ANALYSIS OF THE SHEAR BEHAVIOR OF RAIL PAD ASSEMBLIES AS A COMPONENT OF THE CONCRETE SLEEPER FASTENING SYSTEM

WCRR 2013 Sydney Australia

Thiago Bizarria do Carmo
Graduate Research Assistant, University of Illinois at Urbana-Champaign, USA

J. Riley Edwards
Research Scientist, Senior Lecturer, University of Illinois at Urbana-Champaign, USA

Ryan G. Kernes
Research Engineer, University of Illinois at Urbana-Champaign, USA

Christopher P. L. Barkan
Professor, University of Illinois at Urbana-Champaign, USA

Bassem O. Andrawes
Associate Professor, University of Illinois at Urbana-Champaign, USA

INTRODUCTION

- Rail seat deterioration (RSD) is the degradation of material immediately beneath the rail base and rail pad assembly that serves as the bearing surface on concrete crossties
- Surveys conducted by UIUC show that North American Class I Railroads and other railway infrastructure experts ranked RSD as the most critical problem associated with concrete crosstie and fastening system performance
- The rail pad assembly is the component responsible for providing a protective layer between the sleeper and the rail base distributing the loads to acceptable stress levels
- Analyzing the mechanistic behavior of rail pad assemblies is critical to improving component performance and life cycle
- This study focuses on the shear behavior of rail pad assemblies, combining laboratory and field experimentation in an attempt to analyze how surfaces interact, show how materials deform, and quantify the amount of relative displacement

FAILURE MODE AND EFFECT ANALYSIS (FMEA)

- Geometry and materials used to manufacture rail pad assemblies have significantly changed over the past thirty years
- Layered pad assembly components are capable of combining materials with distinct qualities to obtain an improved rail pad assembly
- Despite improvements, fastening system components still experience failure prior to the end of intended life
- FMEA is used to define, identify, evaluate and eliminate potential failures from the system
- FMEA was used to guide the process of answering questions related to the component behavior and also to better understand the failure modes of this components when submitted to service conditions

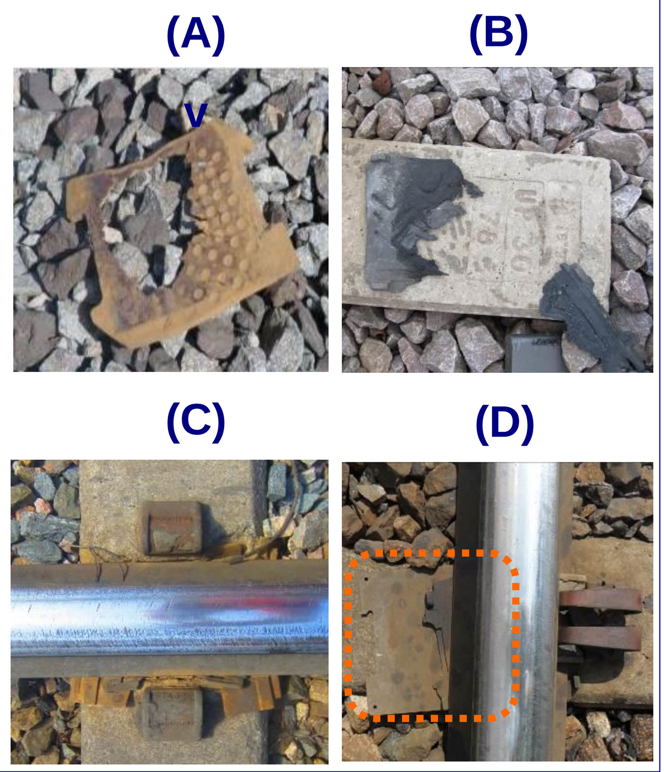
Failure Modes

- Tearing (A, B, C)
- Crushing (A, B, C)
- Abrasion (A)
- Rail Pad "walk out" (D)

Failure Causes

- Relative Displacement
- High Compressive Stress
- High Shear Stress

Deteriorated Pad Assemblies

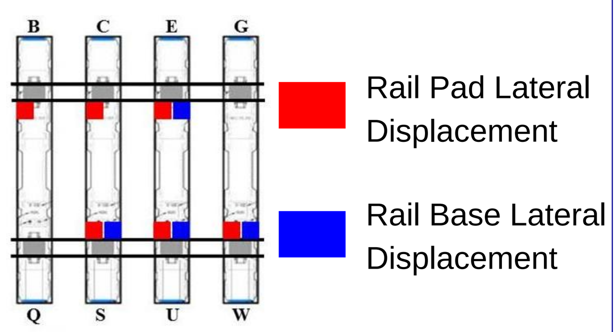


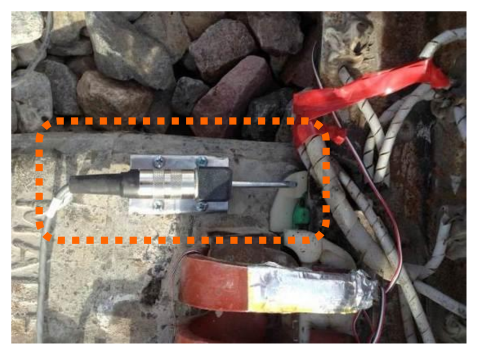
LABORATORY AND FIELD INSTRUMENTATION

- Development of a representative laboratory experiment and field test protocol to quantify the total lateral displacement of rail pad assemblies is critical to the understanding of the mechanistic behavior of this component
- The Amsted RPS Pulsating Loading Testing Machine (PLTM) was used to execute the laboratory experiments
- Realistic service conditions were represented by applying full-scale static and dynamic loads with hydraulic actuators
- Field tests performed at the Transportation Technology Center (TTC) on a curve (HTL) and tangent (RTT) section
- Field loading applied by the Track Loading Vehicle (TLV), passenger consist, and freight consist

Laboratory

Field





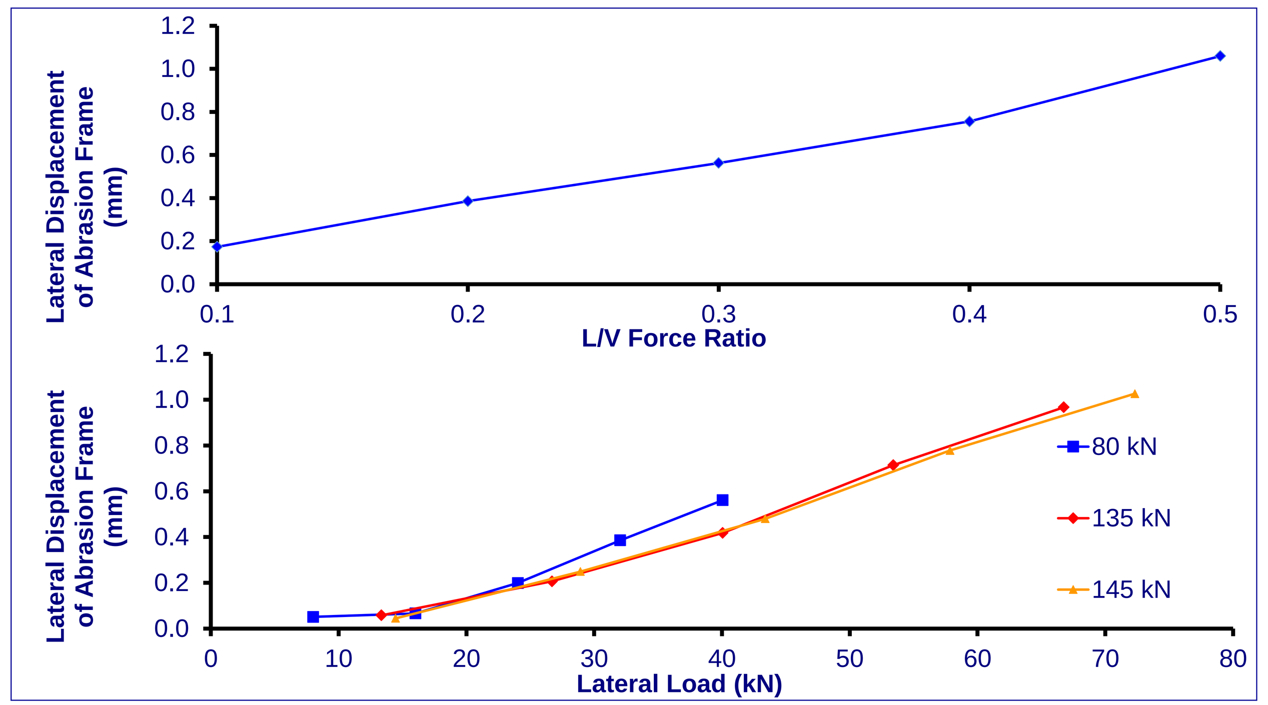
RAIL PAD ASSEMBLY LATERAL DISPLACEMENT

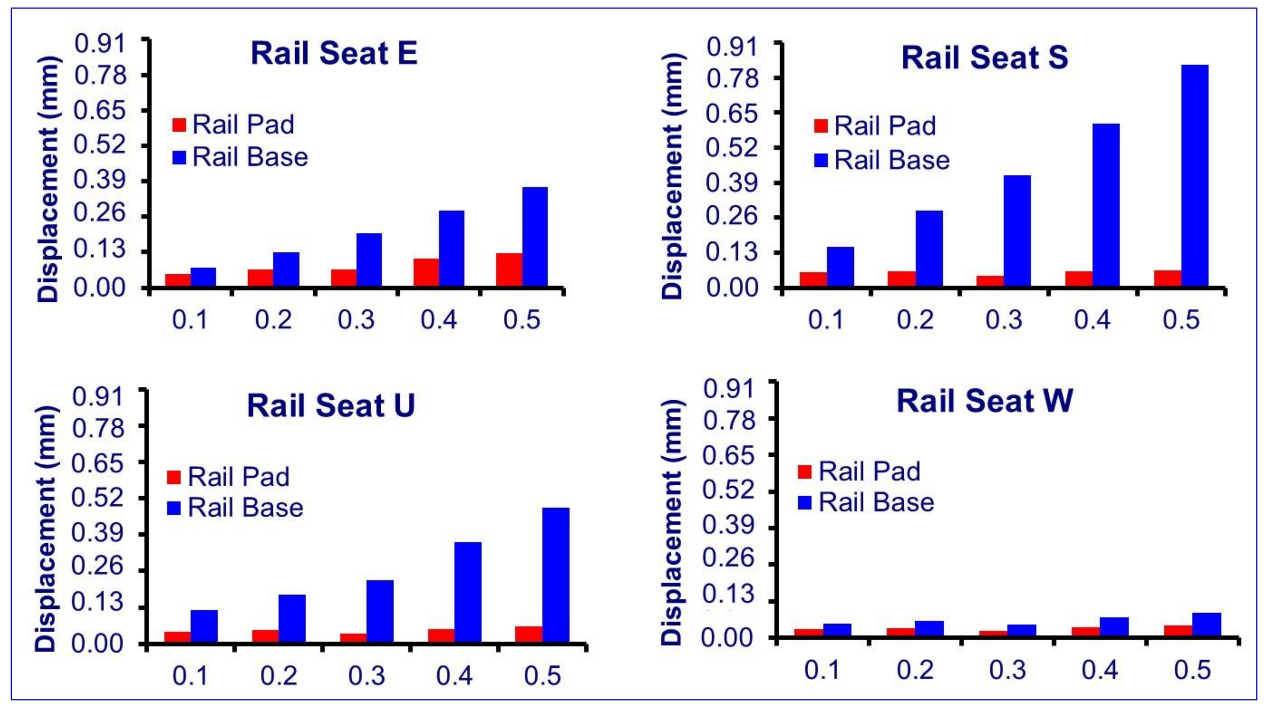
Laboratory

- Lateral and vertical loads were applied to the rail, with L/V force ratio varying from 0.1 to 0.5
- Maximum lateral load applied was 80kN (18,000 lbf)
- Maximum recorded lateral displacement was equal to 1.05 mm (0.042 in) for a 0.5 L/V ratio and 160 kN (36,000 lbf) vertical load
- For high L/V ratio and high lateral loads, the magnitude of the wheel load will likely affect the lateral displacement of the rail pad assembly
- Rail pad assemblies that appeared to have a tighter fit resulted in lower lateral displacements

Field

- Instrumentation focused on understanding the load path through the system and its impacts on the track structure
- Deployment: 6 potentiometers measuring lateral displacement of the rail pad assembly and 4 measuring rail base displacement
- Maximum force applied on the rail was equal to 178 kN vertical with a 0.55 L/V force ratio
- For a 178kN (40 kip) vertical load applied at crosstie CS on the RTT, the maximum lateral pad assembly displacement recorded was approximately 0.15 mm (0.006 in) at rail seat E for a 0.55 L/V





CONCLUSIONS

- Relative displacements between the pad assembly and the rail seat were measured successfully
- These experiments verified the hypothesis that lateral displacements increase as the lateral wheel load increases
- Only high magnitudes of vertical loads appeared to affect the lateral displacement of the rail pad assemblies
- Larger lateral and longitudinal displacements are less likely to occur when the rail pad fits tightly within the rail seat
- Additional research should focus on the relationship between component tolerances and geometry and its impact on life cycle of the fastening system and potential mitigation of RSD
- Future investigations should focus on the shear capacity of current and innovative materials to optimize the design of rail pad assemblies to efficiently resist shear forces and protect critical interfaces

AKNOWLEDGEMENTS

U.S. Department of Transportation Federal Railroad Administration
Amsted RPS Amsted Rail
National University Rail Center - NURail
USDOT-RITA Tier I University Transportation Center
RAILTEC University of Illinois at Urbana-Champaign