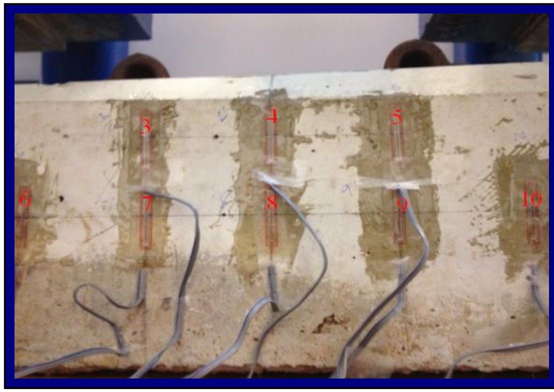
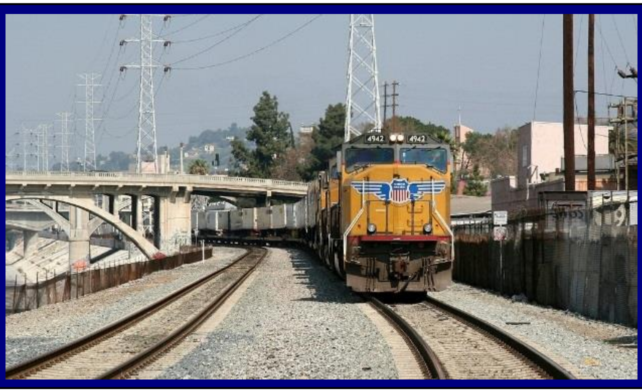
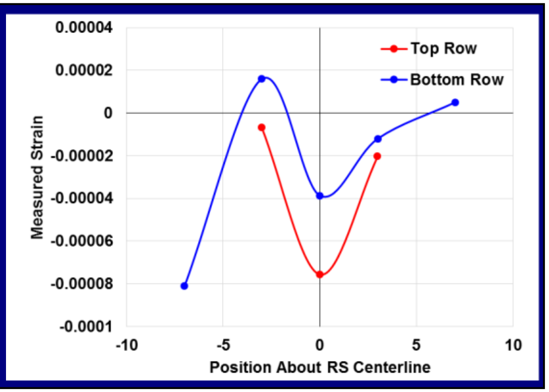
Compressive Fields in Prestressed Concrete Monoblock Crosstie Rail Seats







Joint Rail Conference

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Henry E. Wolf, Marcus S. Dersch, J. Riley Edwards, and Yu Qian

RAILTEC
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Outline

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  - Compressive Field
  - UIC 713R
  - Design Implications
- Experimentation
  - Experimentation Plan
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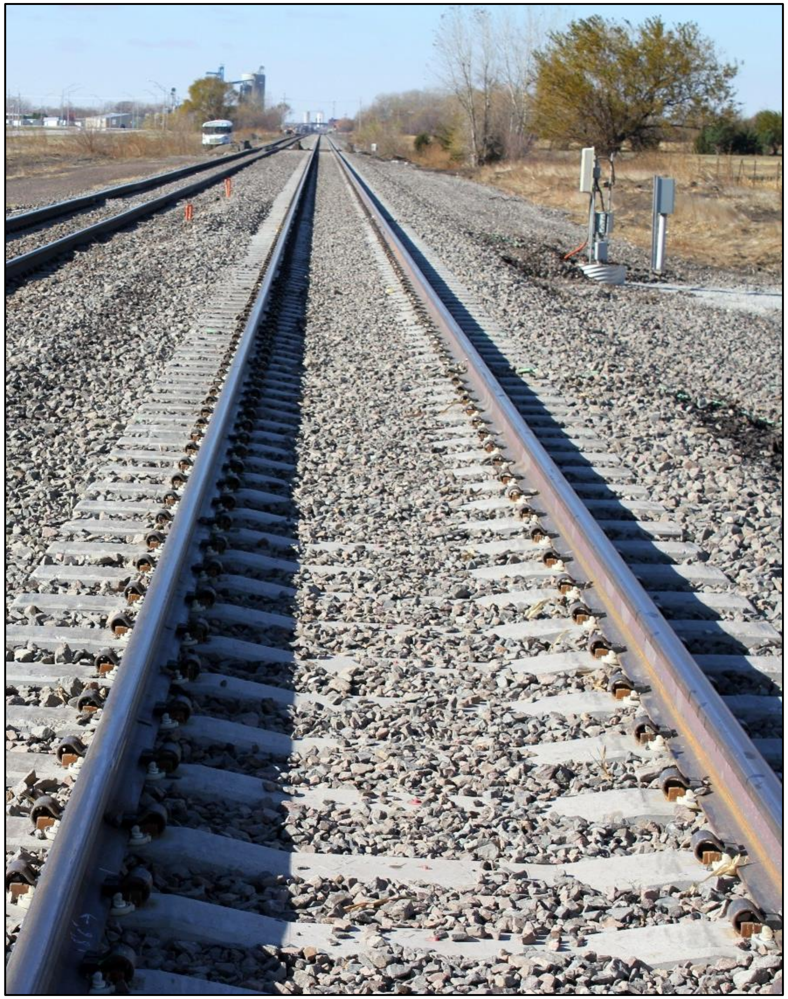
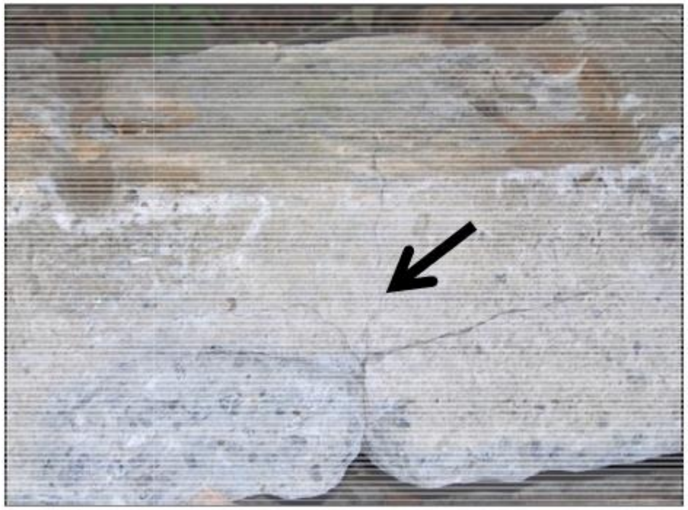
  - Results
- Preliminary Conclusions
- Future Work
- Questions/Comments



Motivation for Research

- Industry partners have stated on numerous occasions that rail seat positive cracks are not an issue in field, two possible reasons:
  - – Crosstie is overdesigned at rail seat (design is over-conservative)
  - – Load is being transferred differently than expected in analysis (analysis is over-conservative)



Motivation for Research (cont.)

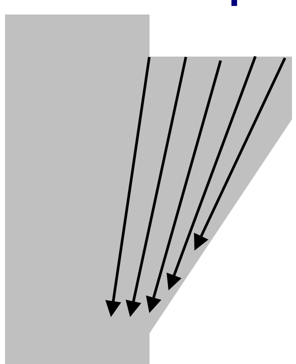
- Russell Lutch's thesis stated "deep beam behavior likely exists in the rail seat region"
- Talks with UIUC concrete structures experts have steered away from true deep beam behavior, but have supported the possibility of compressive field development in the rail seat region
- Proving this compressive field behavior could lead to smaller, cheaper, and more efficient crosstie designs

Current

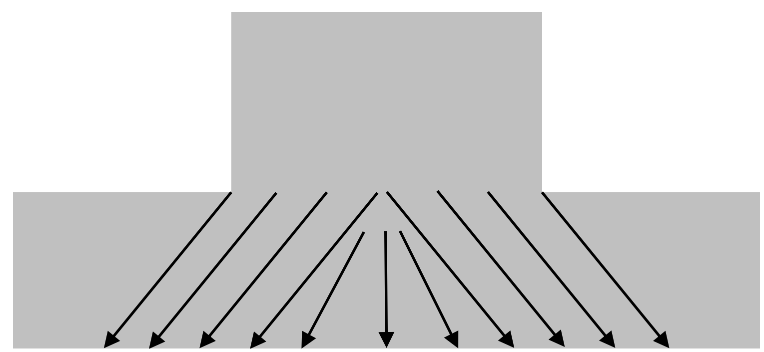
Future?

Introduction to Compressive Fields

- A compressive field is a region of a loaded material where the material is only in compression
- This type of behavior is well-documented and expected in many branches of engineering
  - As load flows through a structural system the load spreads, following the geometry
- For concrete, this behavior is seen in the design of corbels and spread footings



Corbel



Spread Footing

Comparison of International Standards Assumptions

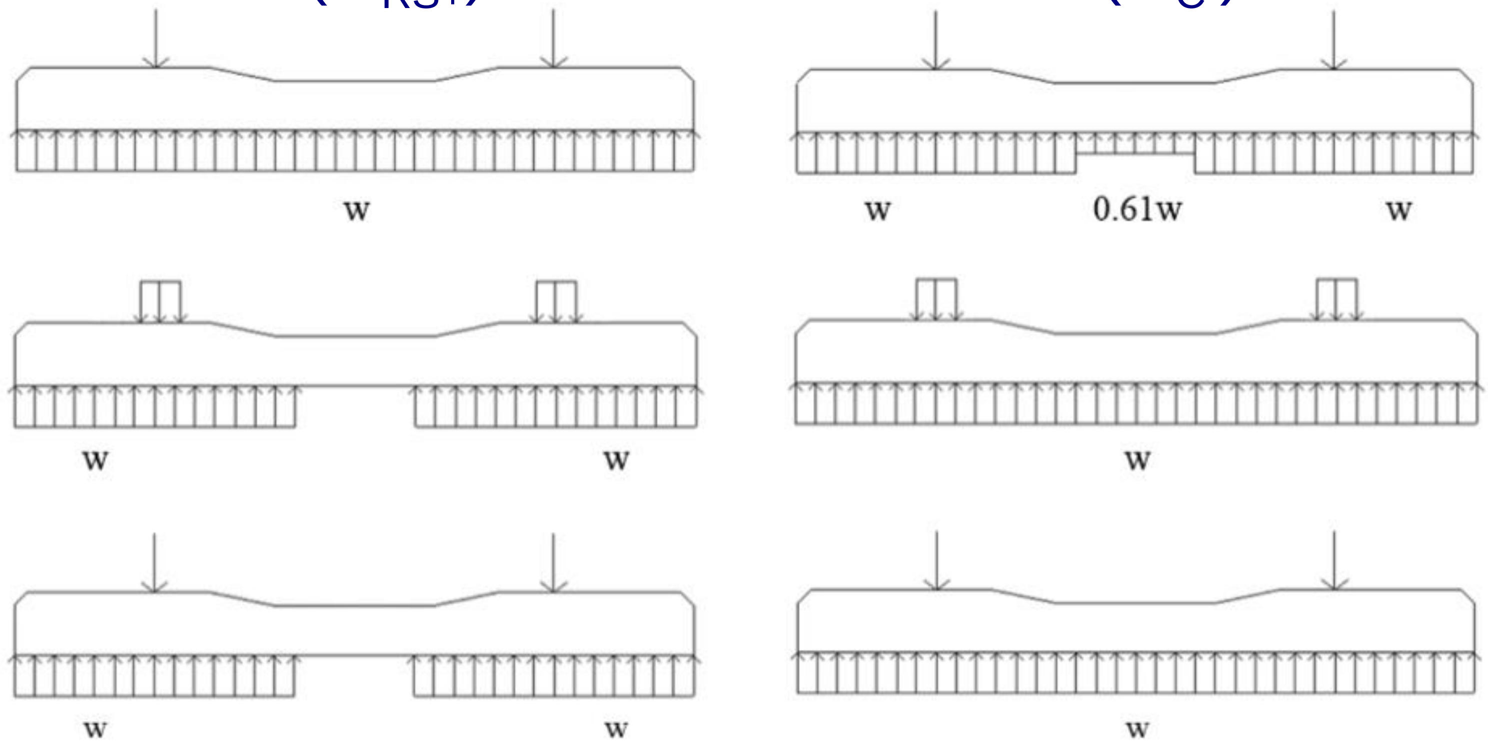
Rail Seat Positive (M_{RS+})

Center Negative (M_{C-})

AREMA*
American Railway Engineering and Maintenance-of-Way Association

UIC
INTERNATIONAL UNION OF RAILWAYS

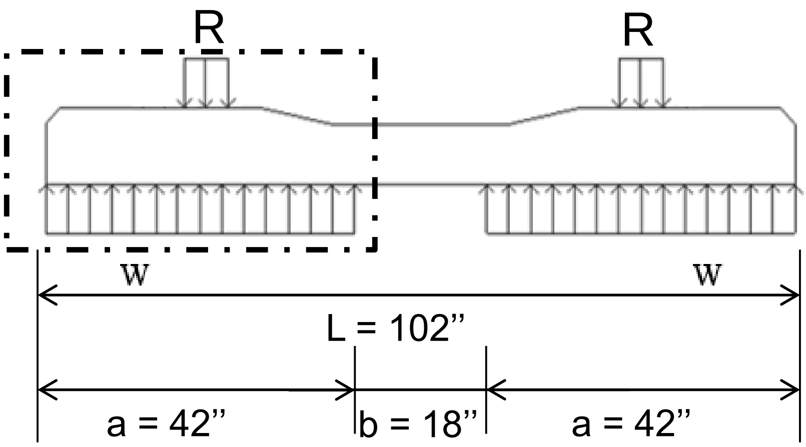
STANDARDS Australia



* *Backcalculated from McQueen*

UIC 713R Assumption

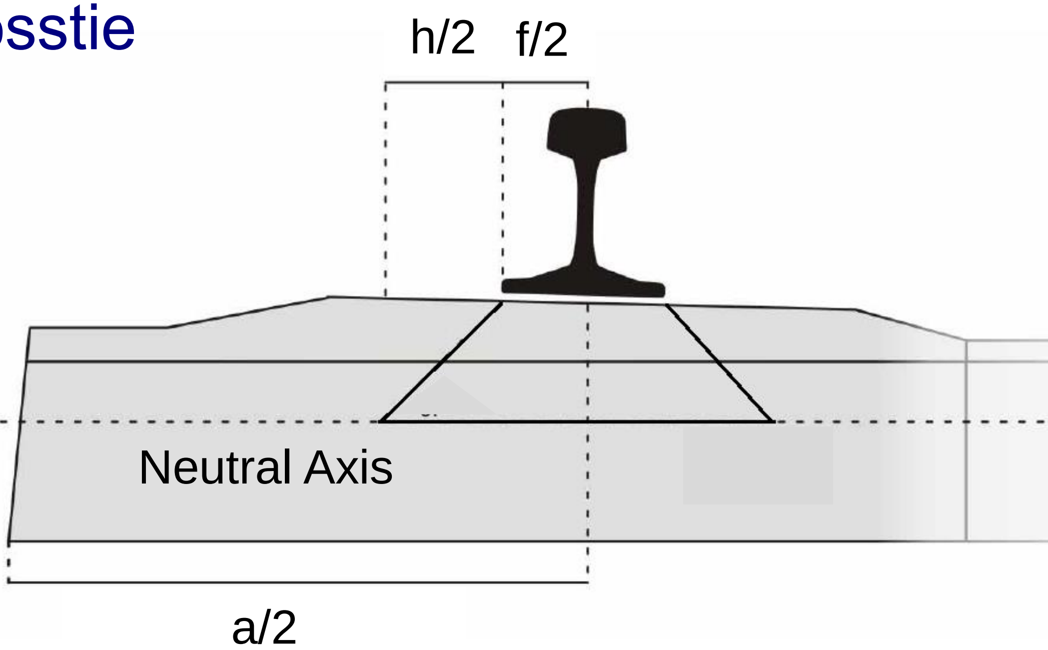
- **UIC 713R Rail Seat Positive Bending Moment (M_{RS+}) Calculation**
- Assumes compressive field acting at 45-degree angle from end of rail seat to neutral axis
- For 8'-6" long, 9" deep crosstie with 6" rail base,



$$M_{RS+} = \frac{R}{4}\left(\frac{a}{2} - \frac{f}{2} - \frac{h}{2}\right)$$

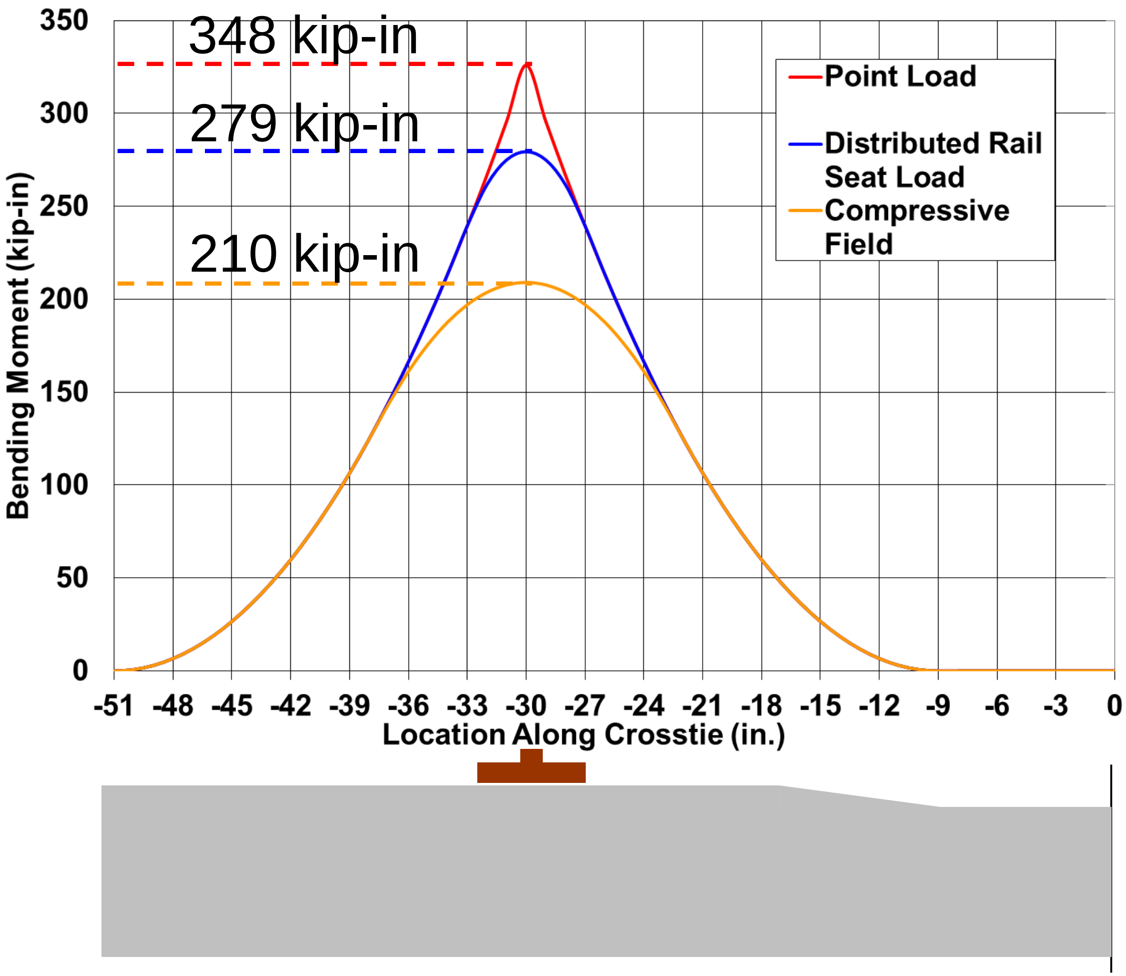
$$= \frac{62.1\ kip}{4}\left(\frac{42''}{2} - \frac{6''}{2} - \frac{9''}{2}\right)$$

= 210 kip-in



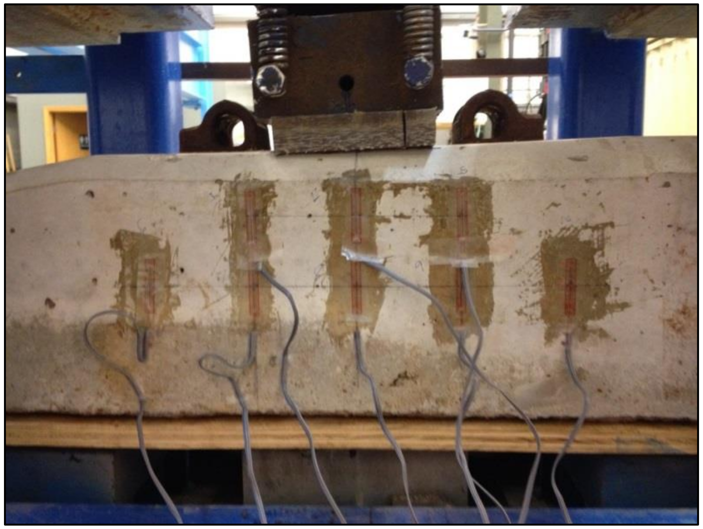
Design Implications of Compressive Field

- Rail seat loading area makes a significant difference on bending moment analysis at that region

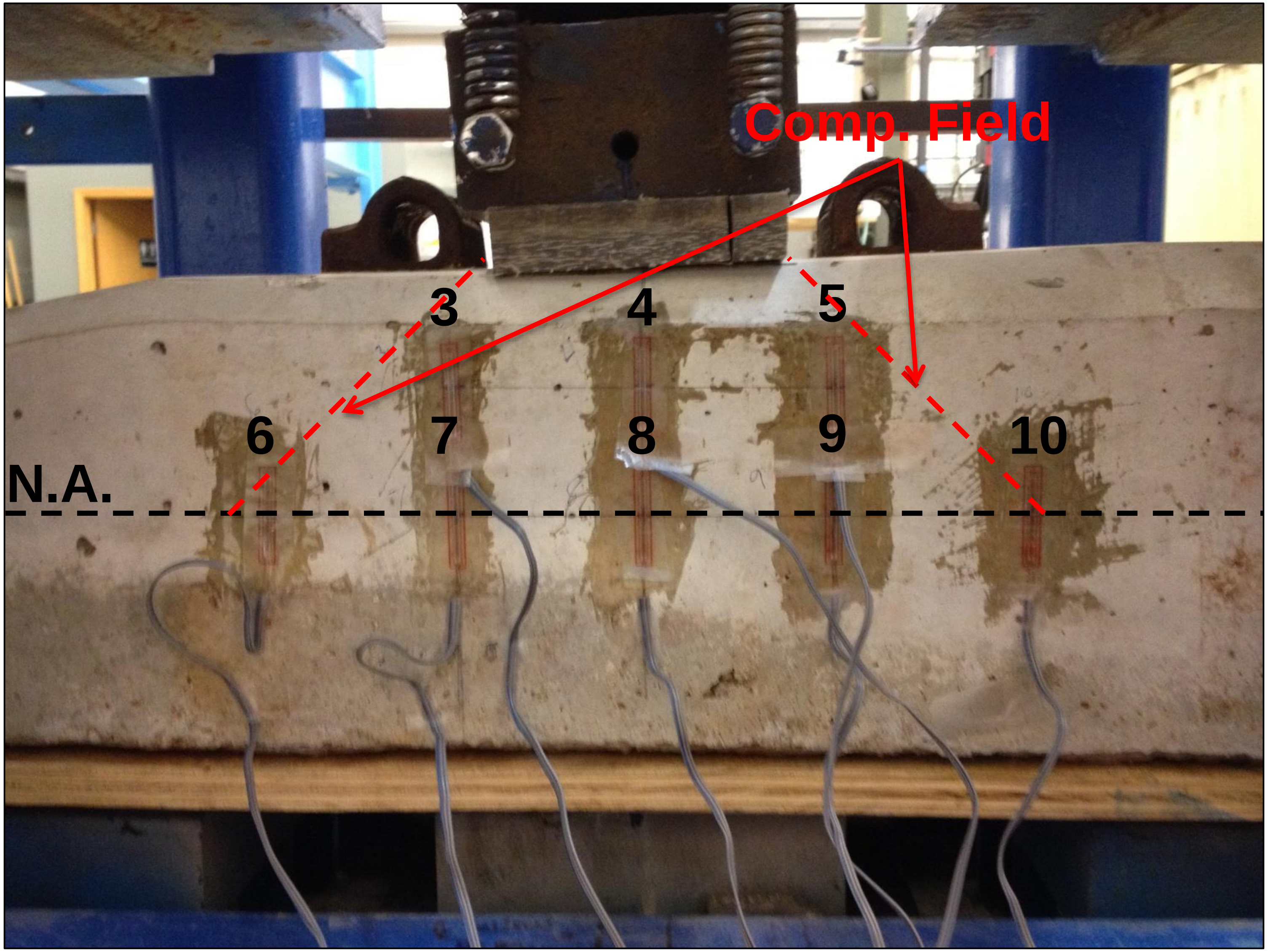


Experimental Plan

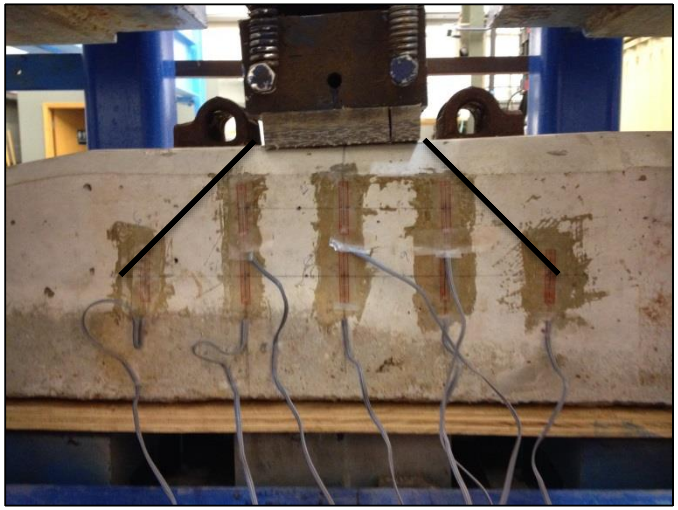
- **Use vertically-oriented surface strain gauges to record compressive strains experienced by crosstie**
  - Measure three points along rail seat section
  - Measure five points along neutral axis of crosstie
    - Testing UIC 713R assumption
  - Entire rail seat region (42”) supported by wood
  - Loaded from 0-60 kips (Test 1-2) and 0-80 kips (Test 3-4) over 5” 50A Durometer pad

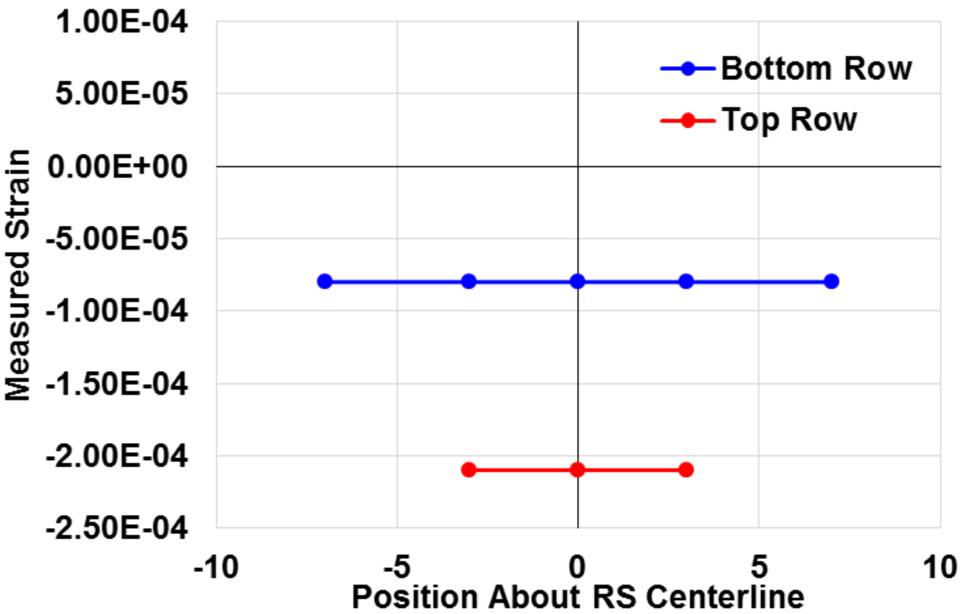


Instrumentation Layout

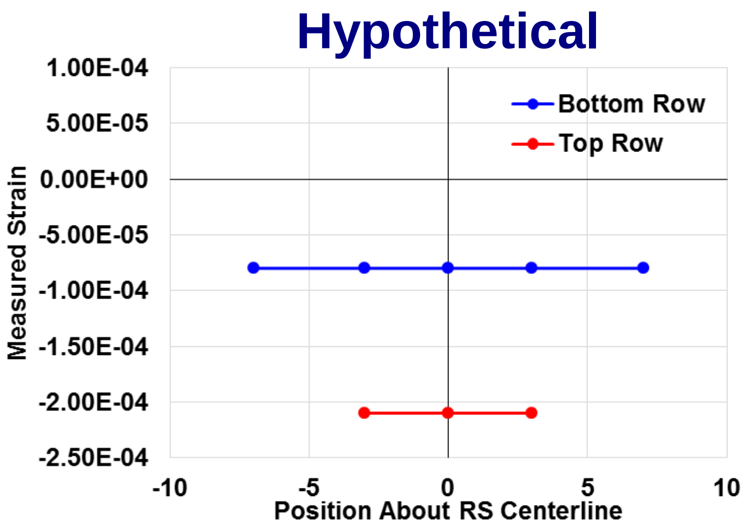


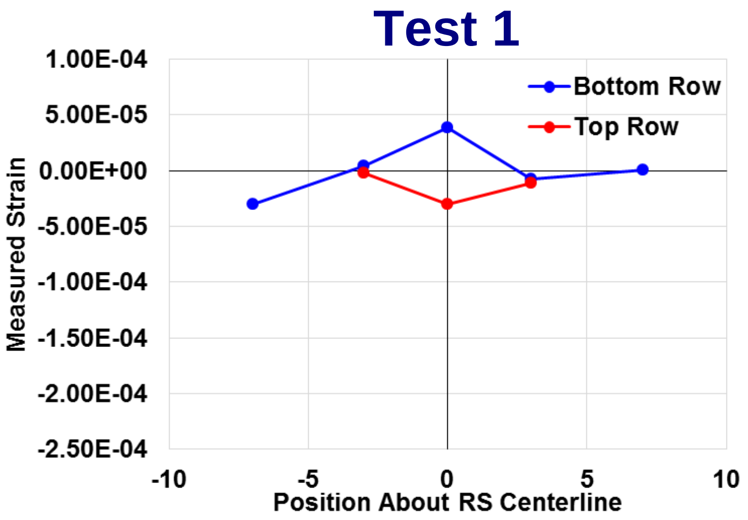
Hypothetical Results

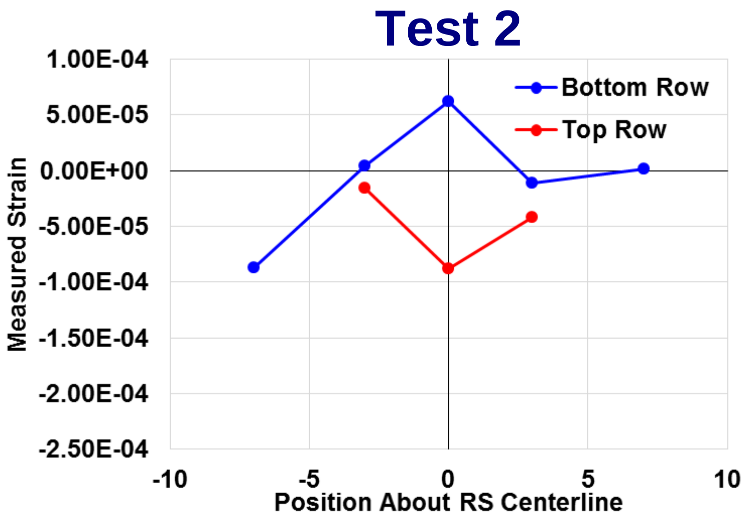




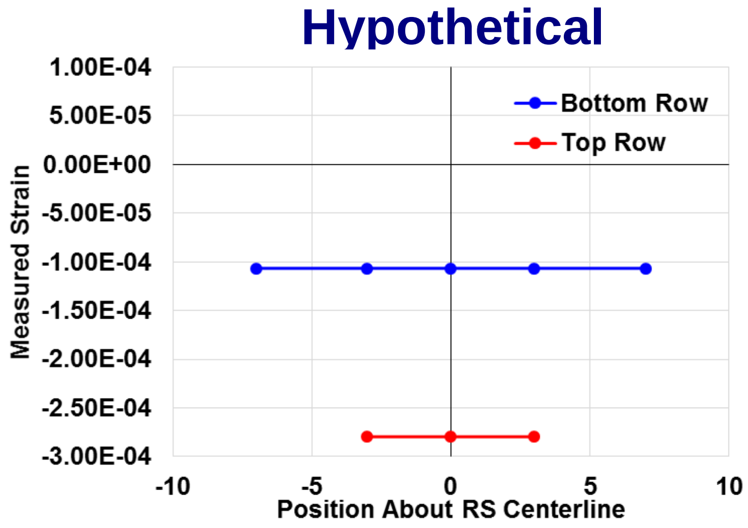
Preliminary Results (0 – 60 kips)

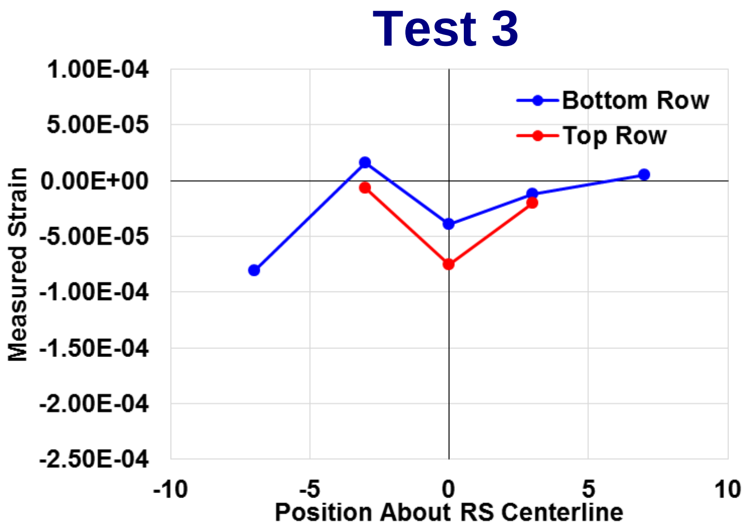


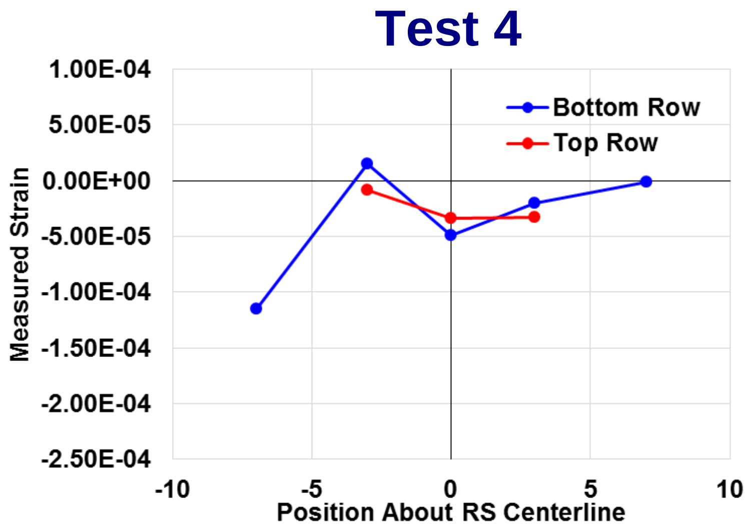




Preliminary Results (0 – 80 kips)





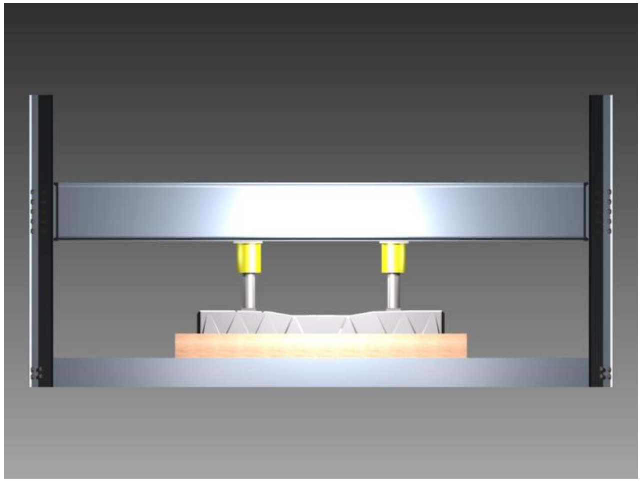


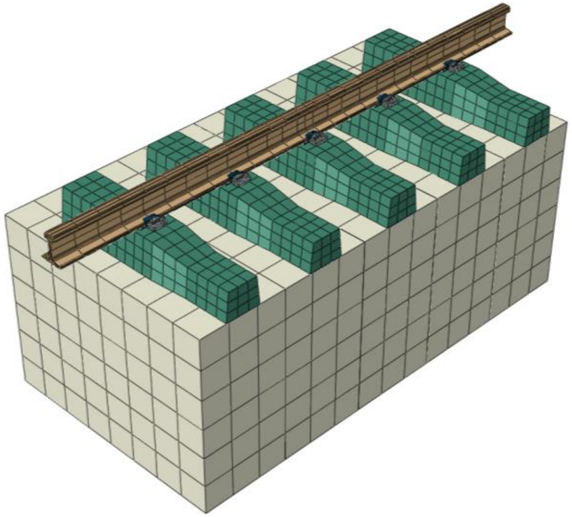
Preliminary Conclusions

- **Preliminary results are inconclusive**
  - Some gauges are experiencing compression, some tension
  - Strain magnitudes are lower than expected
  - Likely due to improper support
    - Steel plates may not be “bridging” gap between supports effectively enough to promote compressive field
    - Wood may be too stiff to promote load spreading
- **Some evidence is shown for compressive field formation**
  - Test 3 (80 kips) shows lower strains at gauges 7 – 9 (bottom row) than gauges 3 – 5 (top row)
  - This could indicate that a certain level of stress is required to initiate compressive field formation
  - However, 80 kip rail seat loads are highly uncommon

Future Work

- **Test with softer support to ensure crosstie bottom is in full contact**
  - Softer support may also initiate more load spreading
- **Test on Static Load Testing Machine (SLTM)**
  - Machine will allow uniform support under rail seat regions
- **Perform finite element analysis and run parametric study varying applied load, loading area, and support conditions**





Acknowledgements

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Amsted RPS
An Amsted Rail Company
GIC
HANSON
LBFoster
CXT Concrete Ties
TTX®

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Questions or Comments?

RAILTEC
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Riley Edwards
Senior Lecturer and Research Scientist
email: jedward2@illinois.edu

Marcus Dersch
Senior Research Engineer
email: mdersch2@illinois.edu

Yu Qian
Research Engineer
email: yuqian1@illinois.edu

Henry Wolf
Graduate Research Assistant
email: wolf24@illinois.edu