FRA Crosstie and Fastener Research: Overview and Value Assessment

May 15, 2018

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Agenda

- Investment Objectives
- Strategy
- Progress Report
- Summary
- BAA 2018

Why Invest in Research?

DOT Strategic Goals

- ***Safety***: Reduce transportation-related fatalities and serious injuries across the transportation system.
- ***Infrastructure***: Invest in infrastructure to ensure mobility and accessibility and to stimulate economic growth, productivity and competitiveness for American workers and businesses.
- ***Innovation***: Lead in the development and deployment of innovative practices and technologies that improve the safety and performance of the nation's transportation system.
- ***Accountability***: Serve the nation with reduced regulatory burden and greater efficiency, effectiveness and accountability.

https://www.transportation.gov/sites/dot.gov/files/docs/mission/administrations/office-policy/304866/dot-strategic-plan-fy2018-2022508.pdf

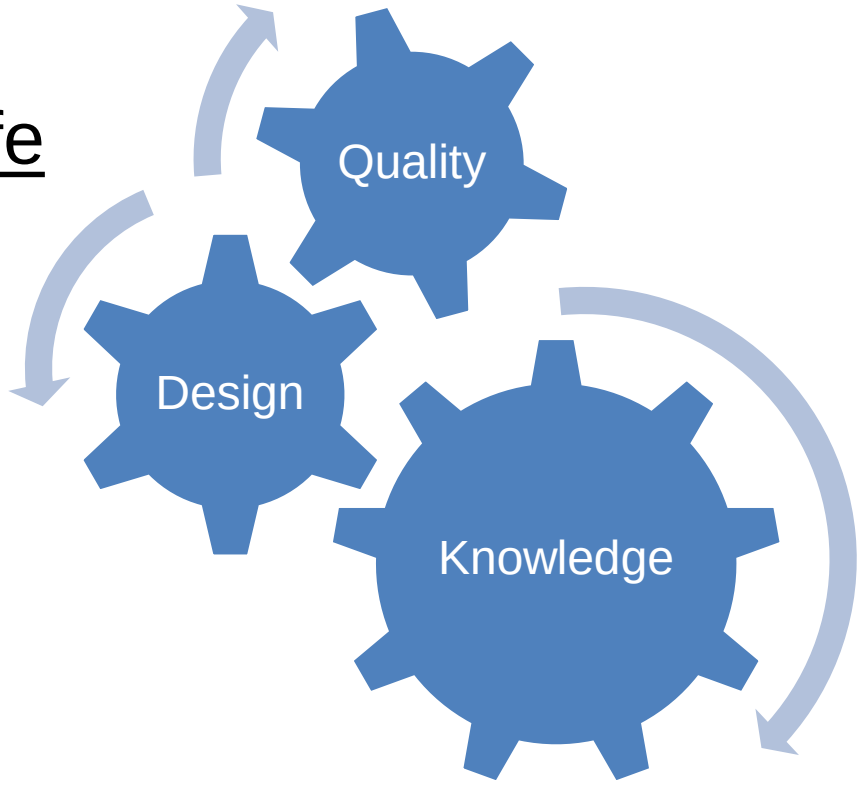
FRA RD&T Goals

- ***Safety*** – No Track Caused Derailments
  - Identify Risks
  - Create Solutions
- ***Innovation and Accountability***
  - Leverage automation where possible
  - Improve industry efficiency and effectiveness
  - Systems approach

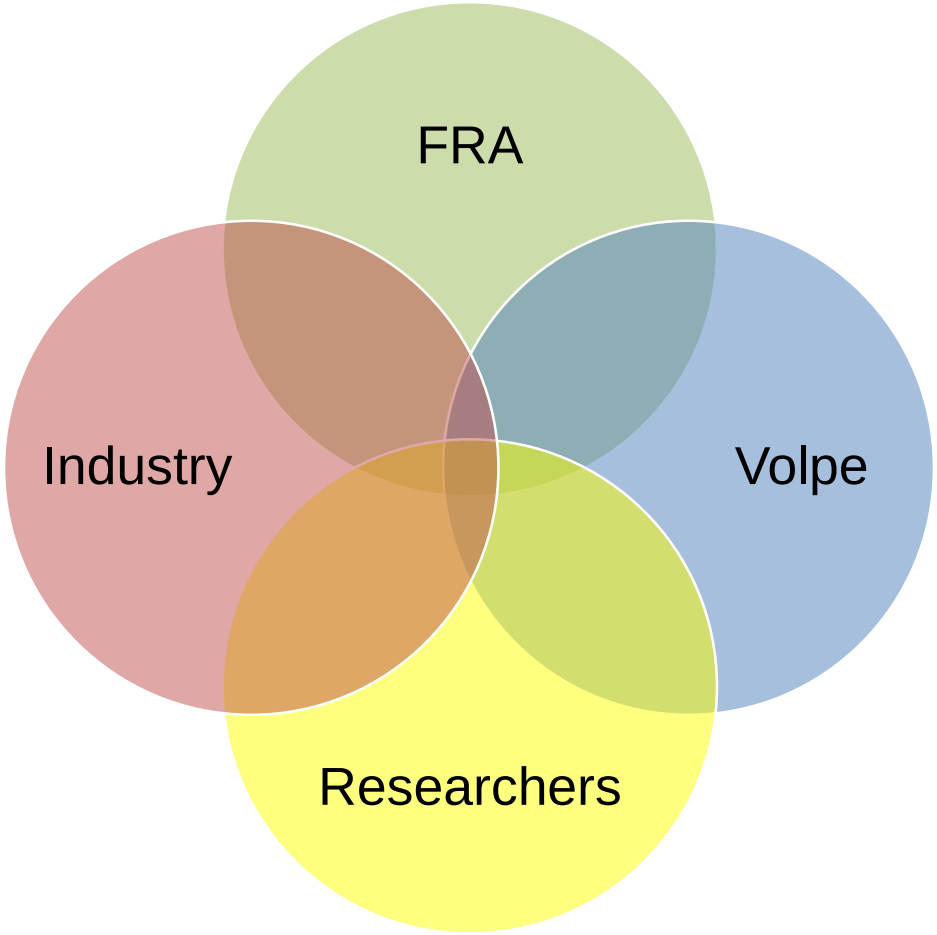
What to Avoid

Bottom Line

- Improve performance
- Advance technology
- Extend safe service life



Teamwork!



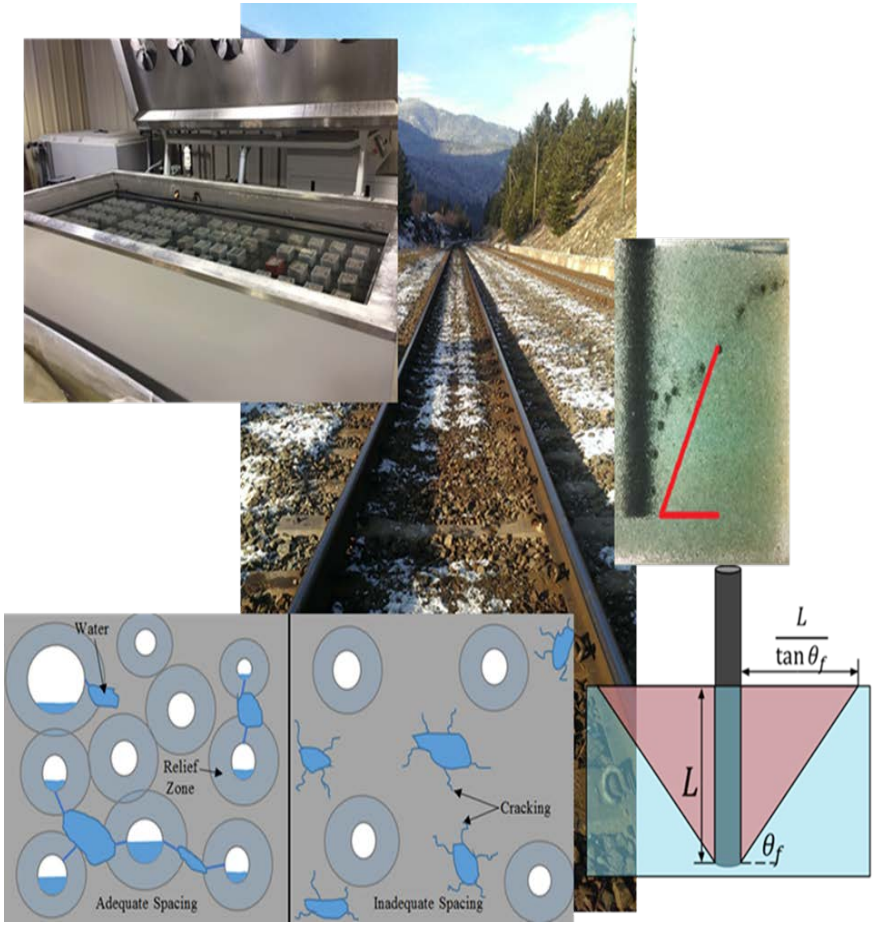
You've Come a Long Way, Team!

Review past conference presentations:

http://railtec.illinois.edu/Crosstie/2018/pastconf.html

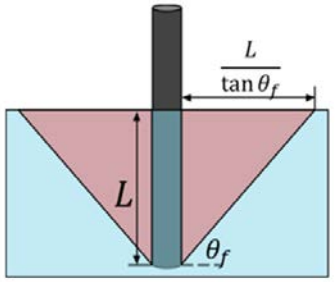
Freeze-Thaw Performance of Concrete Ties

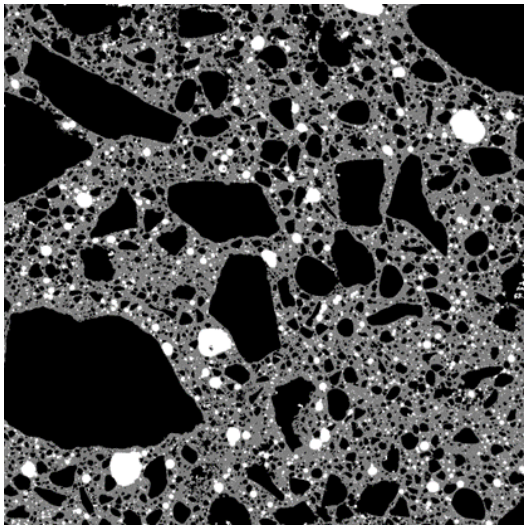
- KSU/UIUC (2012–2016)
- Mission:
  - ASTM C-666 applicability to prestressed concrete ties
  - Study physics of air voids
  - Determine effects of materials and handling
  - Measure environmental factors in field



Freeze-Thaw Performance of Concrete Ties - Results

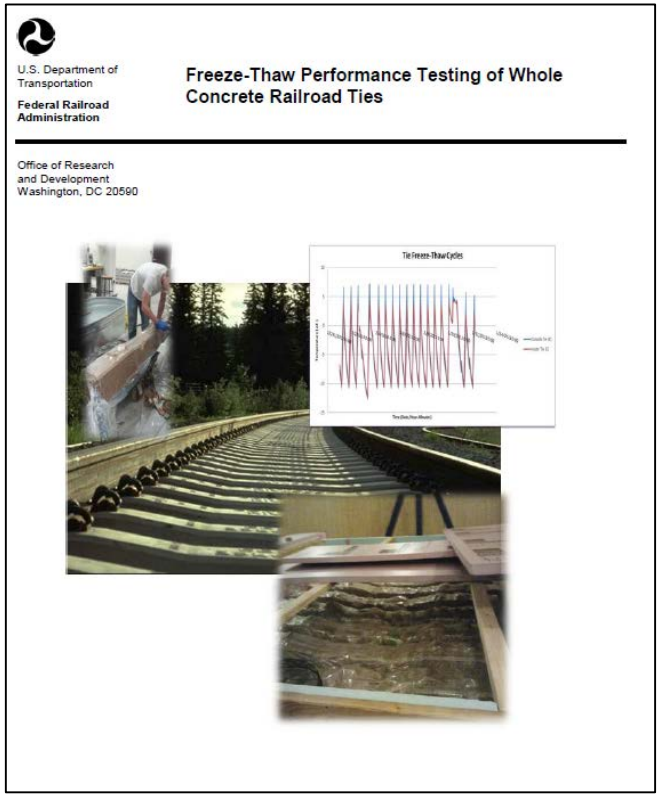
- Avoid saw-cutting specimens for ASTM C-666 – micro-cracks/bursting stresses
- New model to predict vibration requirements that yield effective entrained air bubbles in concrete
- Assessment of in-plant variables that effect air bubble distribution
- Hardened air void analysis using flatbed scanner
- Concrete ties stay very humid in the field (ballast) – new model
- Material and process recommendations to control F/T durability
- Pre-Qualification Tests
  - Aggregates
  - Concrete mixture
- Quality Control Tests





Freeze-Thaw Performance of Concrete Ties - Lasting Value

- Publications:
  - Whole tie testing – ASTM C666
    - http://www.fra.dot.gov/eLib/details/L04792
  - Full project report - pending
  - JRC, TRB, AREMA, UIUC
- Full sized tie testing machine – KSU
- AREMA C30 Standards – new ballot
- Graduates!


U.S. Department of Transportation
Federal Railroad Administration

Freeze-Thaw Performance Testing of Whole Concrete Railroad Ties

Office of Research and Development
Washington, DC 20590

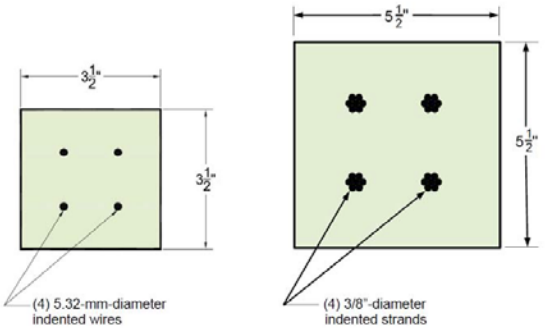
Freeze-Thaw Performance of Concrete Ties - In Plant Project

- KSU/UIUC/UF (2017-2018) w/ Nortrak
- Mission: Develop in-plant F/T performance management system
  - Match-vibrated sample prisms
  - Scanner based hardened air void
  - Near real-time production feedback loop
  - Validate and demonstrate performance-based protocol for plant freeze-thaw durability
  - AREMA updates

Validation of Performance Test

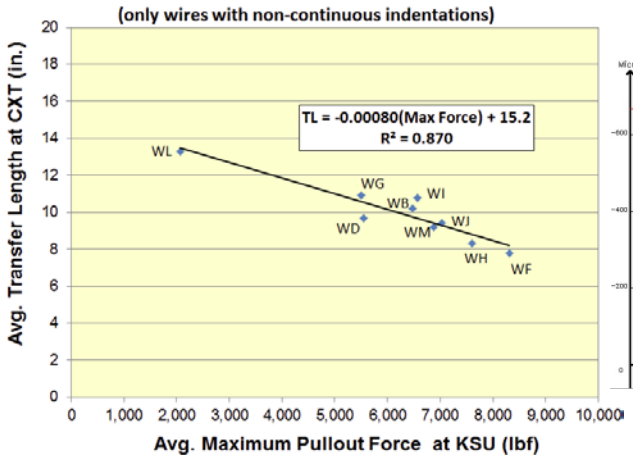
Tie Transfer Length Variables

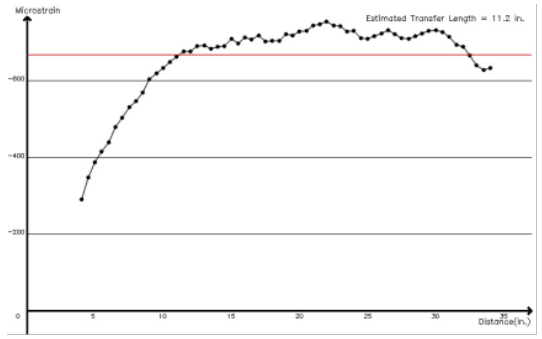
- KSU (2011–2016) w/ CXT
- Mission: Prestressing steel and concrete variables
  - How do these variables affect transfer length?
- Wires and strands
- Characterize indents
- Tensioned and untensioned pull out testing
- Experiments with prisms
- Develop automated transfer length measurement system
- In-plant test and comparison to lab results

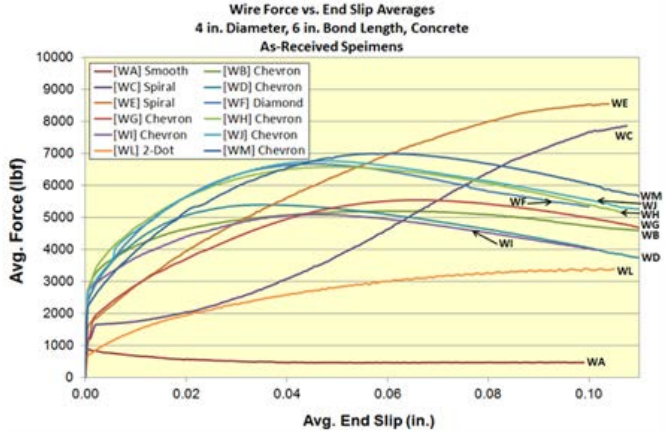


Tie Transfer Length Variables - Results

- Automated method for measuring indent geometry
- Established relationship between release strength, wire/strand characteristics, and transfer length in full ties
- Zhao-Lee method for transfer length assessment
- Automated tools for in-plant transfer length measurement

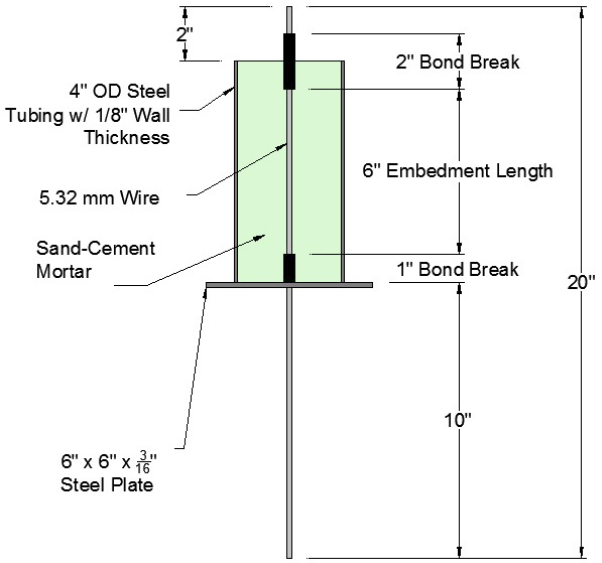


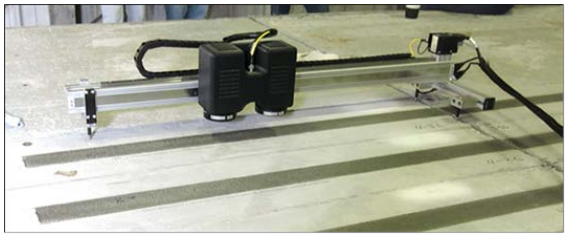




Tie Transfer Length Variables - Lasting Value

- ASTM A1096 – Standard Test Method for Evaluating Bond of Individual Steel Wire, Indented or Plain, for Concrete Reinforcement
- 2-camera, automated transfer length measurement system
- Publications: FRA (pending), JRC, PCI, UIUC (20+)
- Prism format for qualification testing
- Graduates!



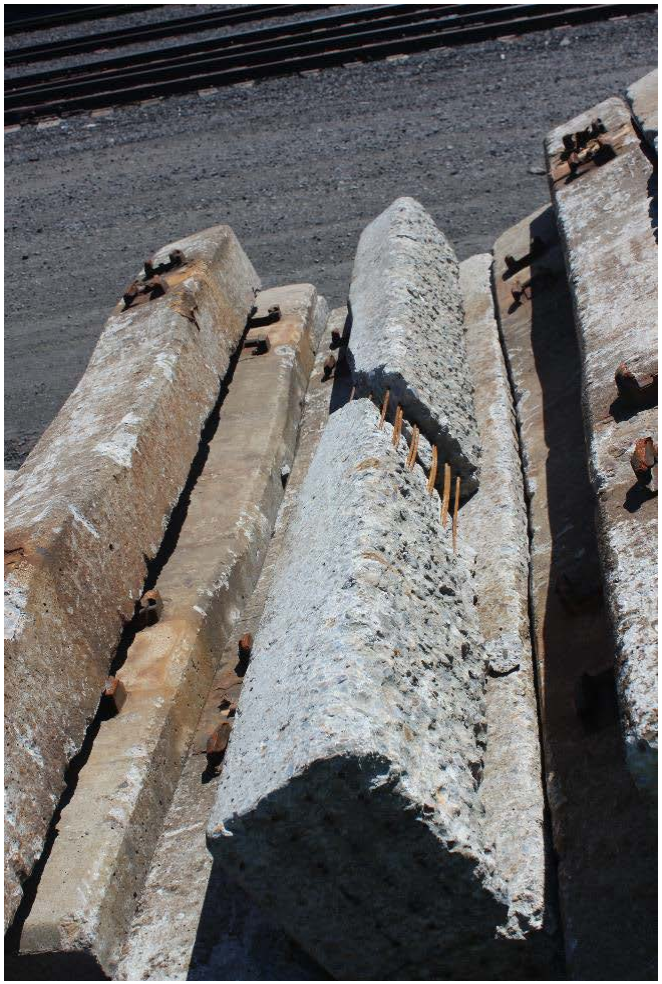


Design Qualification Tests for Concrete Ties

- KSU (2014–2018)
- Mission: Develop design level qualification test series to minimize risk of splitting and structural failures in concrete crossties
- Capture lessons from service-proven designs
- Quantify the sources of bursting stresses (with Volpe, WNEU)
  - Bond/slip relationships at various release strengths, cover levels.
  - Finite Element (FE) modeling
- Leverage prisms for efficient testing
- Outputs – ASTM, AREMA

Concrete Tie Abrasion

- KSU/UF (2016) (RR partners)
- Mission: Determine the extent of concrete tie abrasion and possible causes – field investigation
- Result: Common issues – water, fouled ballast, track stiffness
- Lasting Value:
  - Publications: FRA report pending, JRC 2018



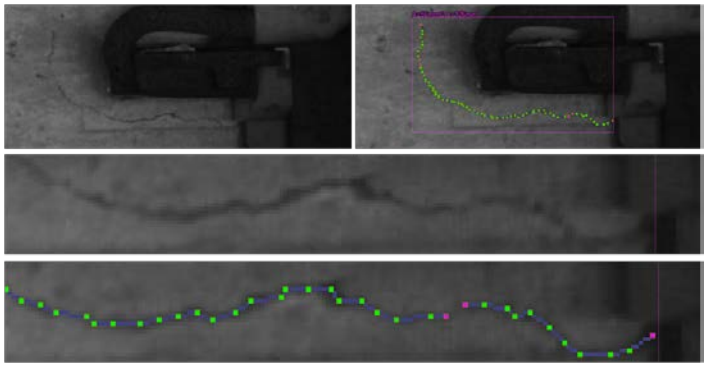
Field Testing of Concrete Ties

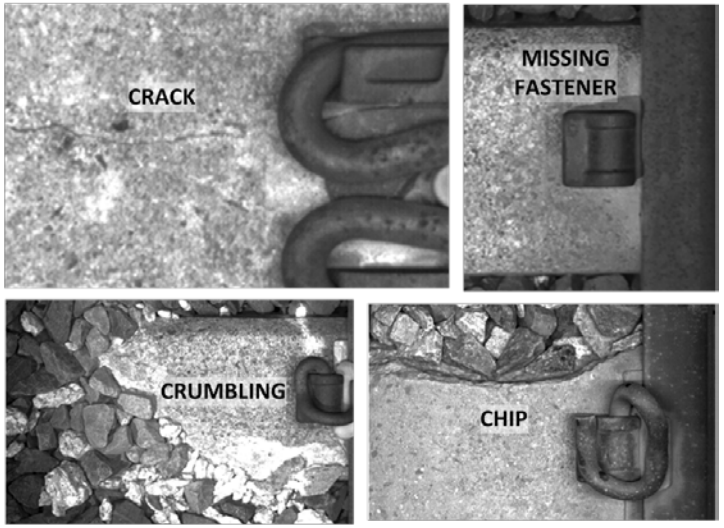
- NDT Corp. (2012–2016)
- Mission: Develop non-destructive concrete tie field evaluation technology
- Result: accurate and repeatable system based on impulse echo and pulse velocity measurements
  - Measures extent of internal cracking and thickness loss
- Lasting Value:
  - Functioning prototype
  - http://www.ndtcorporation.com/en/services/railroad-tie-testing
  - Publications: pending

Machine Vision Concrete Tie Inspection

- ENSCO/UMD (2011-2013)
- Mission: Use machine vision techniques to detect and measure crack growth over time, and grade ties
- Result: Technique effective, crack growth is very slow.
- Lasting Value:

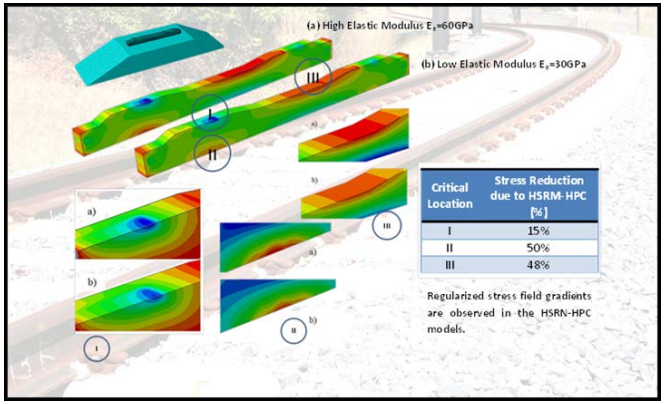
  http://www.fra.dot.gov/eLib/details/L16634





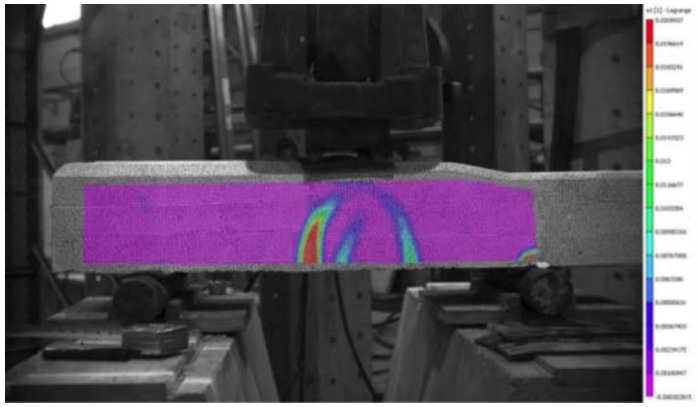
Alternative Materials Research

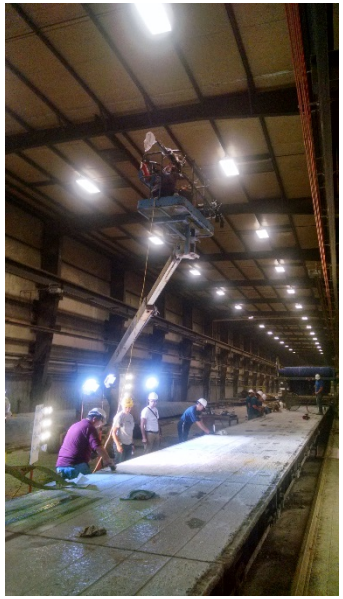
- University of South Carolina (2014–2018)
- Mission: High Strength/Reduced Modulus tie performance using weathered aggregates
- Local source aggregates
  - Material characterization
  - Prism testing
- Full scale tie testing
  - Comparison with limestone production tie
  - Innovative use of Digital Image Correlation (DIC) for strain/displacement data
  - AREMA test series
- FE Modeling
- Dynamic testing lab and test track



Alternative Materials Research - Results To Date

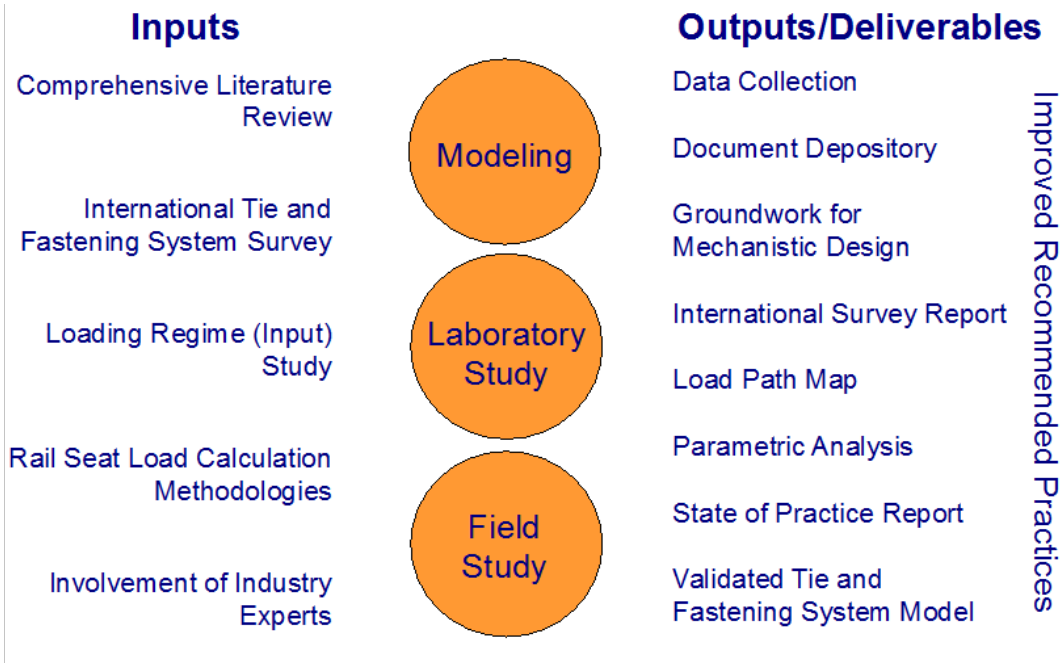
- All the strength, but greater elastic range than standard ties
- Effective use of local sources
- Passes all AREMA testing
- Dynamic testing underway





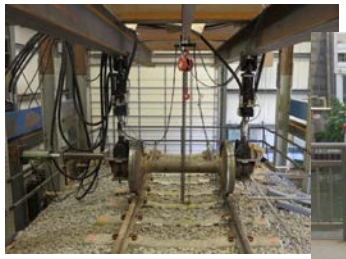
Improved Concrete Tie Design

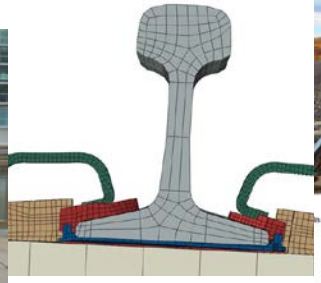
- UIUC (2011–2014)
- Mission: Research loading conditions and load paths. Conduct field and lab experiments. Develop improved, system level design requirements.



Improved Concrete Tie Design Lasting Value - "Top Ten"

1. Quantification of wheel loads
2. Development of technique for measuring lateral forces
3. Quantification of rail seat pressures
4. Development of revised crosstie bending analysis methodology
5. Development of full-scale laboratory setup (RAIL)
6. Performance modeling tools – I Track
7. Mechanistic design framework for ties/fasteners
8. Additions and revisions to AREMA Chapter 30 (Ties)
9. Industry outreach – papers, presentations
10. Workforce development (student education and career placement)





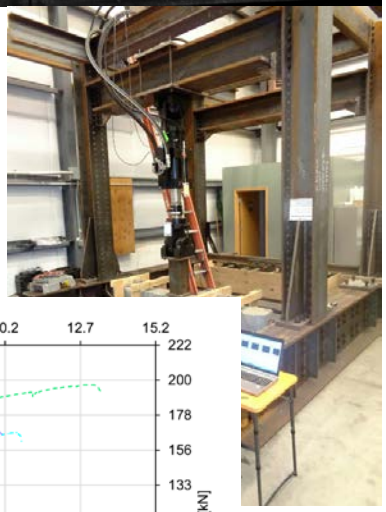
Improved Concrete Tie Design - Publications

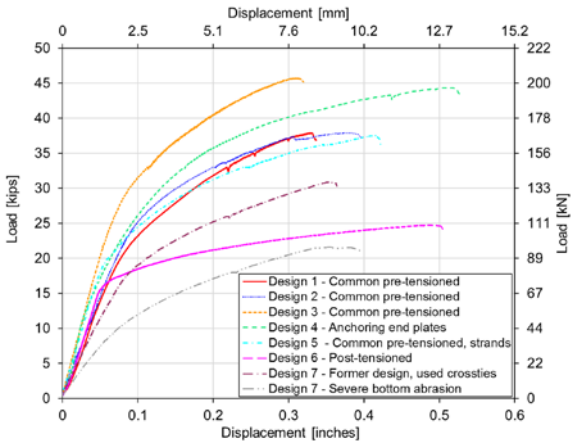
- Full Report – 2 Volumes: https://www.fra.dot.gov/eLib/details/L19184
- TTC Testing Report: https://www.fra.dot.gov/eLib/details/L05317
- Survey Results: http://www.fra.dot.gov/eLib/details/L04284

Year	Conference / Meeting	Papers	Presentations	Posters
2009	AREMA	1	1	
	IHHA	1	1	0
2010	TRB	1	1	0
	AAR Research Review			1
	JRC	1	2	0
	AREMA	2	2	
2011	TRB	1	0	1
	IHHA	3	0	2
	AAR Research Review			1
	JRC	0	2	0
	WCRR	2	0	2
	AREMA	1	1	
2012	TRB	1	1	1
	AAR Research Review			1
	JRC	2	6	0
	WRI		1	
	PCI	1	1	0
	AREMA	1	1	
	ACerS Concrete Conference	0	0	1
2013	TRB	2	2	0
	IHHA	6	6	1
	AAR Research Review			4
	JRC	3	8	0
	WRI		1	
	AREMA	1	1	
	WCRR	4	1	3
2014	TRB	4	3	1
	JRC	4	8	
	AREMA	1	1	
2015	TRB	4	1	3
	JRC	2	6	
	IHHA	5	3	2
	Total	54	61	24

Support Conditions and Limit States

- UIUC (2014–2018)
- Mission: Isolate tie failure modes related to track support. Study center negative capacity. Input to FRA regulations and AREMA.
- Laboratory experiments and FE modeling
- Lasting Value:
  - Publications: pending
  - AREMA C30 – updates 2018
  - FRA Compliance Manual enhancement (213.109 – Crossties): https://www.fra.dot.gov/eLib/details/L19471#





Progress?

Knowledge

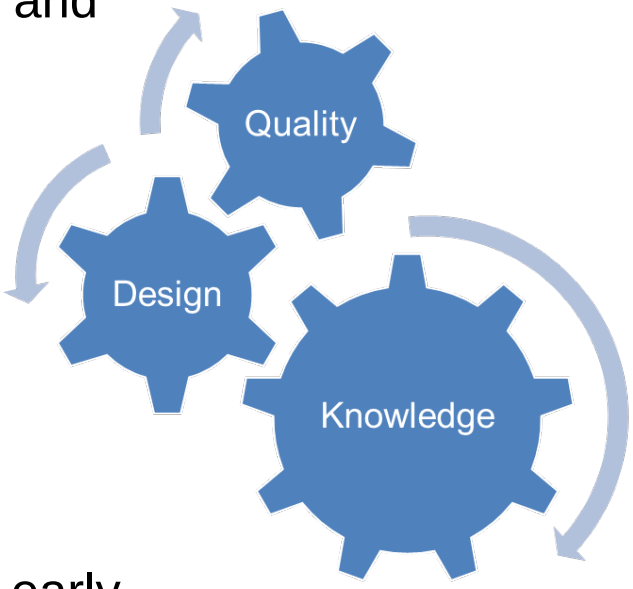
- ✓ Understand the load environment and quantify the load path
- ✓ Identify the fundamental properties of materials and components

Design

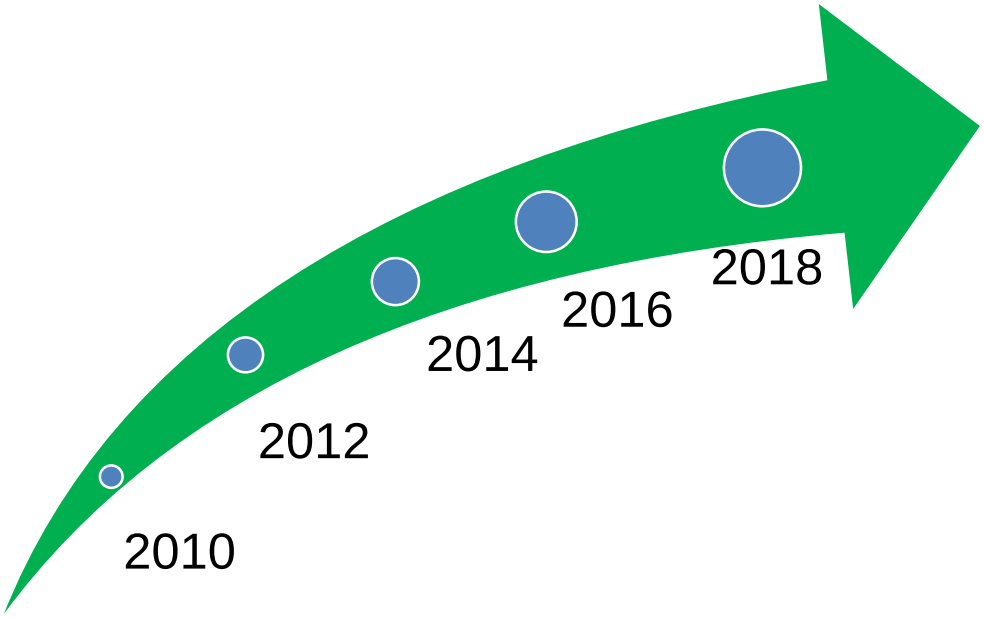
- ✓ Establish relationships between elements
- ✓ Create working boundaries for designs
- ✓ Improve industry standards

Quality

- ✓ Develop performance criteria
- ✓ Create tools and techniques to evaluate quality early in the manufacturing process and also in the field



Value Summary



1. Advanced State of Knowledge
2. Innovative Solutions and Techniques
3. Skilled Workforce
4. Cooperative Environment

Knowledge + Design + Quality = Safety and Efficiency

Thank You for Your Support!

FRA Broad Agency Announcement (BAA) Process

- Research Topics
  - Short paragraphs describing need and objective
- Announce (FedBizOps) – 2-month open period
- Evaluate – 2-step process with a very fine filter
  - Concept papers – 5 pages
    - Receive up to 100 each year
  - Proposals – 20 pages (Tech, Cost, Supplemental)
- Award
  - 10% - 20% annual award rate

U.S. Department of Transportation
Federal Railroad Administration

BROAD AGENCY ANNOUNCEMENT

BAA-2018

Federal Railroad Adminstration

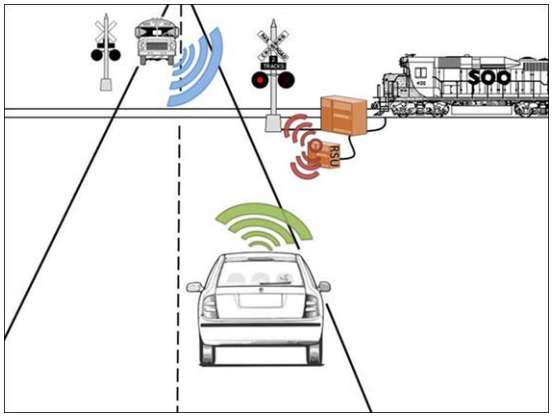
Office of Research, Development and Technology

Research Initiatives In Support of Rail Safety

March 2018

2018 BAA Plan

- General BAA 2018
  - https://www.fbo.gov/spg/DOT/FRA/OAGS/BAA20182/listing.html
  - Same format as prior years
  - 8 topics
  - Concept papers due May 24th!
- Intelligent Railroad Systems BAA
  - https://www.fbo.gov/spg/DOT/FRA/OAGS/BAA20181/listing.html
  - Congressional direction for research into connected/automated vehicle technologies for rail
  - $2M funding
  - Competition limited to universities and university-led teams
  - Single stage process - proposals
  - Proposals due by July 27, 2018
  - Award recommendations – Sept 2018



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