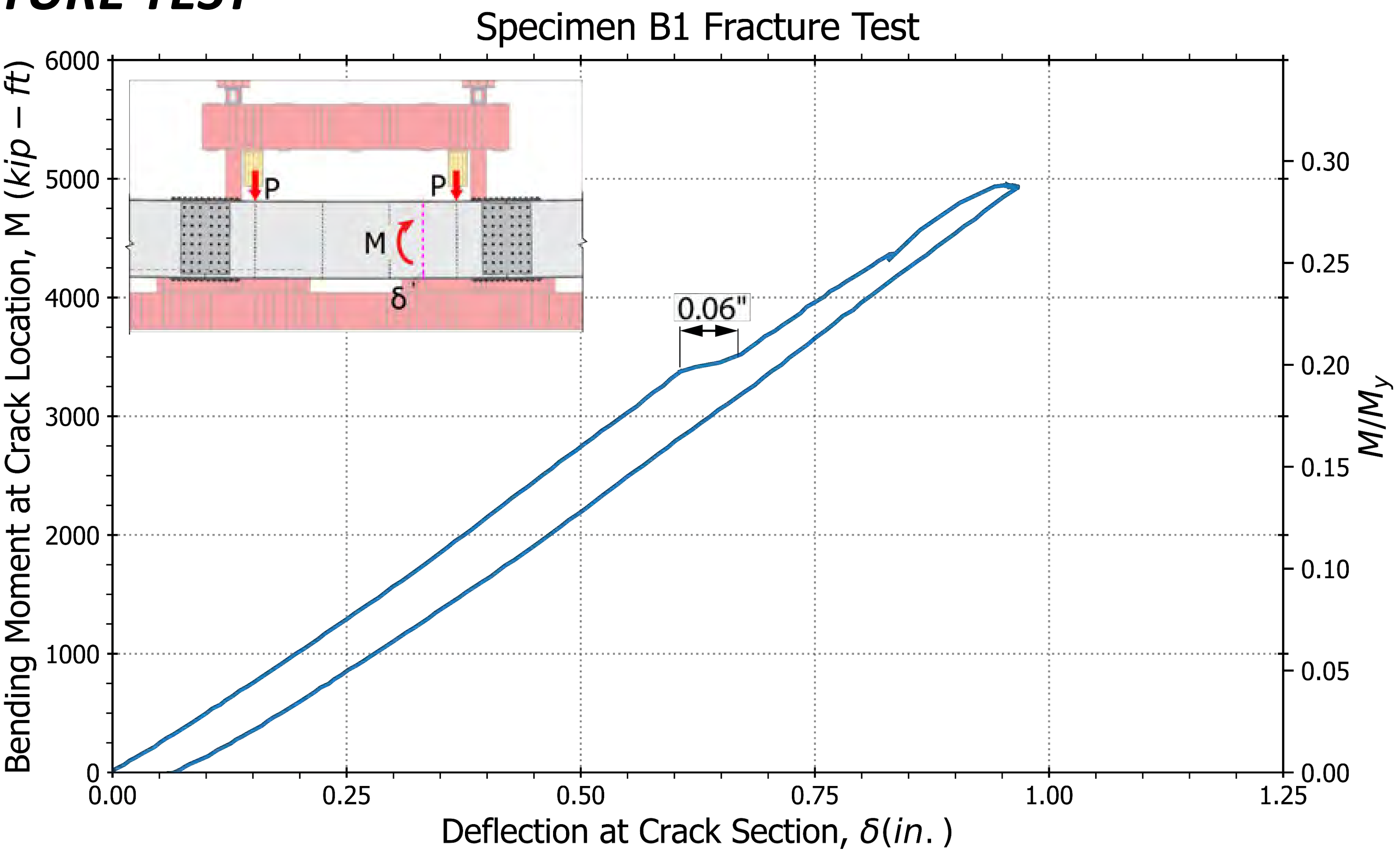
A. FRACTURE TEST

1. NOTCH SPECIMEN
2. FATIGUE LOADING
3. COOL USING LN2
4. LOAD TO FRACTURE

Fracture Loading using 3,000 psi HPU

SPECIMEN B1 TESTING

A. FRACTURE TEST



SPECIMEN B1 TESTING

B. POST-FRACTURE TEST

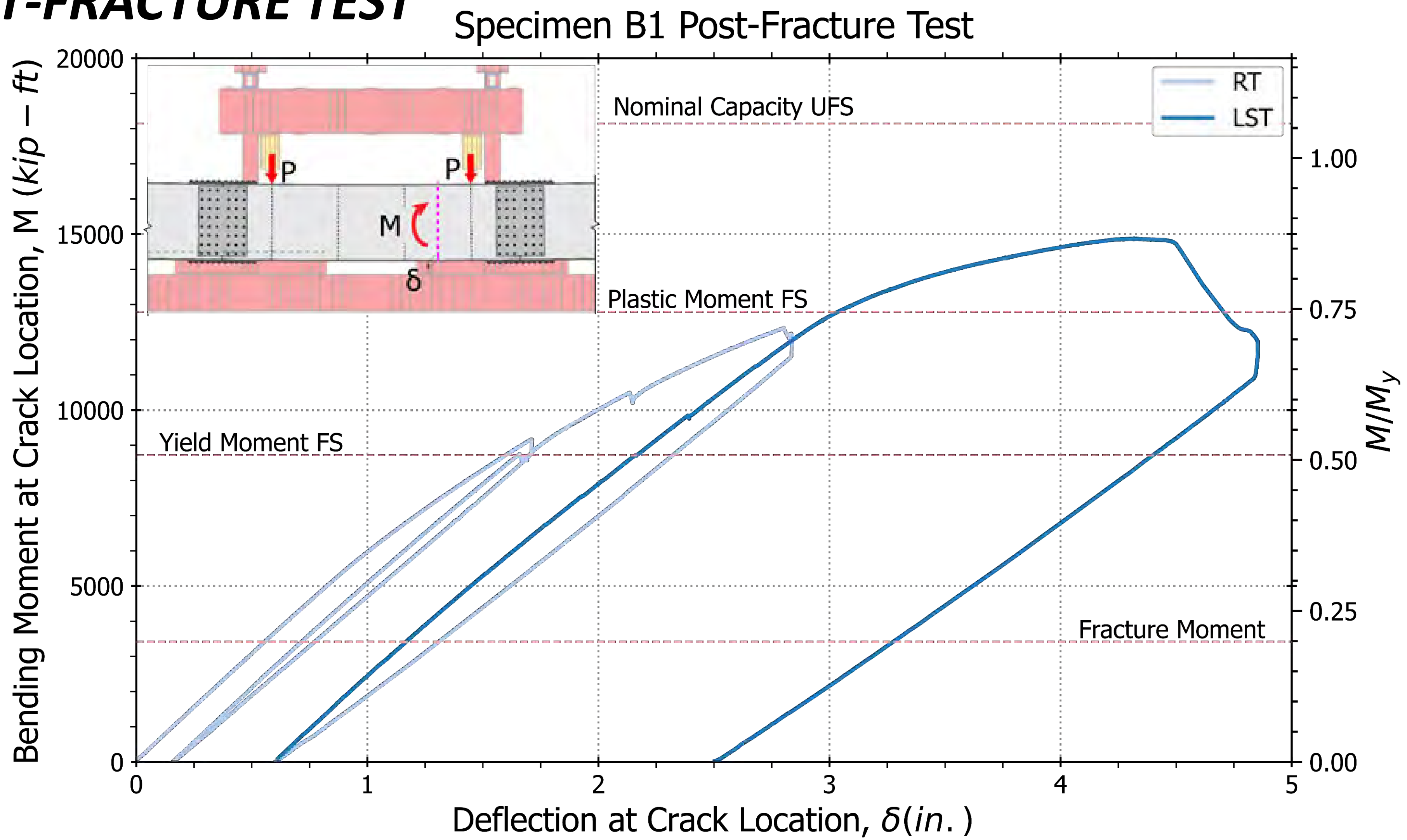
Objective: assess specimen capacity with a fractured component

1. AT ROOM TEMPERATURE
2. AT LOWER-SHELF TEMPERATURE

Post-Fracture Loading using 10,000 psi pneumatic pump

SPECIMEN B1 TESTING

B. POST-FRACTURE TEST



FUTURE WORK – SPECIMEN A TEST

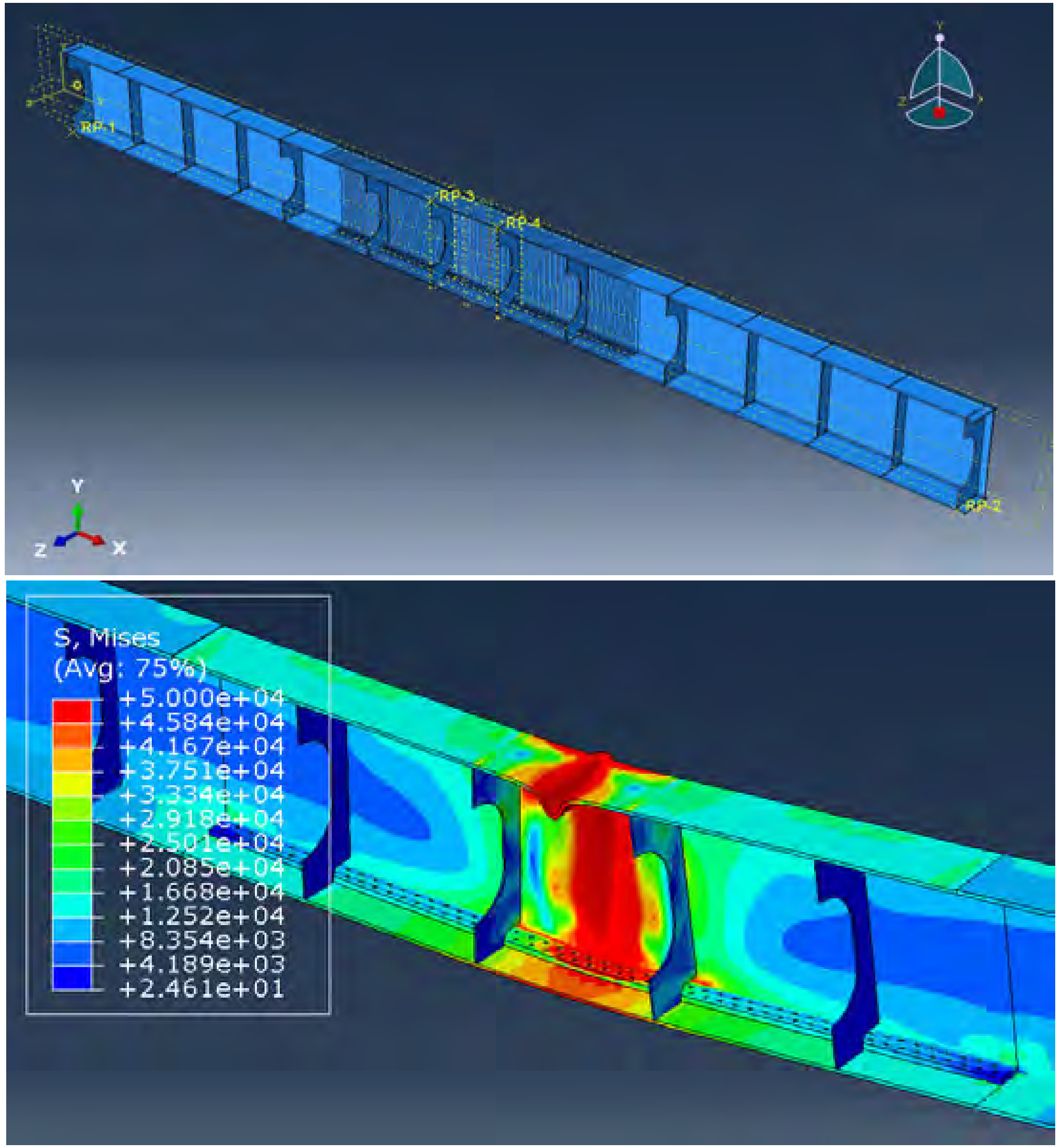
Assembly of Specimen A to be tested with addition of high-strength bars

FUTURE WORK – SPECIMEN B2 TEST

Specimen B2

PARAMETRIC STUDIES

- Validate FE models using experimental test results
- Model fracture propagation (XFEM) for different notch sizes, locations, and load configurations
- Determine post-fracture capacity of different design concepts for worst conditions
  - Determine controlling design parameters



FE Models developed by Chen Liang

QUESTIONS?

Texas Department of Transportation

FERGUSON
STRUCTURAL ENGINEERING
LABORATORY

THE UNIVERSITY OF TEXAS AT AUSTIN
PRAESIDIUM
DISCIPLINA CIVITATIS

THANK YOU!

Texas Department of Transportation

FERGUSON STRUCTURAL ENGINEERING LABORATORY

THE UNIVERSITY OF TEXAS AT AUSTIN
PRAESIDIUM
DISCIPLINA CIVITATIS