Quantification of Concrete Sleeper and Elastic Fastening System Demands Utilizing Concrete Sleeper Rail Seat Contact Area

Matthew J. Greve
Graduate Research Assistant, University of Illinois, USA

Christopher T. Rapp
Graduate Research Assistant, University of Illinois, USA

Marcus S. Dersch
Research Engineer, University of Illinois , USA

J. Riley Edwards
Senior Lecturer, University of Illinois, USA

Christopher P. L. Barkan
Professor, University of Illinois, USA

Jose Mediavilla
Director of Engineering, Amsted RPS, USA

Brent Wilson
Director of Research and Development, Amsted Rail Inc., USA

RAILTEC
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

U.S. Department of Transportation
Federal Railroad Administration

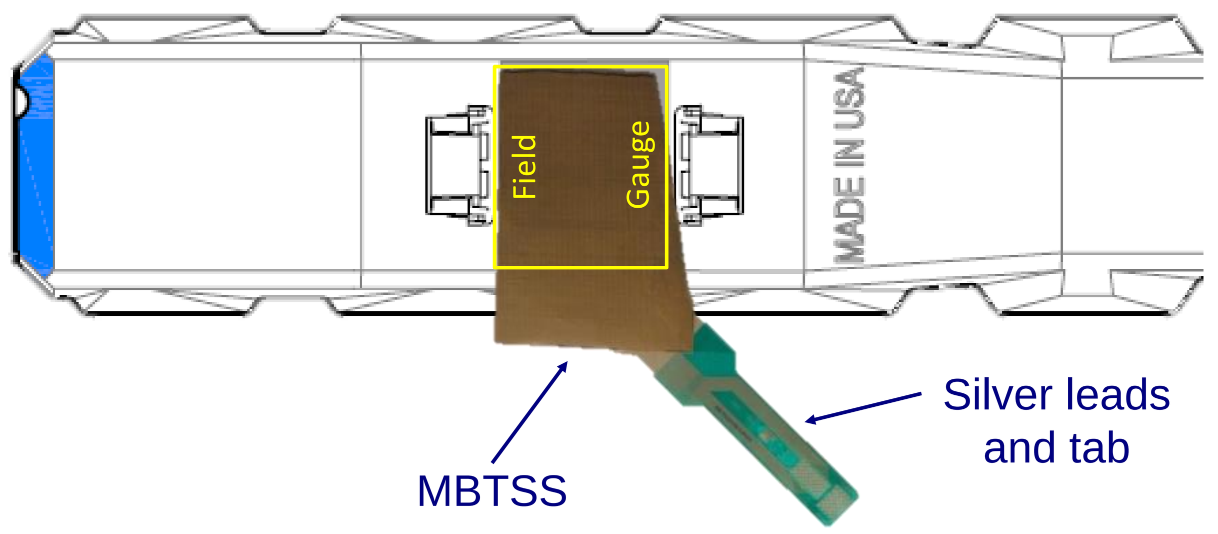
WCRR 2013
Sydney Australia

INTRODUCTION

- Surveys conducted by UIUC report that North American Class I Railroads and other railway infrastructure experts ranked rail seat deterioration (RSD) as one of the most critical problems associated with concrete sleeper and fastening system performance (2008, 2012). *RSD is the degradation of concrete underneath the rail pad, resulting in track geometry problems*
- **Research objective: measure the magnitude and distribution of pressure at the concrete sleeper rail seat and investigate crushing as a feasible failure mechanism leading to RSD**
- Experimentation is being performed to compare pressure distributions on rail seats under various loading scenarios and fastening systems, and identify regions of high pressure while quantifying peak values
- Results from Matrix-Based Tactile Surface Sensors (MBTSS) are providing a better understanding of the load transfer from the wheel/rail interface to the rail seat

MBTSS TECHNOLOGY

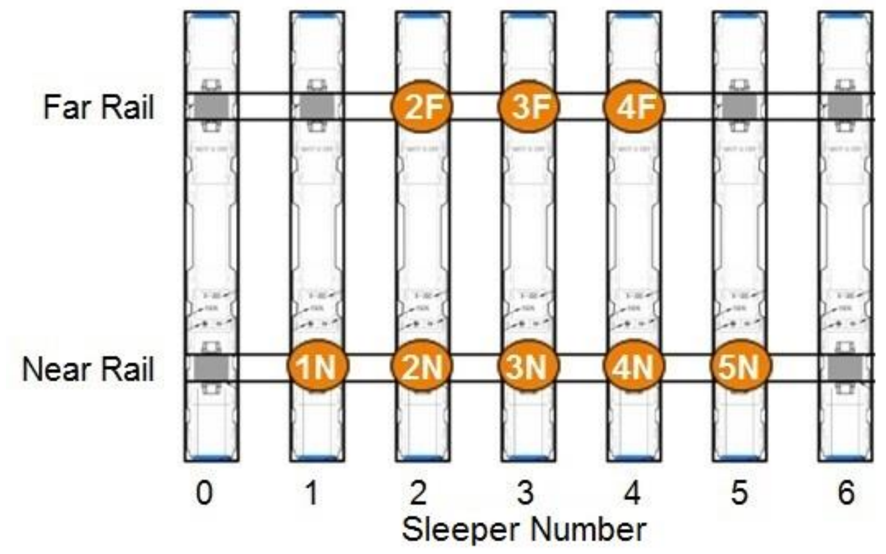
- Sensors are comprised of two thin sheets of polyester with a total thickness of 0.10 mm
- On one sheet, a pressure sensitive semi-conductive material is printed on rows; on the other, in columns, which forms a grid when overlaid
- Conductive silver leads extend from each column and row to the "tab" from which data is collected by a data acquisition handle
- Known input loads are currently applied to MBTSS data to quantify the pressure distributions
- Sensors can be trimmed to fit various concrete rail seat dimensions
- Sensors must be protected from puncture and shear with BoPET and PTFE respectively



Plan View of MBTSS Installed on Concrete Sleeper with Relative Rail Seat Area

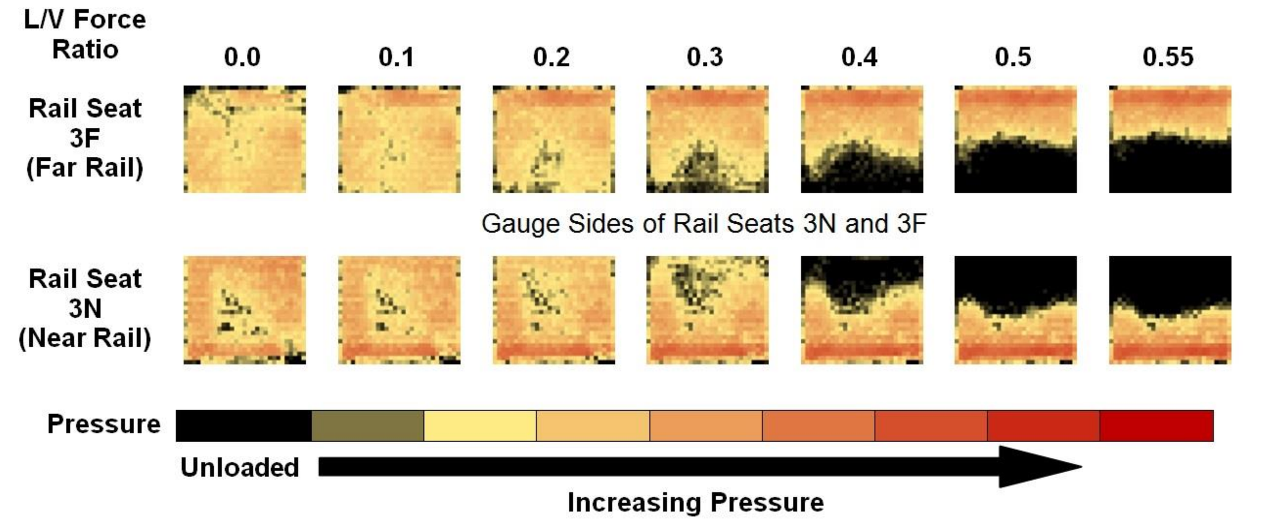
FIELD INSTRUMENTATION

- Field experimentation was conducted at the Transportation Technology Center (TTC) in Pueblo, CO, USA
- Eight rail seats were instrumented with MBTSS
  - Five consecutive rail seats were instrumented to capture the complete distribution of a single wheel load
  - Three sleepers were instrumented at both rail seats to investigate the variability between rail seats of a single sleeper in areas of curvature
- Results presented focus on data acquired from static loads applied to tangent track using the Association of American Railroad's (AAR) Track Loading Vehicle (TLV) which can apply precise vertical and lateral loads via a deployable axle



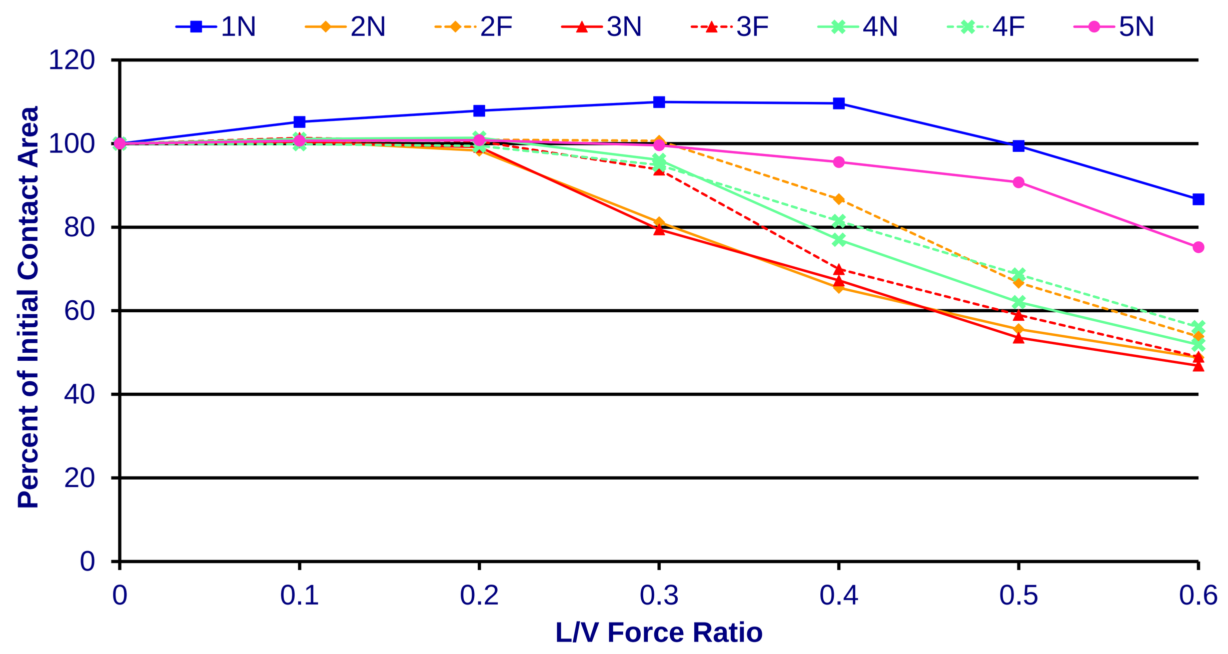
Plan View of MBTSS Field Instrumentation Installation

RAIL SEAT PRESSURE DISTRIBUTION

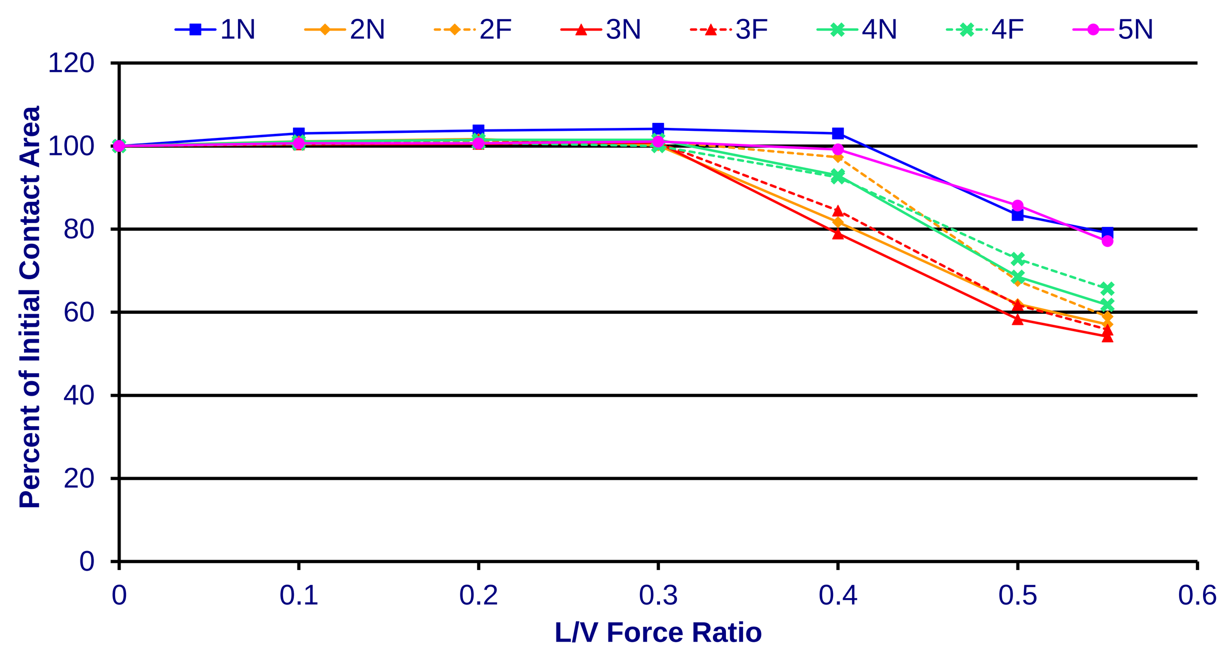


Rail Seat Pressure Distributions Under Varying L/V Force Ratios

- Data analysis shows a reduction in rail seat contact area as L/V force ratio increases while maintaining a constant vertical load
- At L/V force ratios higher than 0.4 , a portion of the gauge side of the rail seat may become unloaded
- There exists a "threshold" L/V force ratio where a clear division between regions of constant and rapidly decreasing contact area is visible
- The decreasing of contact area is caused by rail base rotation



Contact Area Reduction at 88.9 kN (20,000 lb) Vertical Load



Contact Area Reduction at 178 kN (40,000 lb) Vertical Load

CONCLUSIONS

- Rail seat pressure distributions are not uniform across a rail seat
- High L/V force ratios can cause force concentrations on the field side of the rail seat, which could lead to accelerated RSD through high-pressure abrasion
- Rail base rotation at high L/V force ratios can lead to a complete unloading of the gauge side of the rail seat
- A load-dependent threshold L/V force ratio exists at which force concentrations on the field side of the rail seat become significant

FUTURE WORK

- The effect of clamping force magnitude and location on the "threshold" L/V force ratio will be investigated using the Railway Engineering Research Facility at the University of Illinois, USA
- The effect of increased pressure on the rate of concrete abrasion will be investigated via scaled representative laboratory experiments

UIUC Full-Scale Railway Engineering Research Facility

ACKNOWLEDGEMENTS

Amsted RPS
Amsted Rail
Union Pacific
BUILDING AMERICA
BNSF RAILWAY
AMTRAK
GIC INGENIERIA Y CONSTRUCCIÓN S.A. DE C.V.
HANSON
LB Foster
CXT Concrete Ties