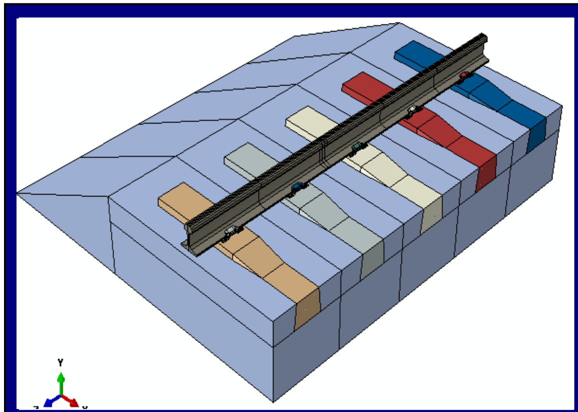
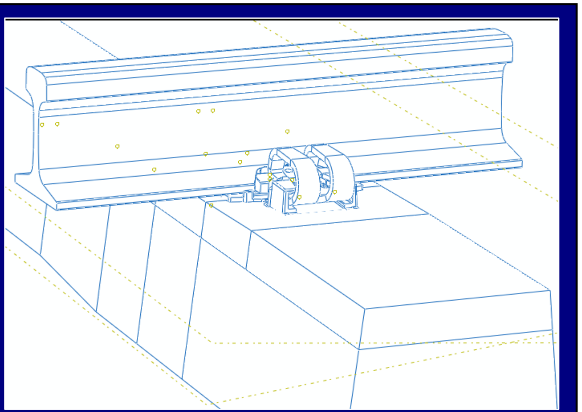
Update on UIUC Crosstie and Fastening System Finite Element Modeling





AREMA Committee 30 Fall 2012 Meeting

Tampa, FL

24-26 October 2012

George Zhe Chen, Moochul Shin, and Professor Bassem O. Andrawes

U.S. Department of Transportation

Federal Railroad Administration

RAILTEC

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Outline

- Role of Modeling in UIUC FRA BAA Concrete Tie and Fastening System
- 2D Tie And Fastening System Modeling
- 3D Tie And Fastening System Modeling
- Conclusions
- Future Work

FRA Tie and Fastener Project Structure

Inputs

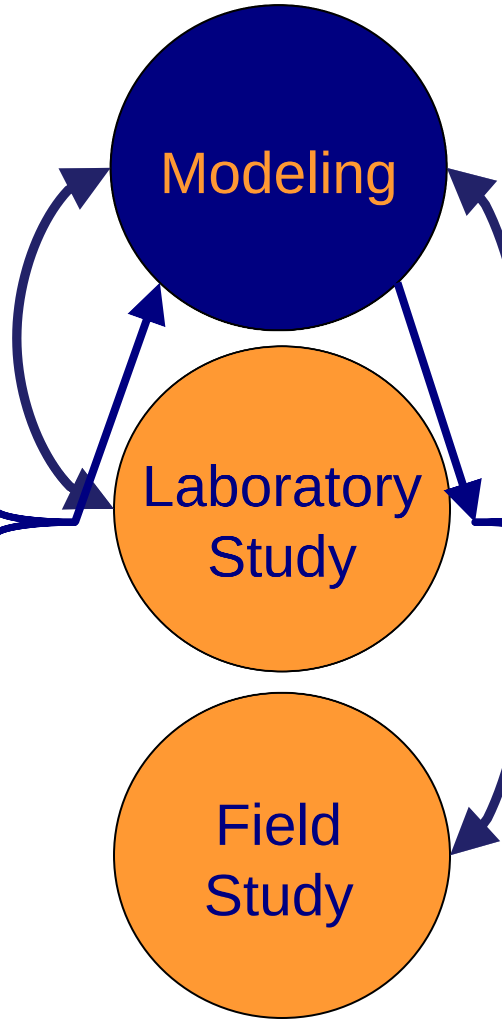
Comprehensive Literature Review

International Tie and Fastening System Survey

Loading Regime (Input) Study

Rail Seat Load Calculation Methodologies

Involvement of Industry Experts



Outputs/Deliverables

Data Collection

Document Depository

Groundwork for Mechanistic Design

International Survey Report

Load Path Map

Parametric Analysis

State of Practice Report

Validated Tie and Fastening System Model

Improved Recommended Practices

Flexural Strength of Prestressed Ties
AREMA Chapter 30 Section 4.4.1

- **Existing Content:**
  - Charts of unfactored bending moment values and relevant factors
  - Recommendations for specific tie designs e.g. tie pad & changing width of tie
- **Proposed Improvements:**
  - Update design methodology to include other critical parameters (e.g. tie geometry)
  - Determine updated equation about flexural performance requirement
- **Methodology:**
  - Validation of models based on lab and field experimental data
  - Parametric study based on validated model
- **Timeline:**
  - Present model updates to Subcommittee 4 (C-30 Spring 2013)
  - Submit ballot proposal to Subcommittee 4 (C-30 Fall 2013)

Flexural Strength of Prestressed Ties

AREMA Chapter 30 Section 4.4.1

4.4.1.2 Factored Design Flexural Values

a. In consideration of the influence of speed and annual tonnage on tie design, the factored capacity may be determined from:

M = B.V.T.

Where:

M = the factored design positive bending moment at the center of the rail seat

B = the bending moment in inch-kips taken from Figure 30-4-3. For a particular tie length and spacing

V = is the speed factor from Figure 30-4-4

T = the tonnage factor obtained from Figure 30-4-4

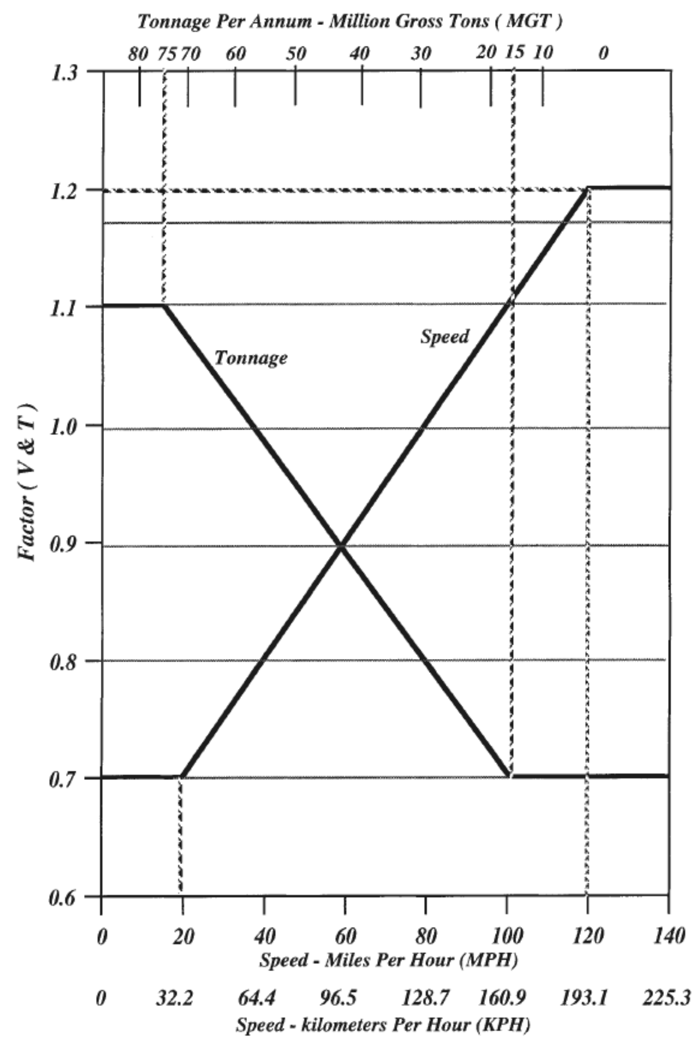
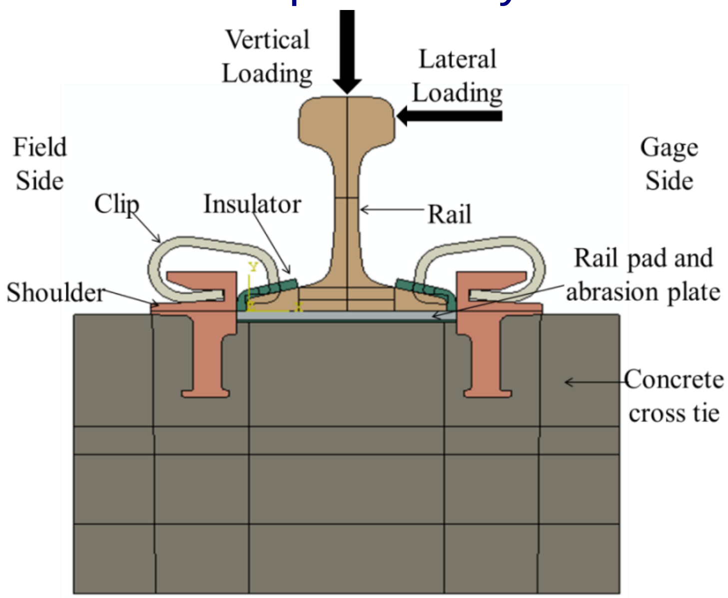
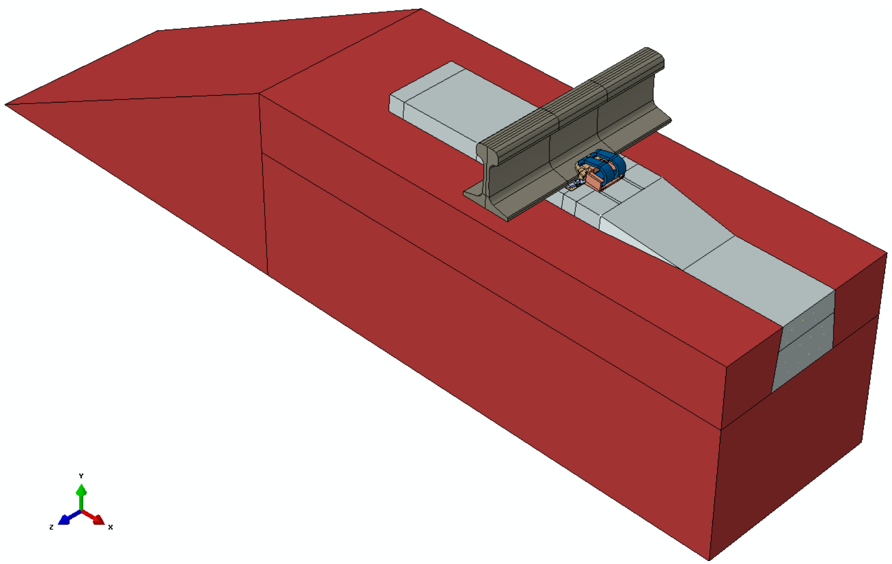


Figure 30-4-4. Tonnage and Speed factors

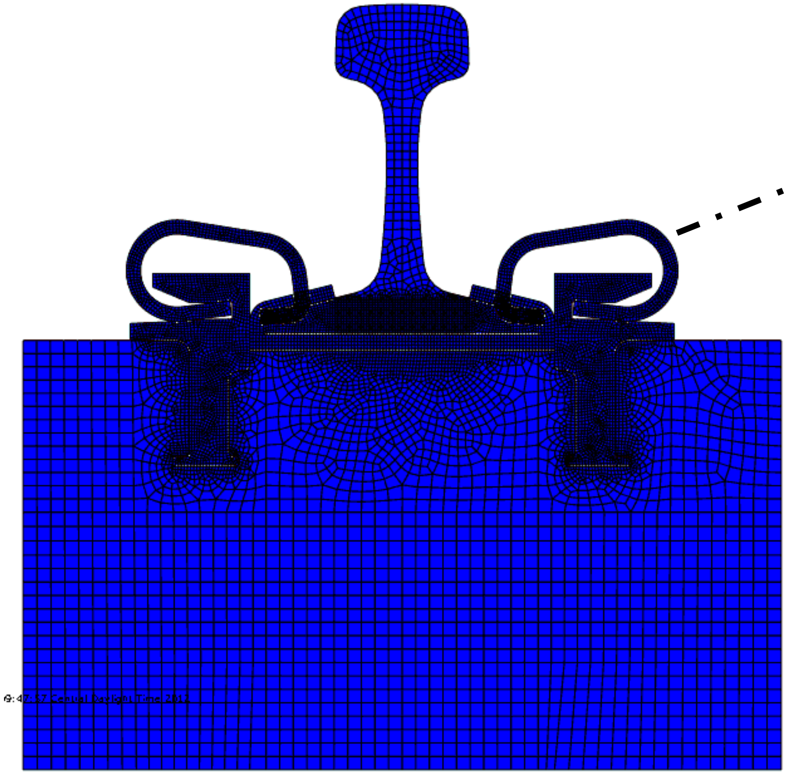
Modeling Group Objective

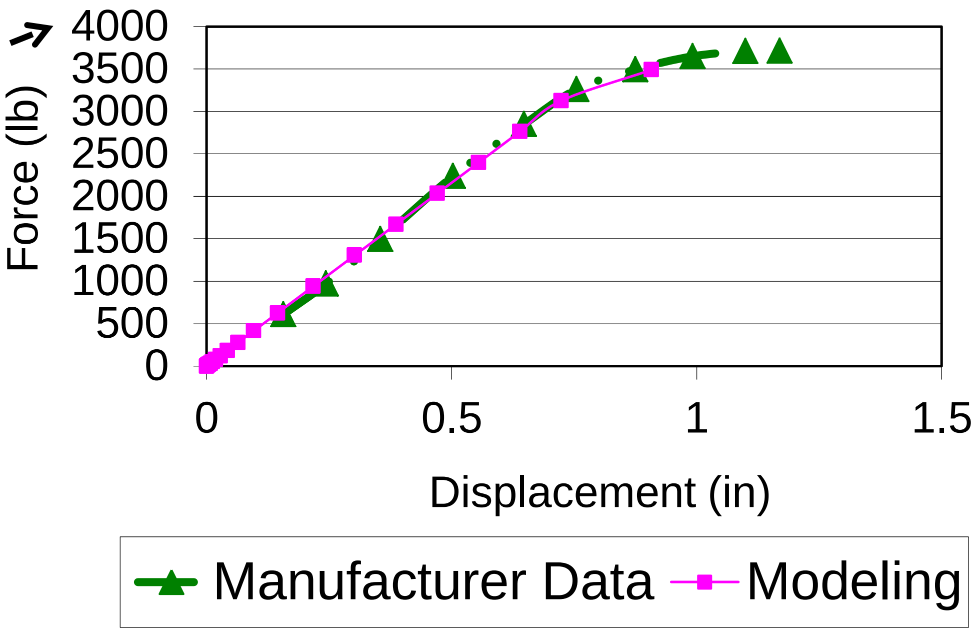
- 2D Modeling
  - Verify modeling techniques
  - Assist instrumentation team by recommending measurement placement and estimating deflection mode
  - Serve preliminary test validation
- 3D Modeling
  - Implement verified techniques
  - Validation of component model and system model performance
  - Conduct parametric study based on validated model



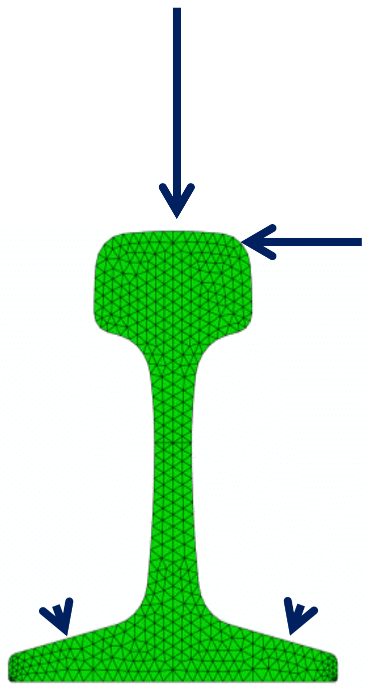


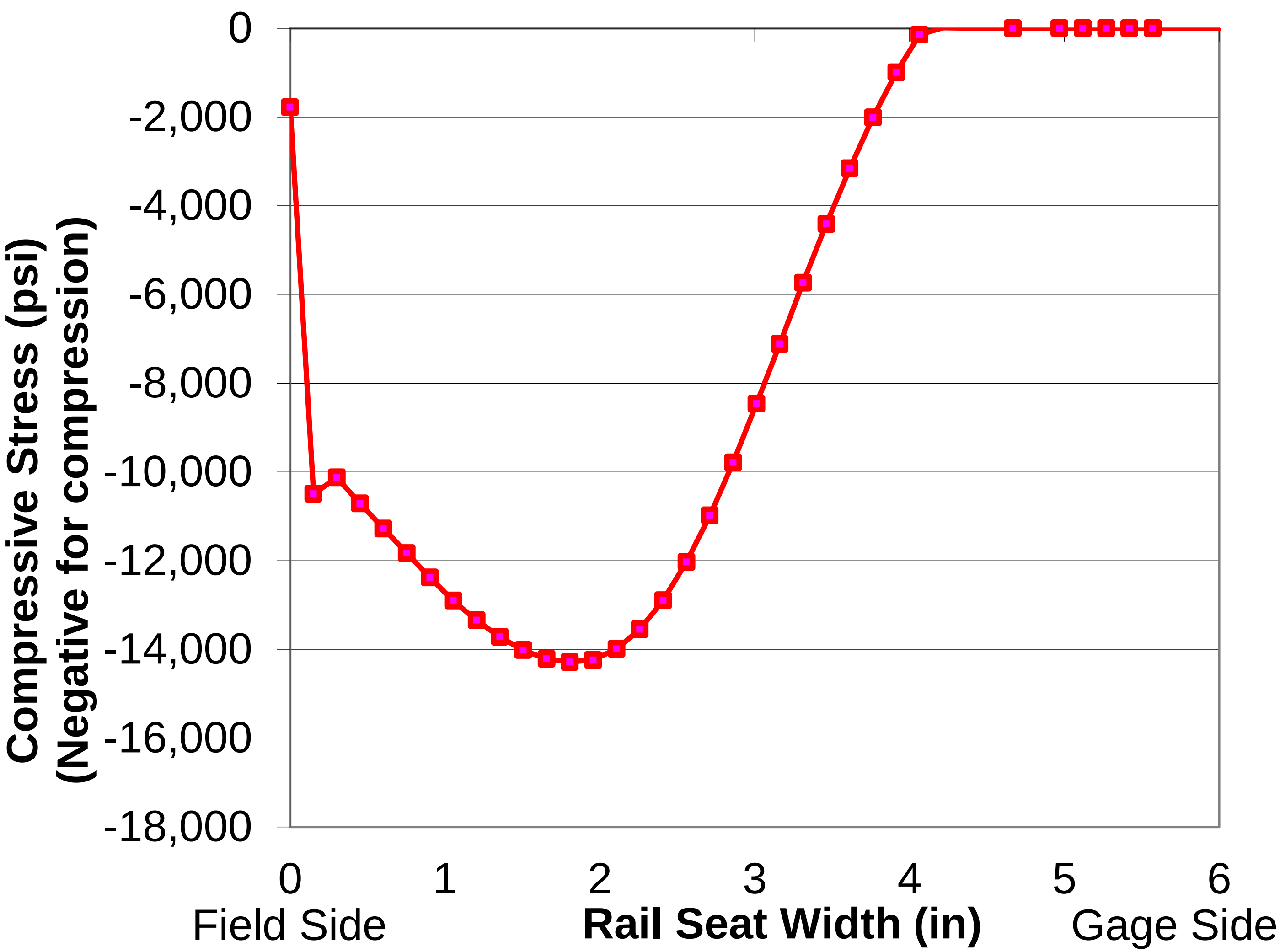
2D Modeling: Concrete Crosstie and Fastening System





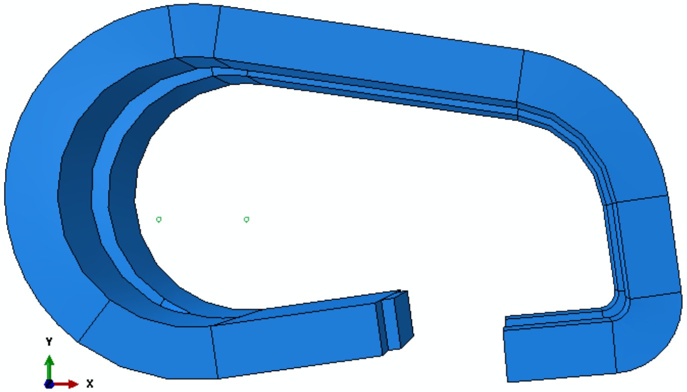
2D Modeling: Stress Distribution

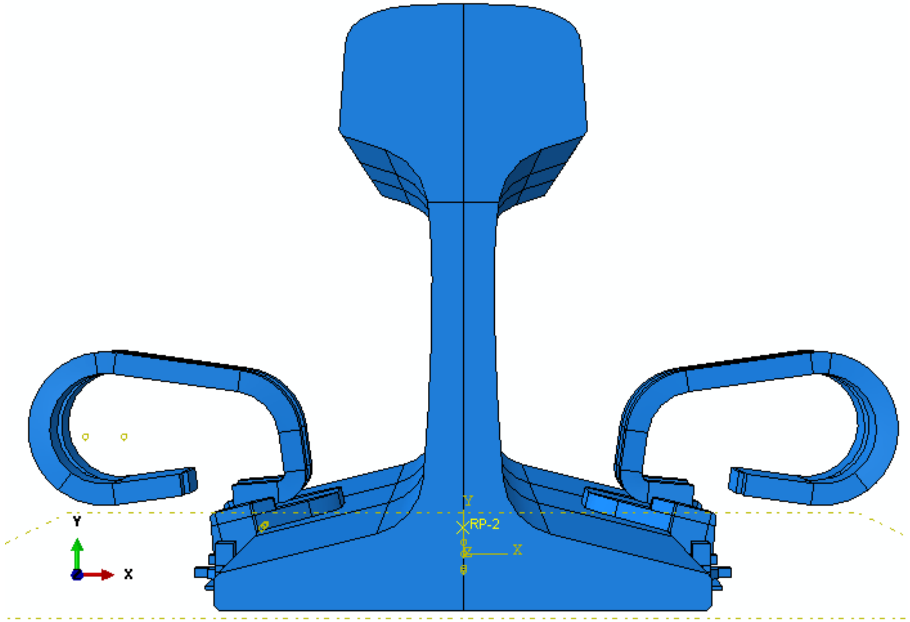




3D Modeling: Comparison Between Component And Assembly Model

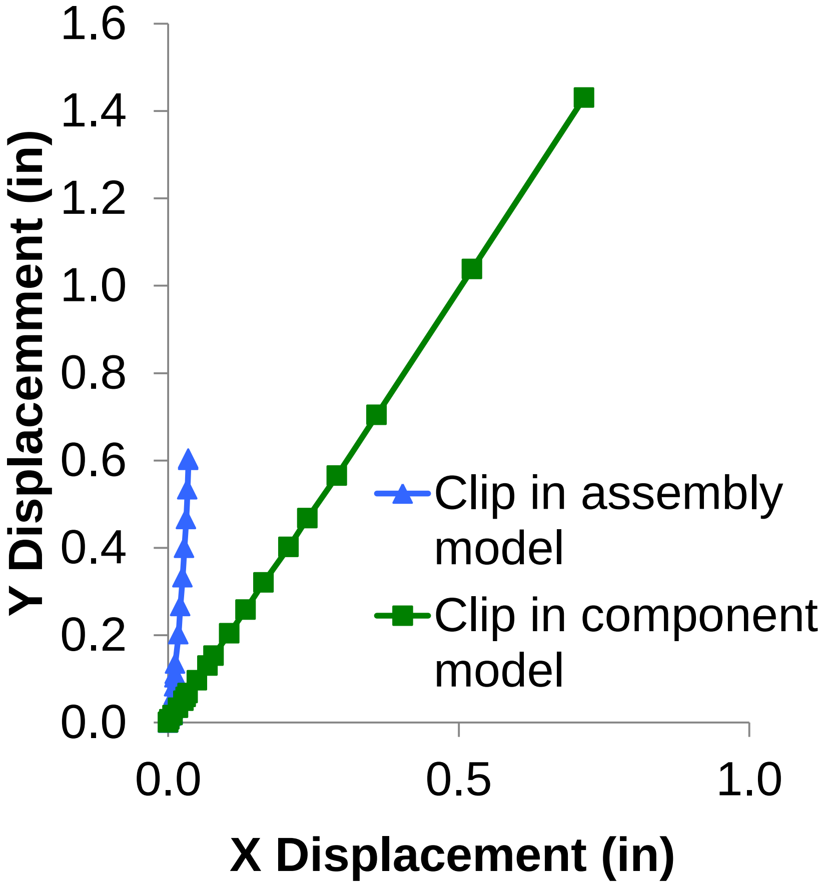
- Clip performance in the component model is compared with clip performance in the assembly model
- A coefficient of friction of 0.5 is assumed for clip-insulator interaction

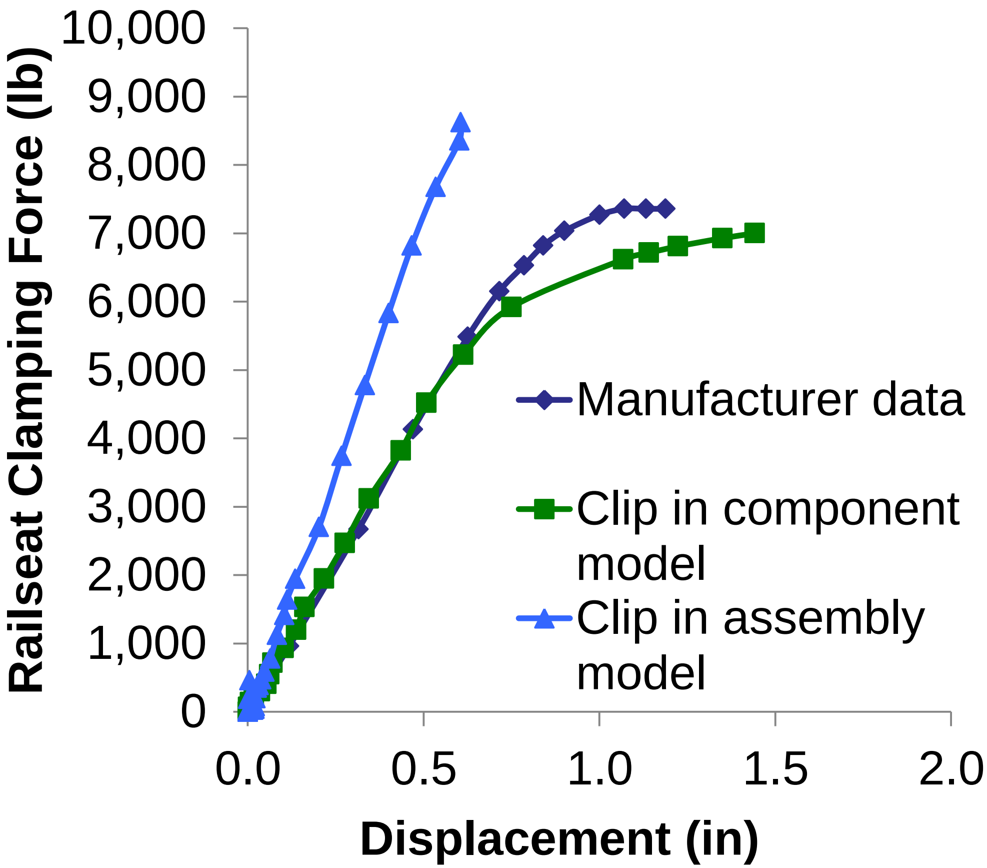




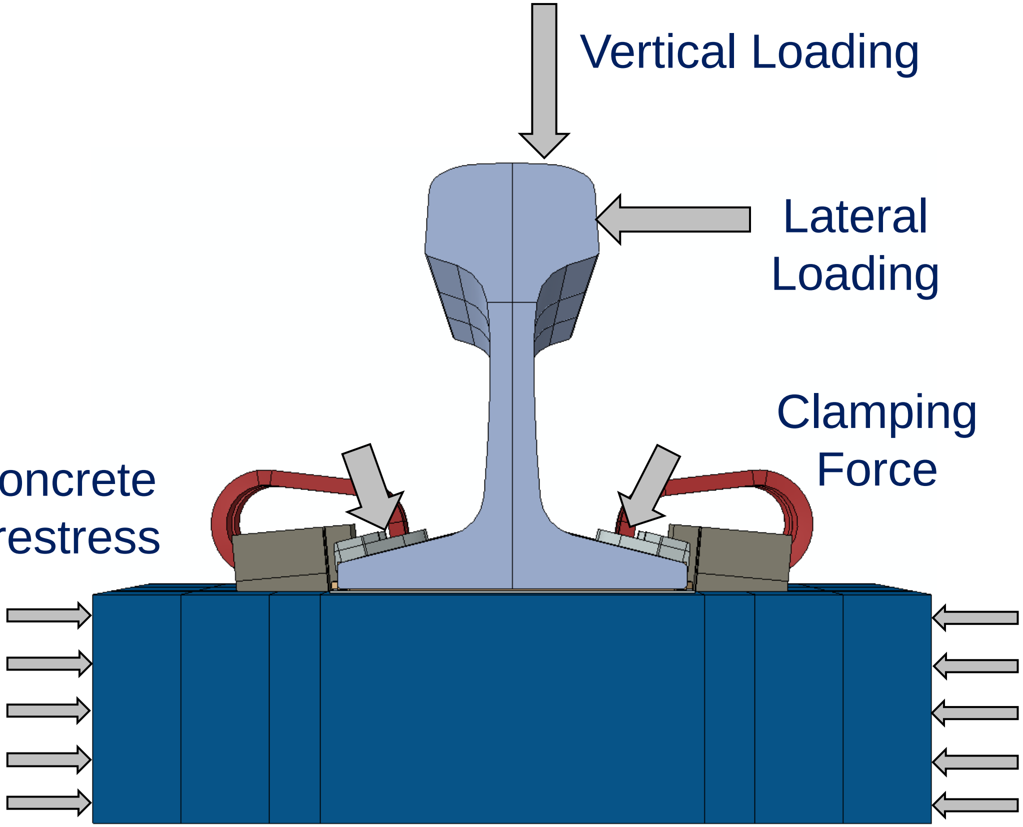
3D Modeling: Comparison Between Component And Assembly Model

- Based on the displacement trace of clip toe, the loading conditions in the models are quite different

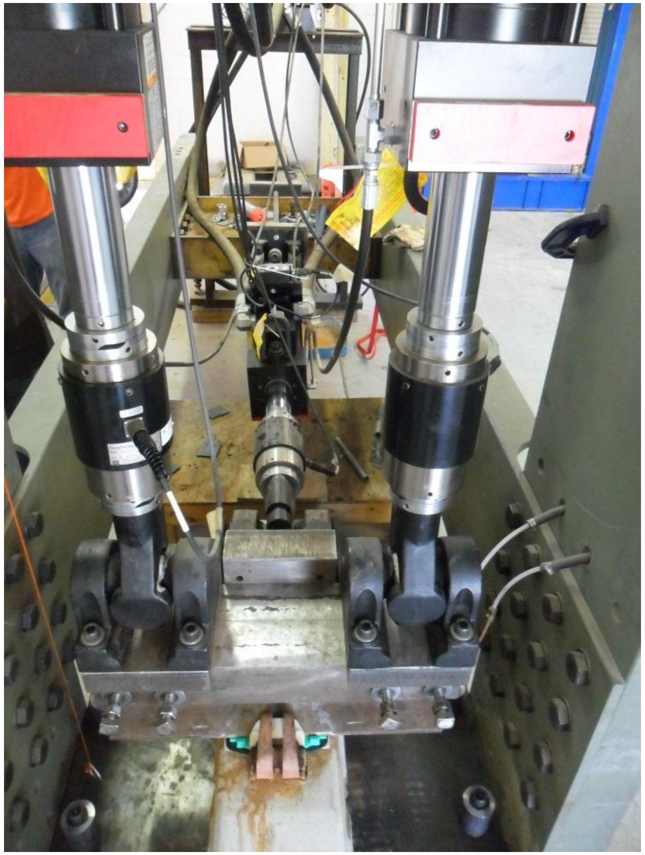




3D Modeling: Concrete And Fastening System Model



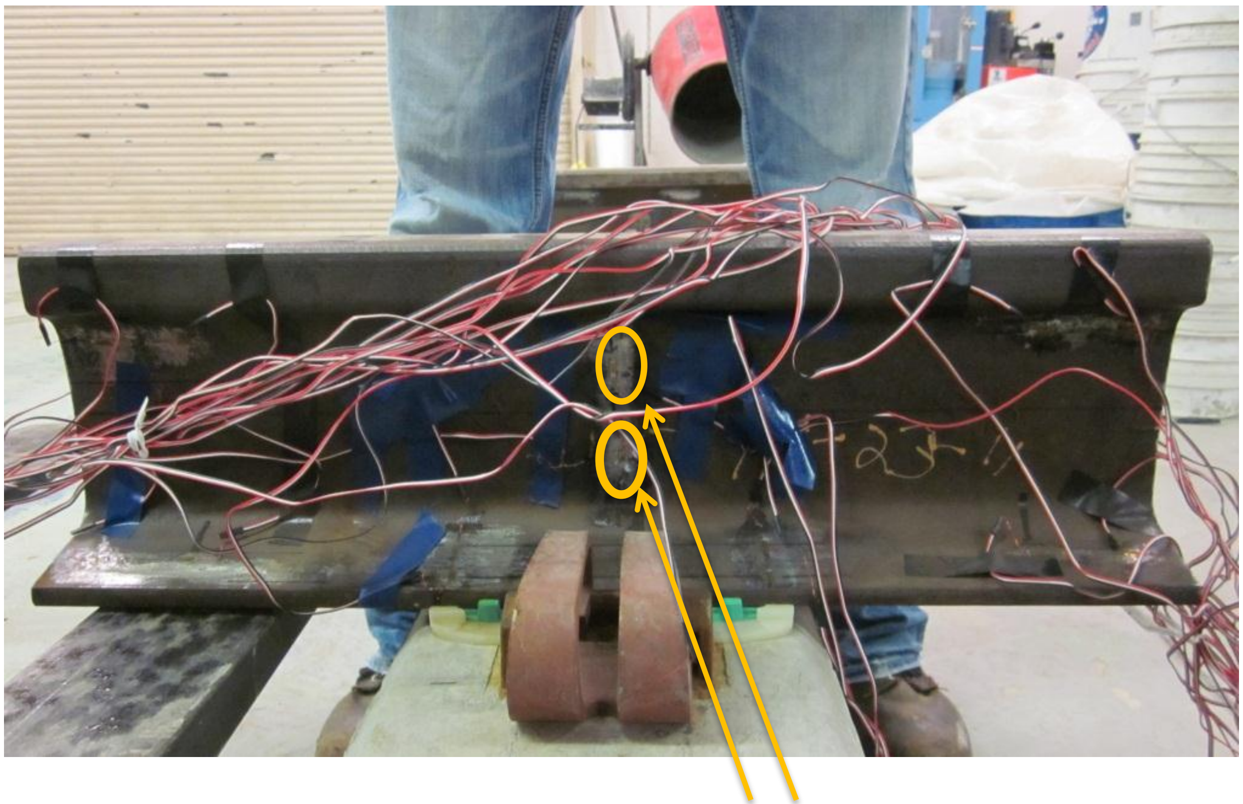
Concrete And Fastening System Model (UIUC Model)

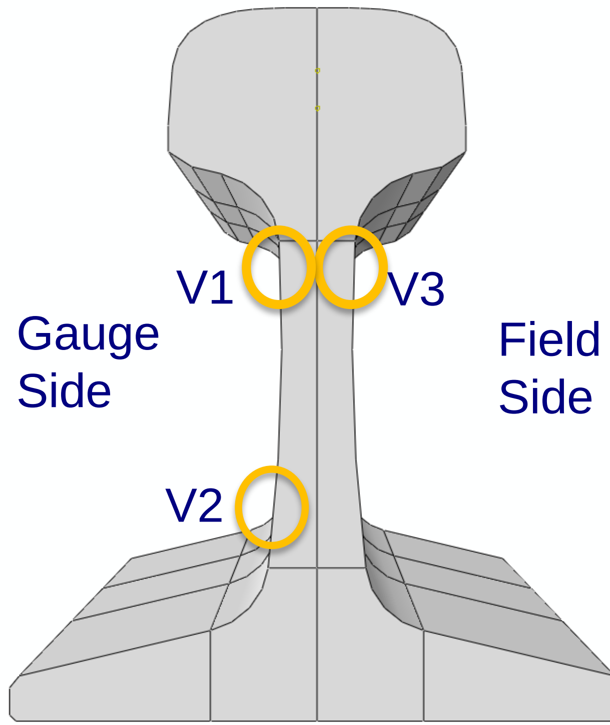


PLTM Test Setup (Pulsating Load Testing Machine)

3D Modeling: Concrete And Fastening System Model

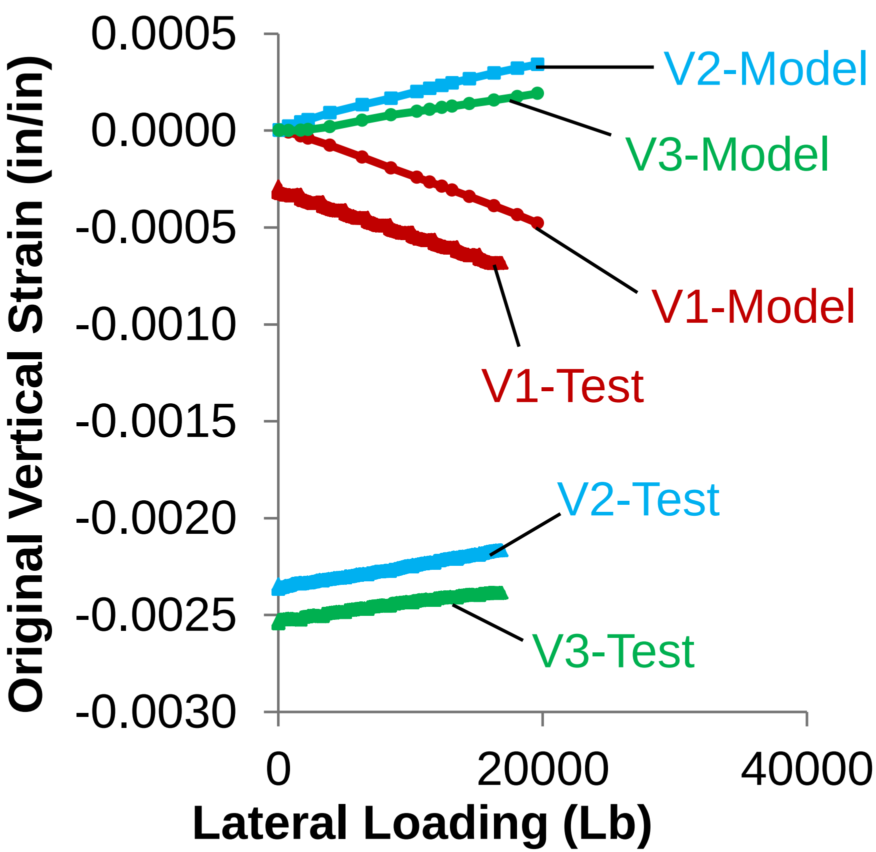
- Position of strain gauges on the rail is as shown

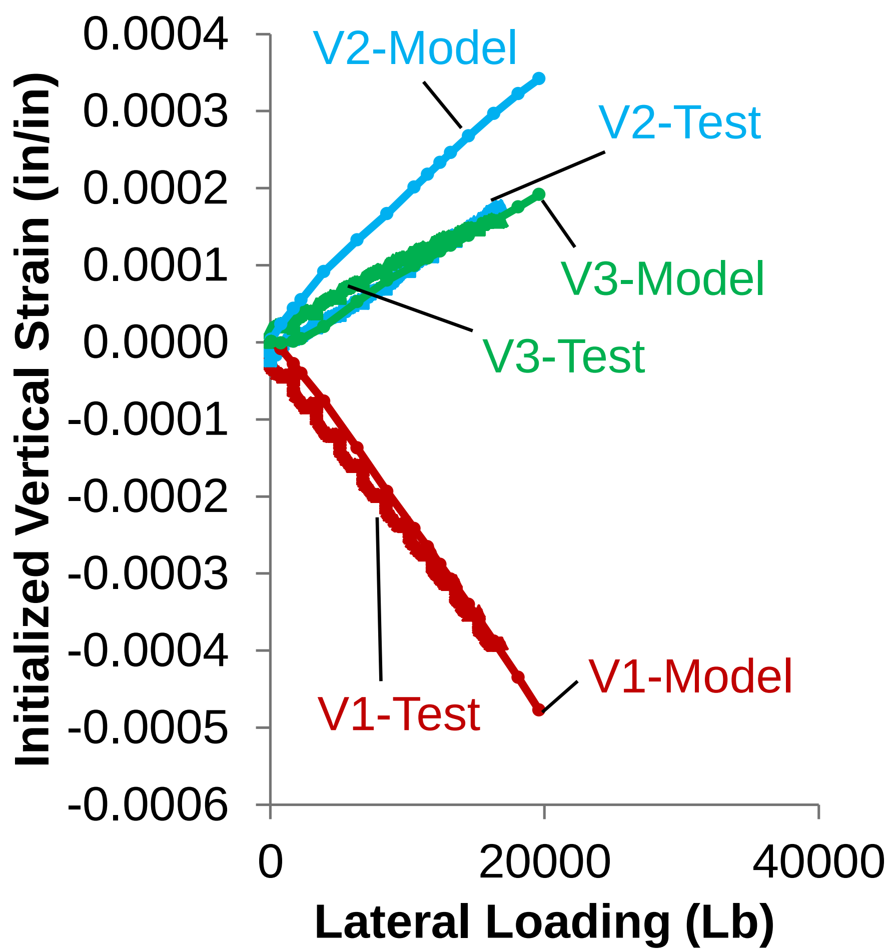




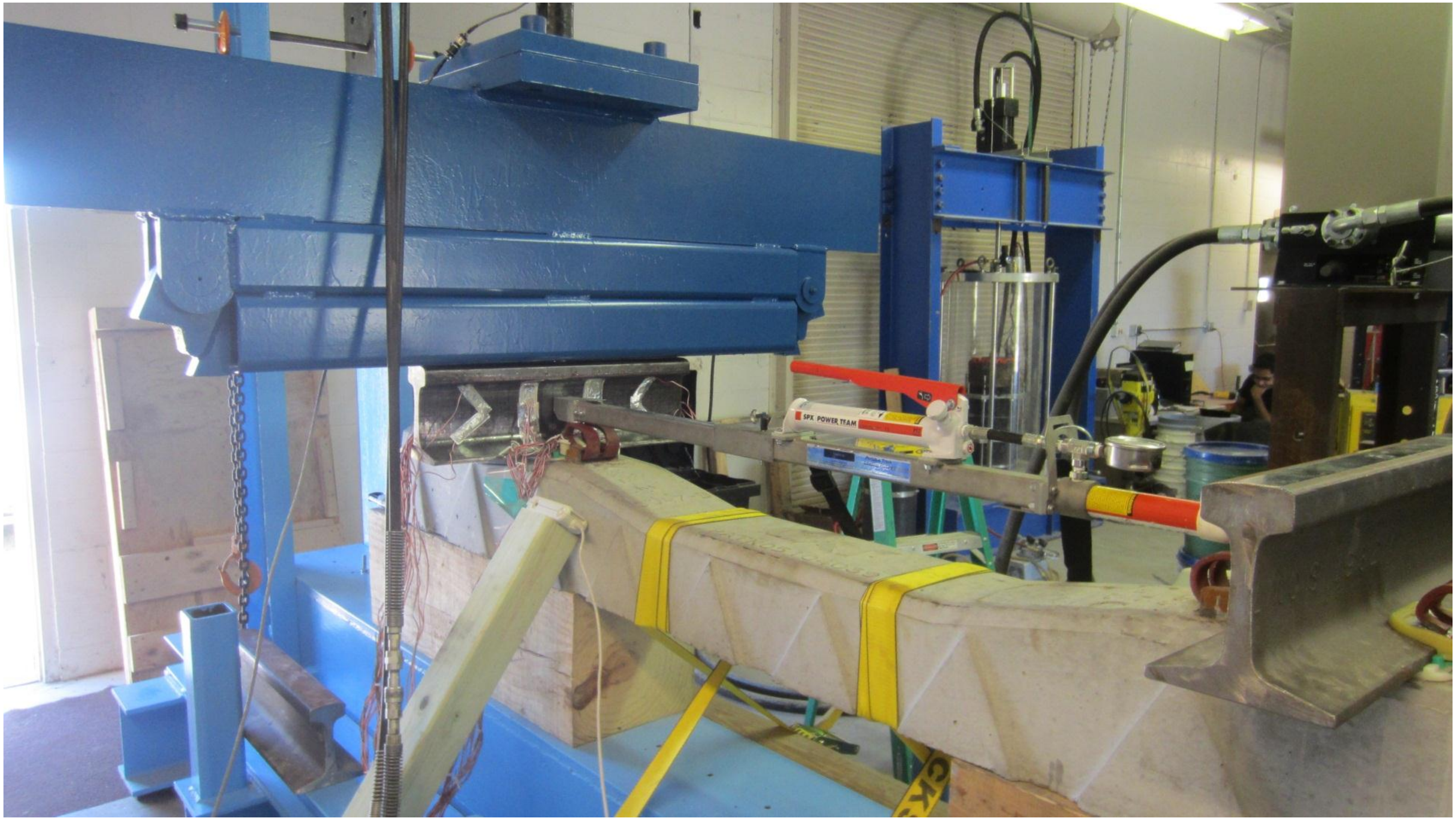
3D Modeling: Concrete And Fastening System Model

- Eccentricity of vertical loading result in local bending of the rail head
- Difference comes from both gauge position and strain direction



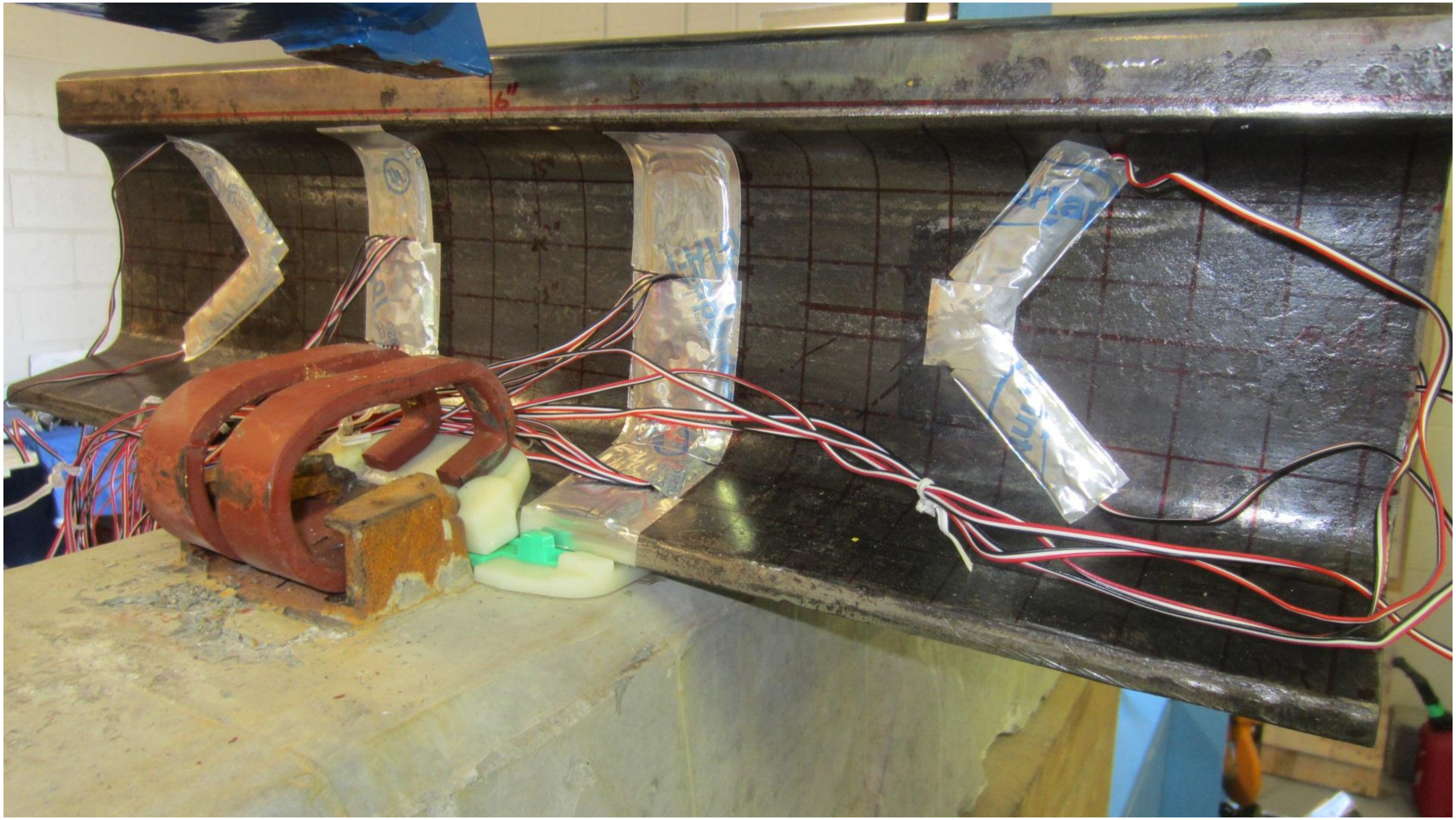


3D Modeling: Simplified Modeling
Static Load Testing Machine (SLTM)



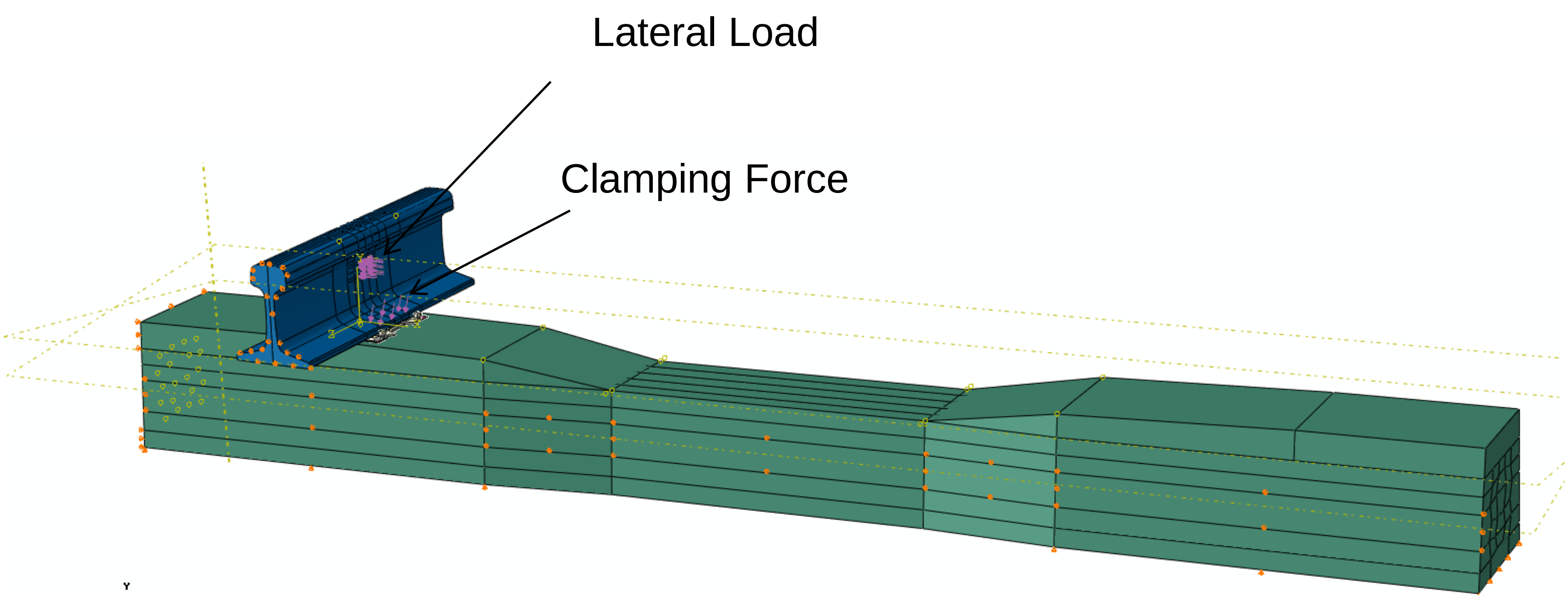
3D Modeling: Simplified Modeling

Strain Gauges On The Web Of The Rail



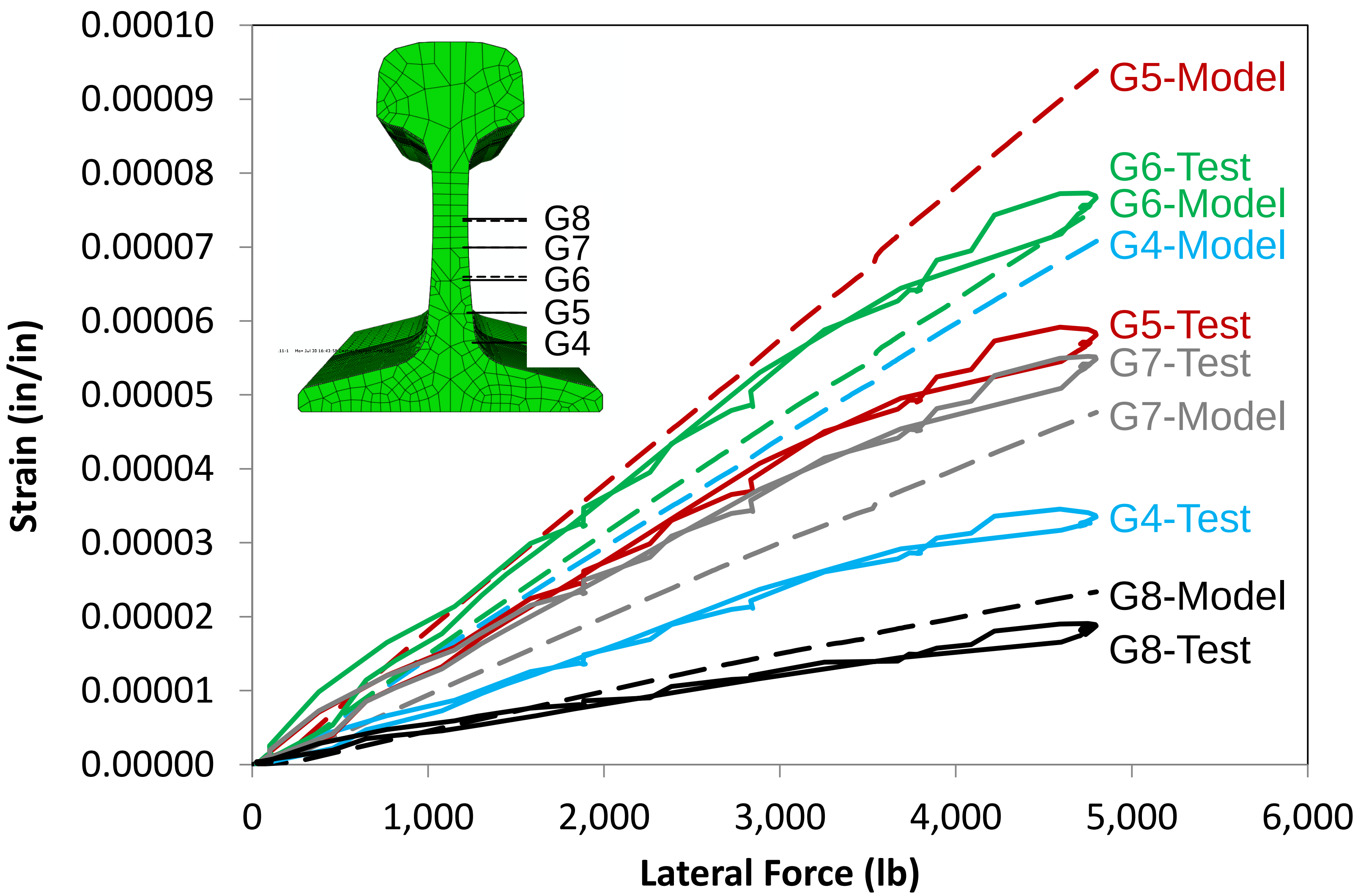
3D Modeling: Simplified Modeling

SLTM Model



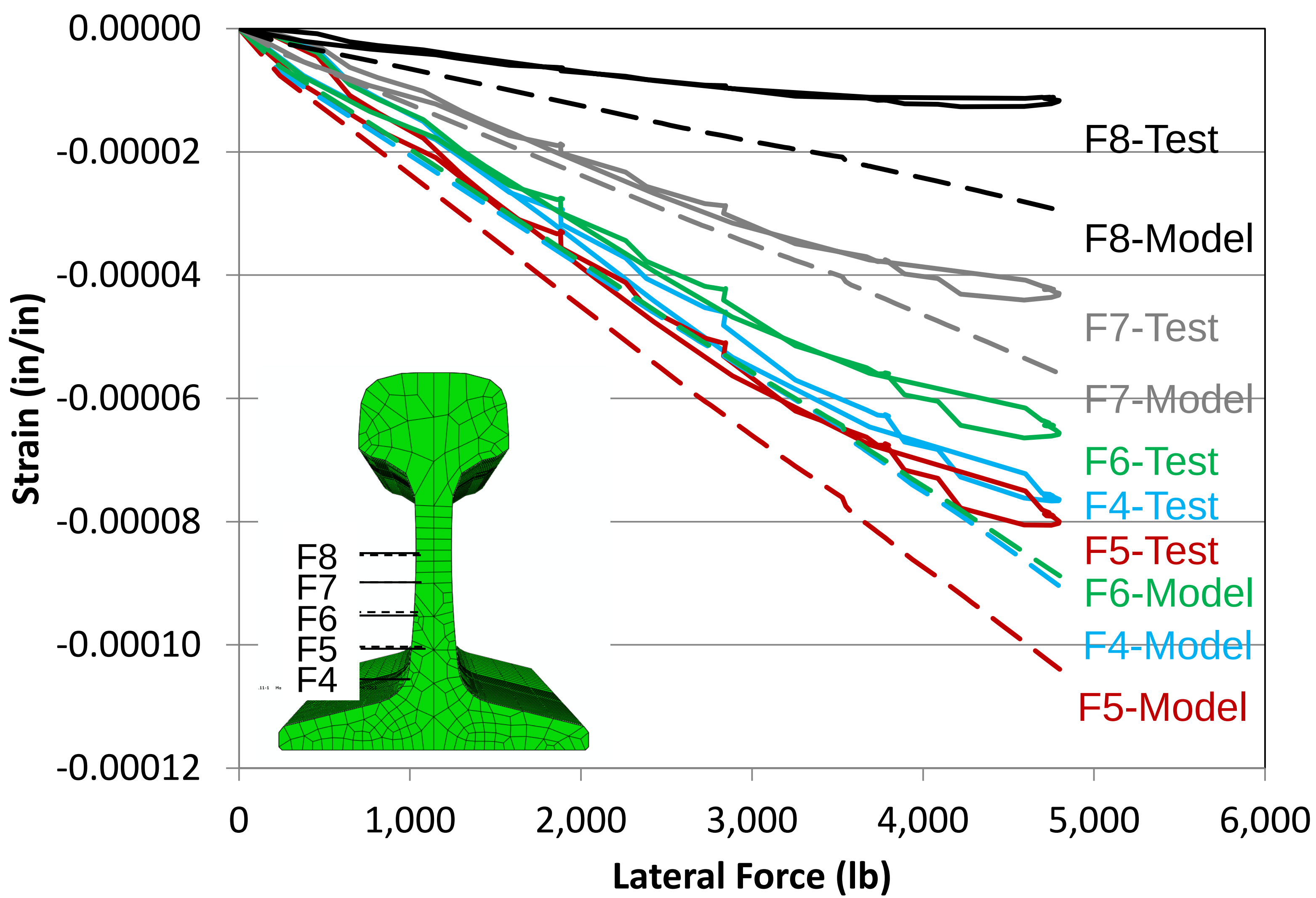
3D Modeling: Simplified Modeling

Comparisons Of Strains On The Web (Gage Side)



3D Modeling: Simplified Modeling

Comparisons Of Strains On The Web (Field Side)



Preliminary Conclusions

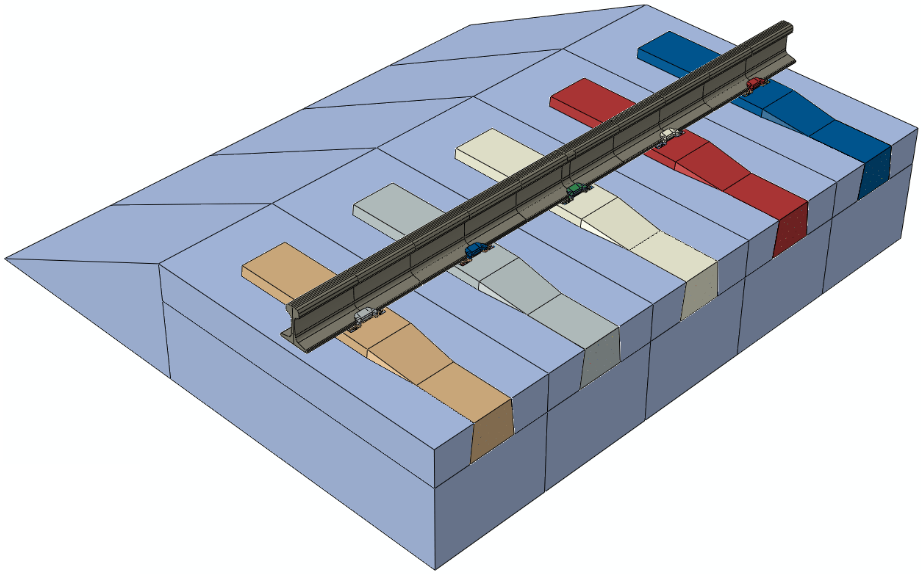
- Clip component model was validated with manufacturer data
- Clip performance in the component model is considerably different from clip performance in the assembly model
- Current laboratory tests (PLTM and SLTM) are validated, and good agreement is observed
- Concrete crosstie and fastening system has been modeled and been a good tool to estimate the rail seat pressure

Future Work

- **Further laboratory comparisons:** Conduct additional experimentation in the lab to compare results with the models
- **Large-scale modeling:** finalize model that include multiple ties and simplified fastening system to consider the distribution of loading among multiple ties and the discrete support condition of rail
- **Realistic loading**: Introduce additional load types (vertical, lateral, and longitudinal loads) and load forms (static and dynamic load) will be applied to the track system to better simulate the actual loading environment
- **Parametric studies**: Conduct parametric studies related material properties and geometric dimensions will be conducted using the model

Future Work: Possible Challenges

- **Possible challenges:**
  - Moving loads along the rail
  - Change from static analysis to dynamic analysis
  - Distribution of crosstie lateral resistance (bottom friction & lateral support)
  - Modeling of non-uniform support condition



Acknowledgements

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Federal Railroad Administration

FRA Tie and Fastener BAA Industry Partners:

UNION PACIFIC BUILDING AMERICA®

BNSF RAILWAY

AMTRAK®

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Amsted Rail

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HANSON

LBFoster CXT Concrete Ties

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Questions?

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