Vertical load path under static and dynamic loads in concrete crosstie and fastening systems

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Outline

- Research objective and scope
- Instrumentation Overview
- Defining the vertical load path
- Understanding rail seat loads
  - Fraction of vertical load
- Vertical tie deflections
  - Effect on rail seat load
- Dynamic wheel loads

Purpose of Vertical Load Path Analysis

- Identify the load path of vertical forces through the concrete crosstie and fastening system
- Quantify the demands on each component in the system
- Determine how crosstie support variability effects the demands on the components within the vertical load path
- Provide vital inputs to the development of a finite element (FE) model and method of performing mechanistic design of the concrete crossties and fastening systems
- Provide insight for future field testing in revenue service applications

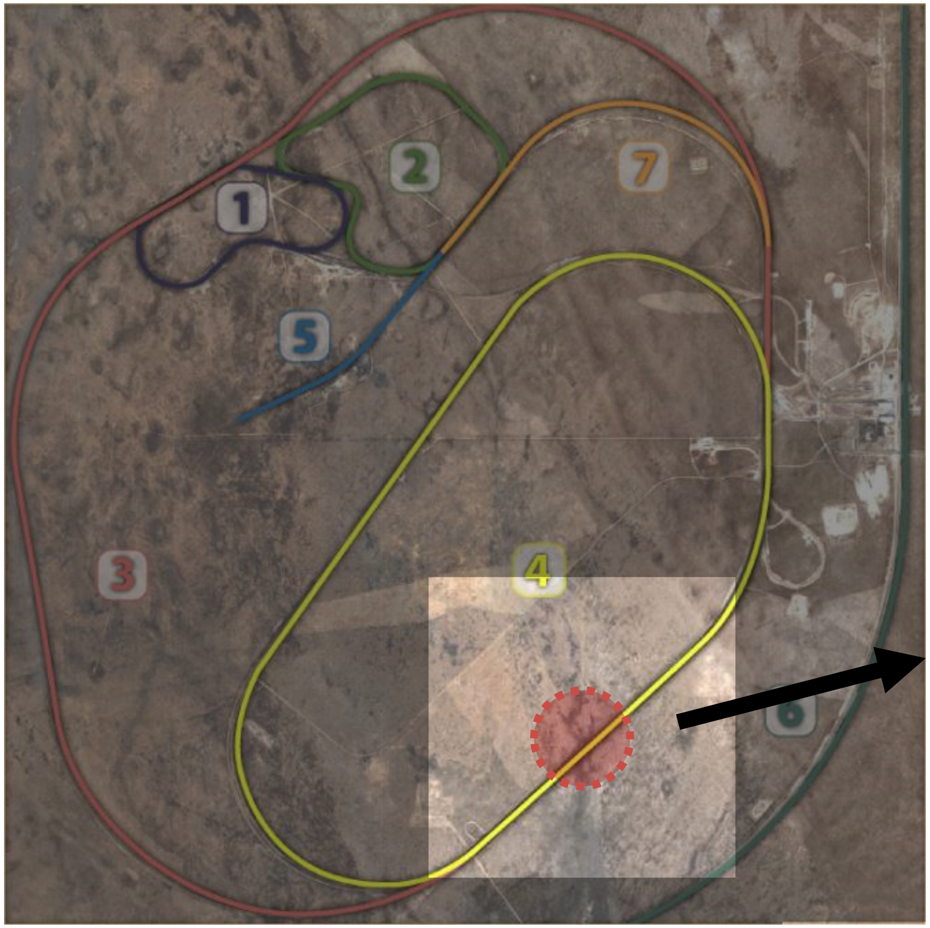
Background Knowledge and Findings

- Field experimentation and modeling show that vertical load is distributed over multiple ties
- Rail seat load is of more relevance than the wheel load with respect to the design of the concrete crosstie and fastening system
- Stiffness of each component is critical to the system and contributes to overall behavior

Field Instrumentation Locations

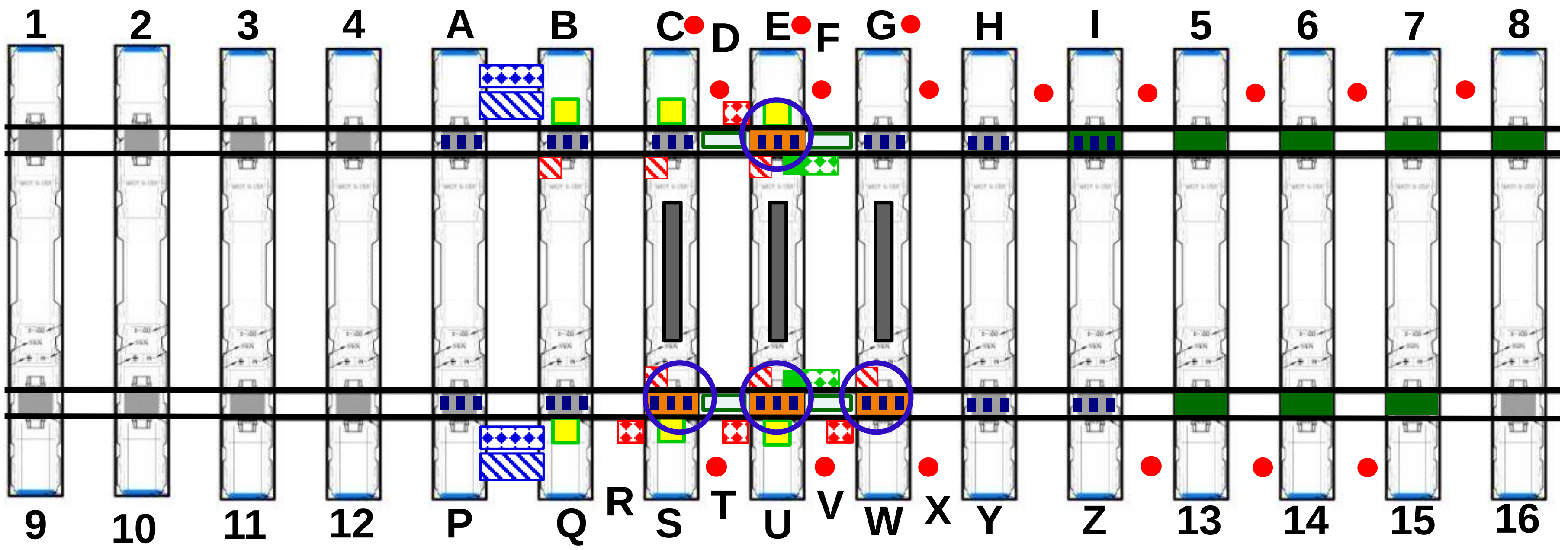
- TTCI (Pueblo, CO)
- High Tonnage Loop (HTL)
  - Curve (2-3°)
  - Safelok I Fasteners

Field Instrumentation Locations



- TTCI (Pueblo, CO)
- Railroad Test Track (RTT)
  - Tangent
  - Safelok I Fasteners

Field Instrumentation Strategy (May 2013)



Rail Displacement Fixture

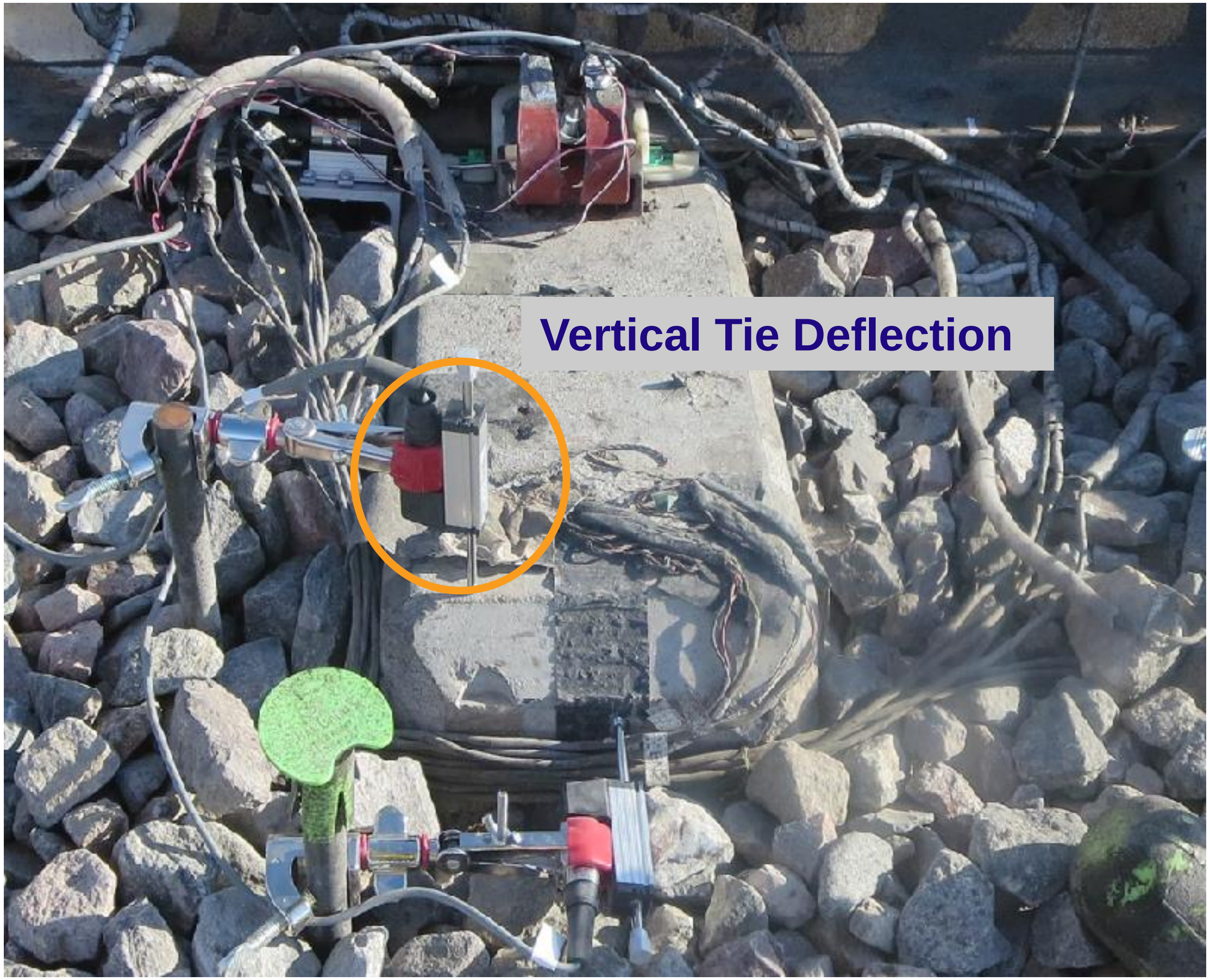
Rail Longitudinal Displacement/Strains

Vertical Web Strains

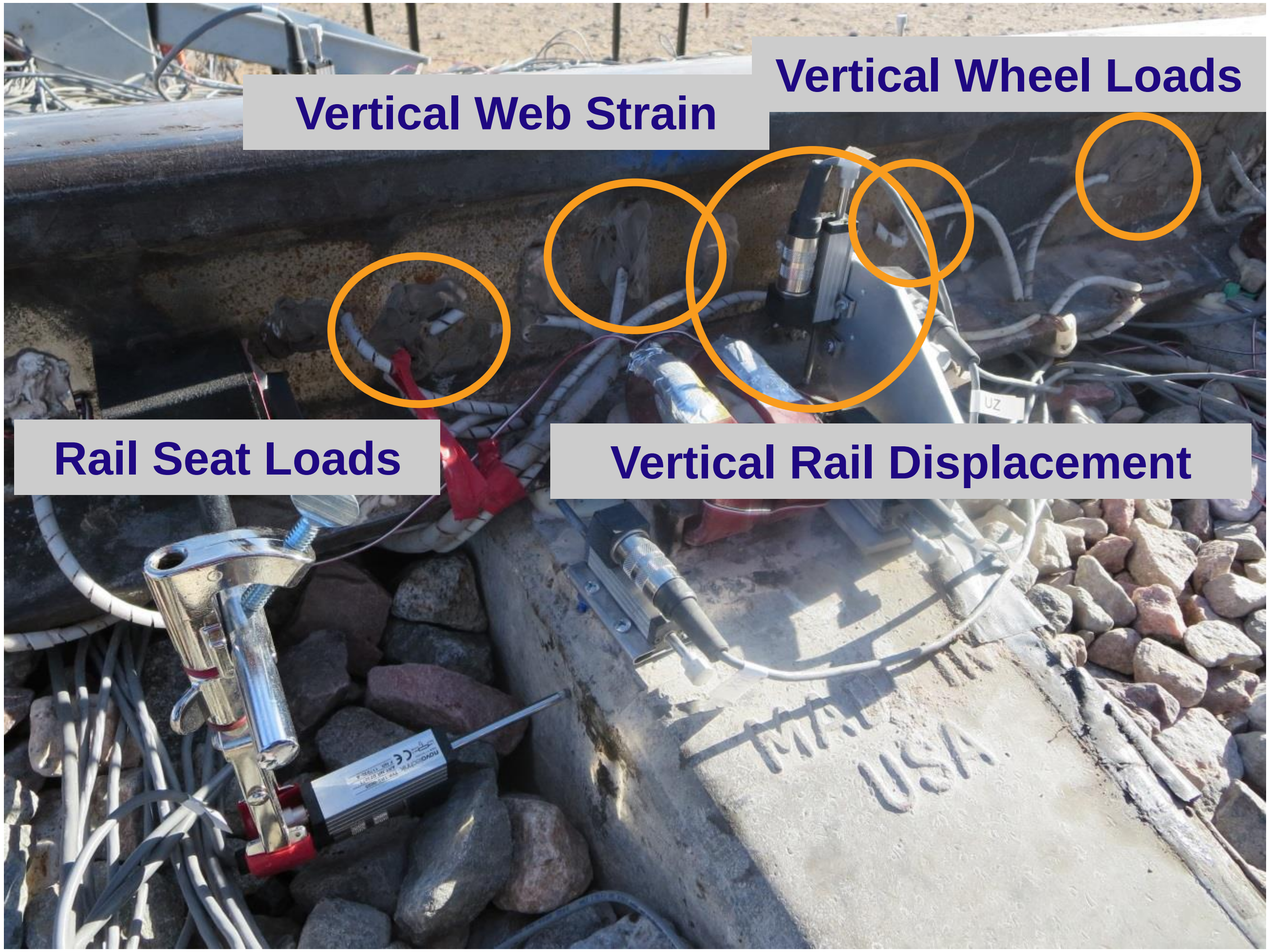
Vertical and Lateral Circuits

Steel Rods

Vertical Load Path Instrumentation
Field Side

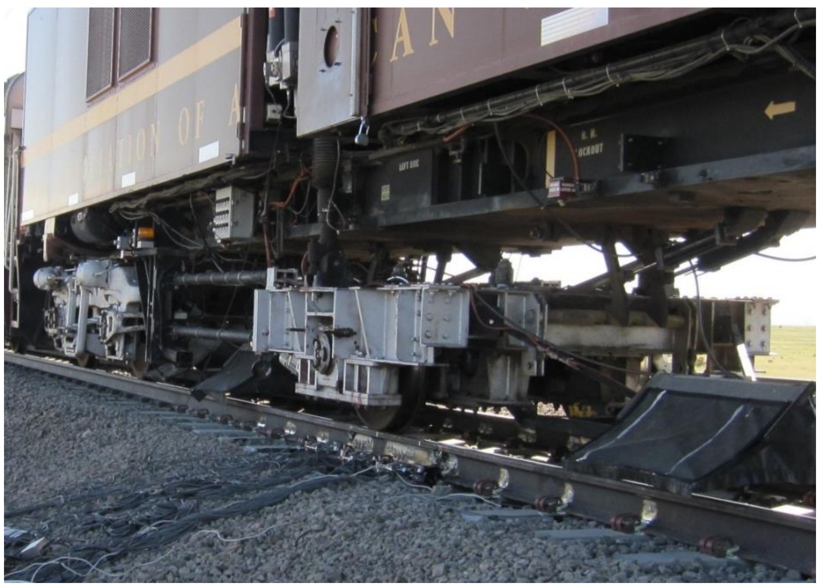


Vertical Load Path Instrumentation
Gauge Side



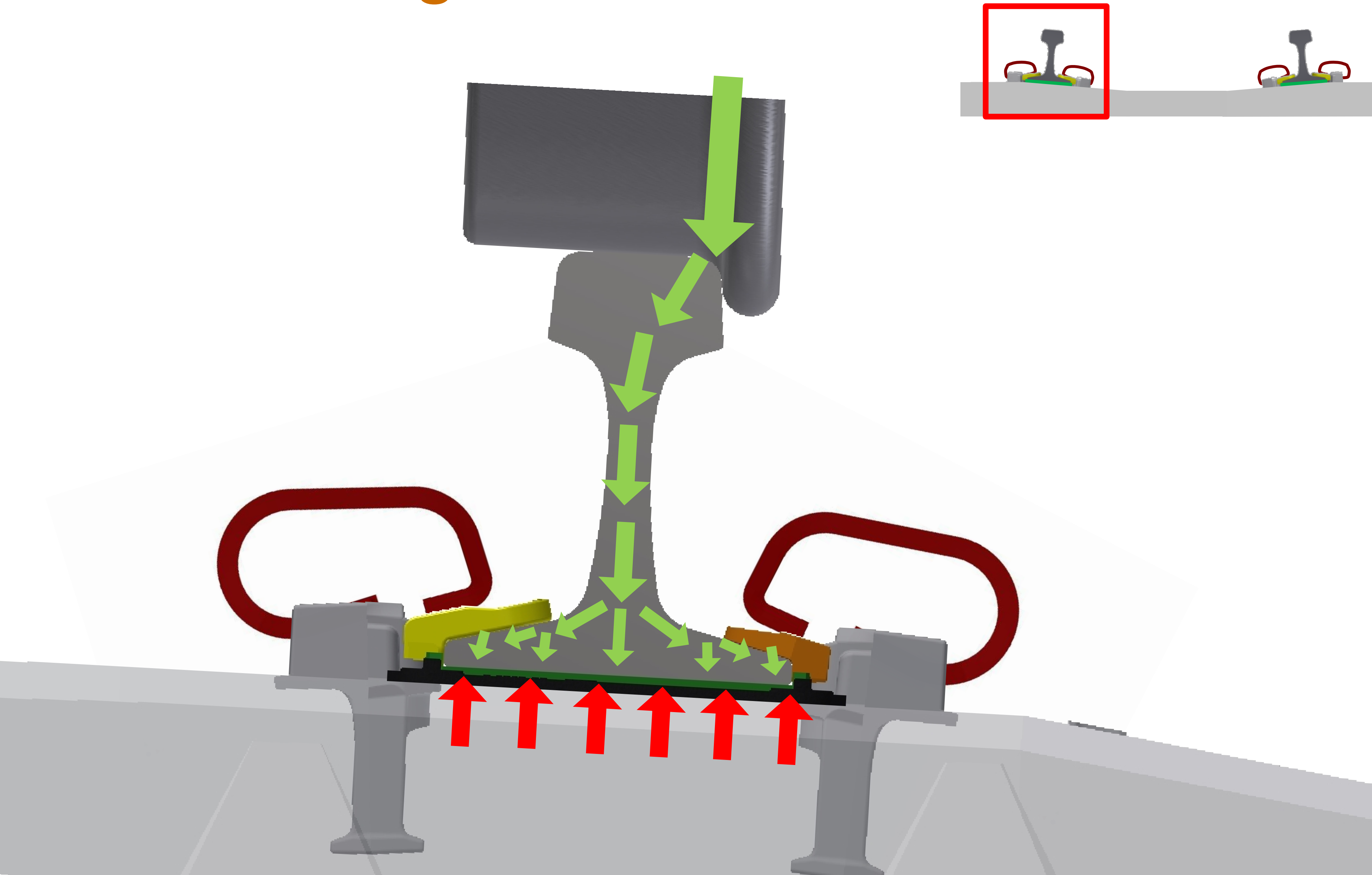
Loading Environment

- Track Loading Vehicle (TLV)
  - Static
  - Dynamic

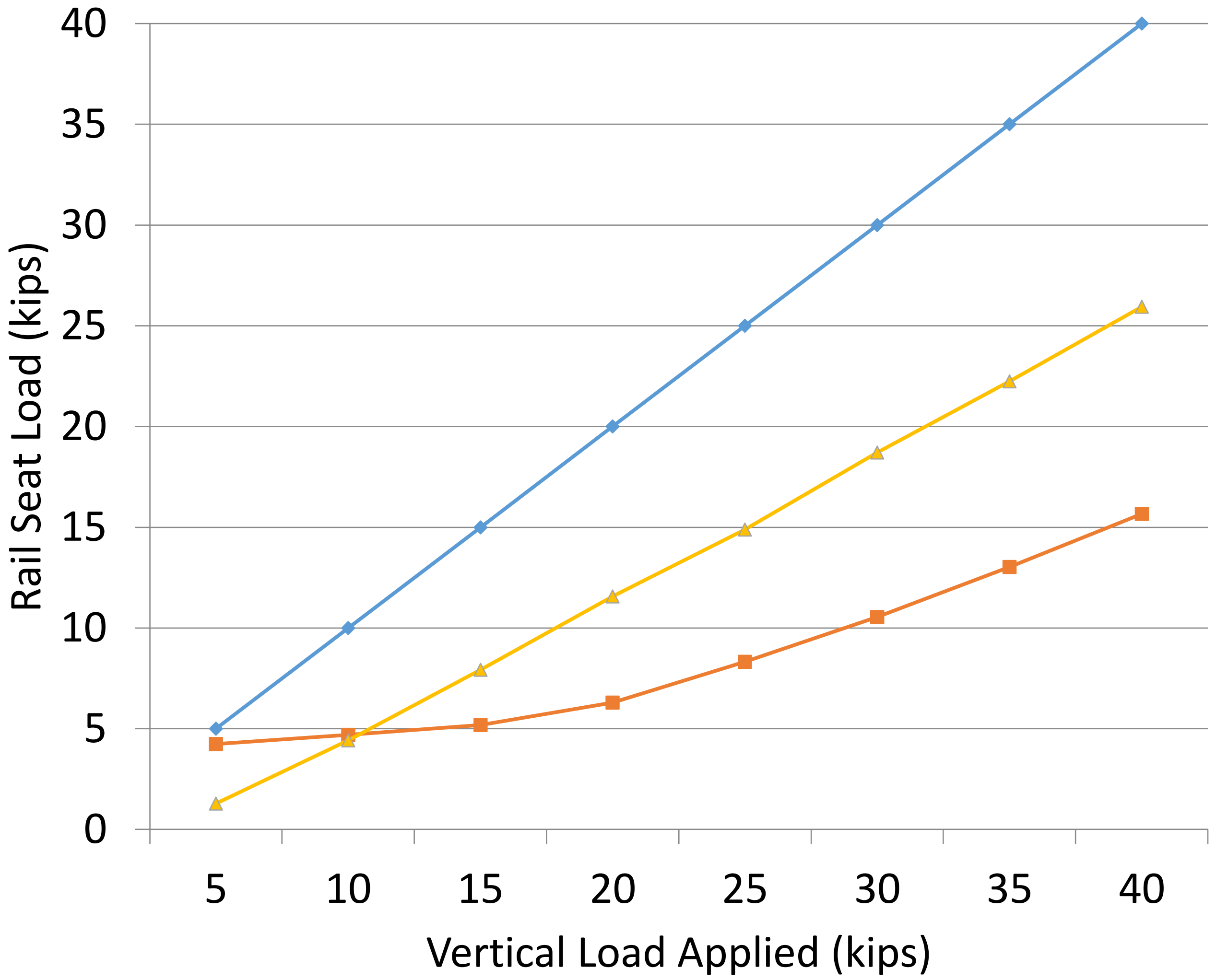


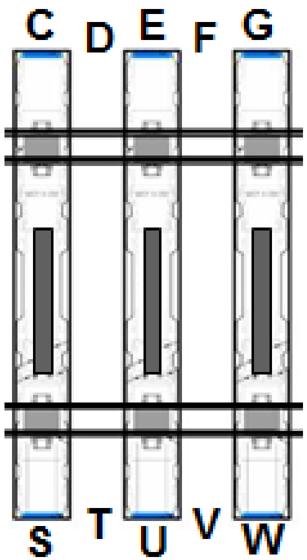
- Freight Consist
  - 3, 6-axle locomotives on HTL
  - 4-axle locomotives on RTT
  - 9 loaded and one empty freight cars
- Passenger Consist
  - 6-axle locomotive on HTL
  - 4-axle locomotive on RTT
  - 10 coaches
- FAST Train

Defining the Vertical Load Path

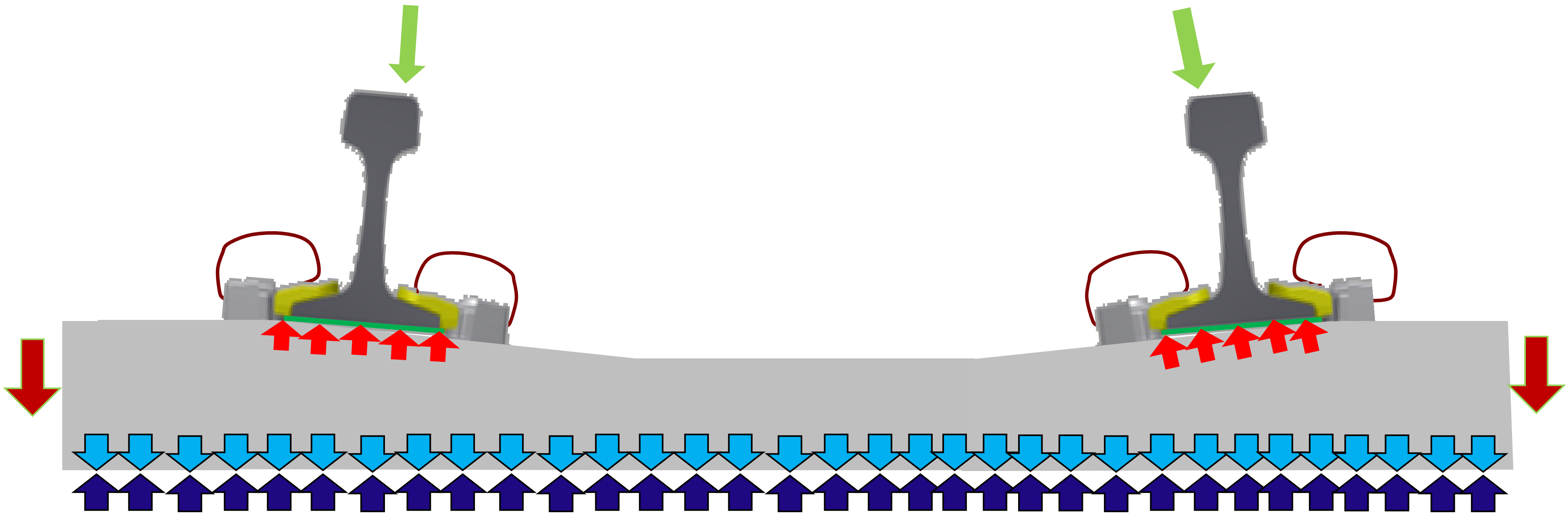


Rail Seat Loads
Tangent Track, RTT



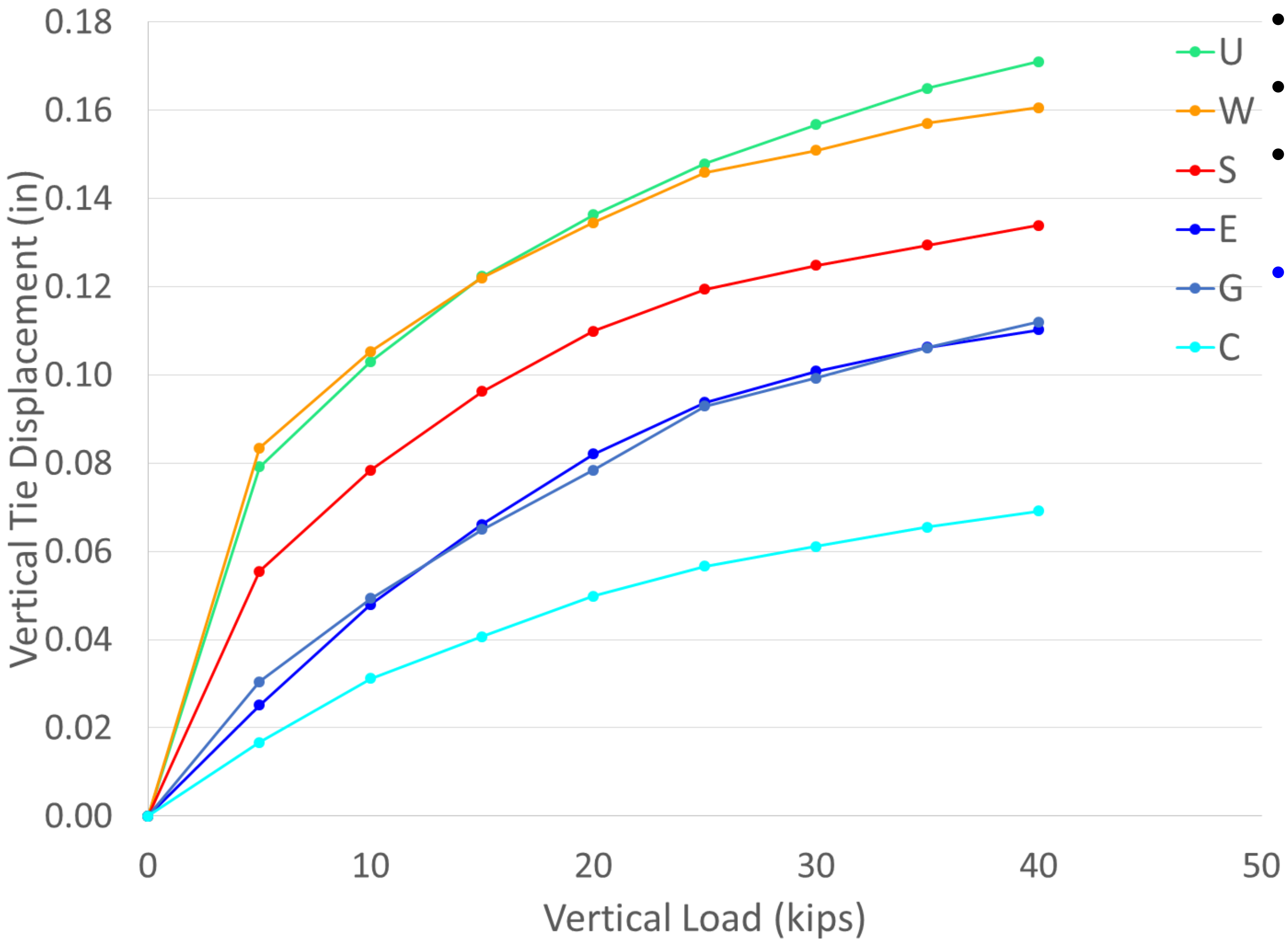


Defining the Vertical Load Path

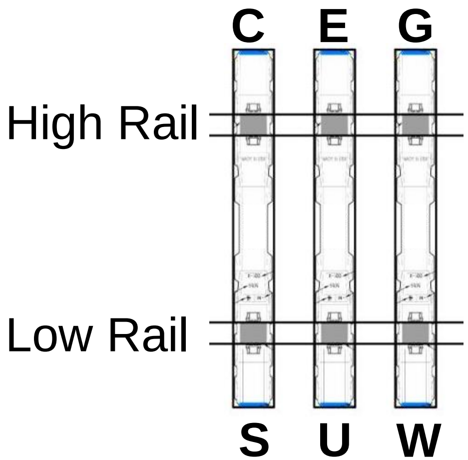


Crosstie Support Variability:

Vertical Crosstie Displacement

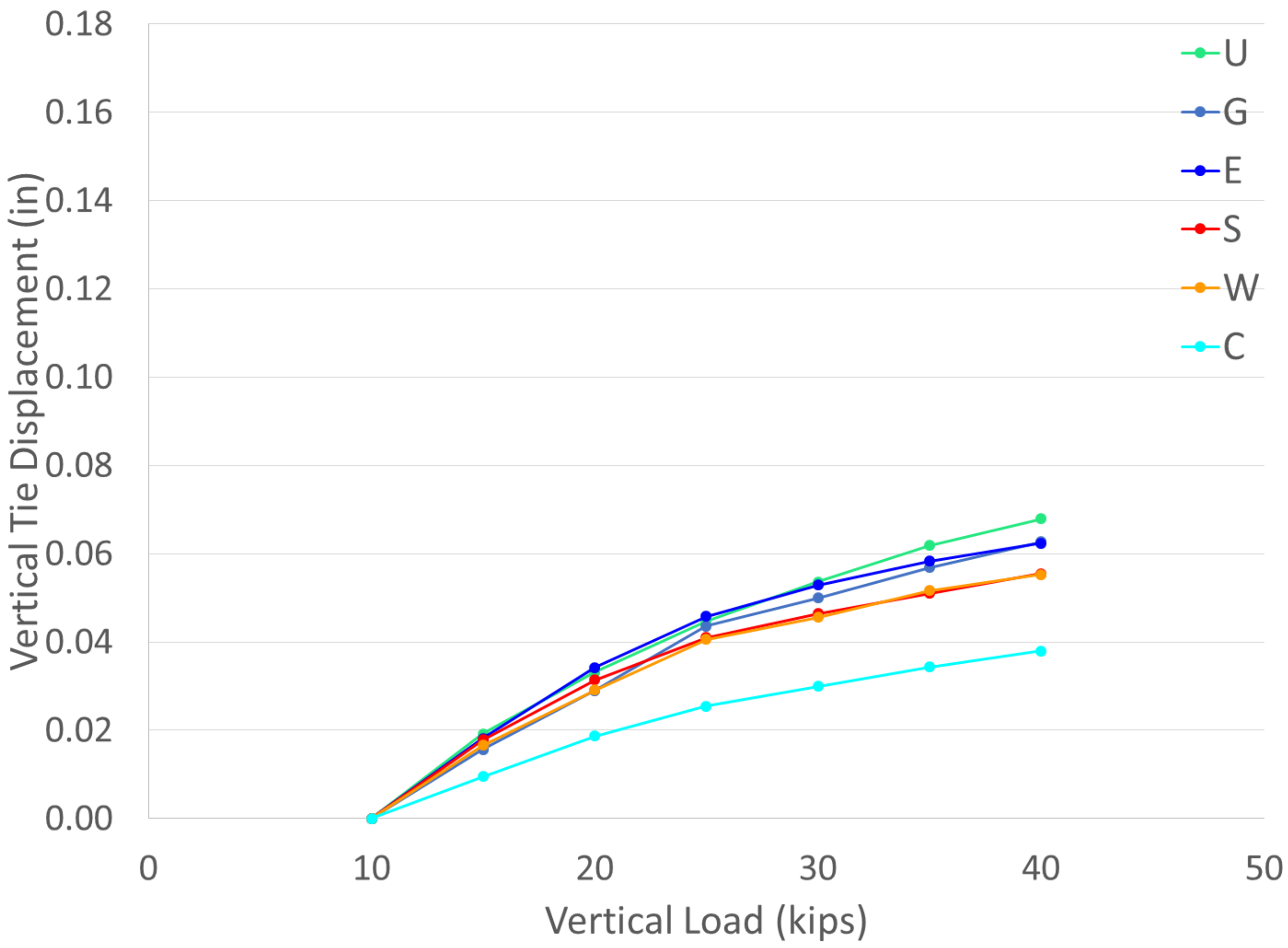


- Curve track
- Static vertical loads
- Max applied load = 40 kips
- Low rail: soft support (slack or gap in support system)



Crosstie Support Variability:

Vertical Crosstie Displacement – with 10 kip preload



- Curve track
- Static vertical loads
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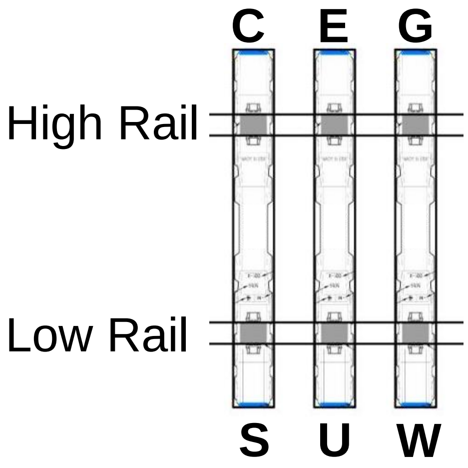
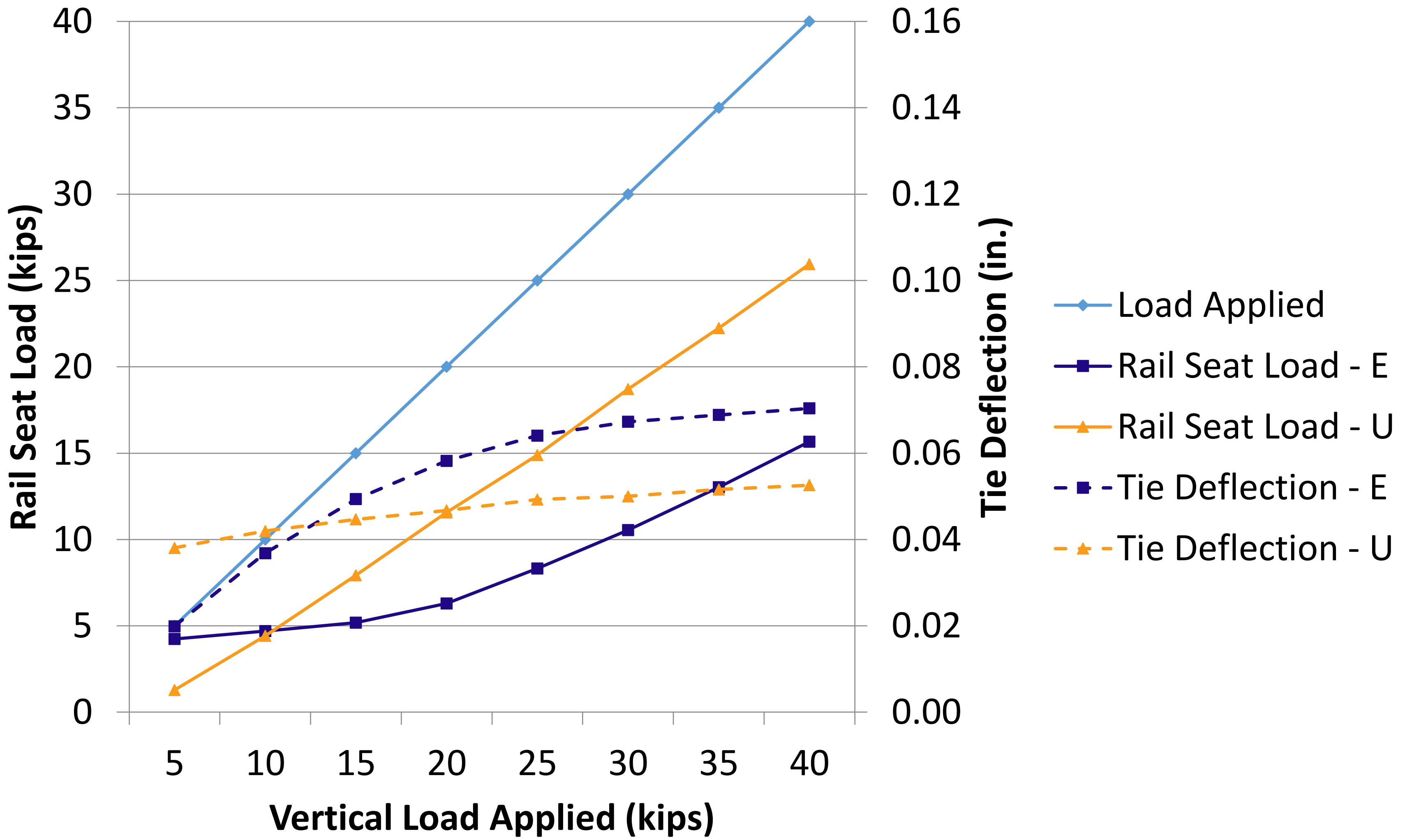
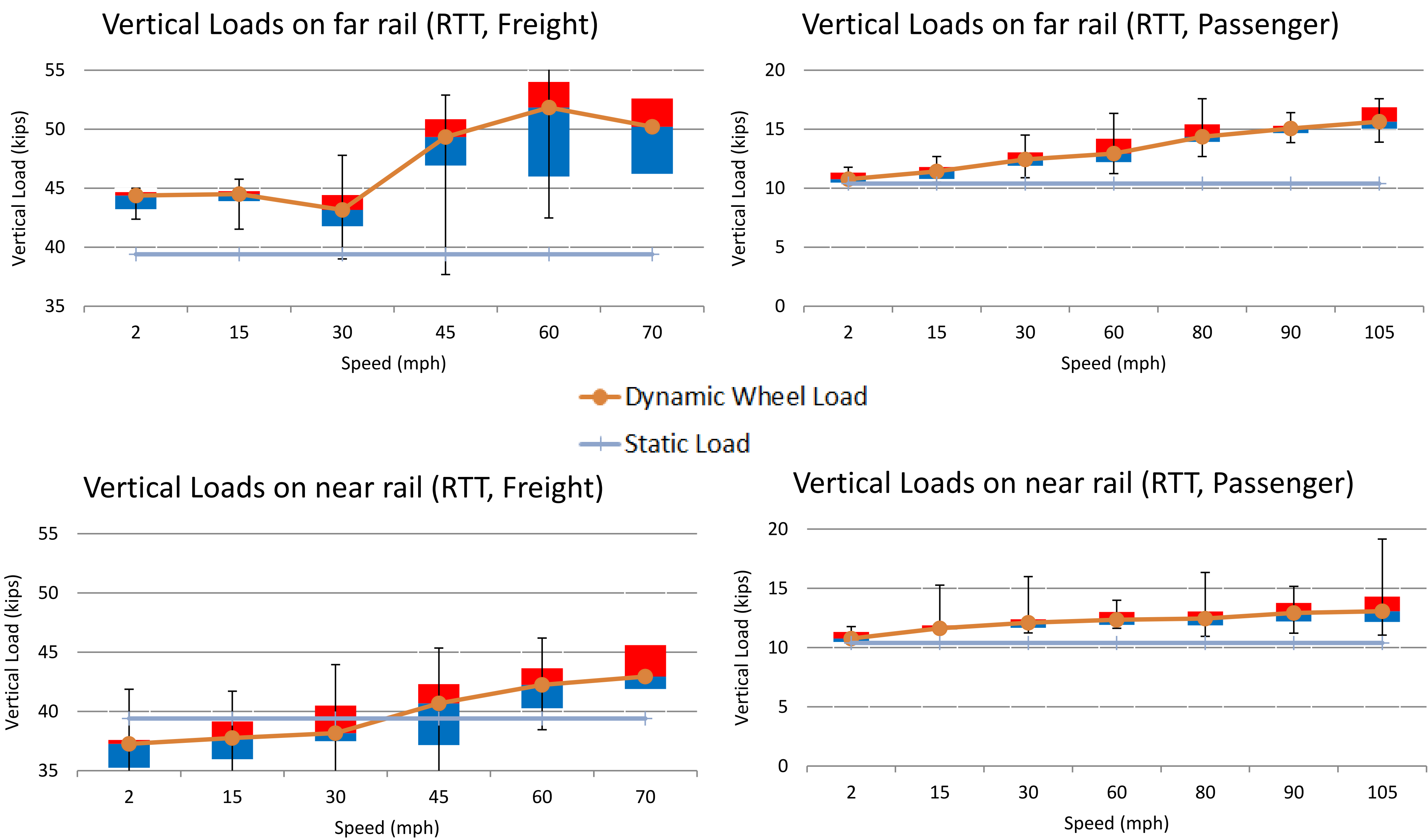


Rail Seat Loads and Deflection



Dynamic Wheel Loads - RTT



Conclusions

- **Observed Loads**
  - Dynamic wheel loads are not significantly higher than static wheel loads
  - Observed loads are similar to revenue service loads, minus the impact loads
- **Rail Seat Loads**
  - 30-80% of the vertical wheel load is resisted by each rail seat (high variability)
  - Ballast stiffness plays key role
  - Vertical rail seat load is independent of lateral loads
- **Tie Deflection**
  - Tie deflections are highly affected by track stiffness
  - Static tie deflection is considered an important system parameter for design

Future Work

- Continue analysis of data to understand the governing mechanisms of the tie and fastener system
- Continue to compare and validate the FE model
- Relate ballast stiffness to the tie deflections
- Create empirical models relating stiffness to loading demands on each component (rail pad, rail seat, etc.)
- Conduct small-scale, evaluative revenue service testing on Class I railroads

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Questions or Comments?

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