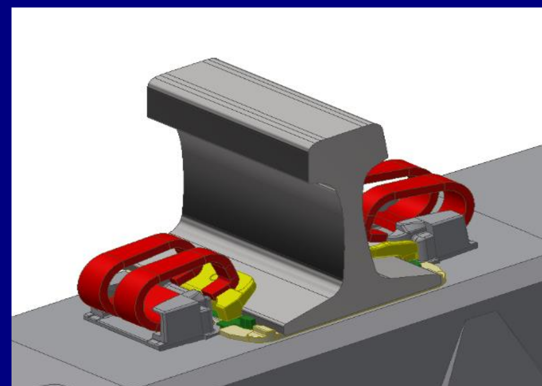
Analysis of Rail Pad Assemblies Responses




Joint Rail Conference – JRC 2014

Colorado Springs, CO

3 April 2014

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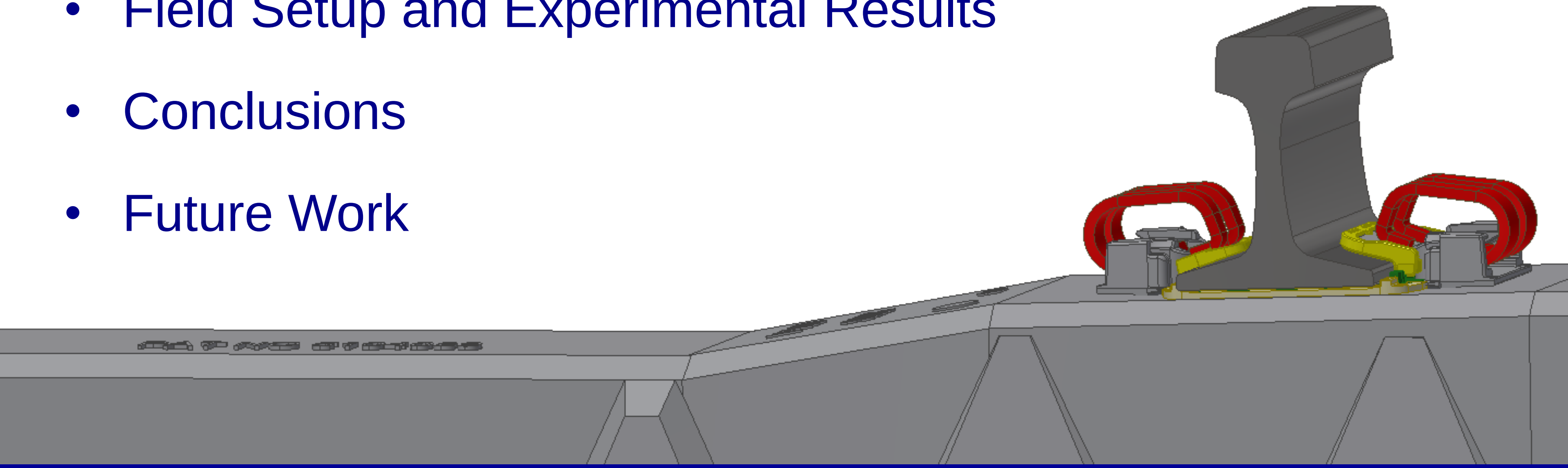
U.S. Department of Transportation
Federal Railroad Administration

Outline

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



Background

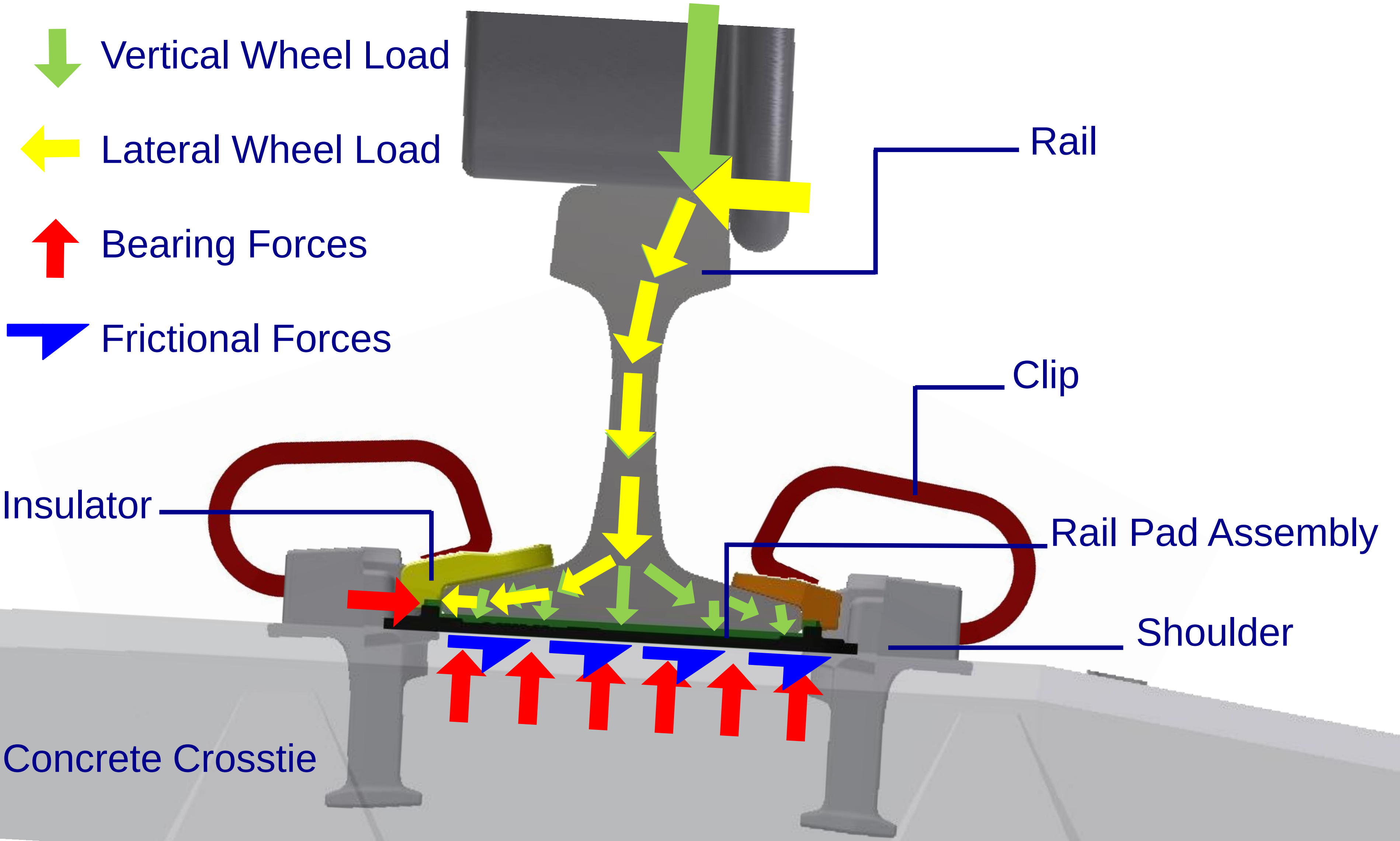
- Over 25 million concrete crossties are in use on North American heavy haul freight railroads
- **Industry Trends**:
  - Increasing heavy axle loads (HAL) and traffic volumes
  - Many variations in fastening system design, performance, and life cycle
  - Some fastening system components are failing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

Examples of Failure Modes in the Fastening System Components



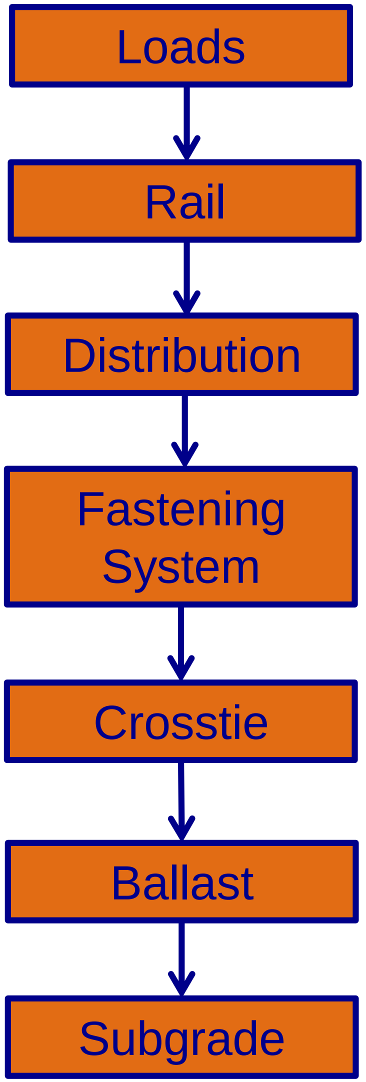

Tearing, crushing, and cracking observed in deteriorated components

Defining the Load Path



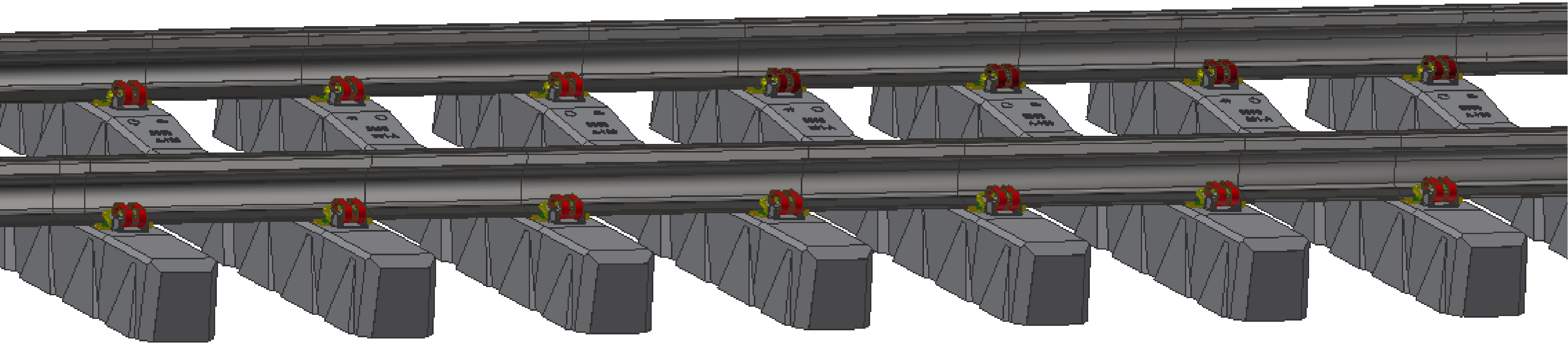
Mechanistic Design Framework

- Representative input loads and loading distribution factors are not a clear part of the current design methodology, particularly in the lateral direction
- Mechanistic design is an 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
- Can be supplemented with practical experience
- Used in other engineering applications (e.g. pavement design, concrete design, structural steel design)



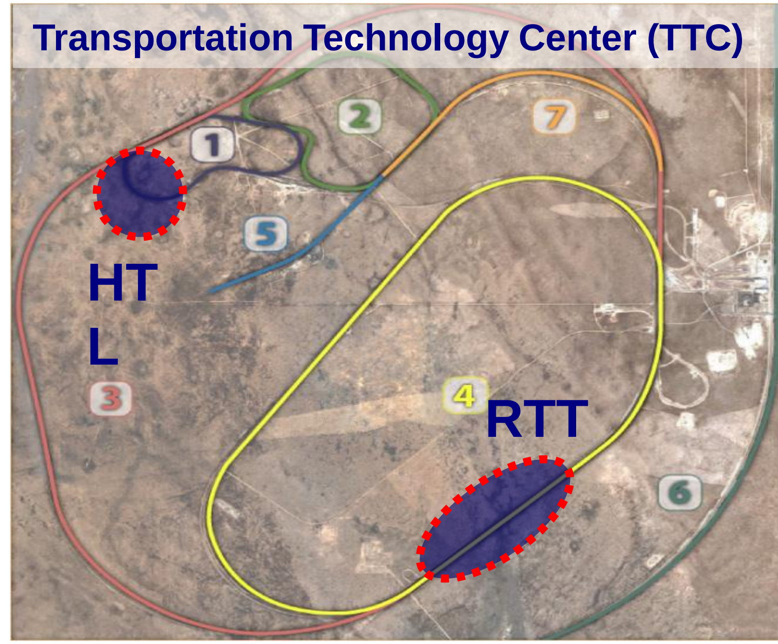
Research Project Objectives

- 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 based on the analysis of vertical and lateral load path



Field Experiment Program

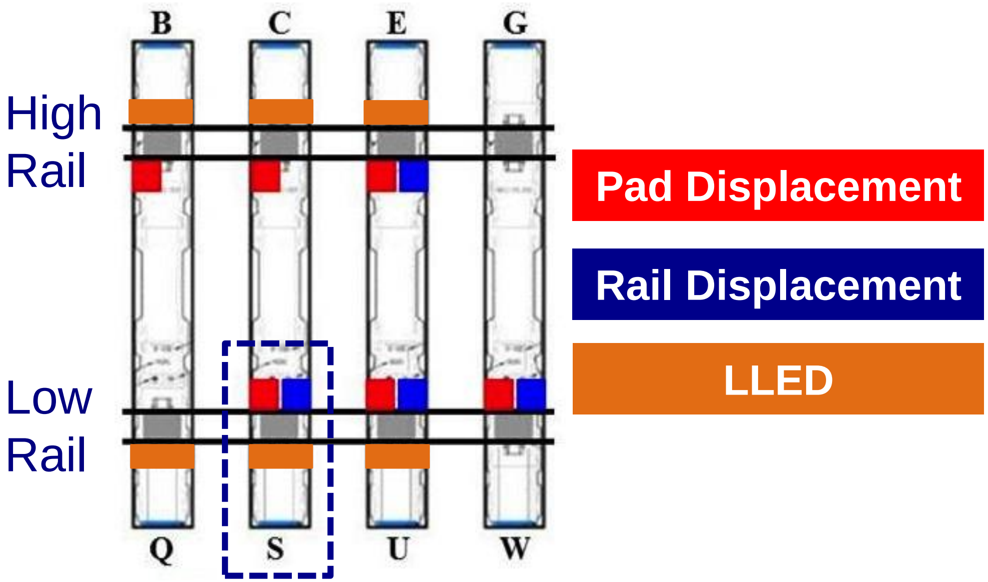
- **Objective:** Analyze the distribution of forces through the fastening system and impact on components relative displacements
- **Location:** Transportation Technology Center (TTC) in Pueblo, CO
- **High Tonnage Loop (HTL):** 2 degree curve section with Safelok I fasteners
- **Railroad Test Track (RTT):** tangent section with Safelok I fasteners
- **Instrumentation:**
  - 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
- **Loading:** Track Loading Vehicle (TLV) and train consists (passenger and freight) were used to apply loads

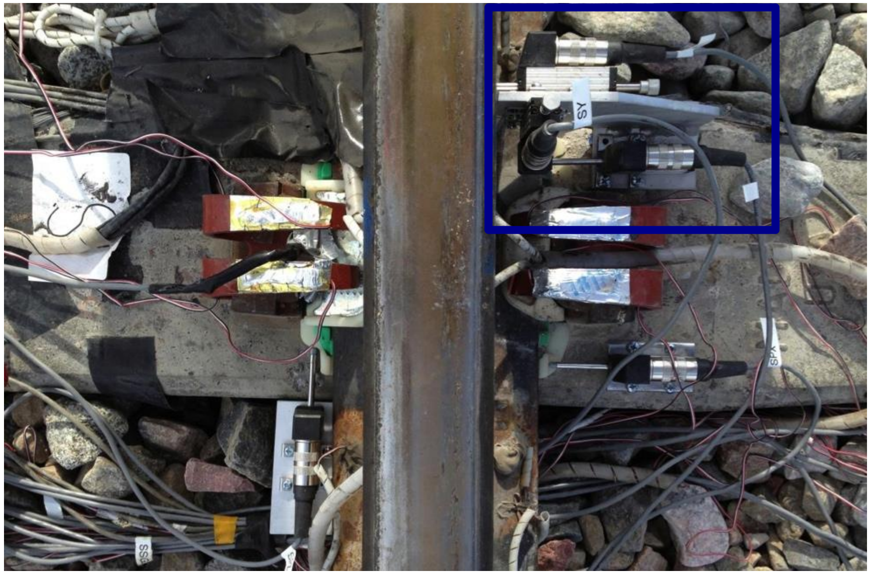


Transportation Technology Center (TTC)


High Tonnage Loop (HTL)

Field Instrumentation

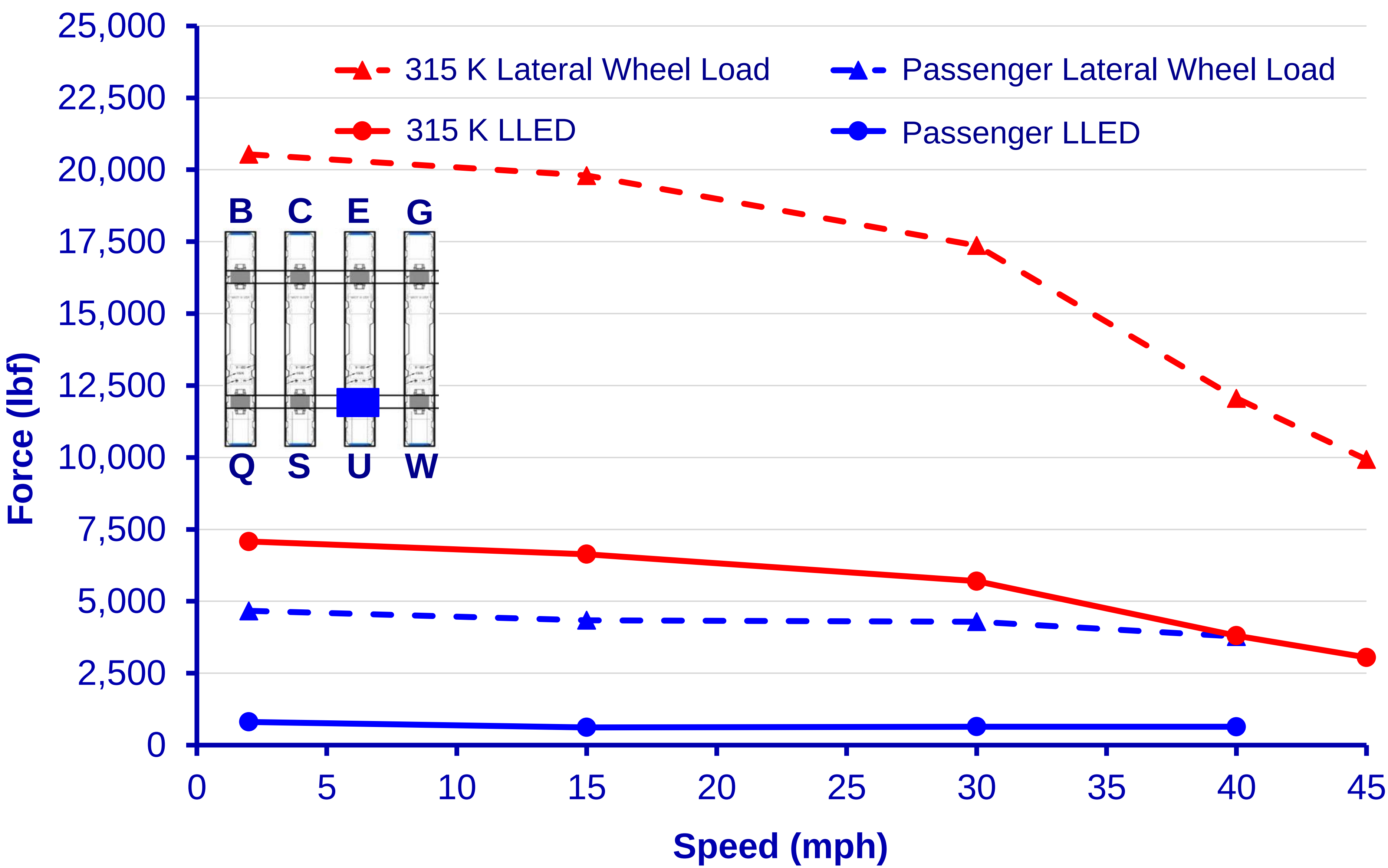




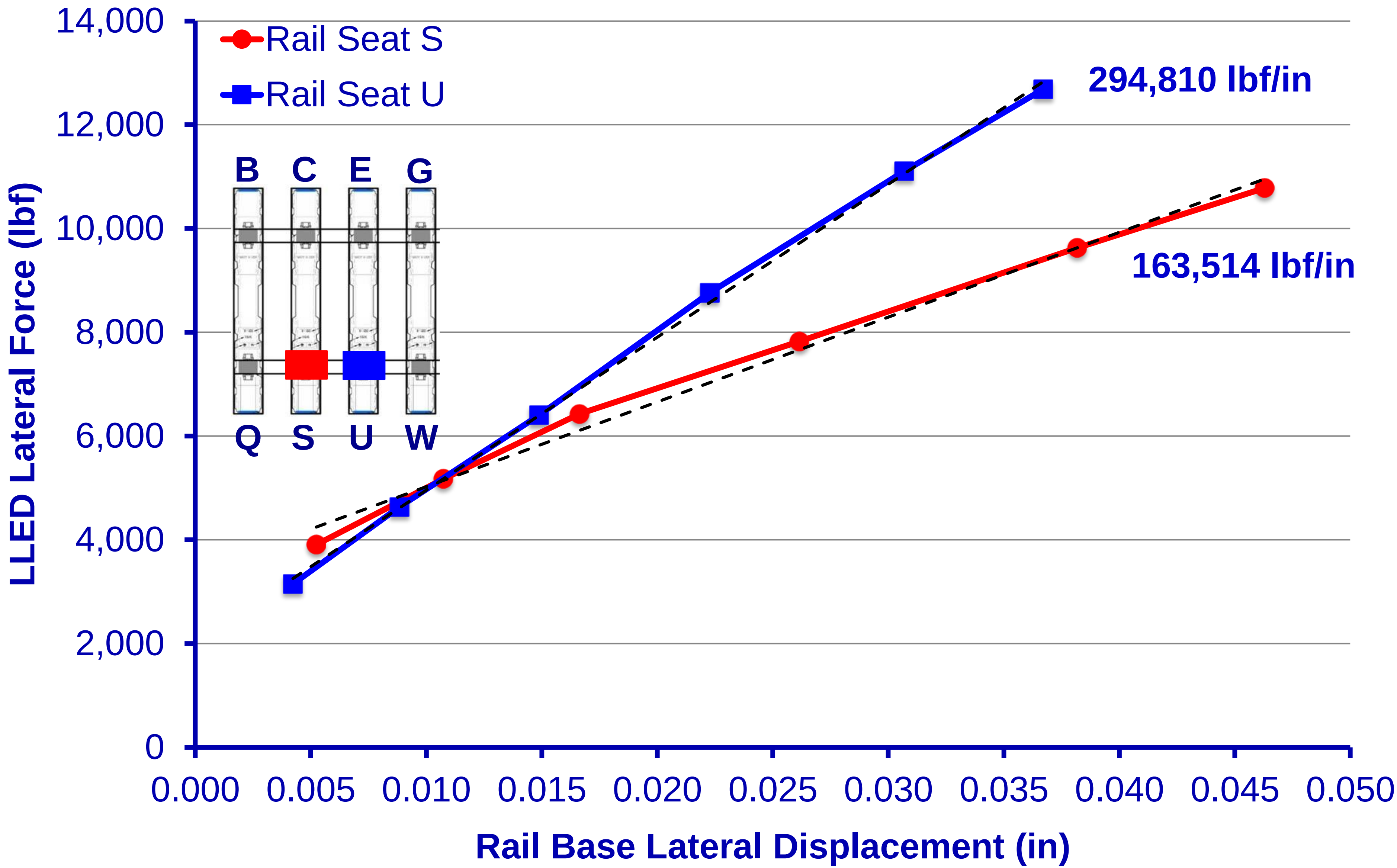
Potentiometer measuring pad lateral displacement

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

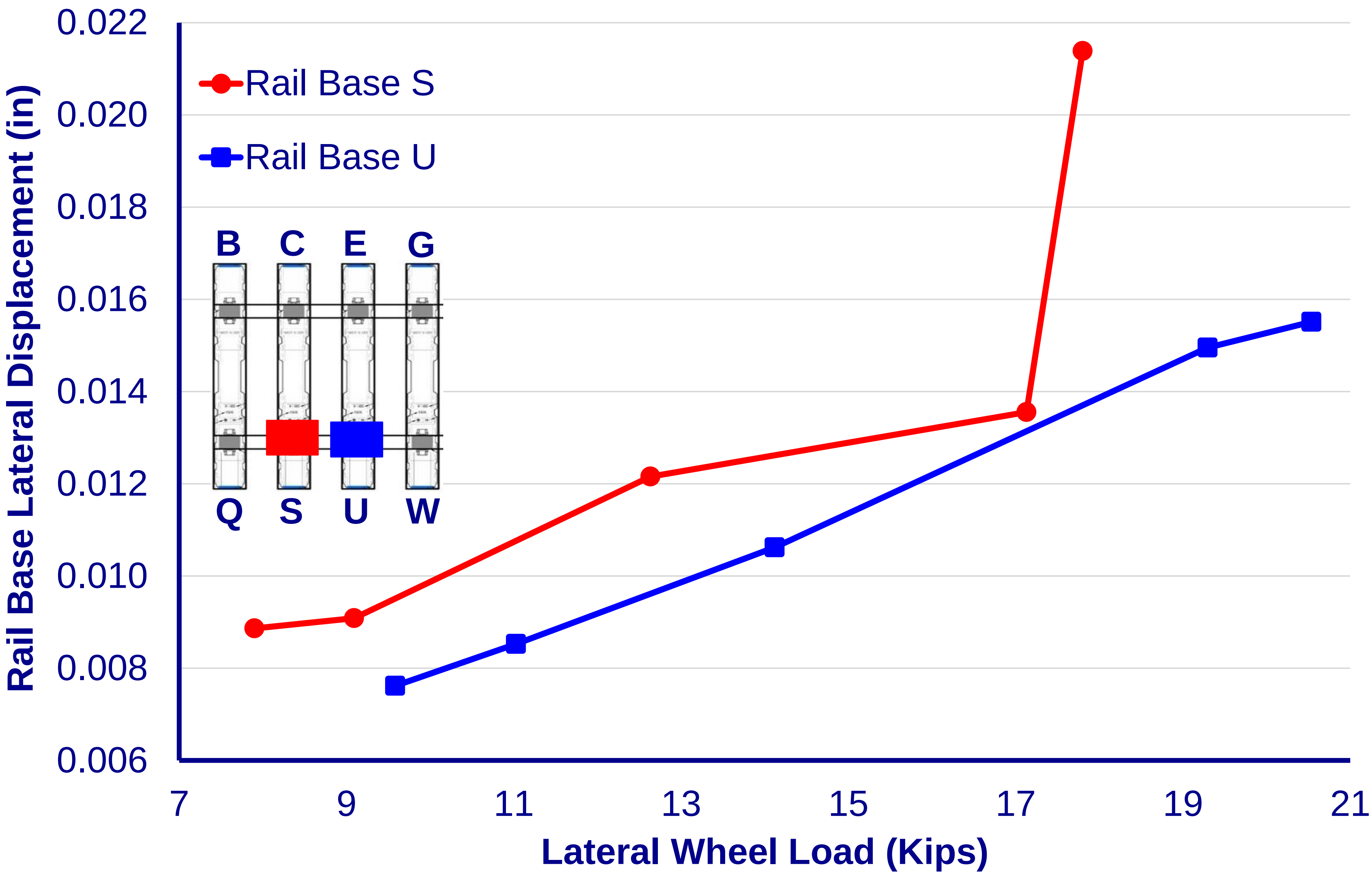
Maximum Lateral Wheel Loads and Lateral LLED Forces at Rail Seat U for Increasing Speed



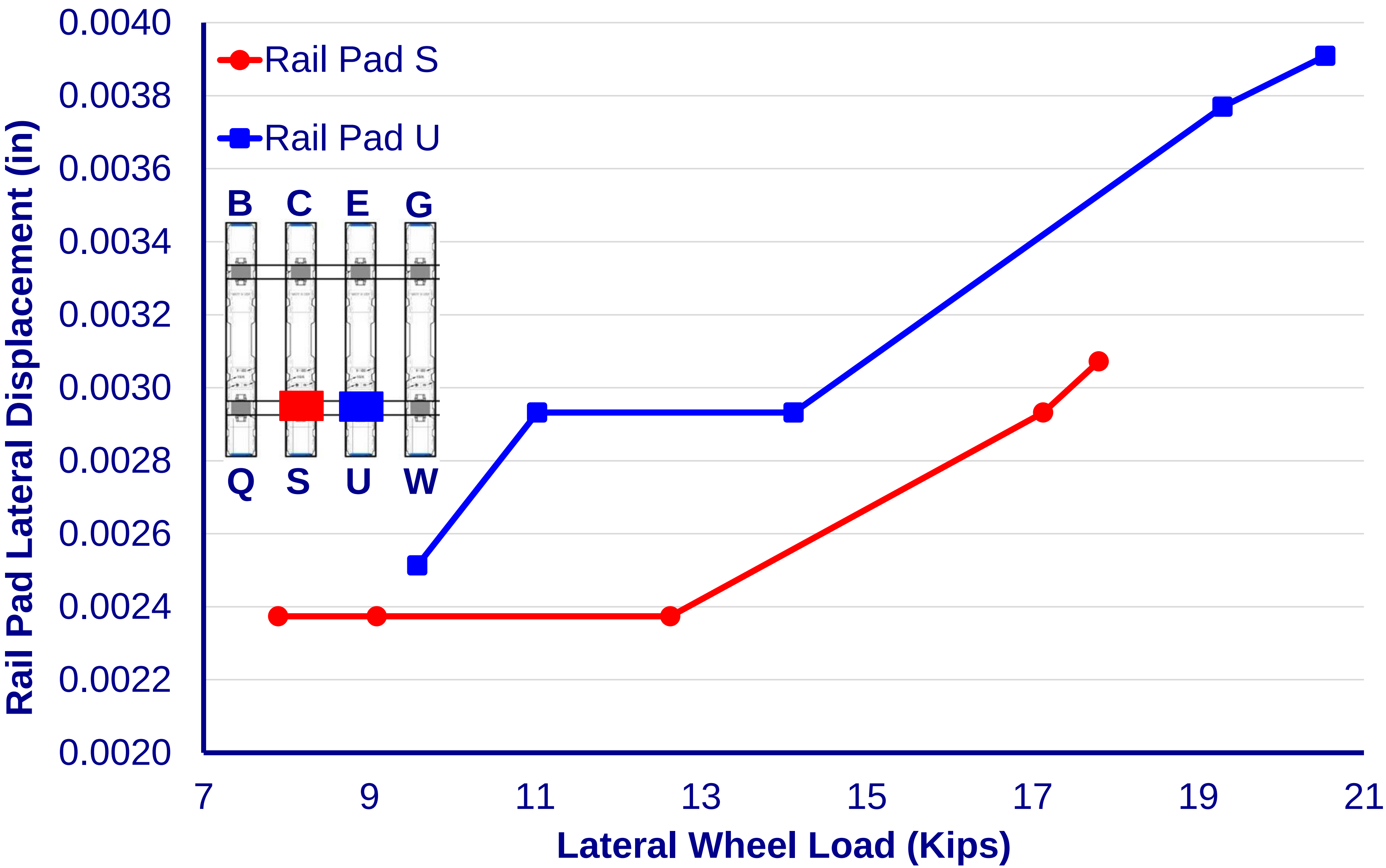
Comparison of Fastening System Lateral Stiffness
(Freight Consist on HTL)



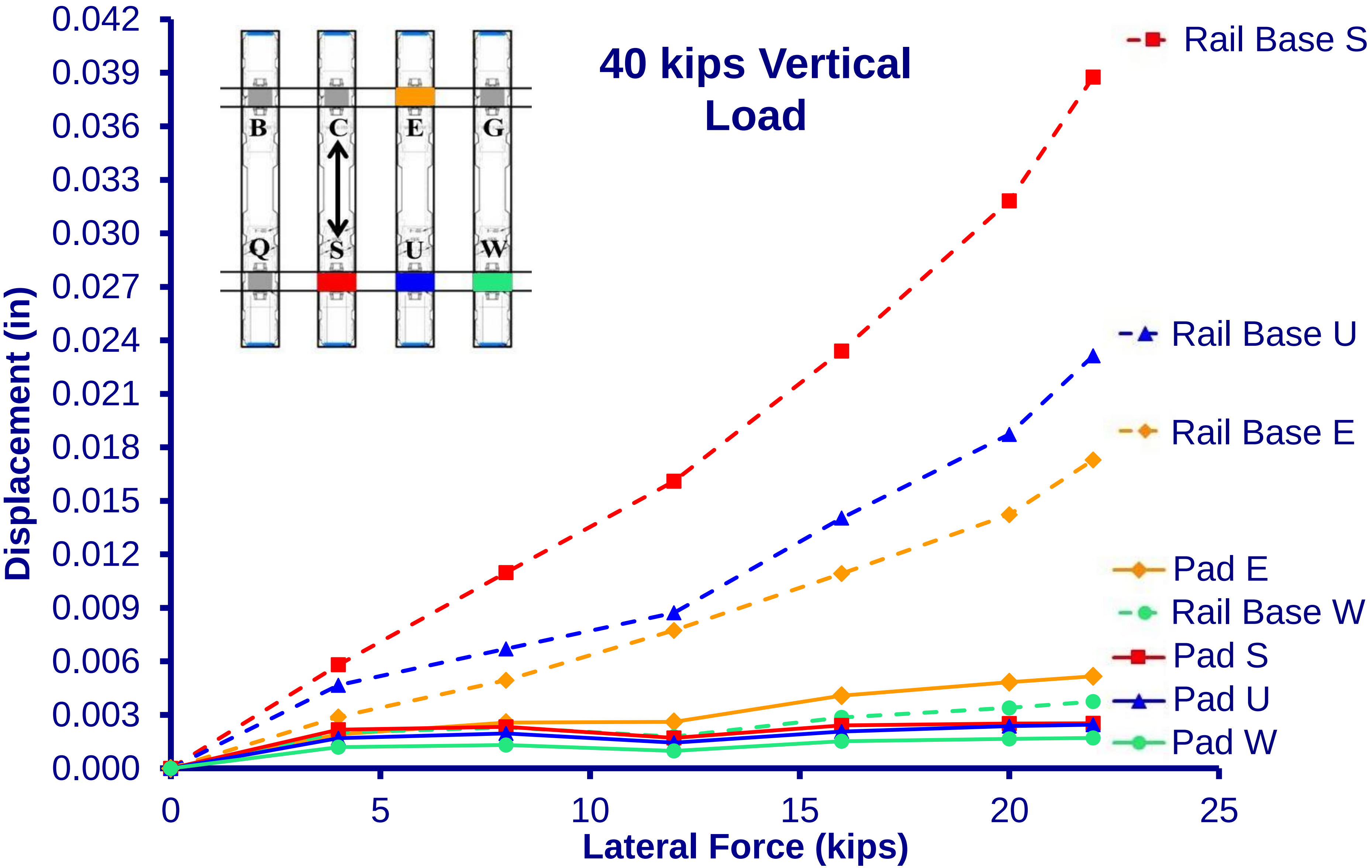
Rail Base Lateral Translation
(Freight Consist on HTL)



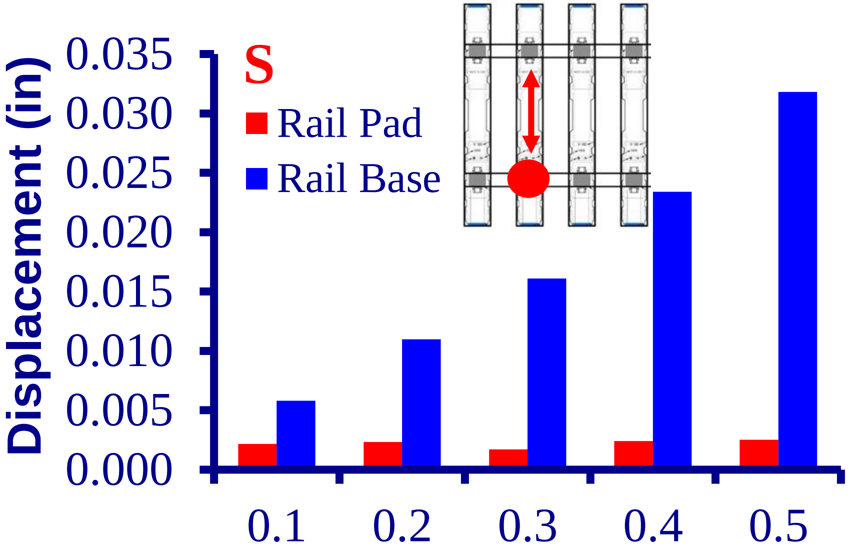
Rail Pad Lateral Displacement
(Freight Consist on HTL)

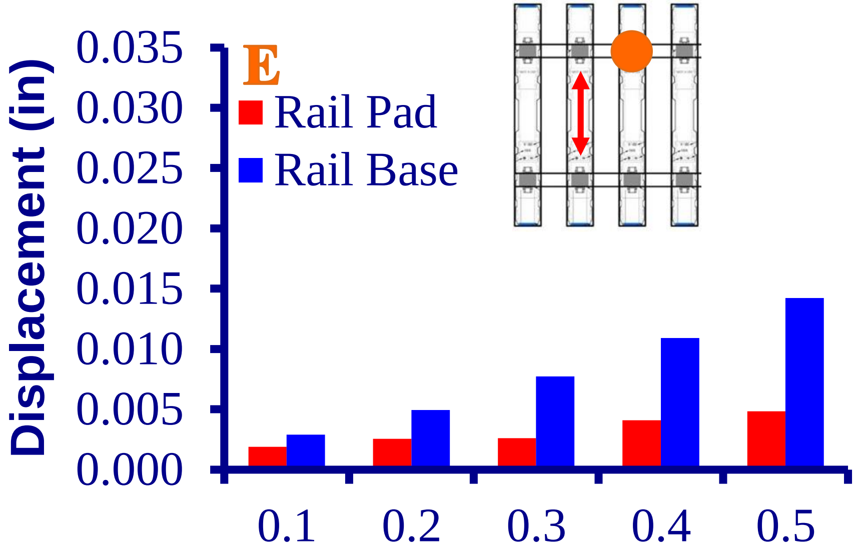


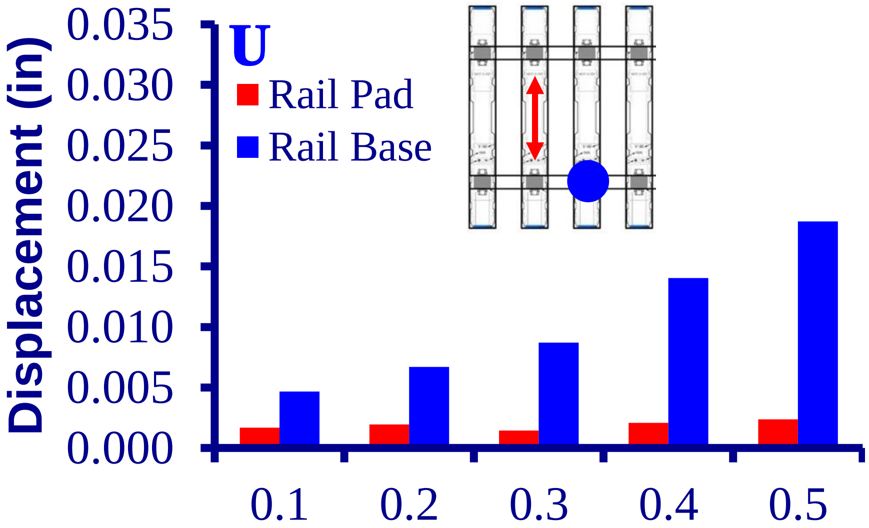
Rail Base and Rail Pad Lateral Displacement
(Track Loading Vehicle on RTT)

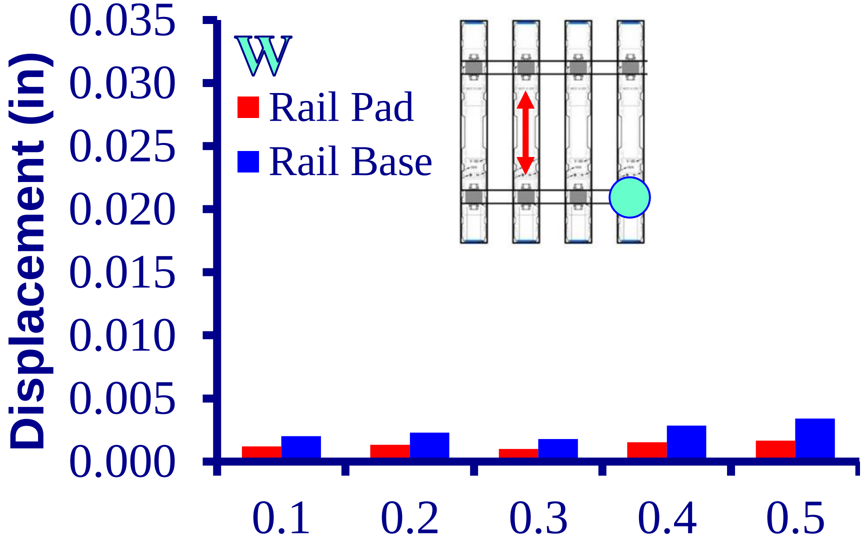


Relative Lateral Displacement Between Rail Base and Rail Pad Assembly (40 kips Vertical Load)





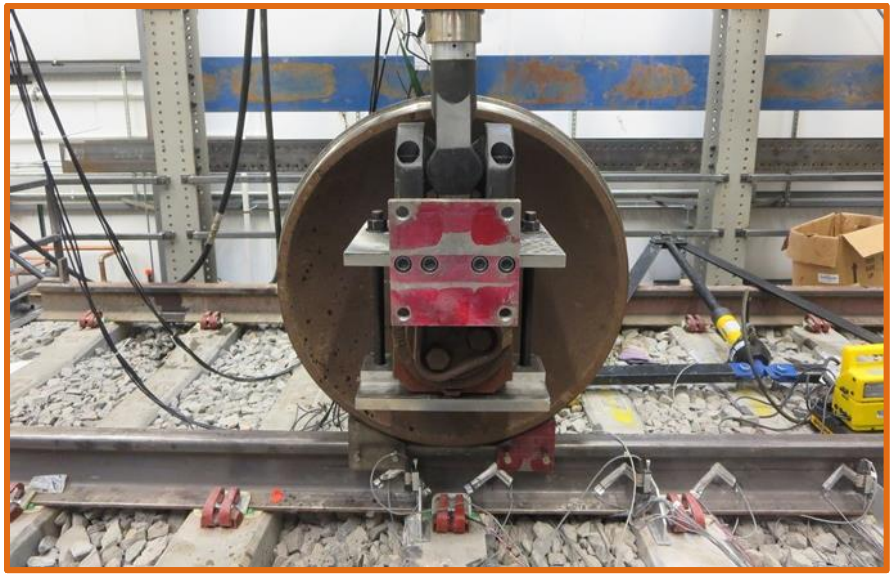


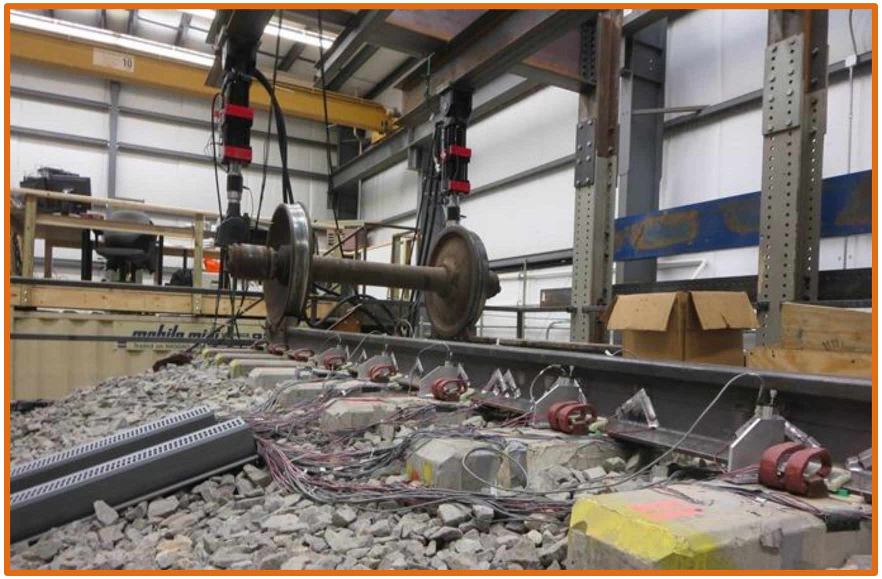


Conclusions

- Relative displacements of the rail pad assembly and rail base with respect to the concrete crosstie were successfully measured 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 six 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 magnitudes of lateral forces
- Lateral displacement of rail and rail pad assembly should be considered in fastening system design and material selection

Future Work: RailTEC's Research and Innovation Laboratory (RaIL)





Acknowledgements

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FRA Tie and Fastener BAA Industry Partners:

- Funding for this research has been provided by
  - Federal Railroad Administration (FRA)
  - National University Rail Center - NURail
- Industry Partnership and support has been provided by
  - Union Pacific Railroad
  - BNSF Railway
  - National Railway Passenger Corporation (Amtrak)
  - Amsted RPS / Amsted Rail, Inc.
  - GIC Ingeniería y Construcción
  - Hanson Professional Services, Inc.
  - CXT Concrete Ties, Inc., LB Foster Company
  - TTX Company
  - Transportation Technology Center, Inc (TTCI)
- For assisting with research and experimentation
  - Marcus Dersch, George Chen, Brandon Van Dyk

Questions or Comments?

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Thank you!