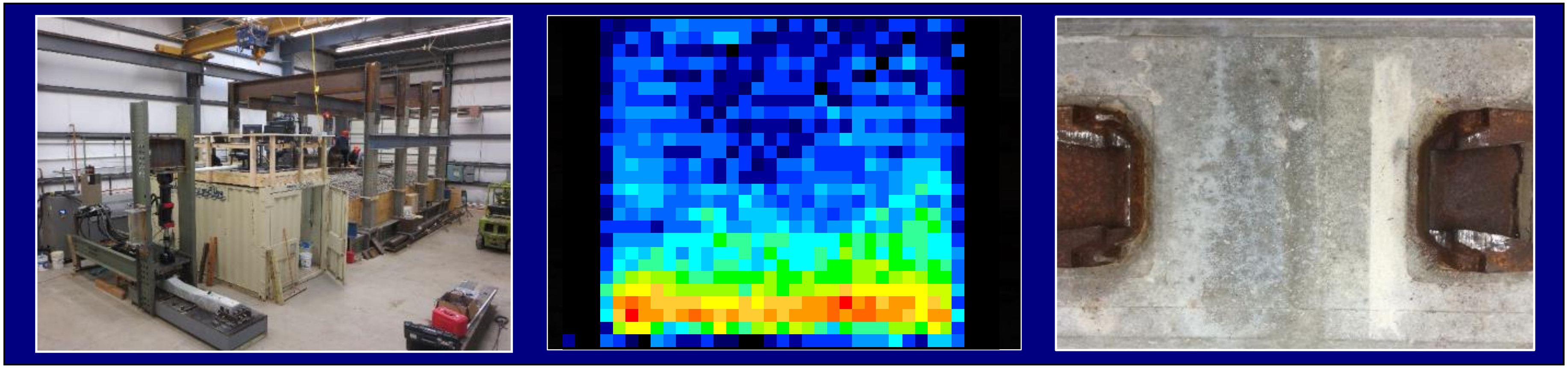
The Effect of Particle Intrusion on Rail Seat Load Distributions



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RAILTEC
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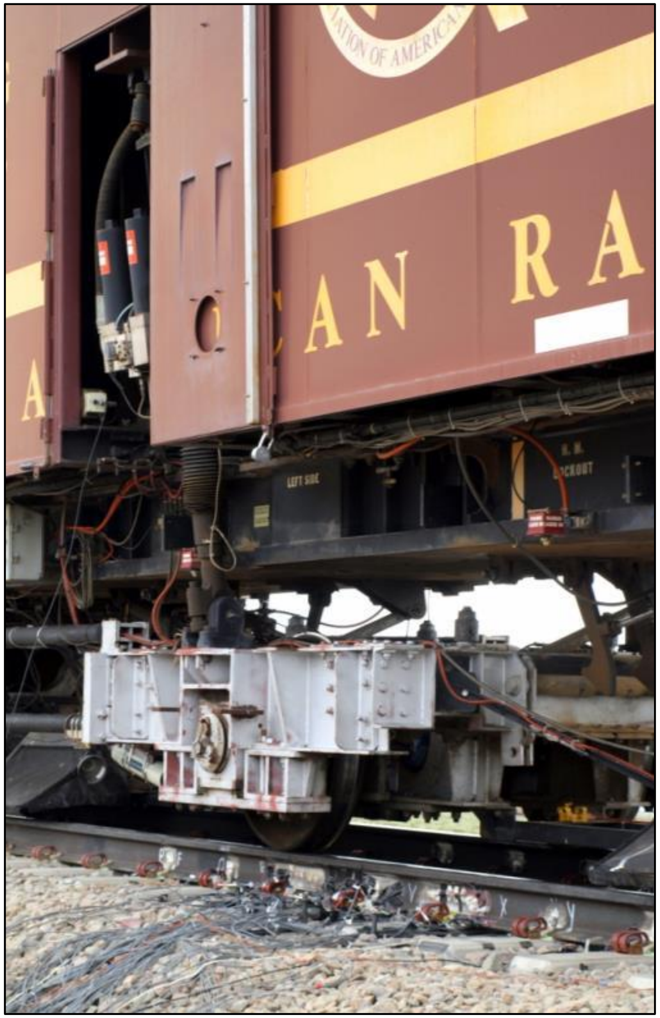
Outline

- Motivation for Research
- Equipment Overview
- Crushing as a Failure Mechanism
- Experimental Matrix
- Preliminary Results
- Conclusions
- Future Work



Current Objectives of Experimentation with Matrix Based Tactile Surface Sensors (MBTSS)

- Compare pressure distribution on rail seats:
  - Under various loading scenarios
  - Under various stages of rail seat wear
  - Under presence of fines and small particles
- Develop design metric for mechanistic evaluation of rail seat load distribution

Motivation for Research

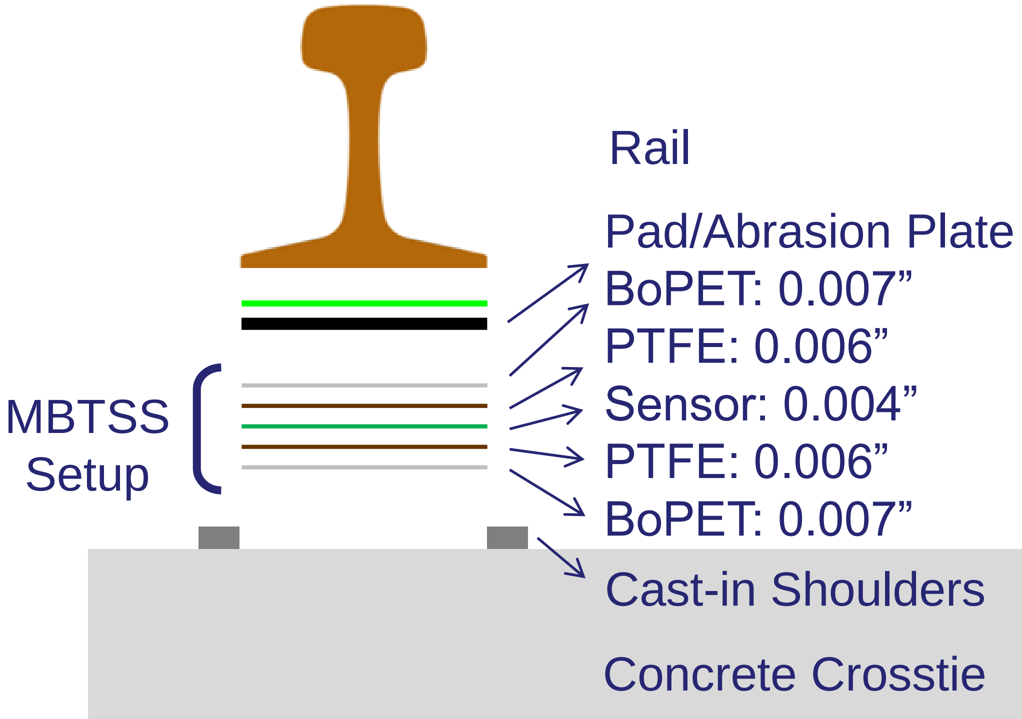
- Rail Seat Deterioration (RSD) is the degradation of concrete directly underneath the rail pad, resulting in track geometry problems
- Surveys conducted by UIUC report that North American Class I Railroads and other railway infrastructure experts ranked RSD as one of the most critical problems associated with concrete crosstie and fastening system performance
- Potential RSD mechanisms as determined through research at UIUC:
  - Abrasion
  - Crushing
  - Freeze-thaw
  - Hydraulic pressure cracking
  - Hydro-abrasive erosion

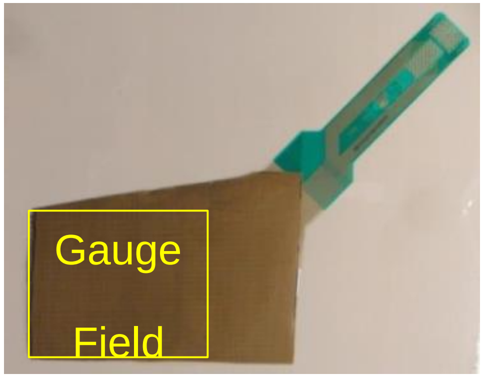
Gauge

Field

Equipment Preparation and Protection

- Matrix Based Tactile Surface Sensors (MBTSS) trimmed to fit rail seat
- BoPET and PTFE layered on each side of sensor to protect from shear and puncture damage
- Plastic sleeves and plastic bags to protect sensor tabs and handles from puncture and debris





Plan View of Sensor and Protective Layers

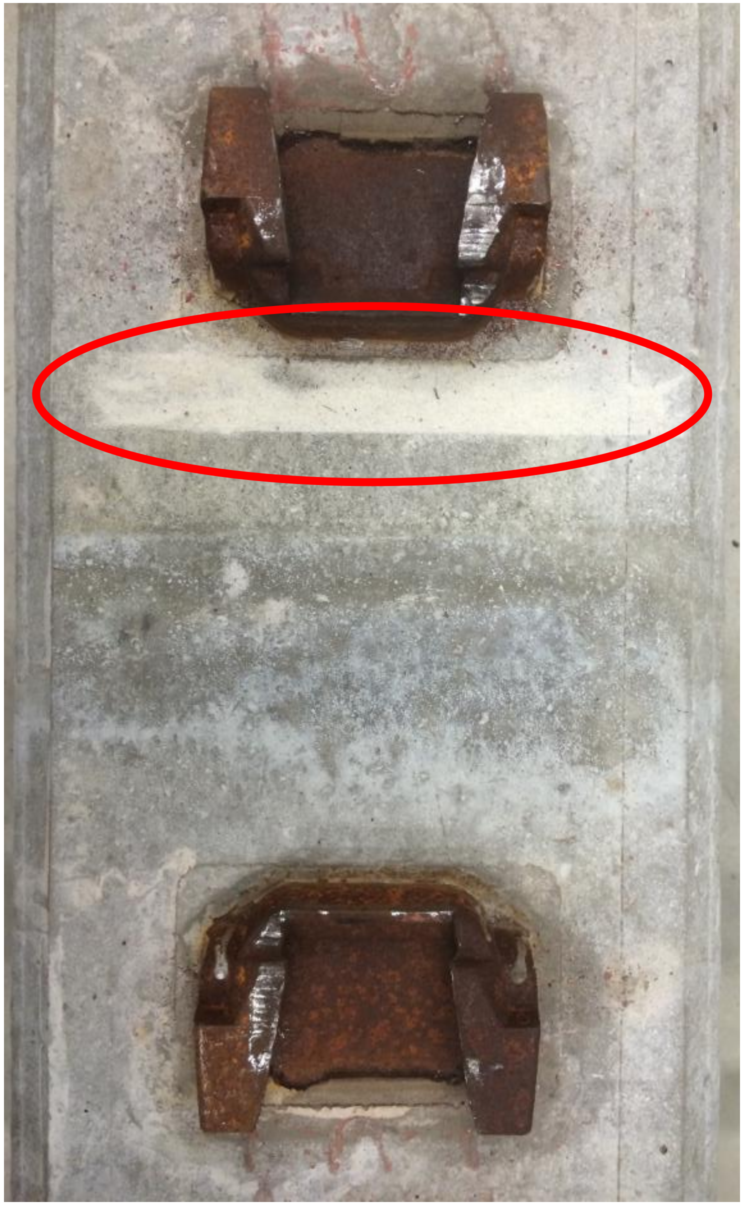
Laboratory Experiment Program

- **Objective:** Explore behavior of rail seat load distribution under the presence of fines and small particles at high rail seat loads.
- **Location:** Research and Innovation Laboratory (RAIL) at Schnabel, UIUC
  - **Pulsating Load Testing Machine (PLTM):** Biaxial loading frame owned by Amsted RPS able to simulate various L/V force ratios by varying loads
- **Instrumentation:**
  - MBTSS deployed to capture rail seat load concentration
  - Potentiometers deployed to capture vertical rail base displacement
- **Loading:** hydraulic actuators used to apply lateral and vertical loads to single fastening system assembly

Pulsating Load Testing Machine (PLTM)

Crushing as a Failure Mechanism

- Crushing may occur in the presence of pressures exceeding design compressive strength of concrete (7,000 psi)
- Previous experimentation has not yielded pressures exceeding design strength
  - New fasteners: 1,700 psi
  - Worn fasteners: 2,400 psi
  - 3/4” RSD (20,000 lbf): 4,400 psi
- Particle intrusion at the rail seat may lead to extreme pressures
  - Presence of fines at rail seat noted in field visits on both worn and unworn rail seats
  - Sand is used to generate abrasive environment in AREMA Test 6: Wear and Abrasion



Experimental Matrix

- Particle intrusion scenarios representing both typical and extreme field conditions
- Two-dimensional matrix:
  - Particle size
    - Locomotive sand
    - Class B crushed stone aggregate
      - Smaller than No. 4 sieve
  - Intrusion region
    - Entire rail seat
    - Critical region
      - 1” closest to field side shoulder

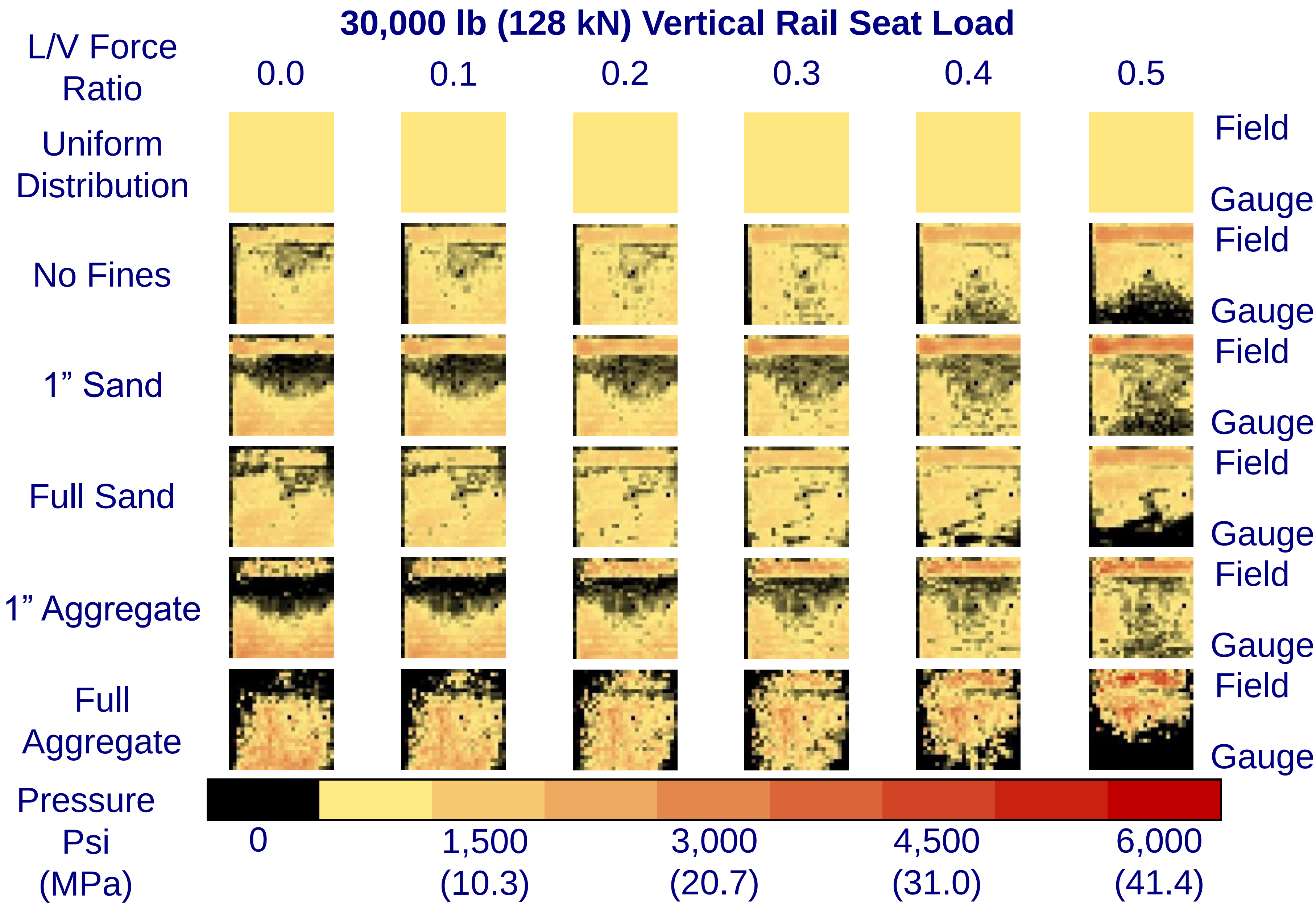
Particle Size

		Locomotive Sand	B-Stone Aggregate
Intrusion Region	Field 1”	1” Sand	1” Aggregate
	Full Seat	Full Sand	Full Aggregate

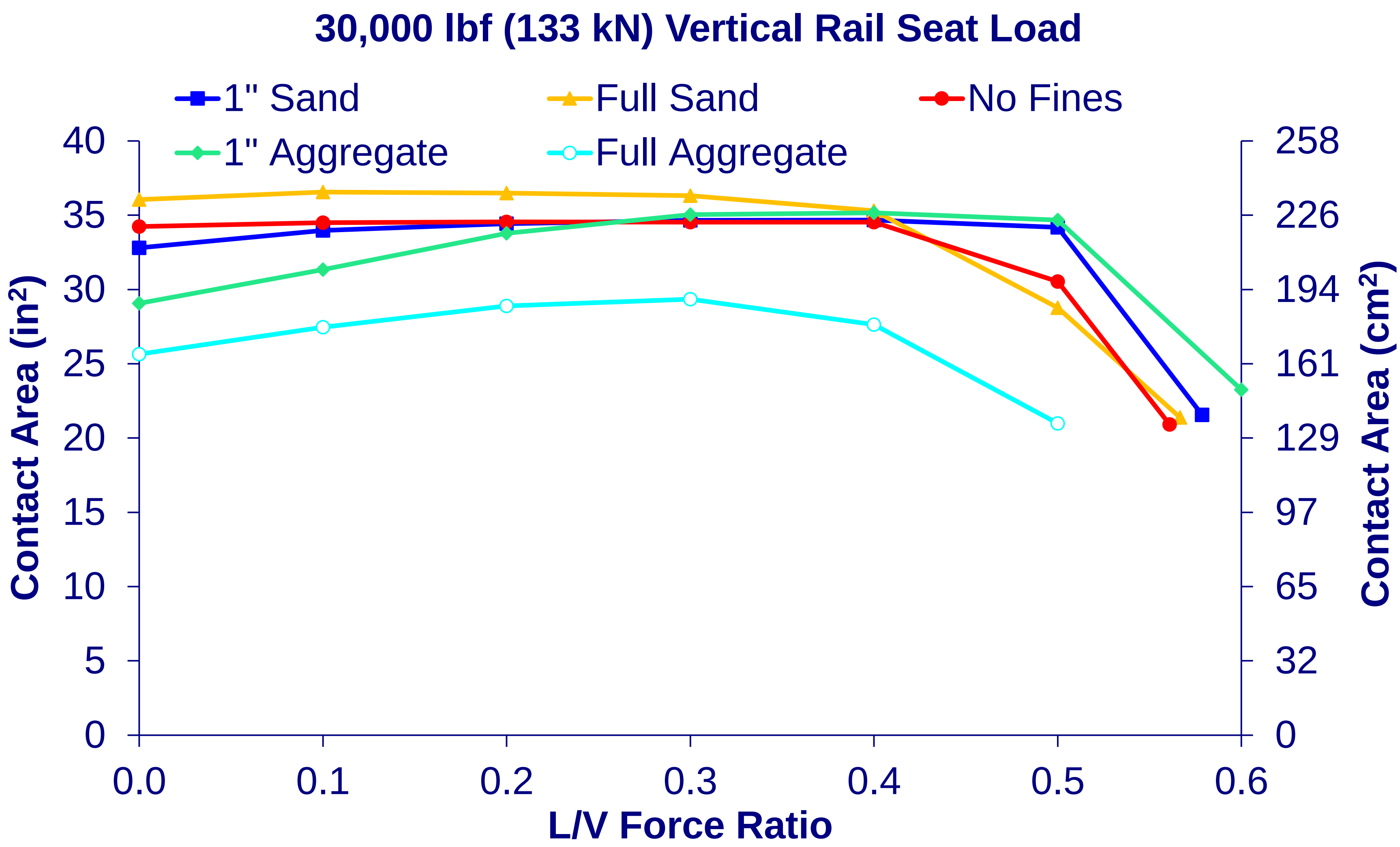
Loading Environment

- 40,000 lbf (178 kN) vertical wheel load assumed
- Rail seat load will be distributed in field conditions, but PLTM only tests one rail seat
- Three primary levels of load transfer selected for experimentation:
  - 25% (10,000 lbf (45 kN) rail seat load)
  - 50% (20,000 lbf (89 kN) rail seat load)
  - 75% (30,000 lbf (133 kN) rail seat load)
- Typical L/V force ratio experimentation range (0 – 0.6) tested at each level of load transfer

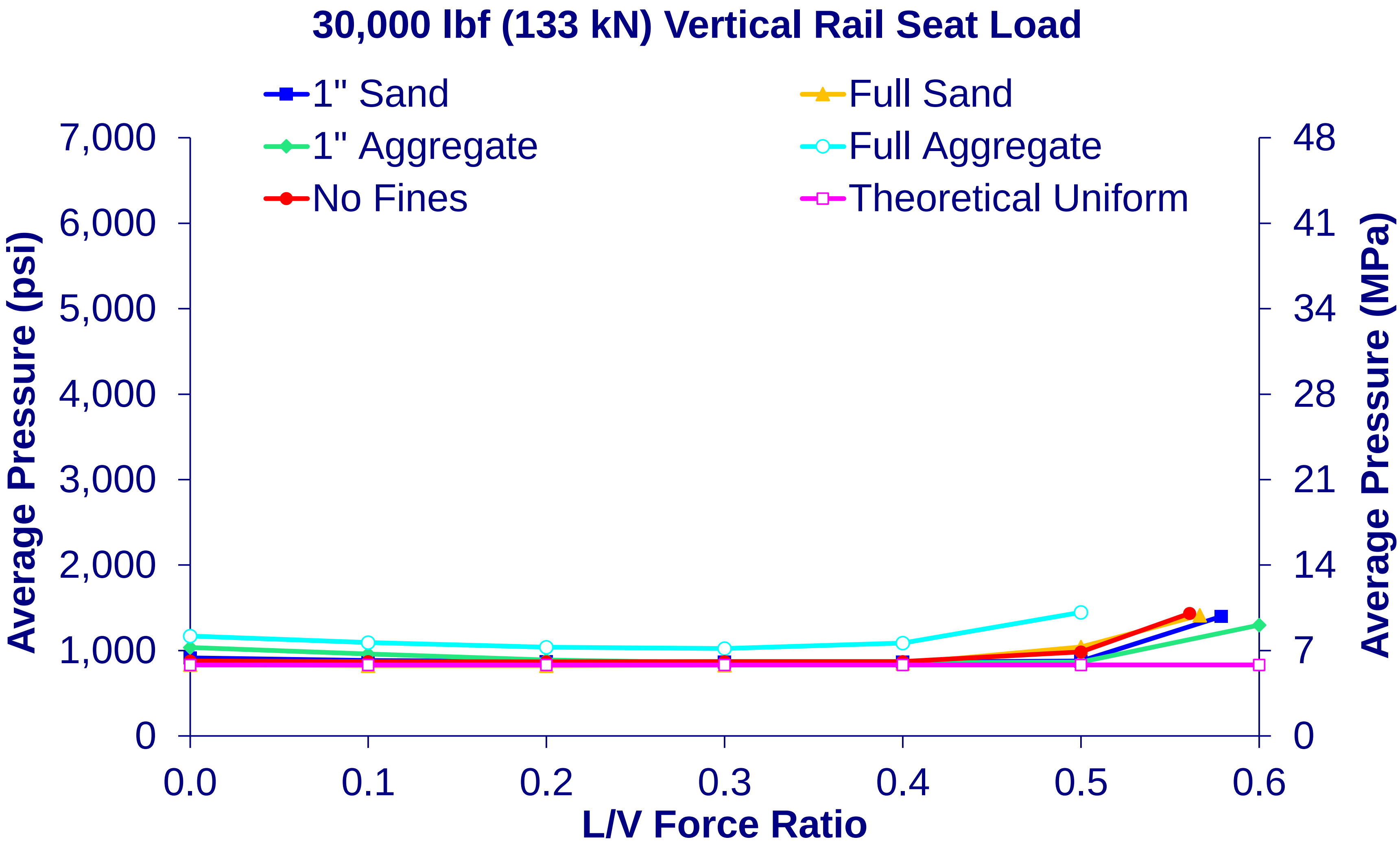
Qualitative Effect of Particle Intrusion



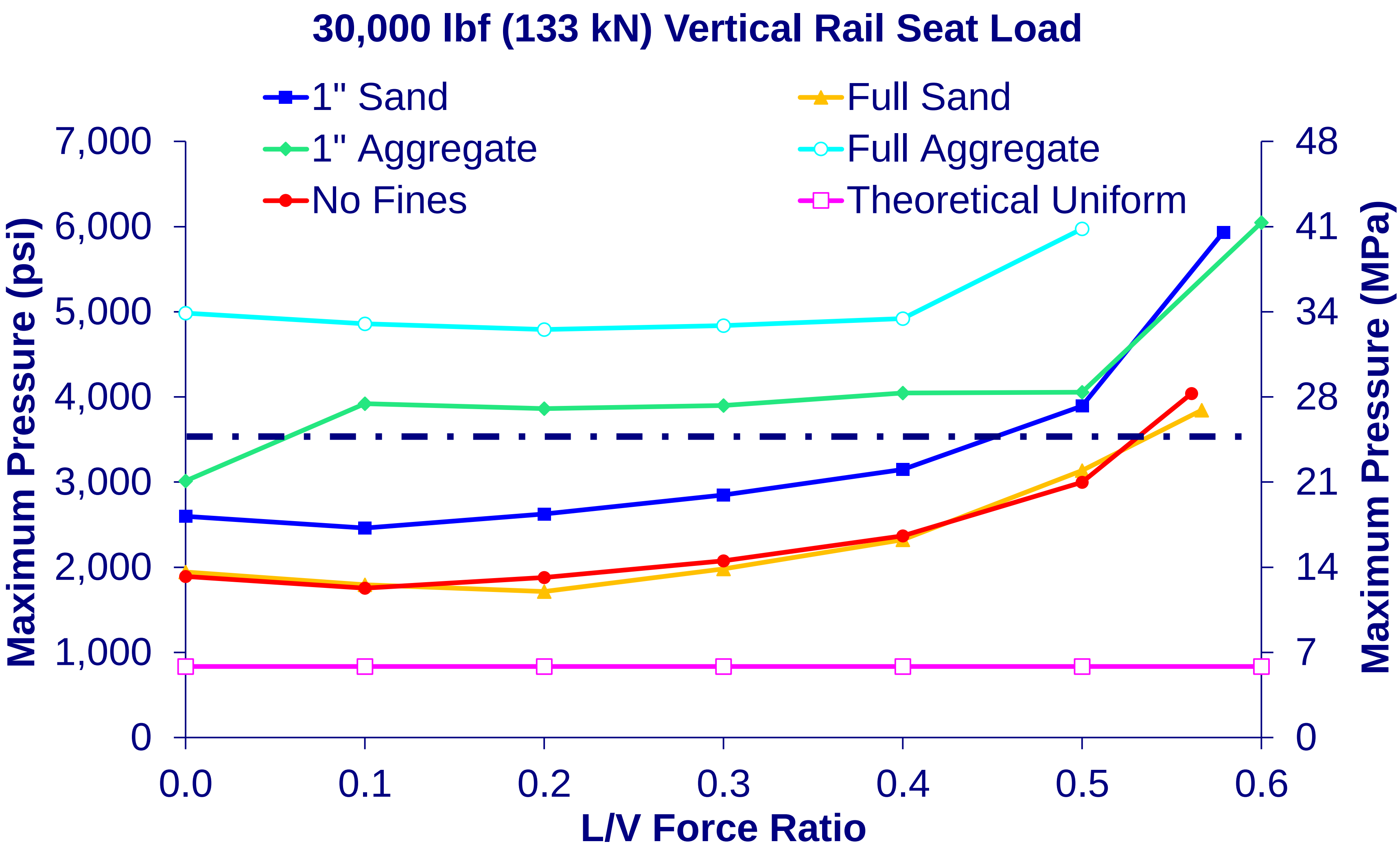
Effect of Particle Intrusion on Contact Area



Effect of Contact Area Reduction



Effect of Contact Area Reduction



Conclusions

- Intrusion of sand particles has little effect on contact area
  - 3% average deviation
- Intrusion of aggregate on entire rail seat leads to load concentrations on aggregate peaks
  - 15% average reduction of contact area below 0.3 L/V
- Particle intrusion only in critical region (field side inch) significantly increases maximum pressure
  - 45% average increase over No Fines case
- Crushing due to a single load application **is not expected** on a healthy rail seat
  - 6,050 psi (41.7 MPa) maximum pressure from experimentation
- Crushing due to repeated loading **is feasible** on a healthy rail seat in the presence of fines
  - 3,500 psi (24.1 MPa) threshold exceeded in extreme loading scenarios

Future Work

- How repeatable are results on additional rail seats?
- How can these findings be applied to the development of RSLI?
- Can we correlate load nonuniformity to RSD?
  - How does rail seat pressure correlate to damage?
  - How does rail seat pressure correlate to crosstie life expectancy?

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Thank You

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