Field Testing for Understanding In Situ Concrete Crosstie and Fastener Behavior




2012 Joint Rail Conference

Philadelphia, PA

17-19 April 2012

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U.S. Department of Transportation
Federal Railroad Administration

RAILTEC
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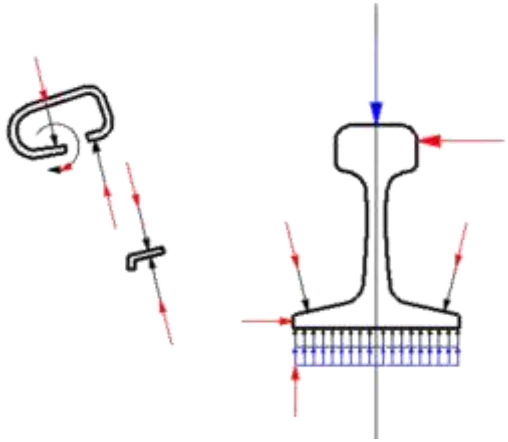
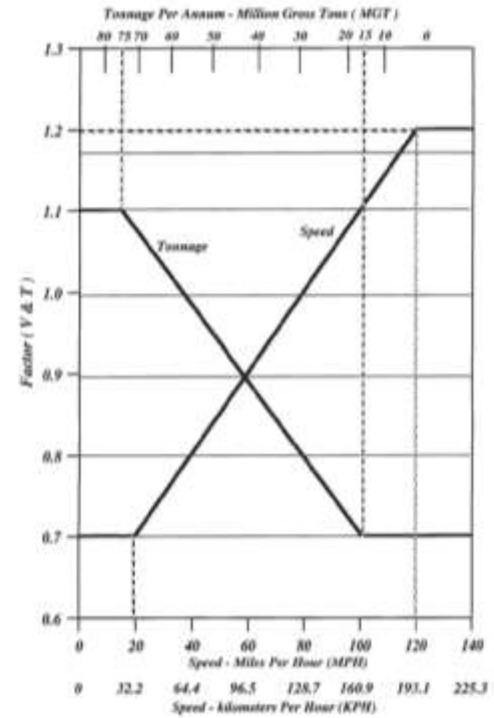
Outline

- Goals of Field Instrumentation
- Areas of Investigation
- Instrumentation Plan
- Preliminary Data Analysis
- Planned Locations for Field Testing
- Conclusion

Goals of Field Instrumentation

- Lay groundwork for mechanistic design of concrete crossties and fasteners
- Map stresses through the fastening system
- Develop an understanding into probabilistic loading conditions
- Provide insight for future field testing



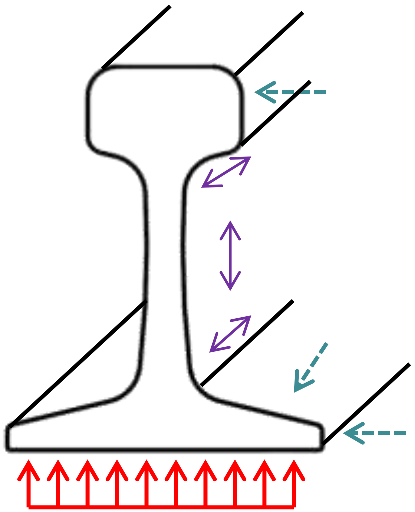


(AREMA 2010)

Areas of Investigation

Rail

- Stresses at rail seat
- Strains in the web
- Displacements of head/base

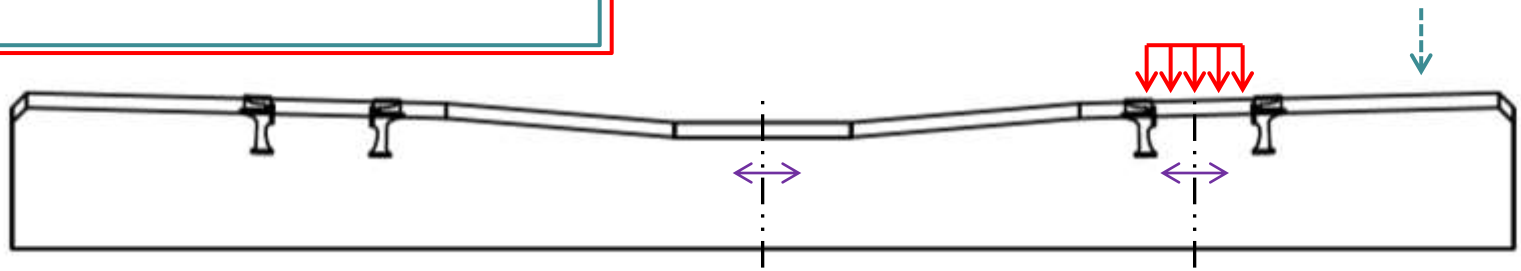


Fasteners/ Insulator

- Strain of fasteners
- Stresses on insulator

Concrete Crossties

- Internal strains
  - Midspan
  - Rail Seat
- Stresses at rail seat
- Global displacement of the crosstie



Data Types

- Understanding of loads
  - Vertical
  - Lateral
- Reaction at the rail base
- Allowable rail movement
  - Translation
  - Rotation
- Insulator stresses
- Concrete crosstie stress/ moment distributions
- Measures of restraint
  - Vertical
  - Lateral

Instruments

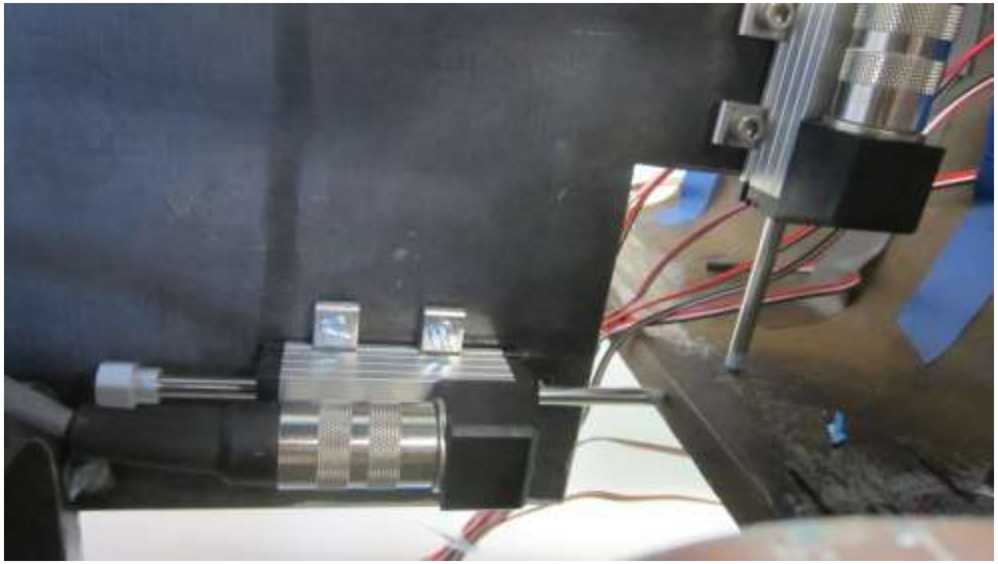
- NI CompactDAQ
  - 56+ Channels
- Linear potentiometers
- Strain gages
  - Convenional
  - Weldable
  - Embedment
- Load cells
- Matrix Based Tactile Surface Sensors

NI cDAQ-9188

Linear Potentiometers

Strain Gauges

Instruments

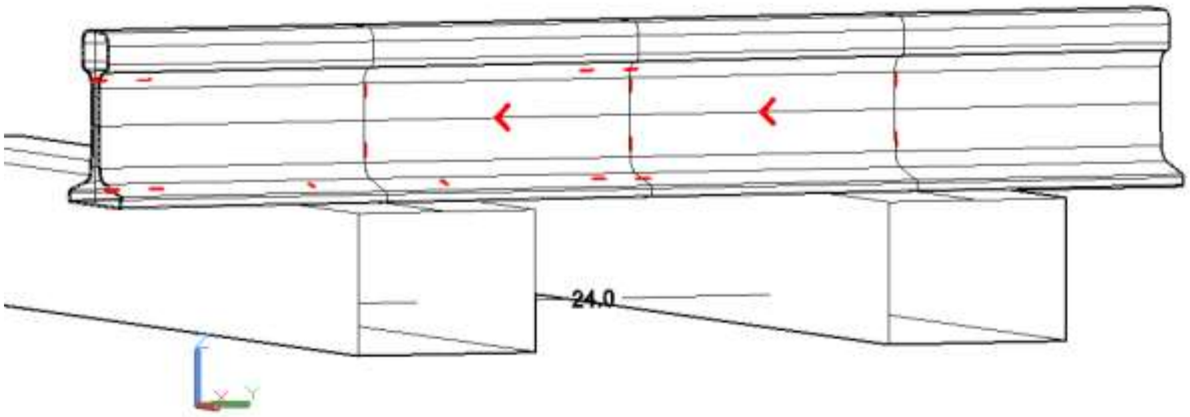


Linear Potentiometer Fixture

Lateral Loader

- Linear Potentiometer Fixture
  - Welded steel frame
  - Designed for flexible positioning
  - Bolted fastening system
- Lateral Loading Fixture
  - Max Capacity ~ 10kips
  - Calibration Load ~ 4kips

Strain Gauge Strategy

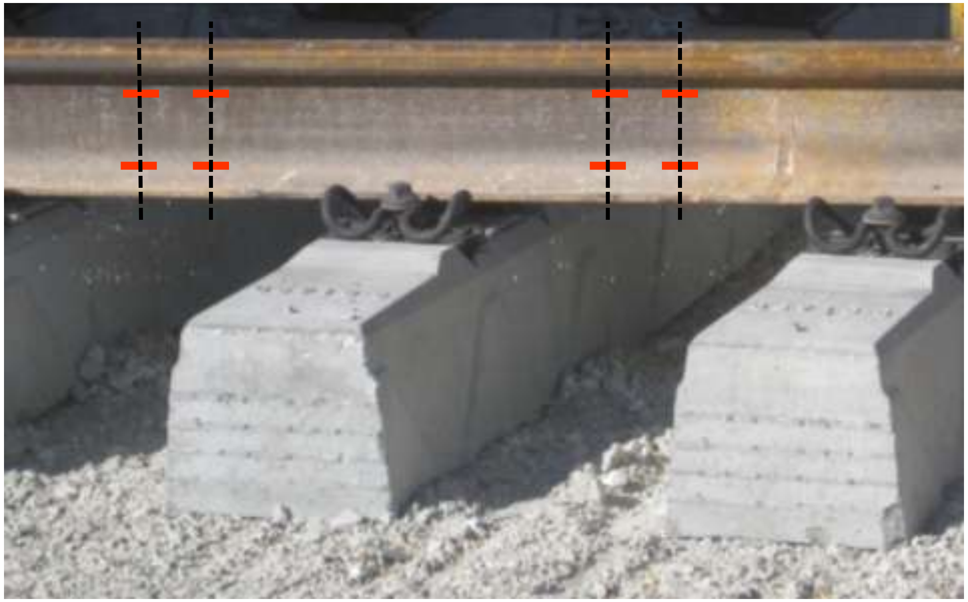


Lateral built-up load cell

Chevron patterns

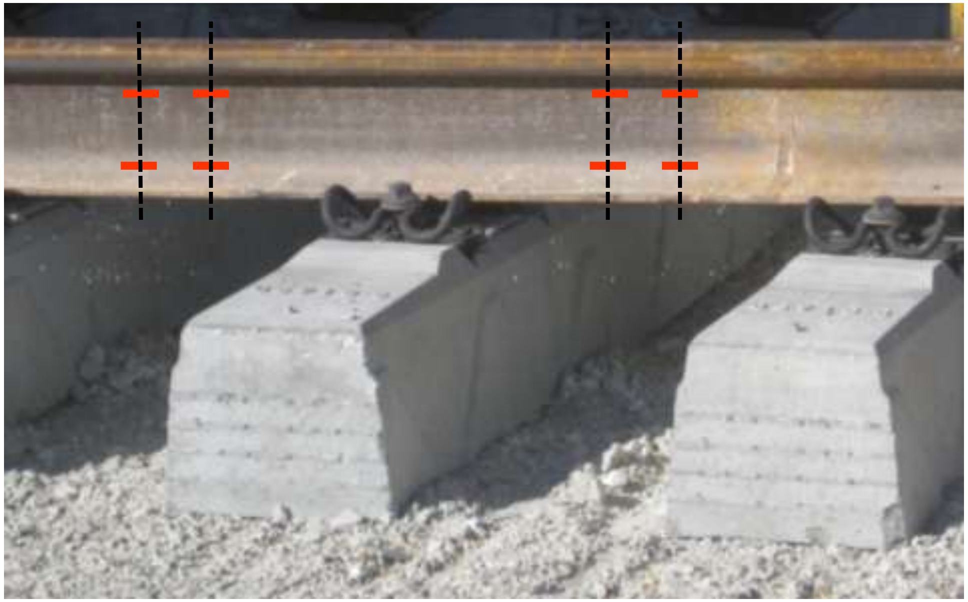
Transverse gages

Strain Gauge Strategy



Lateral built-up load cell

Strain Gauge Strategy



Lateral built-up load cell

Curvature:

$\phi = \varepsilon/d$

Moments:

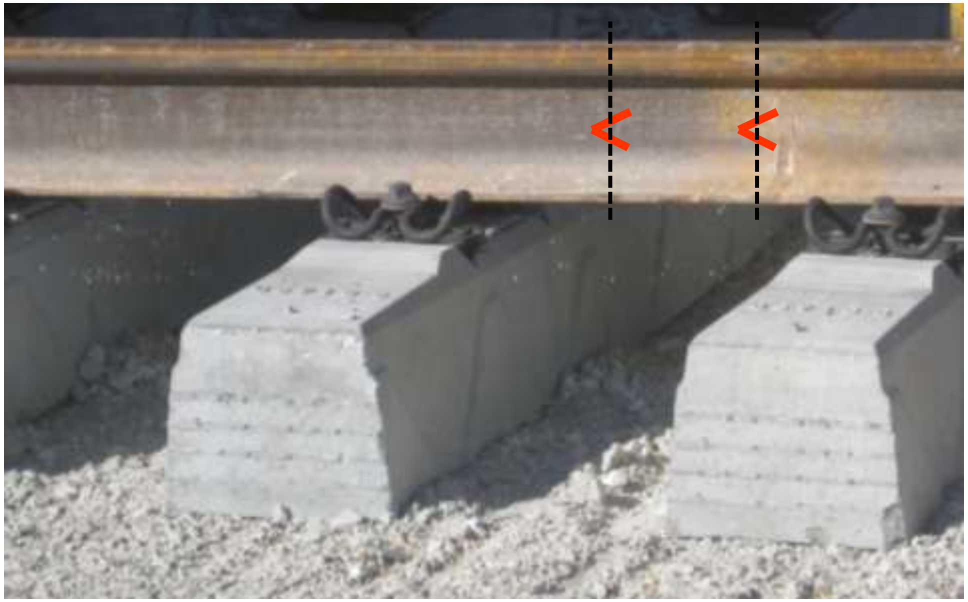
$$M_{XL} = EI\rho_{XL} = EI\left(\frac{\varepsilon_a + \varepsilon_a'}{2}\right)\cdot\frac{1}{d}$$

d = distance to neutral axis

Shear Force:

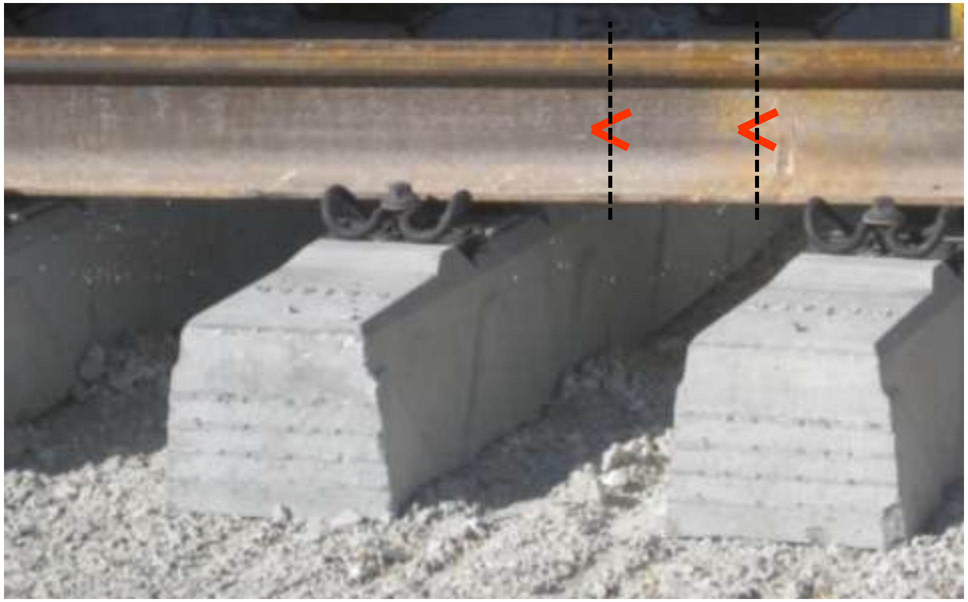
$$V_Z = (M_{XL} - M_{XR})\cdot\frac{1}{L}$$

Strain Gauge Strategy



Chevron patterns

Strain Gauge Strategy



Chevron patterns

Shear Force:

$$V_{Z1} = \frac{EI}{(1+\nu)Q}\varepsilon_1$$

Total Strain:

$$\varepsilon_1 = \varepsilon_a - \varepsilon_b + \varepsilon_{a'} - \varepsilon_{b'}$$

Vertical Load:

$$P_Z = V_{Z1} - V_{Z2}$$

$$= \frac{EI}{(1+\nu)Q}(\varepsilon_1 - \varepsilon_2)$$

Strain Gauge Strategy

Transverse gages

Strain Gauge Strategy

Transverse gages

Curvature:

$$\phi = \frac{\varepsilon}{t/2}$$

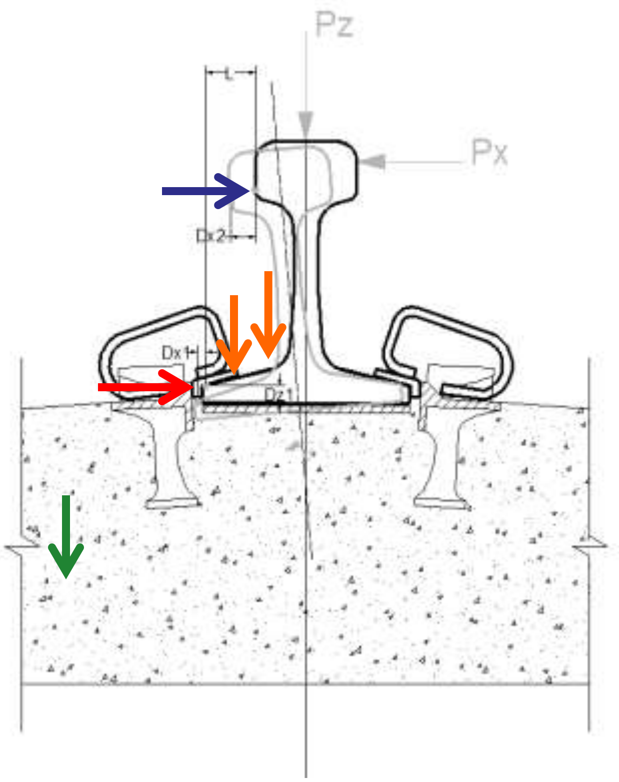
t = thickness of rail base

Moment:

$$M_{XL} = EI\phi = \frac{EI\varepsilon}{t/2}$$

Displacements

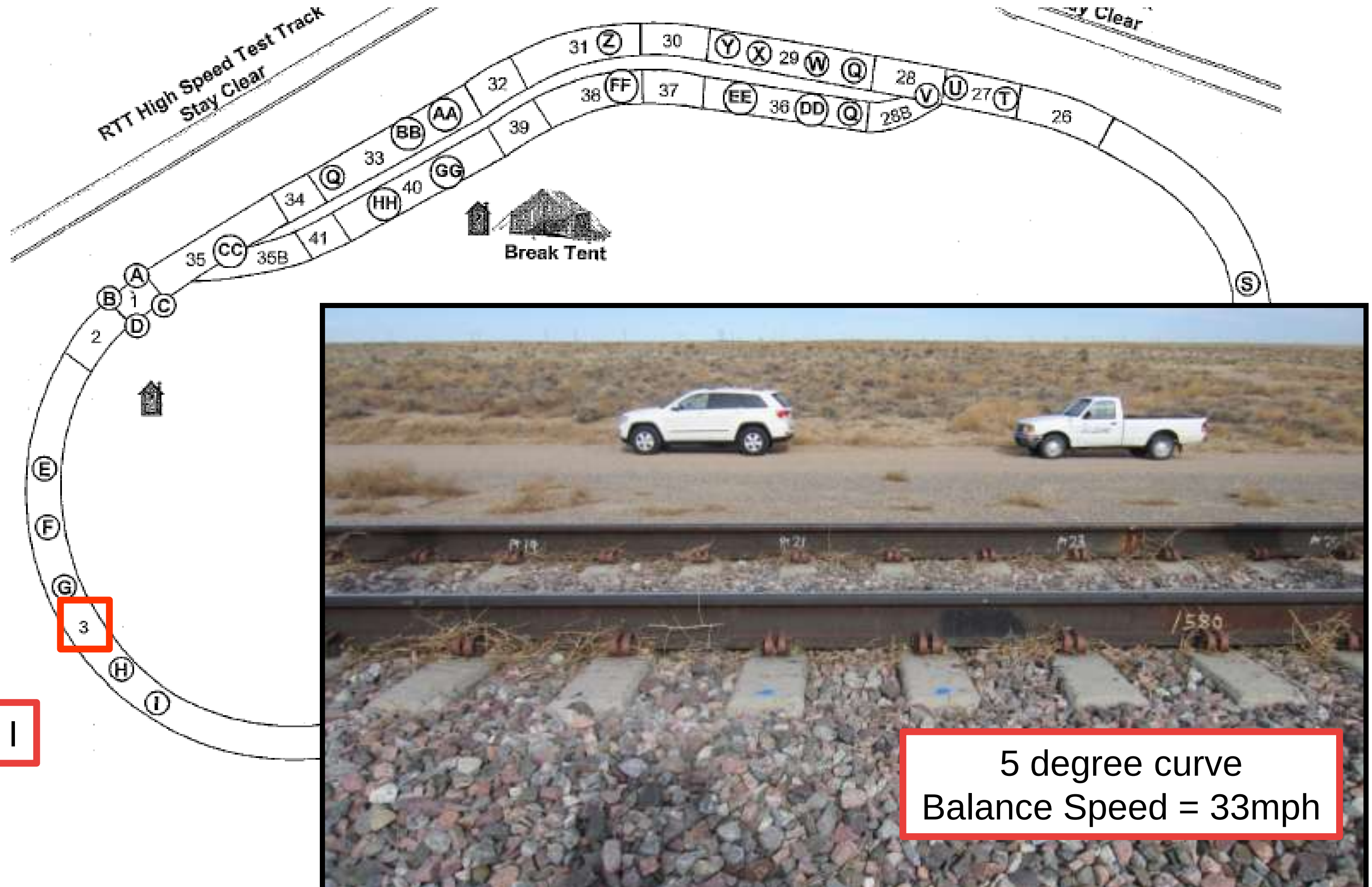
- Lateral disp. of the rail base (Dx_1)
- Vertical disp. of the rail base (Dz_1)
- Vertical disp. of the rail base (Dz_2)
- Lateral disp. of the rail head (Dx_2)
- Global disp. of the tie (Dz_g)



Preliminary Field Test

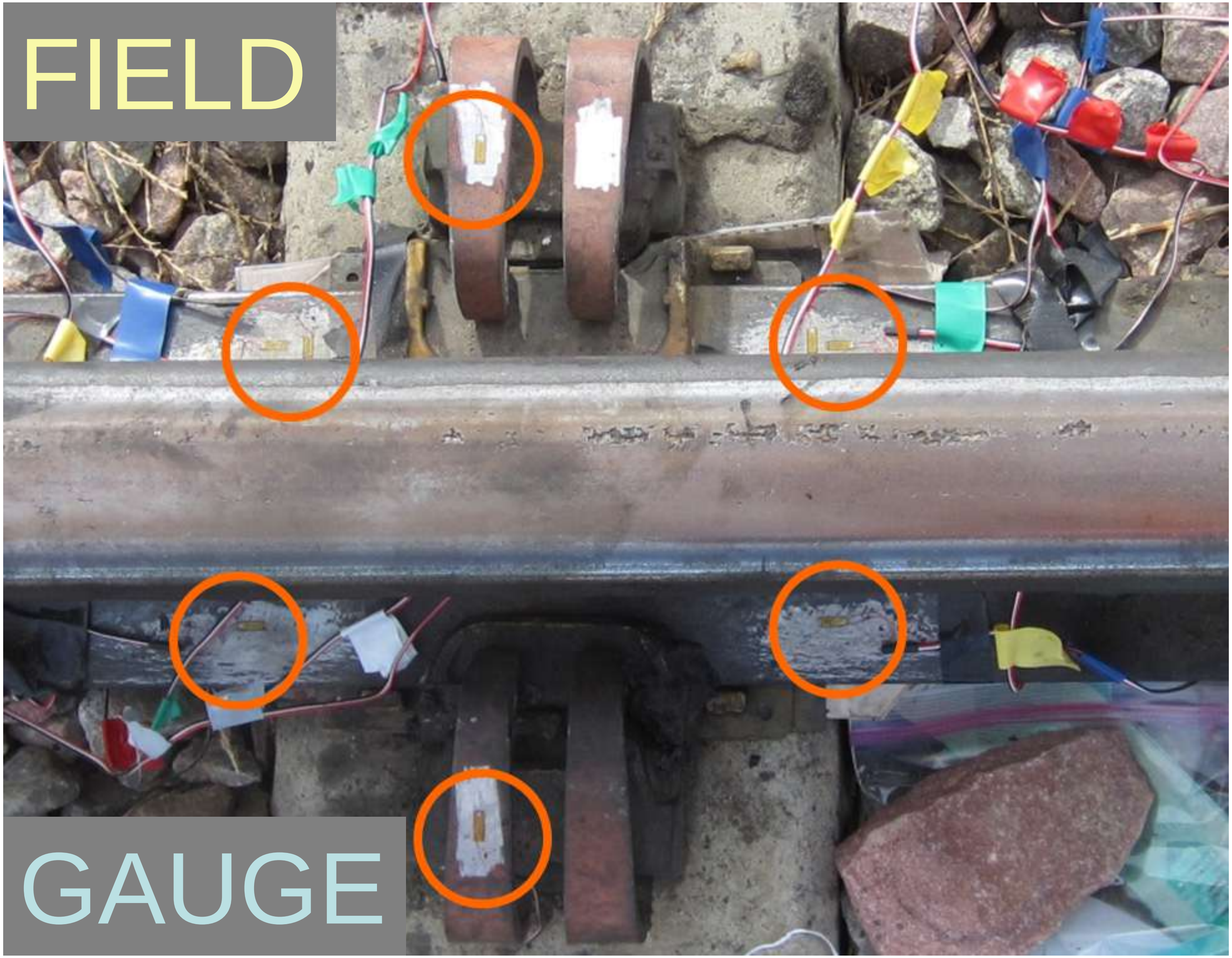
- Preliminary Field Investigation at TTCI
- Test Feasibility of Plans/Ideas
- Validate strain measurements
- Gain Familiarity with TTCI
  - Facility
  - Resources
  - Procedures
- Identify “unknowns”

Strain Gage Location

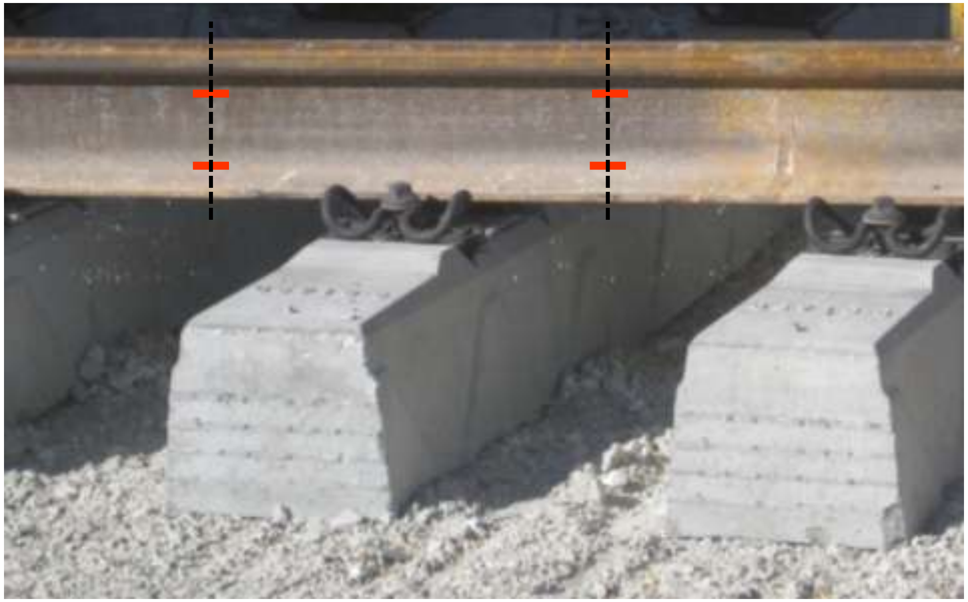


Safelok I

5 degree curve
Balance Speed = 33mph

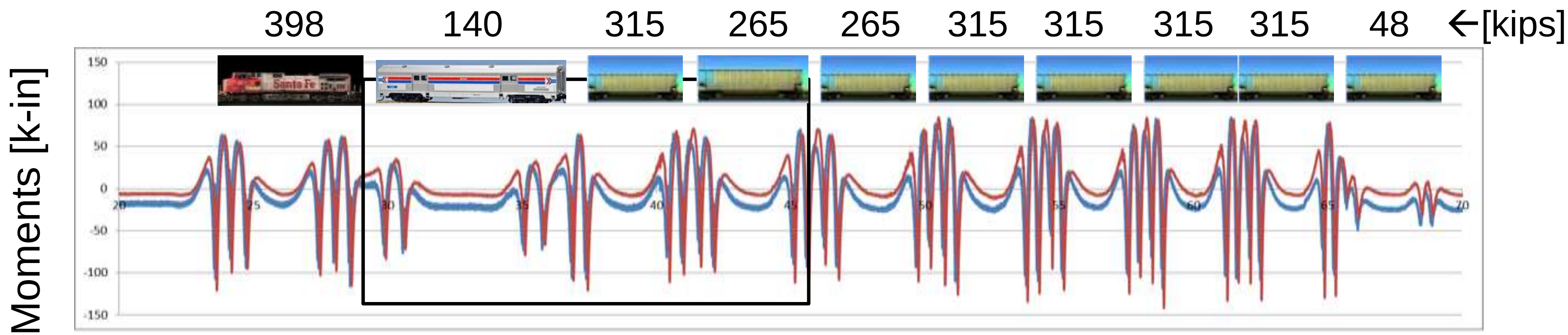

FIELD
GAUGE

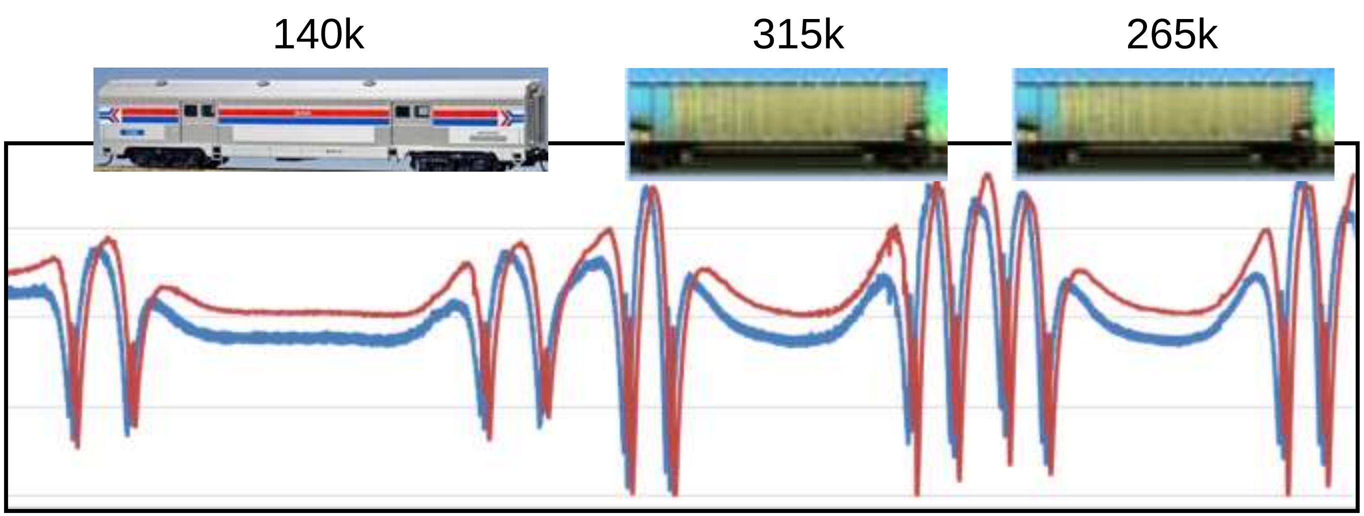
Bending Moments of the Rail



Lateral built-up load cell

Bending Moments of the Rail





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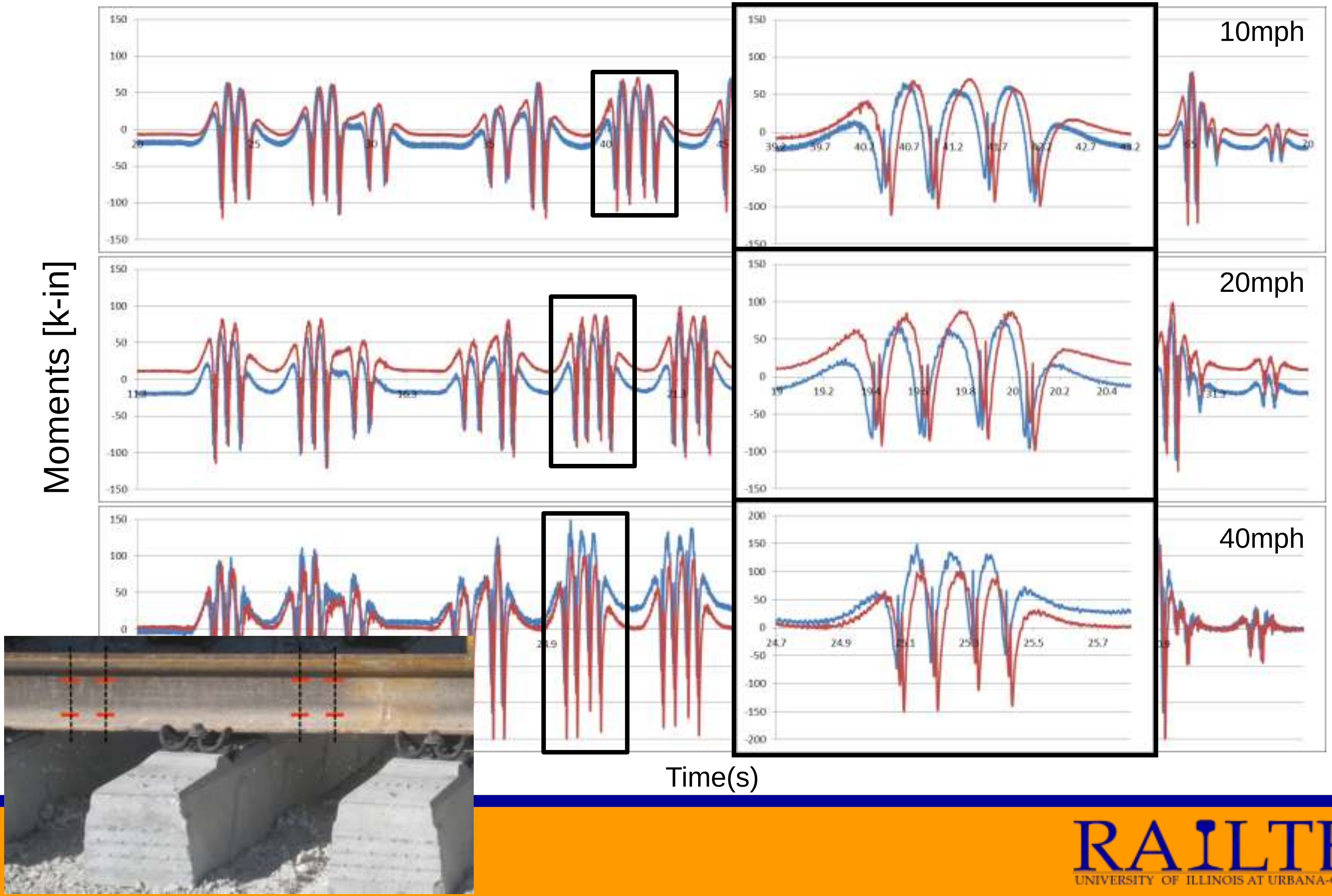

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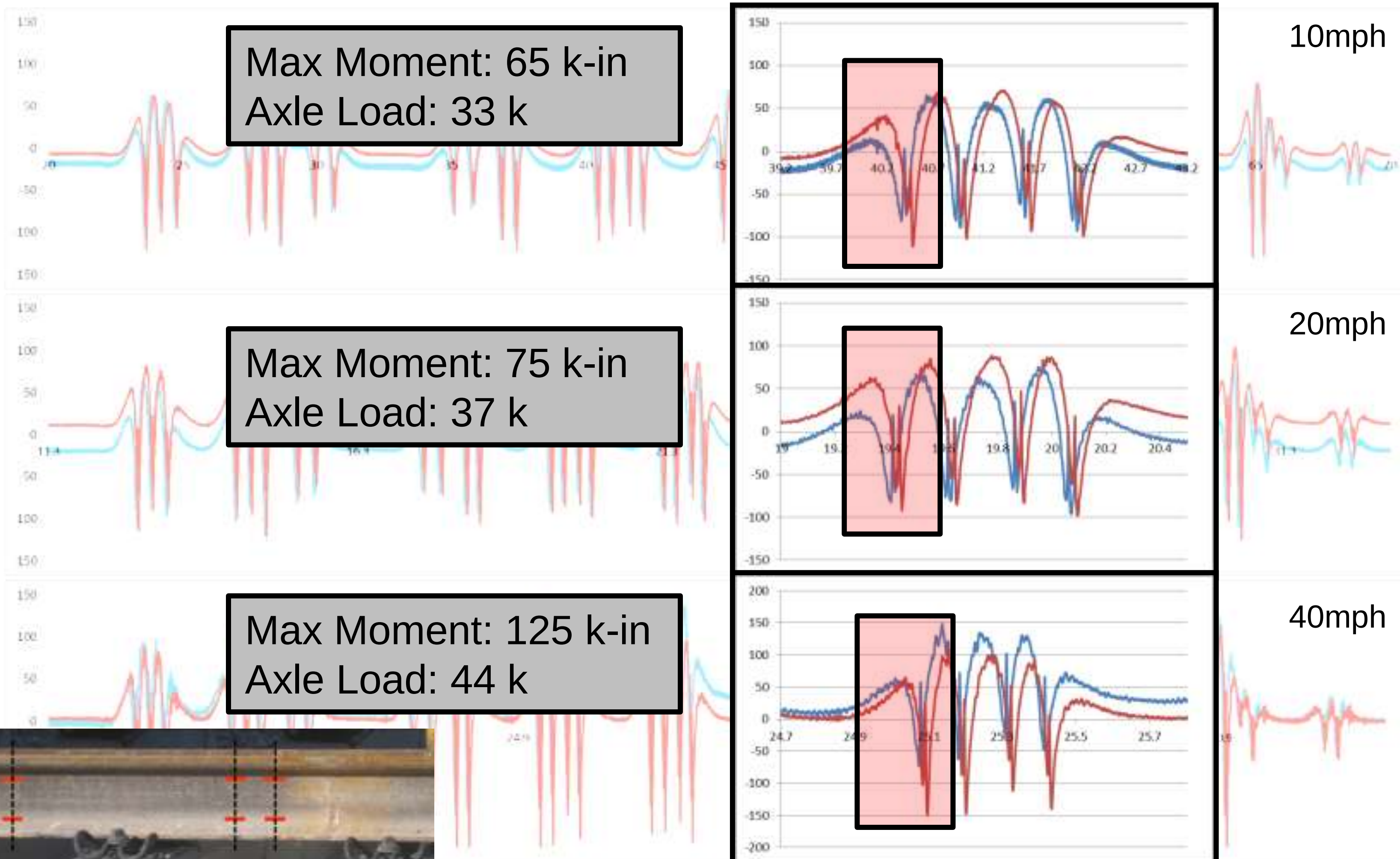
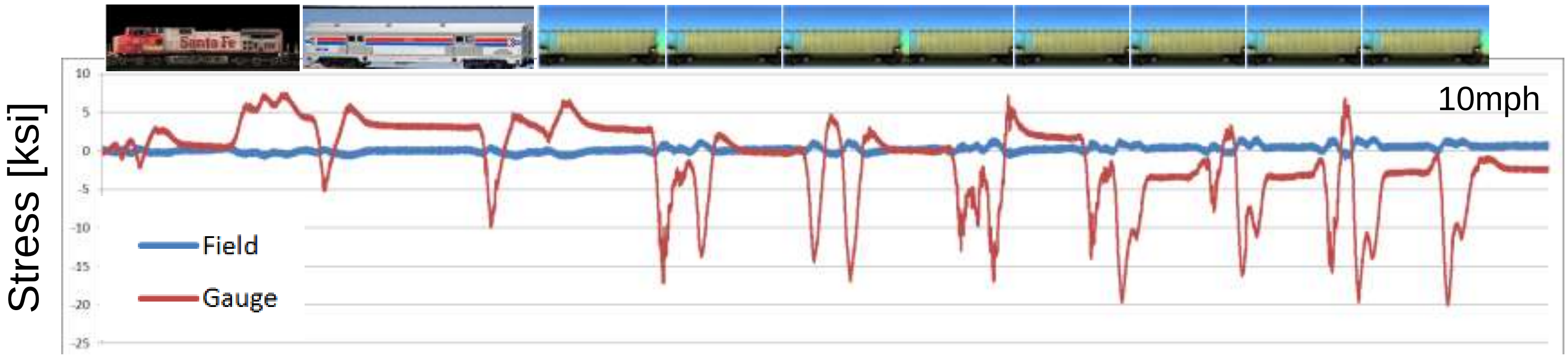


Stress in the Top of the Clips

Instrumented Clip

Stress in the Top of the Clips



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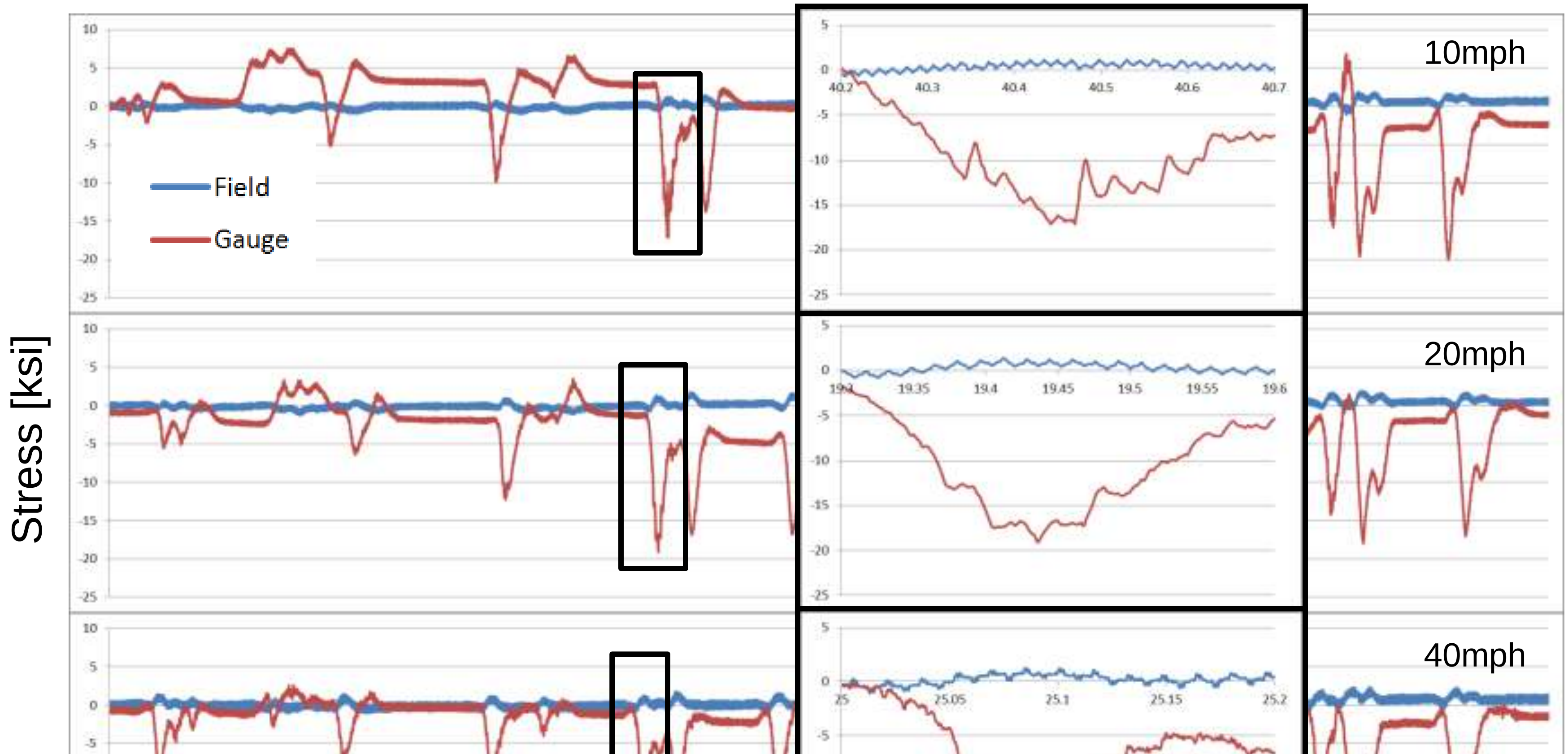

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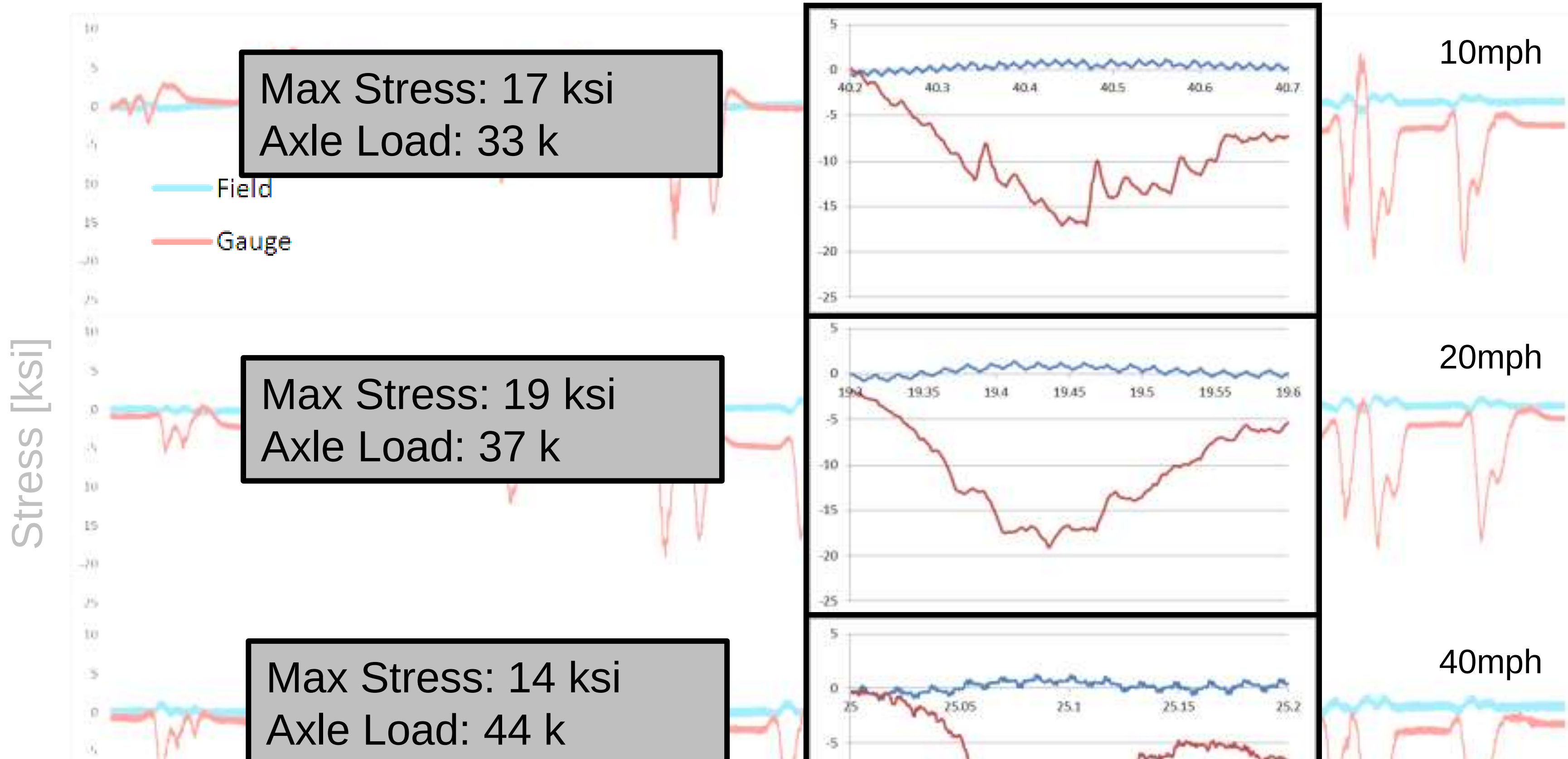
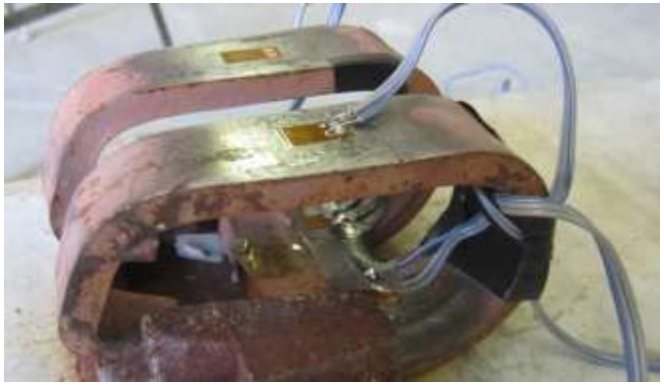
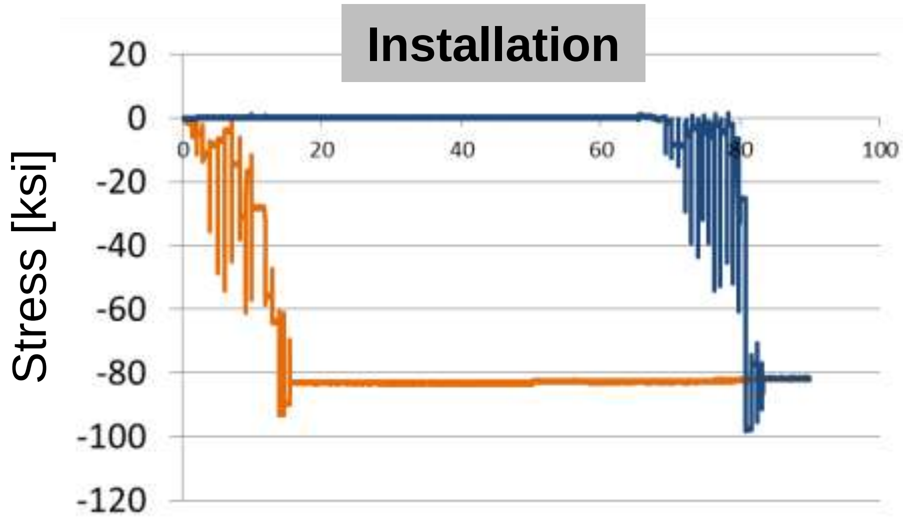
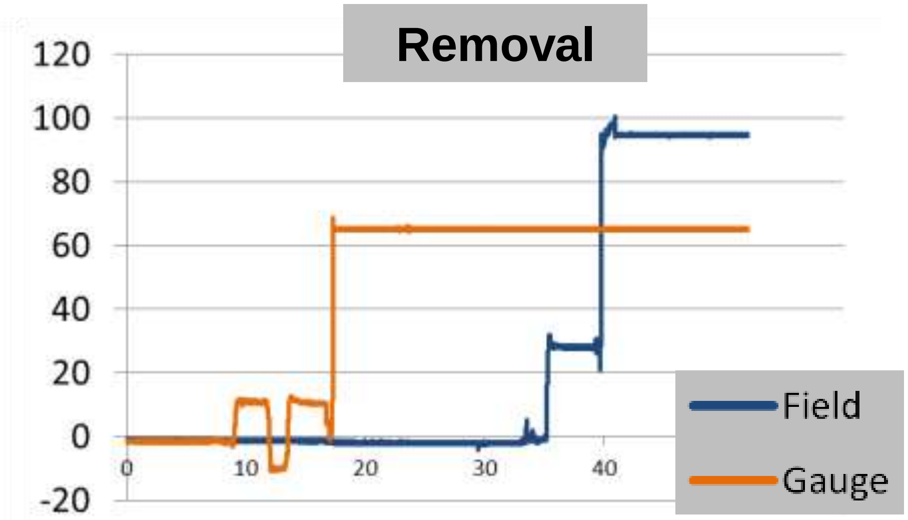


Analysis of Clips

Top Surface of Clips		
	Field	Gauge
After Installation	83 ksi	82 ksi
After Loading	95 ksi	65 ksi

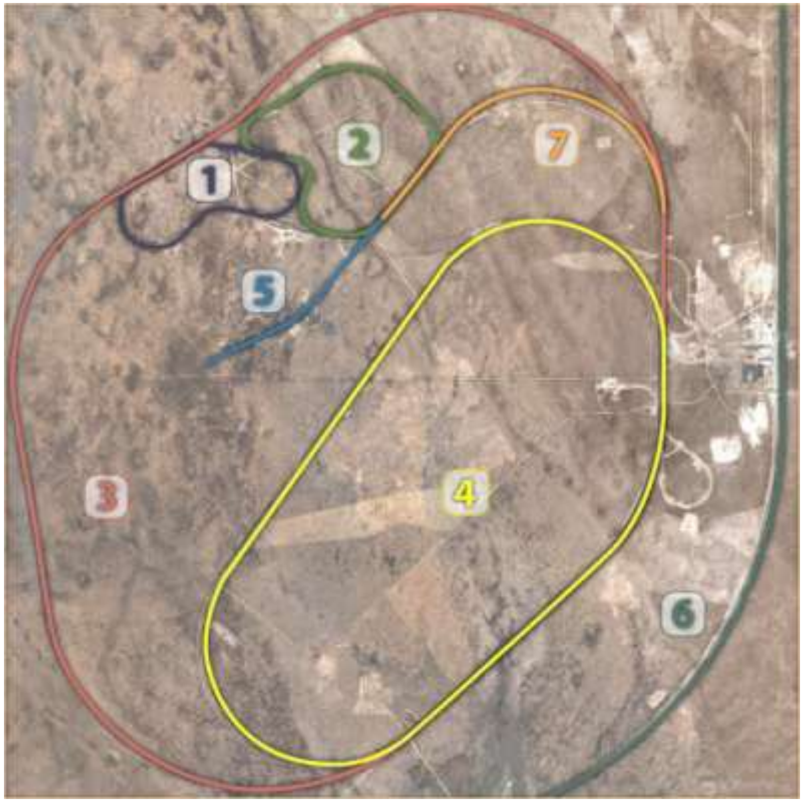






Planned Locations for Field Testing

- Monticello Railway Museum
- Transportation Technology Center (TTC)
  - Summer 2012
- Class I Railroads
  - Amtrak
  - BNSF
  - Union Pacific



Transportation Technology Center (TTC)

Transportation Technology Center, Inc.

AMTRAK®

BNSF RAILWAY

UNION PACIFIC BUILDING AMERICA®

Conclusions

- Instrumentation plan will provide synchronized measurements of:
  - **- Loading conditions**
  - **- Allowable Movement**
  - **- Component stresses**
  - **- Rail seat pressures**
- Results will feed into comprehensive FE model
- Strategy will be implemented in variable track conditions (e.g. fastening systems, curvature) for parametric analysis

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 (UP) 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
- Monticello Railway Museum
  - Tim Crouch
- Transportation Technology Center, Inc.
  - Dave Davis, Dingqing Li, Ken Lane
- For assistance in instrumentation preparation:
  - Sihang Wei, Harold Harrison, Jacob Henschen, Thomas Frankie

FRA Tie and Fastener BAA Industry Partners:

Questions?

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