Results of International Concrete Crosstie and Fastening System Survey

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Outline

- Role of International Survey in UIUC FRA Concrete Tie and Fastener BAA
- Survey Objectives
- Audience
- Development and Content
- Results
- Preliminary Conclusions

FRA Tie and Fastening System BAA Objectives and Deliverables

- Program Objectives
  - Provide mechanistic design recommendations for concrete crossties and fastening system design in the US
  - Conduct experimental laboratory and field testing, leading to improved recommended practices for design
  - **Conduct comprehensive international literature review and state-of-the-art assessment for design and performance**
- Program Deliverables
  - Improved mechanistic design recommendations for concrete crossties and fastening systems in the US
  - Improved safety due to increased strength of critical infrastructure components
  - Centralized knowledge and document depository for concrete crossties and fastening systems

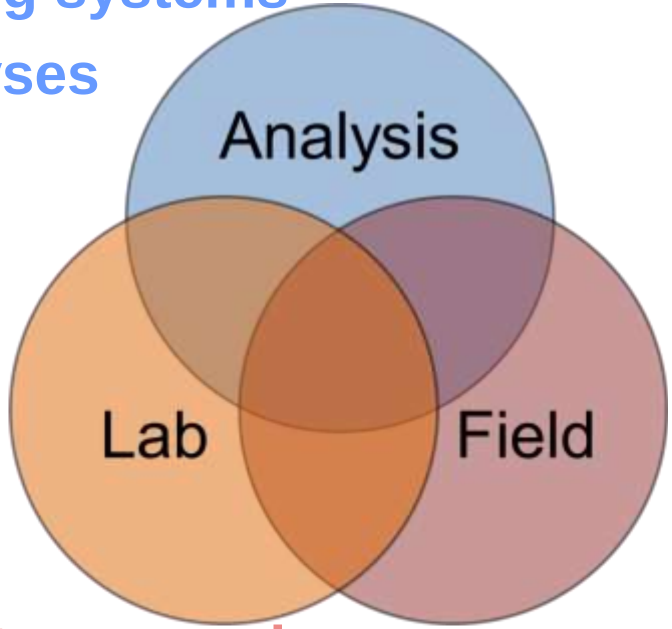
Survey Objectives

- **Conduct an international survey on the use and performance of concrete crossties and fastening systems**
- Understand the current state-of-practice regarding the use of concrete crossties and fastening systems
- Develop an understanding of the most common types of crosstie and fastening system failures
- Continue establishing relationships and encouraging collaboration with railways, researchers, and manufacturers around the world

Role of International Survey

Analysis

- Determine typical loading for modeling systems
- Provide references for previous analyses



Lab

- Identify relevant international testing
- Compare US test criteria and practices with various international standards

Field

- Identify conditions where failure most commonly occurs
- Develop understanding of probabilistic loading conditions

Survey Audience

- Representation from the following continents:
  - North America
  - Europe
  - Asia
  - Africa
  - Australia
- Categories of experts surveyed:
  - Infrastructure owner, operator, or maintainer
  - Academic, industry, or institutional researcher
  - Concrete crosstie or fastening system manufacturer

Incentives for Organizations to Participate

- Acquisition of study results
- Inclusion in release of future publications in concrete tie and fastening system research at UIUC
- Access to reference list of journal and conference papers, design standards, and specifications

Development of Survey

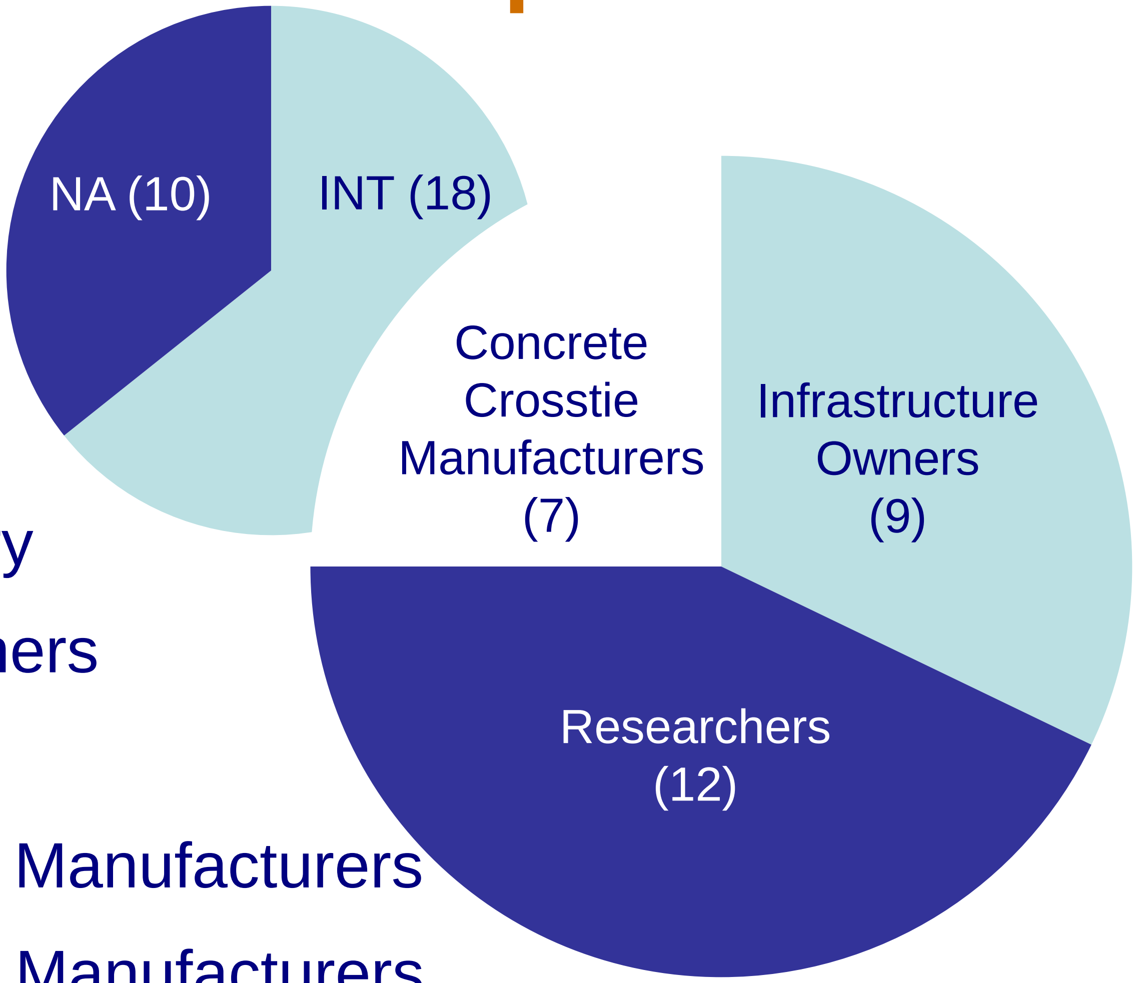
- Created lists of questions for infrastructure owners, researchers, and concrete crosstie manufacturers
- Reviewed by industry partners and internal team
- Survey tool researched and selected – Zoomerang
- Created, revised, and deployed survey

Survey Content

- Usage
- Crosstie Characteristics and Manufacturing Techniques
  - Concrete
  - Prestress
- Fastening System Performance and Characteristics
  - Prevalence
  - Materials
- Effectiveness and Failure
  - Design Life
  - Maintenance
  - Failure Modes
- Industry Recommended Practices and Tests
- Research

Survey Results – Responses

- 28 Total Responses
- Geography
  - 10 in North America
  - 18 internationally
- Role in Railway Industry
  - 9 Infrastructure Owners
  - 12 Researchers
  - 7 Concrete Crosstie Manufacturers
- Two Fastening System Manufacturers



Survey Results – Loading Environment

	International Responses	North American Responses
Average maximum freight axle load*	29.5 tons (26.8 tonnes)	39.1 tons (35.4 tonnes)
Average maximum passenger axle load*	21.6 tons (19.6 tonnes)	29.1 tons (26.4 tonnes)
Average concrete crosstie design axle load	27.6 tons (25.0 tonnes)	37.4 tons (33.9 tonnes)
Average tangent crosstie spacing	24.2 inches (61.4 centimeters)	24.0 inches (61.0 centimeters)
Average annual tonnage (per track)	38.7 million gross tons (35.1 million gross tonnes)	100.0 million gross tons (90.7 million gross tonnes)

*Interpreted from responses due to discrepancies in wheel or axle loads

Survey Results – Criticality of Problems

Problem (higher ranking is more critical)	Average Rank
International Responses	
Tamping damage	6.14
Shoulder/fastening system wear or fatigue	5.50
Cracking from center binding	5.36
Cracking from dynamic loads	5.21
Cracking from environmental or chemical degradation	4.67
Derailment damage	4.57
Other (e.g. manufactured defect)	4.09
Deterioration of concrete material beneath the rail	3.15
North American Responses	
Deterioration of concrete material beneath the rail	6.43
Shoulder/fastening system wear or fatigue	6.38
Cracking from dynamic loads	4.83
Derailment damage	4.57
Cracking from center binding	4.50
Tamping damage	4.14
Other (e.g. manufactured defect)	3.57
Cracking from environmental or chemical degradation	3.50

Survey Results – Importance of Research

Research topic (higher ranking is more important)	Average Rank
International Responses	
Track system design	4.08
Optimize crosstie design	3.93
Fastening system design	3.50
Materials design	2.23
Prevention or repair of rail seat deterioration	1.58
North American Responses	
Prevention or repair of rail seat deterioration	3.60
Fastening system design	3.60
Materials design	3.00
Optimize crosstie design	2.80
Track system design	2.00

Design and Performance Trends

	International Responses	North American Responses
Average minimum allowable concrete strength at transfer	6,500 psi	4,700 psi
Average 28-day concrete compressive strength	8,700 psi	8,250 psi
Prominent concrete crosstie manufacturing process	Carousel	Long line
Abrasion plate or frame	No	Yes
Commonly failed components	Screw, clip	Pad, rail seat
Rail seat deterioration	No	Yes
Focus of research	Loading, testing, design	Life cycle cost reduction

Fastening System Design Considerations

- Tonnage
- Daily train volume and frequency
- Velocity of trains
- Static loads
- Dynamic impact loads
- Ability of pad to evenly distribute load to rail seat
- Abrasion of concrete rail seat by pad or abrasion plate

Conclusions

- North American loads are, on average, substantially higher than those throughout the rest of the world
- The most critical failure concerns in **North America** are related to wear or fatigue on the rail seat, rail pad, or shoulder
- The most critical failure concerns **internationally** are cracking from dynamic loads, shoulder wear, and tamping damage
- Greater emphasis placed on system design and optimization internationally

Future Survey Use

- Follow up with those who are willing to share unpublished test results
- Advance laboratory and field testing procedure in accordance with survey responses
- Pursue completion of research in areas determined to be most critical by industry responses
- Use responses to continue development of mechanistic design practices for concrete crossties and fastening systems

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Questions

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