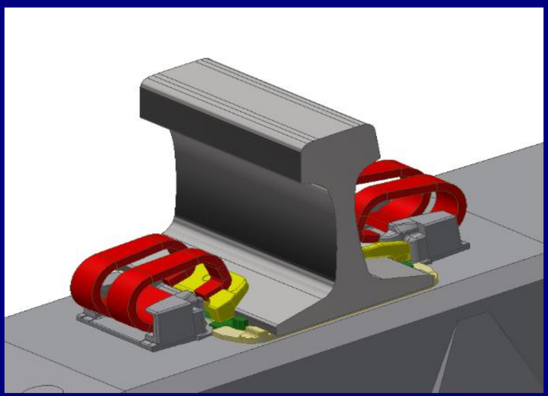
Mechanics of Fastening System Rail Pad Assemblies Through Lateral Load Path Analysis



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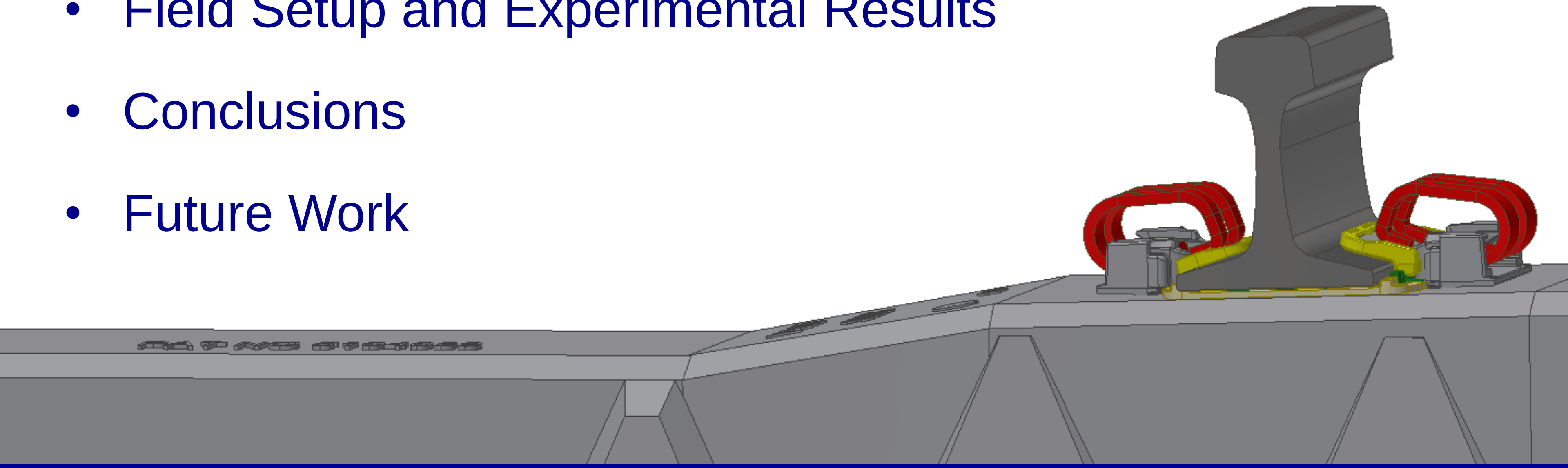
Outline

- Background
- Load Path in the Fastening System
- Mechanistic Design Framework
- Research Project Objectives
- Field Setup and Experimental Results
- Conclusions
- Future Work

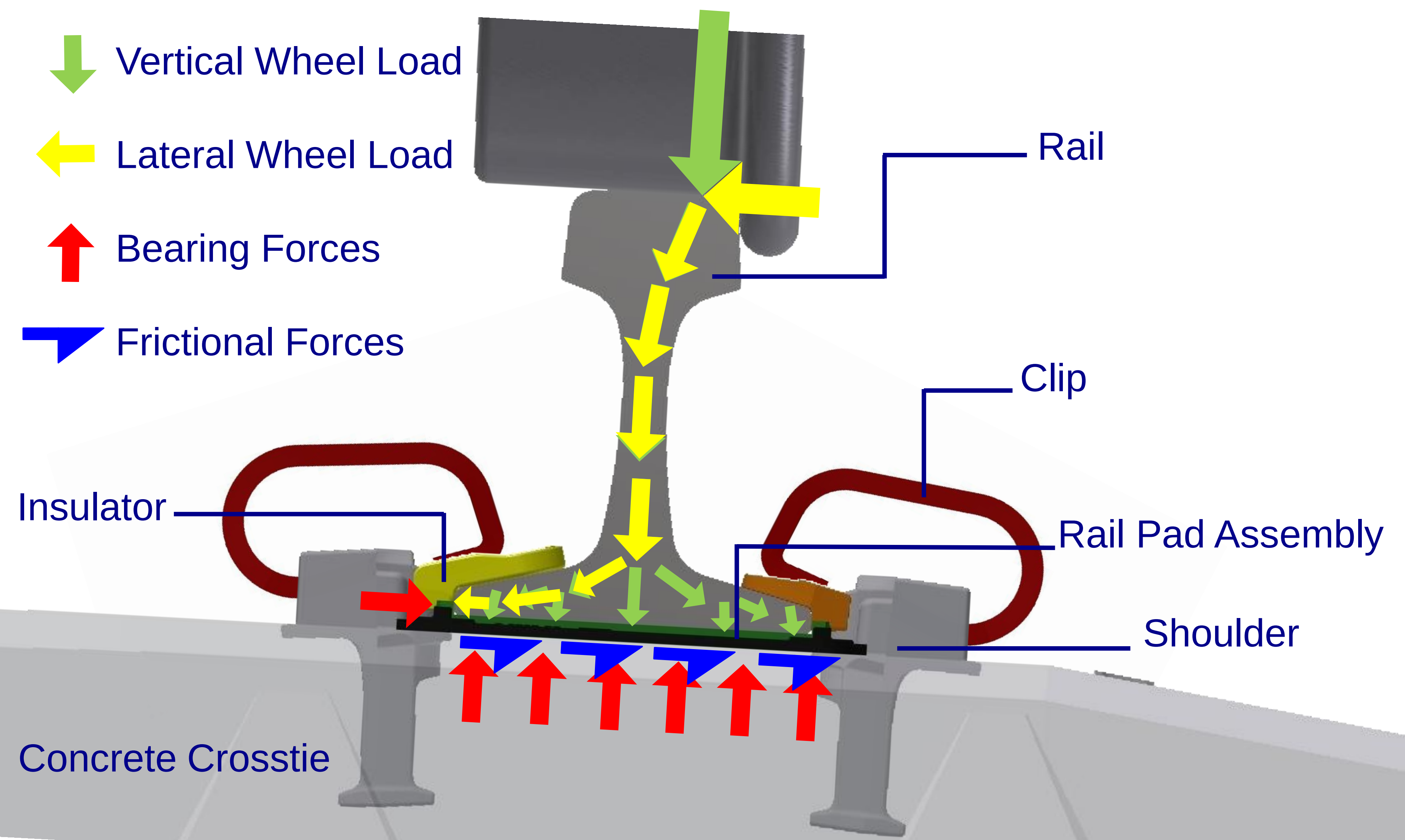


Background

- 25 million concrete crossties are in use on North American heavy haul freight railroads
- **Industry Trends**:
  - Many variations in fastening system design, performance, and life cycle
  - Fastening system components are failing earlier than their intended design life
  - Increasing heavy axle loads (HAL) and traffic volumes
- **Challenge**:
  - More efficient concrete crosstie and fastening system designs that withstand increasingly demanding loading conditions

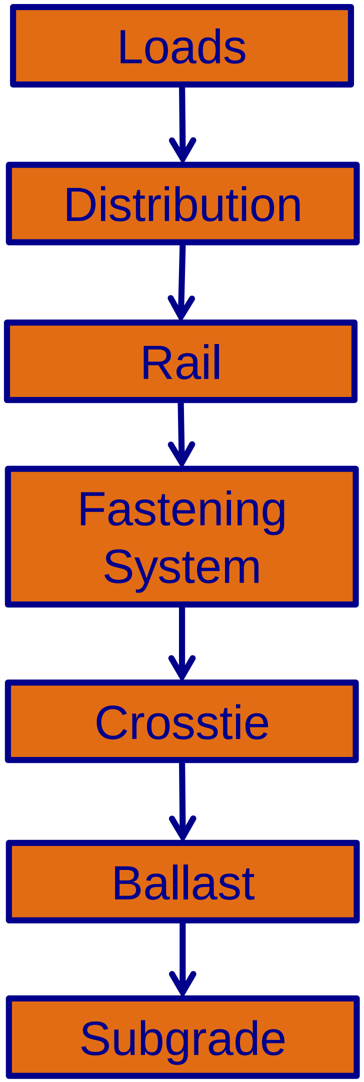
Example of Failure Modes in the Fastening System

Defining the Lateral Load Path



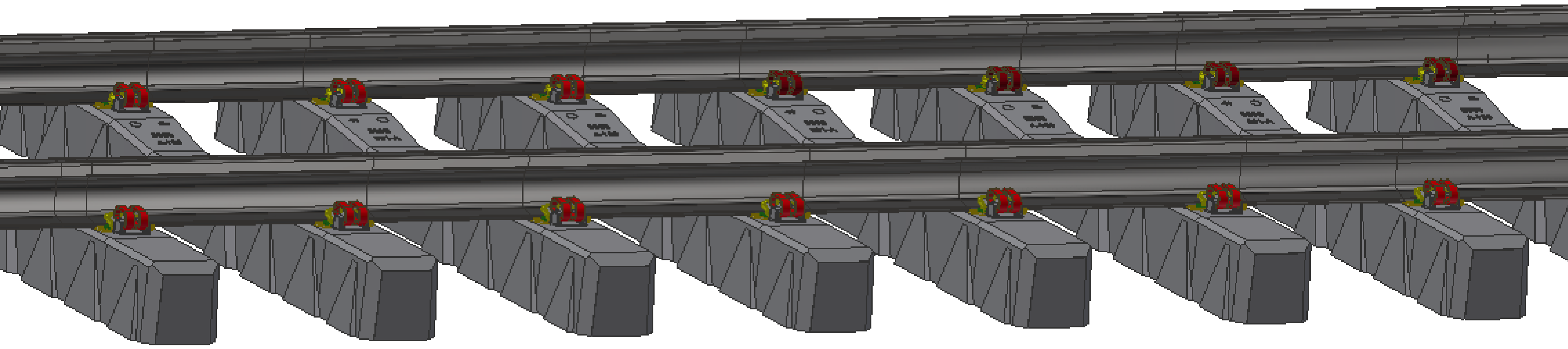
Mechanistic Design Framework

- Representative input loads and loading distribution factors are not a clear part of the design methodology, particularly in the lateral direction
- Approach based on loads measured in track structure and properties of materials that will withstand or transfer them
- Uses responses (e.g. contact pressure, relative displacements) to optimize component geometry and materials requirements
- Based on measured and predicted response to load inputs that can be supplemented with practical experience
- Used in other engineering industries (e.g. pavement design, concrete design, structural steel design)



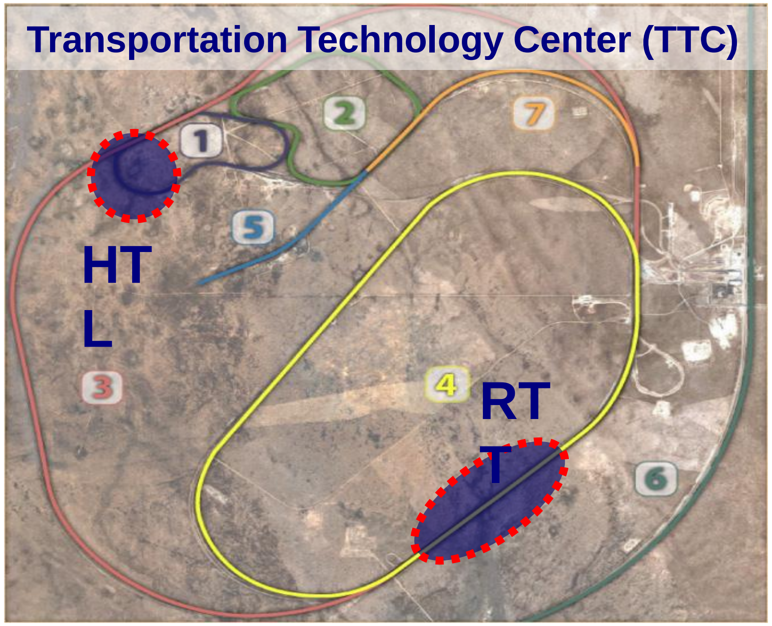
Research Project Objectives

- Increase understanding of vertical and lateral load paths within the track superstructure
- Provide a framework for a mechanistic design approach for concrete crossties and fastening systems
- Quantify displacements of rail pad assemblies relative to crossties in the field and investigate relationship with wheel loads and fastening system lateral stiffness
- Develop recommendations for rail pad assembly design driven by analysis of vertical and lateral load path

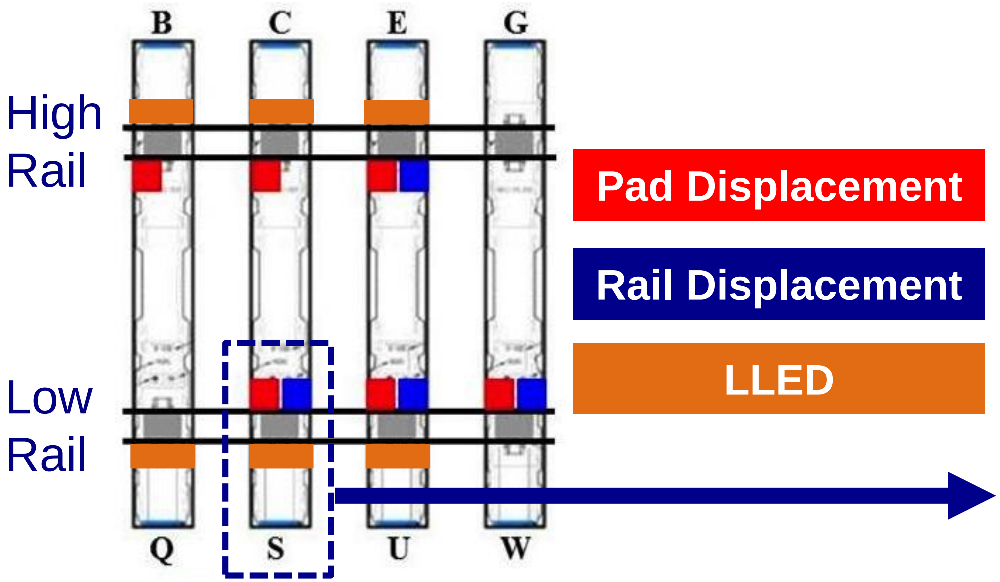


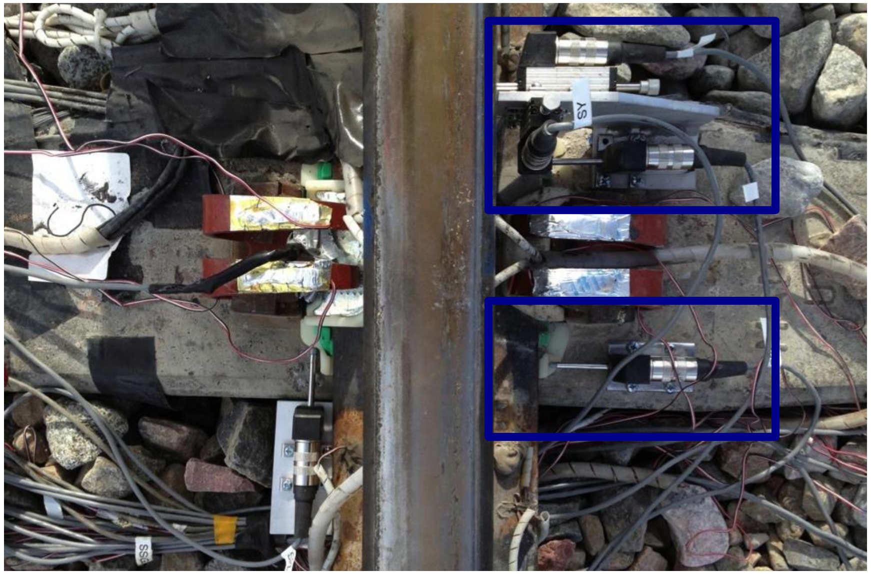
Field Experimental Setup

- Objective: Analyze the distribution of forces through the fastening system and impact on components relative displacements
- Tests carried out at TTC in Pueblo, CO
- **High Tonnage Loop (HTL):** 2 degree curve section with Safelok I fasteners
- **Railroad Test Track (RTT):** tangent section with Safelok I fasteners
- Linear potentiometers were used to measure the lateral displacement of the rail base and rail pads
- Strain gauges placed on the rail were used to measure the vertical and lateral wheel loads
- Track Loading Vehicle (TLV) and train consists (passenger and freight) were used to apply loads



Field Instrumentation

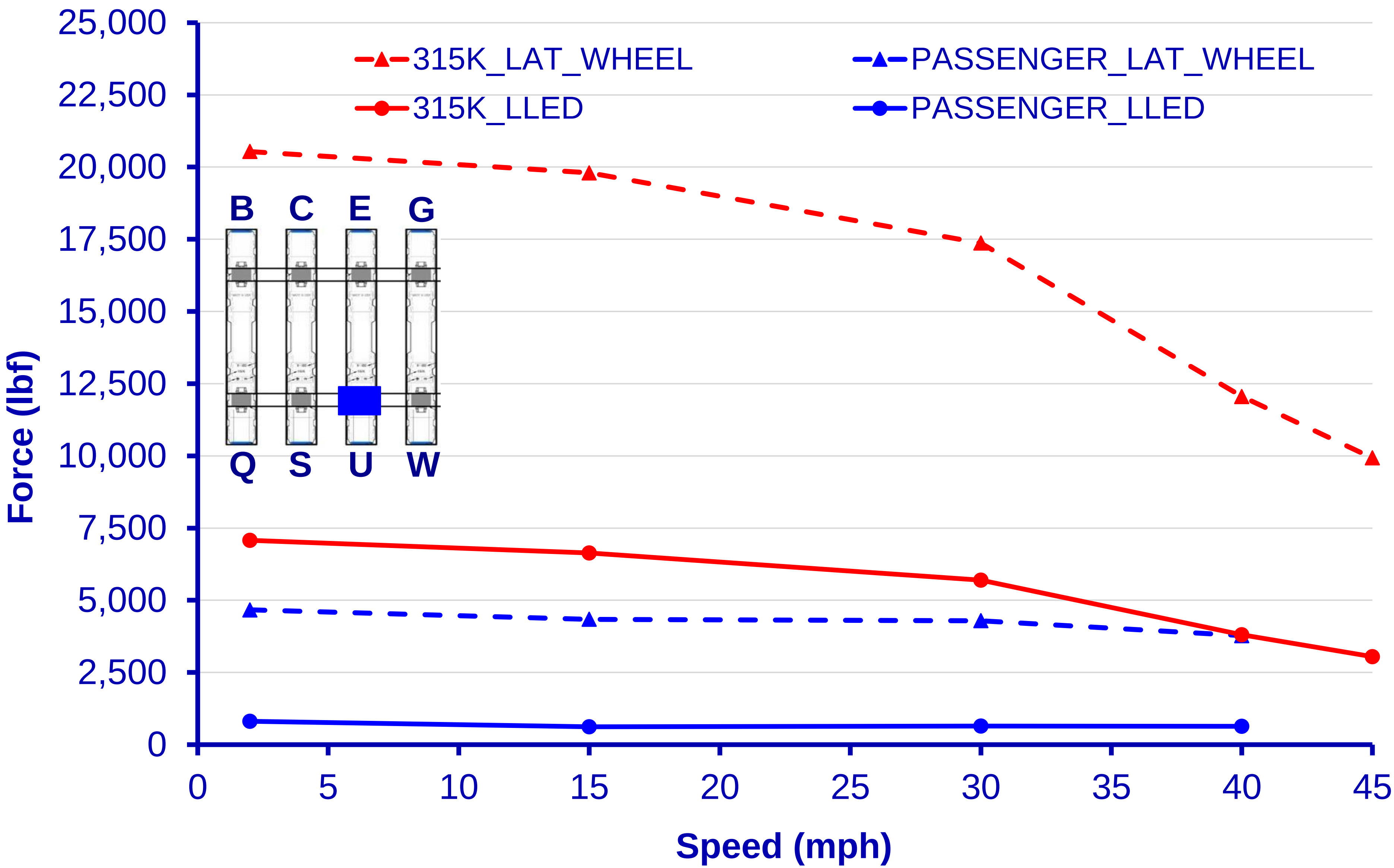




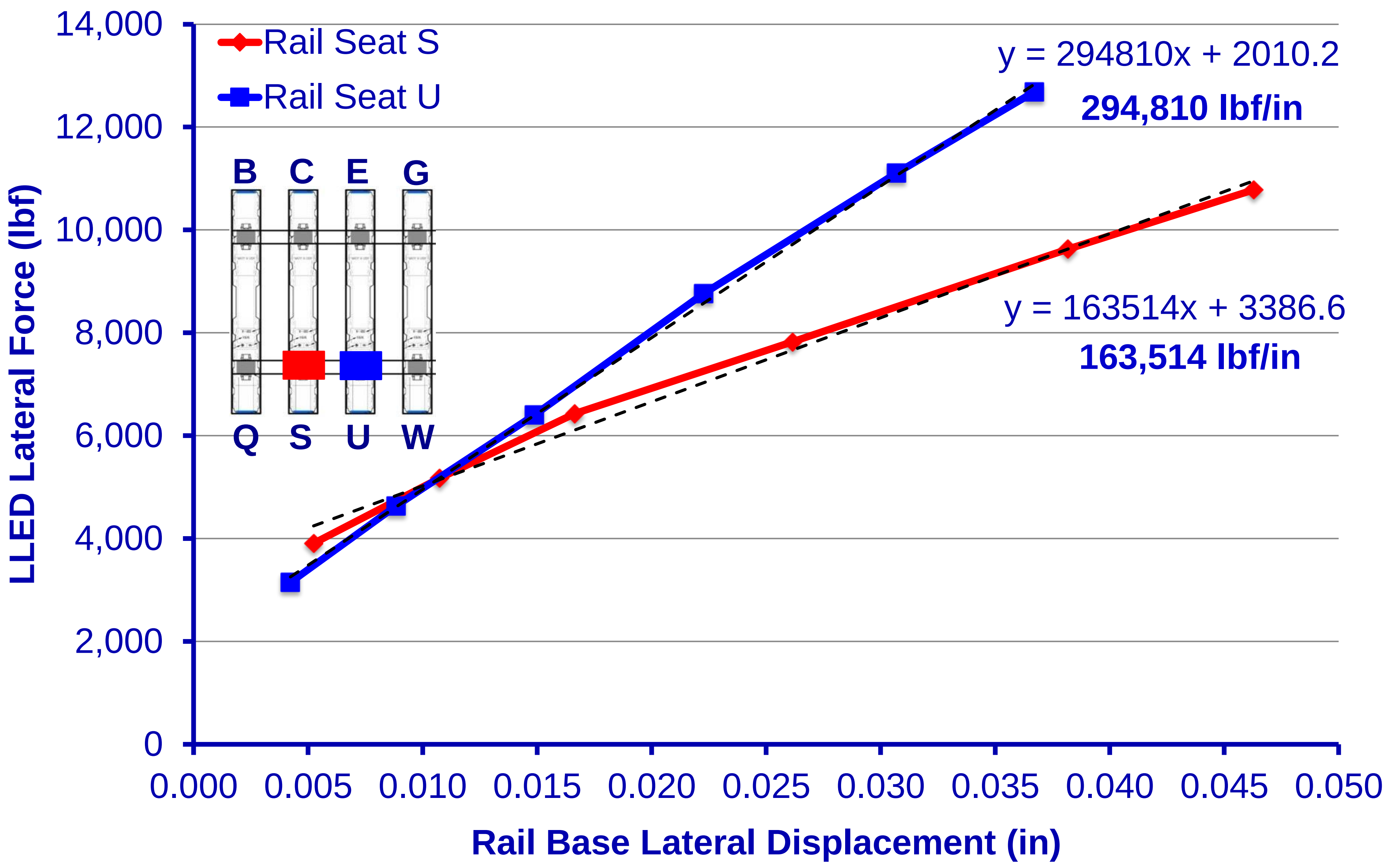
Potentiometer measuring pad lateral displacement

Lateral Load Evaluation Device (LLED) – *Williams 2013*

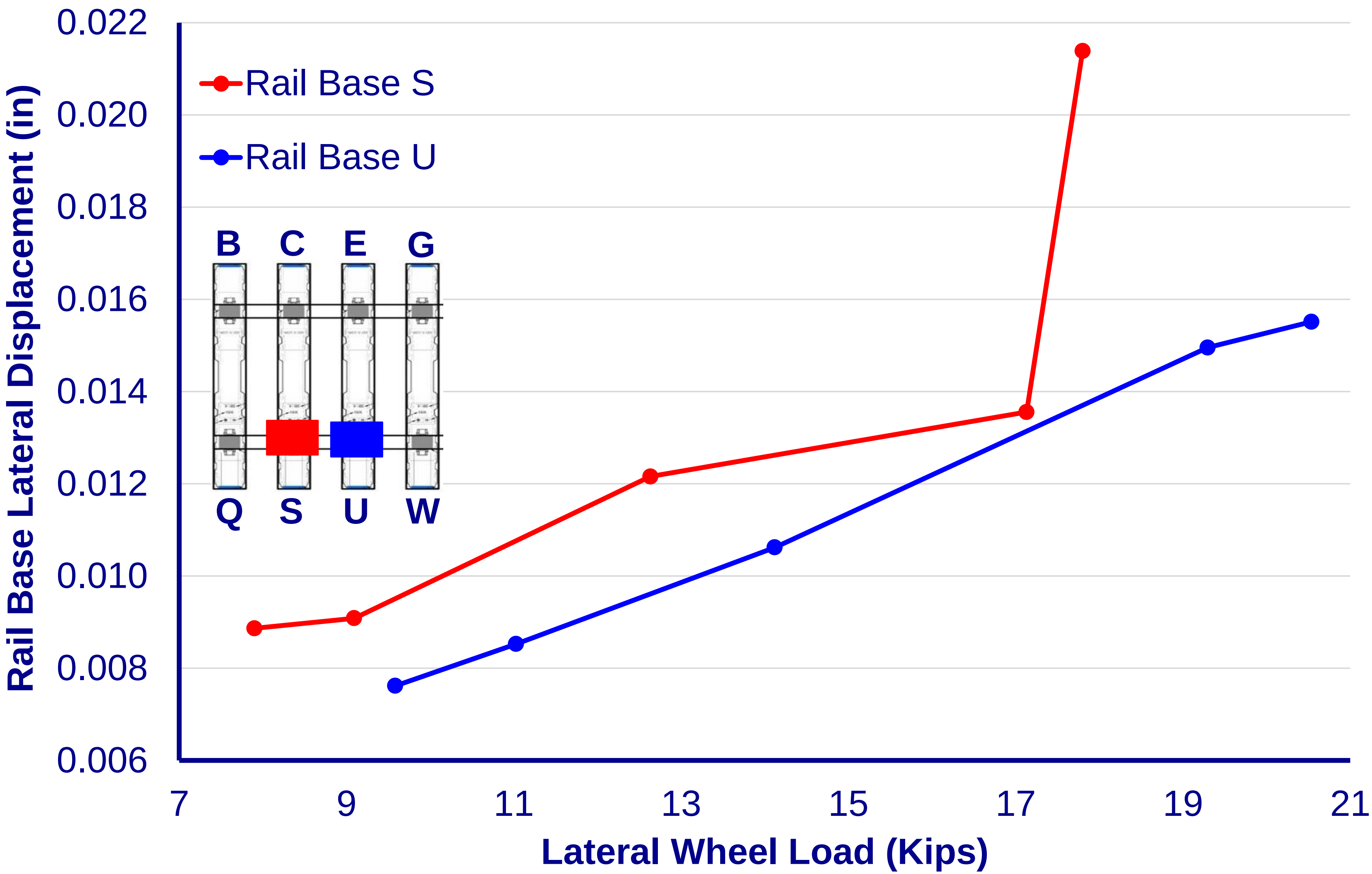
Maximum Lateral Wheel Loads and Lateral LLED Forces at Rail Seat U for Increasing Speed



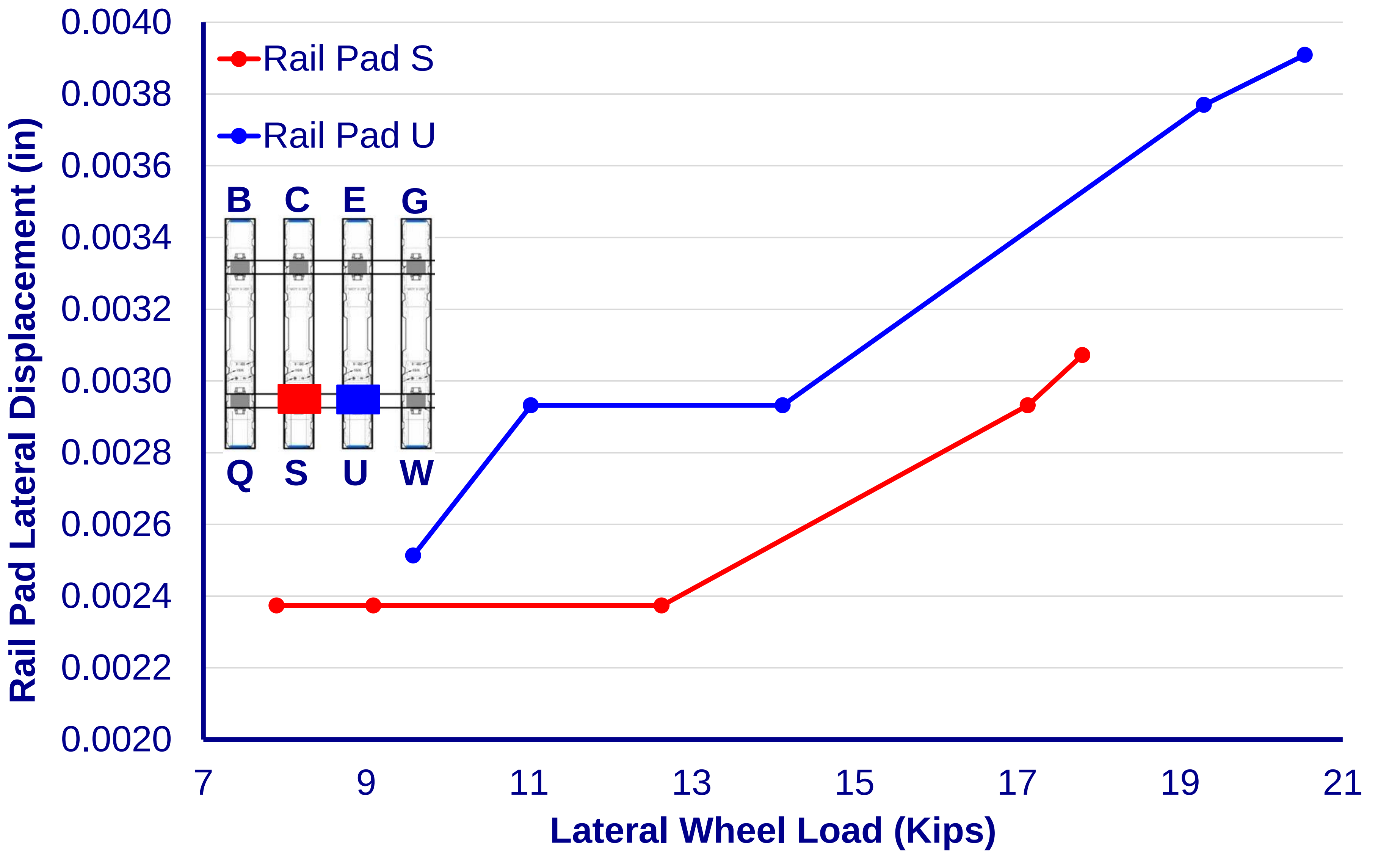
Fastening System Lateral Stiffness (HTL)



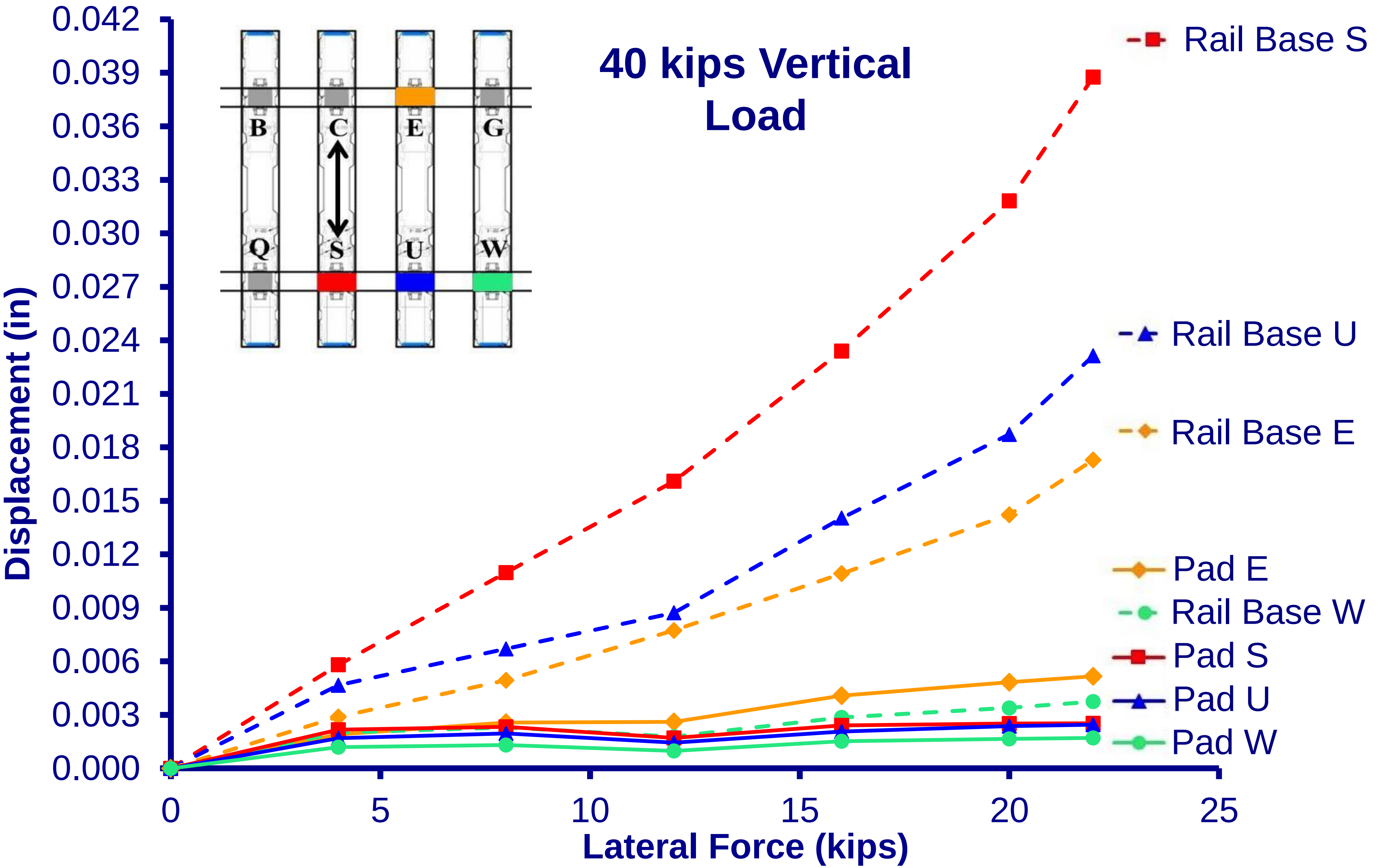
Rail Base Lateral Translation for Increasing Wheel Load (HTL Freight Consist)



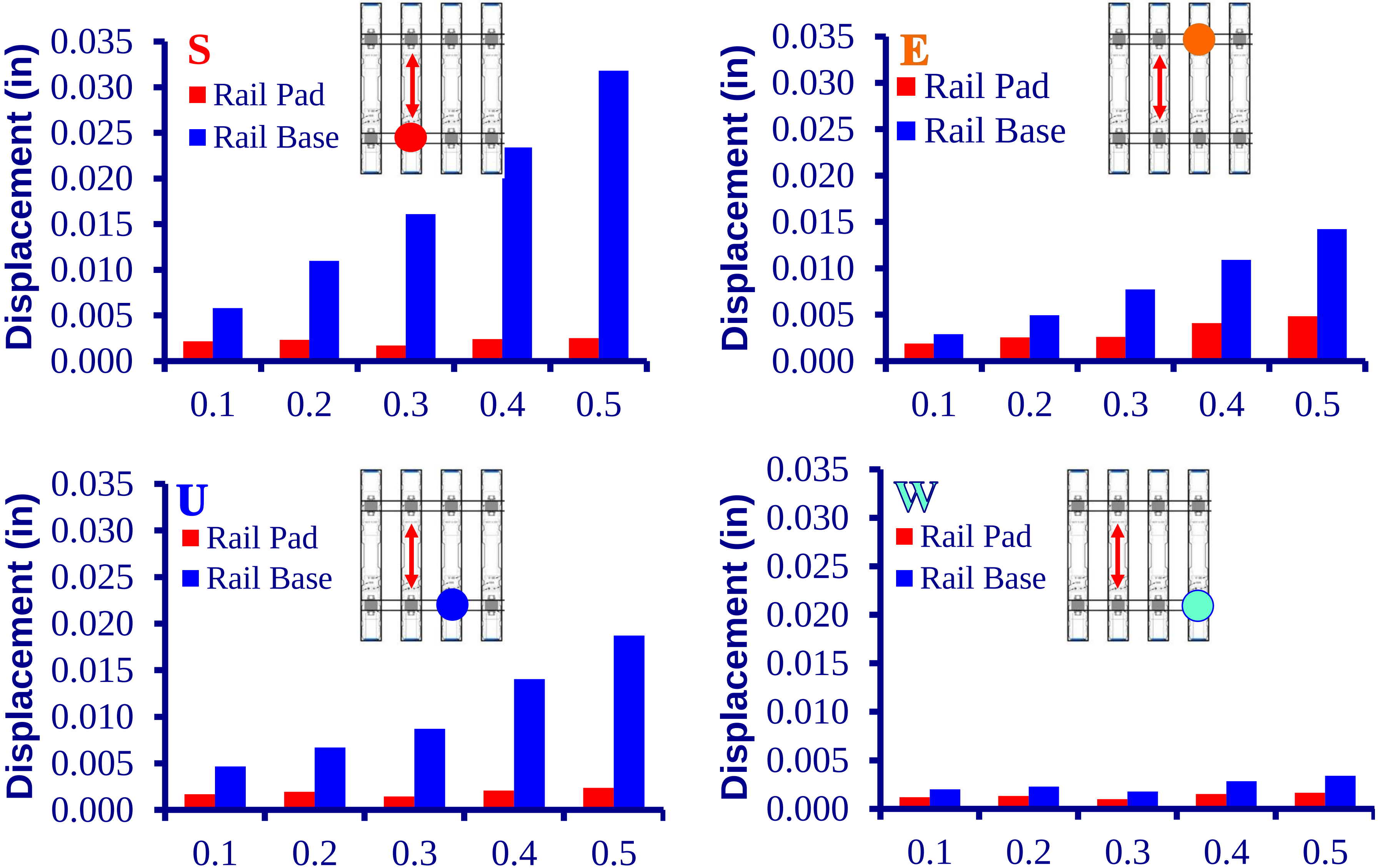
Rail Pad Lateral Displacement for Increasing Lateral Wheel Load (HTL Freight Consist)



Rail Base and Rail Pad Lateral Displacement for a Varying Lateral Load (RTT)



Relative Lateral Displacement Between Rail Base and Rail Pad Assembly (40 kips Vertical Load)



Conclusions

- Relative displacements of the rail pad assembly and rail base with respect to the concrete crosstie were measured successfully in the field
- The lateral displacement of the rail pad and rail base is directly related to the lateral wheel loads applied to the track
- Depending on the location of the load application, the lateral displacement of the rail base is able to reach a value 6 times higher than the lateral displacement of the rail pad.
- Rail seats with higher lateral stiffness resulted in a higher percentage of lateral load bearing on the insulator post and shoulder face
- Adjacent rail seats can have considerable differences in lateral stiffness and resultant magnitude of lateral forces
- Lateral displacement of rail and rail pad assembly should be considered in fastening system design and material selection

Future Work: Schnabel

Acknowledgements

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Questions or Comments?

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Thank you!