Using Wheel Impact Load Detector Data to Understand Wheel Loading Environment

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Outline

• Objectives of quantifying load amplification
• Wheel load distribution on shared infrastructure
  – Causes of load amplification
• Identification of load amplification factors
  – Dynamic wheel load factors
  – Impact factors
• Wheel loads on curved track
• Conclusions and Acknowledgements
Objectives

• Use wheel impact load detector data to understand wheel loading environment, leading to improved design of track structure that reflects actual loading demands

• Characterize and quantify increase above static wheel load due to several factors
  – Temperature
  – Speed
  – Irregularities

• Identify dynamic and impact wheel load factors

• Summarize alternative data collection methods
Wheel Impact Load Detectors (WILD)

- Sixteen sets of strain gauges to detect full rotation of most wheels
- For each wheel,
  - Labels by vehicle type
  - Measures speed, nominal (static) wheel load, and peak wheel load
WILD Data Provided by Amtrak and UP
Traffic Distribution – Nominal Wheel Loads

Source: Amtrak – Edgewood, MD (November 2010)

10 kips ≈ 45 kN
Using WILD Data to Understand Wheel Loading Environment

Traffic Distribution – Peak Wheel Loads

- Freight Locomotives
- Intermodal Freight Cars
- Passenger Coaches
- Passenger Locomotives
- Other Freight Cars

Source: Amtrak – Edgewood, MD (November 2010)

10 kips ≈ 45 kN
Nominal vs. Peak Vertical Load

Source: Amtrak – Edgewood, MD (November 2010)

10 kips ≈ 45 kN
Effect of Traffic Type on Peak Wheel Load

- **Freight Cars**
- **Passenger Coaches**

- **UNLOADED FREIGHT CARS**
- **LOADED FREIGHT CARS**
- **PASSENGER COACHES**

Source: Amtrak – Edgewood, MD (November 2010)

10 kips ≈ 45 kN
Seasonal Variation of Freight Wheel Loads

Source: Union Pacific – Gothenburg, NE (2010)

10 kips ≈ 45 kN
Seasonal Variation of Highest Freight Wheel Loads

Source: Union Pacific – Gothenburg, NE (2010)
Dynamic vs. Impact Load

• Static load – load of vehicle at rest
• Quasi-static load – static load at speed, independent of time
• Dynamic load – high-frequency effects of wheel/rail interaction, dependent on time
  – E.g., \( \text{Dynamic Factor} = 1 + \frac{33 \text{(speed (mph))}}{100 \text{(diameter (in.))}} \)
• Impact load – high-frequency and short duration load caused by track and vehicle irregularities
  – E.g., increase of 200% (found in AREMA Chapter 30)
Effect of Speed on Wheel Load

Source: Amtrak – Edgewood, MD (November 2010)

10 kips ≈ 45 kN, 10 mph ≈ 16 kph
Comparison of Dynamic Wheel Load Factors

- Talbot
- Indian Railways
- Eisenmann
- ORE/Birmann
- German Railways
- South African Railways
- Clarke
- WMATA
- Sadeghi
- AREMA C30

Dynamic Factor, $\phi$

Speed (mph)

10 mph $\approx$ 16 kph
Dynamic Wheel Load Factors

Impact Factor vs Speed (mph)

- Talbot
- Indian Railways
- Eisenmann
- ORE/Birmann
- German
- South African Railways
- Clarke
- WMATA
- Sadeghi
- AREMA C30

Source: Amtrak – Edgewood, MD (November 2010)

10 mph ≈ 16 kph
Using WILD Data to Understand Wheel Loading Environment

Other Effects on Peak Wheel Load

Source: Amtrak – Mansfield, MA (November 2010)
More than a Dynamic Factor: Impact Factor

Impact Factor (IF) = \frac{\text{Peak Load}}{\text{Static Load}}

Source: UPRR – Gothenburg, NE (January 2010)

10 kips ≈ 45 kN
Thoughts on Impact Factor

• AREMA Chapter 30 Impact Factor (300%) exceeds majority of locomotive and loaded freight car loads
  – Greater impact factor may be necessary for lighter rolling stock (passenger coaches and unloaded freight cars)
  – Wheel condition significantly affects load
  – Speed causes highest impacts to be higher

• Evaluating effectiveness of impact factor dependent on static weight of car
Other Factors Affecting Wheel Loads

- Moisture and temperature
- Position within the train
- Curvature
- Grade
- Track quality

UIUC Instrumentation Plan

Need alternative data collection methods

Instrumented Wheel Set

Truck Performance Detector
Alternative Data Collection Methods

- Instrumented Wheel Set
  - Vehicle-mounted; collects data at 300 Hz
  - Measures vertical and lateral loads in tangent, curved, and graded sections
- Truck Performance Detector
  - Wayside detector in tangent and curved sections
  - Measures vertical and lateral loads of each wheel
- UIUC Instrumentation Plan (thus far implemented at TTC)
  - Instrumented track in tangent and curved sections
  - Continuously measures each wheel in multiple locations for vertical load, lateral load, and various deflections
IWS: Wheel Loads on Left-Handed Curve

Source: AAR (2006)
Lateral Loads within Left-Handed Curve

Source: AAR (2006)

10 kips ≈ 45 kN, 0.1 in = 2.54 mm
Conclusions

• Wheel impact load detectors can be used to characterize the loading environment, leading to improved track design.

• Colder temperatures do not increase the majority of the wheel loads; winter conditions do increase highest impact loads.

• Dynamic and impact wheel load factors can be compared and objectively evaluated, resulting in improved decision-making in design.

• The use of technology typically reserved for monitoring mechanical health can also provide increased insight into track design and maintenance.
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Questions

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