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

Joint Rail Conference
Colorado Springs, CO
2 – 4 April, 2014

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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 affects 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 Analysis

Vertical Load Path Instrumentation

Field Side
Vertical Load Path Analysis

**Gauge Side**

- Vertical Load Path Analysis
- Vertical Rail Displacement
- Vertical Web Strain
- Rail Seat Loads
- Vertical Wheel Loads
- Vertical Rail Displacement
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

Vertical Load Applied (kips)

Load Applied
Rail Seat Load - E
Rail Seat Load - U
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)

![Graph showing vertical load path analysis with different rail locations and displacement over load.]
Crosstie Support Variability:
Vertical Crosstie Displacement – with 10 kip preload

- Curve track
- Static vertical loads
- Max applied load = 40 kips

![Graph showing vertical load path analysis with curves for different rail types and loads.](image)
Rail Seat Loads and Deflection

![Graph showing Rail Seat Load and Tie Deflection versus Vertical Load Applied](image_url)
Dynamic Wheel Loads - RTT

Vertical Loads on far rail (RTT, Freight)

Vertical Loads on near rail (RTT, Freight)

Vertical Loads on far rail (RTT, Passenger)

Vertical Loads on near rail (RTT, Passenger)
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
References


Acknowledgements

U.S. Department of Transportation
Federal Railroad Administration

- Funding for this research has been provided by the Federal Railroad Administration (FRA)
- 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.
  - Dave Davis, Justin Penrod
- For assistance in instrumentation preparation:
  - Harold Harrison, Mike Tomas

FRA Tie and Fastener BAA
Industry Partners:
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