Reducing Concrete Crosstie Risk

Designing A New Generation of High Performance Concrete Crossties

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Urbana, IL

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Presentation outline

- Introduction to GIC
- Vision for reduced-risk design
- Field experience
- Path forward

Introduction to GIC

Background

- GIC has been developing optimal and innovative construction and engineering solutions for 40 years
  - Specializing in prestressed concrete elements
  - Complete process integration
    - Design, production, and installation
  - Focus on superior technology and quality
  - Pursuing total satisfaction for clients, employees, and partners
  - Serving communities
    - Headquarters in Monterrey, NL, Mexico
    - Engineering office in Dallas, TX, USA
    - Projects completed in Mexico, USA, Canada

Introduction to GIC

Background

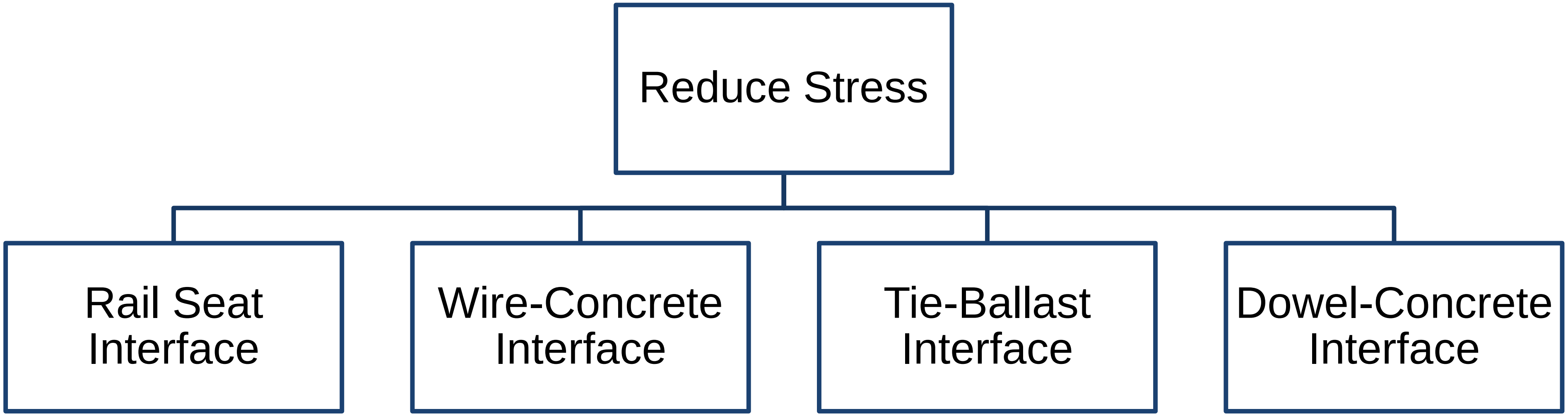
- Design and manufacturing beams, columns, girders, wall panels, slabs, cellular concrete blocks, crossties, rail seat blocks, etc.

Introduction to GIC
Background

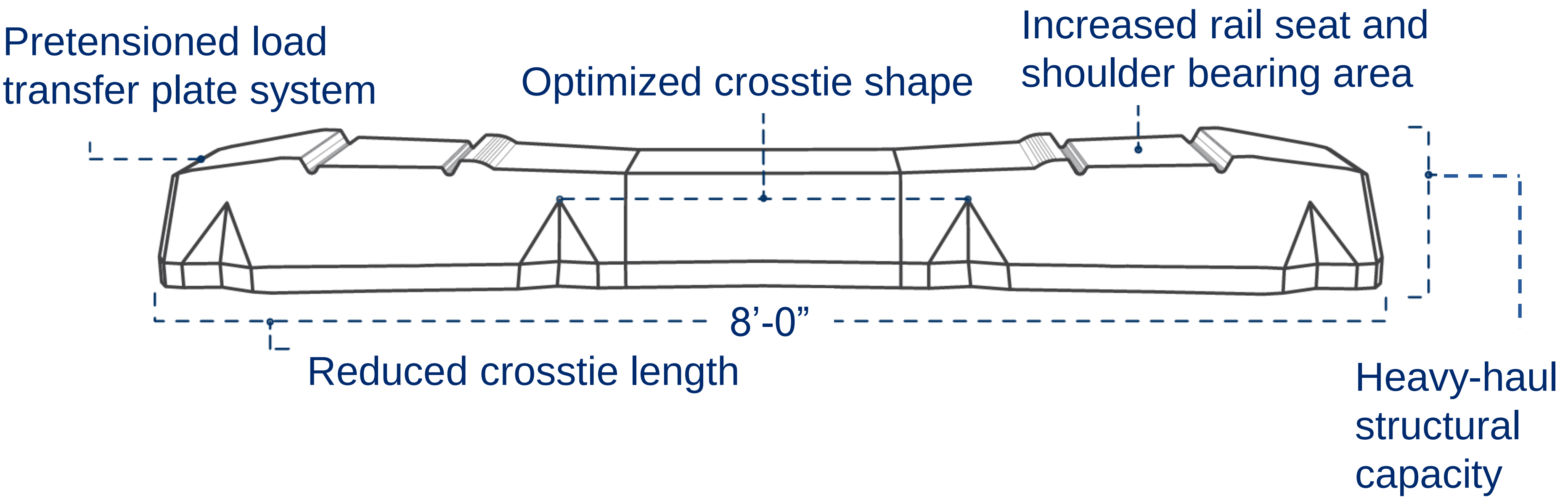
Introduction to GIC
Concrete tie objectives

- **Optimize crosstie design and manufacturing processes to redefine high performance**
  - **Clean-slate approach**
  - **Combining advanced manufacturing and concrete technologies with innovative tie designs**
- **Increase robustness and durability with features that mitigate existing failure modes, reducing user risk**
- **Improve efficiency of track structure**

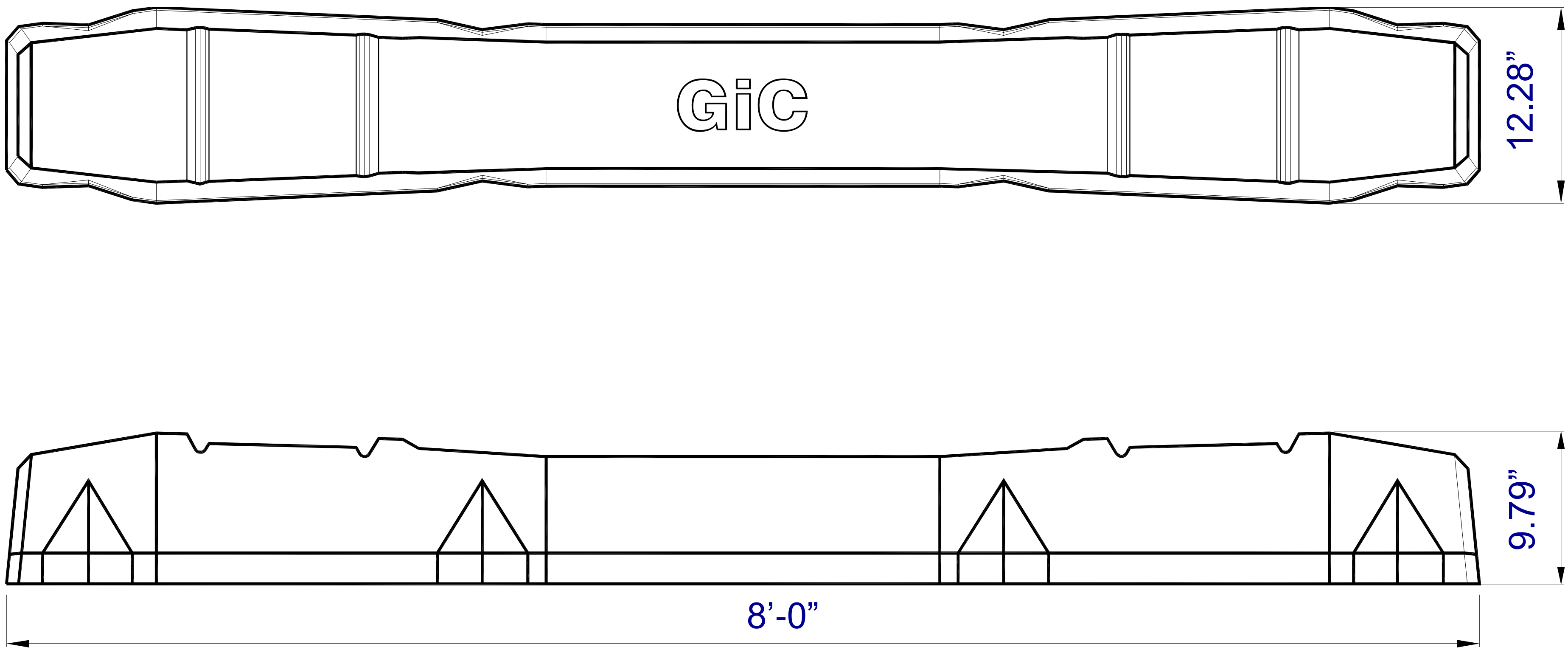
Vision for reduced-risk design



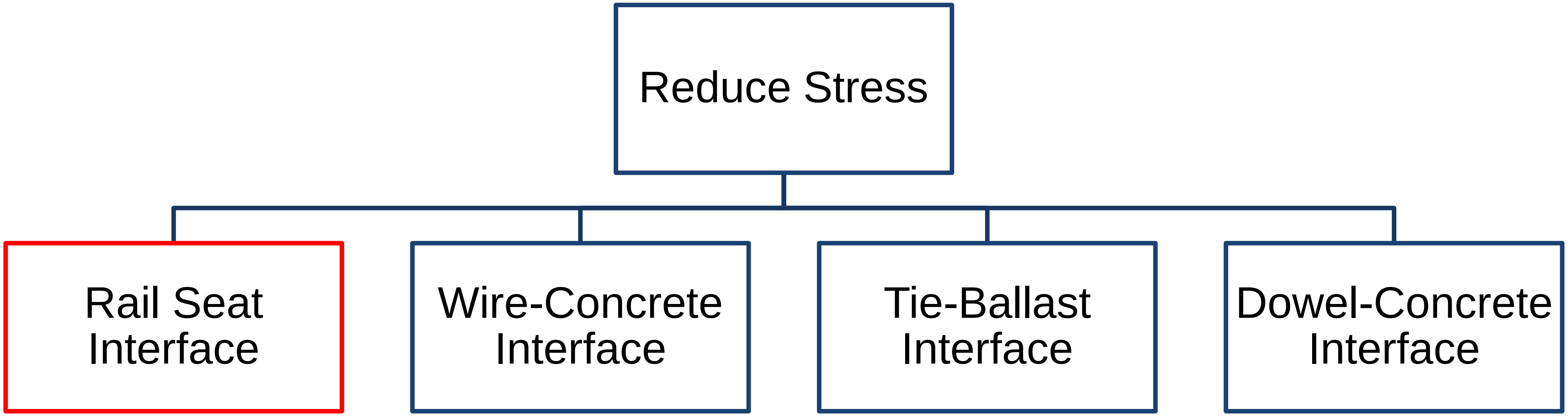
Features of reduced-risk design



G13 freight mainline concrete tie

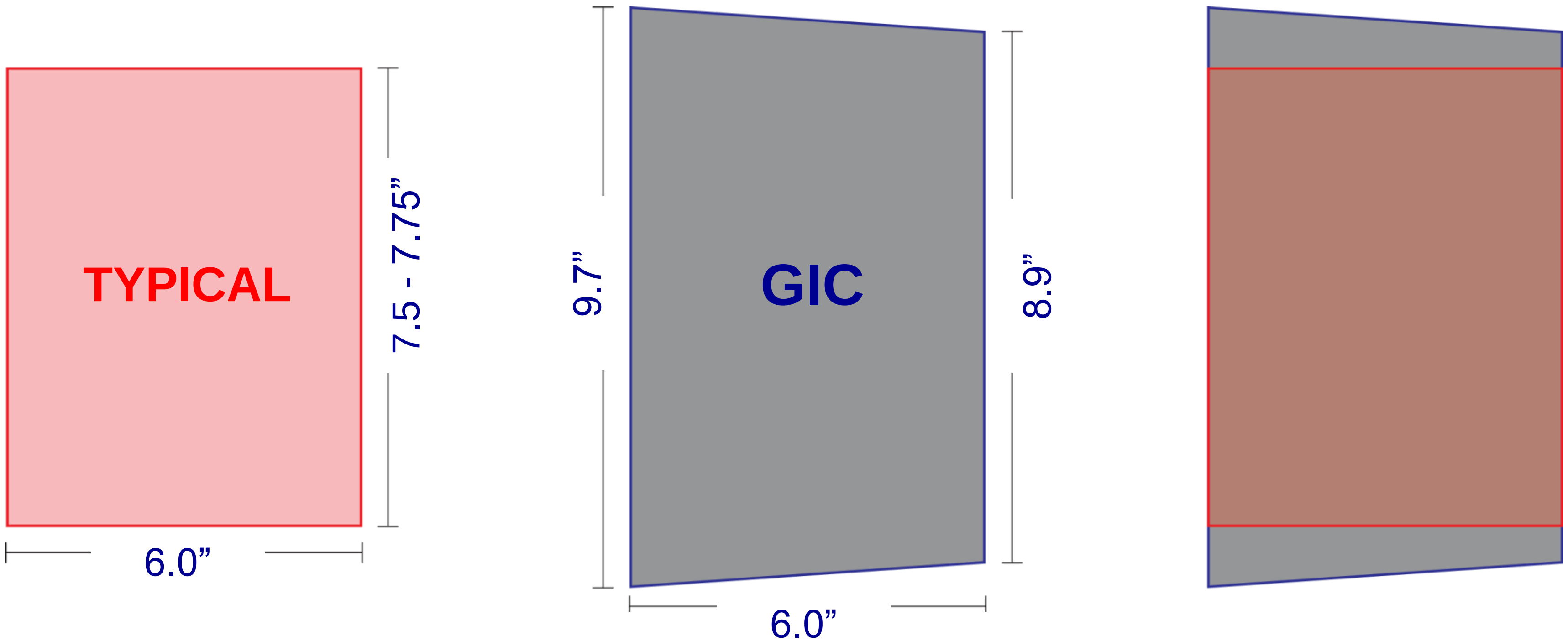


Vision for reduced-risk design



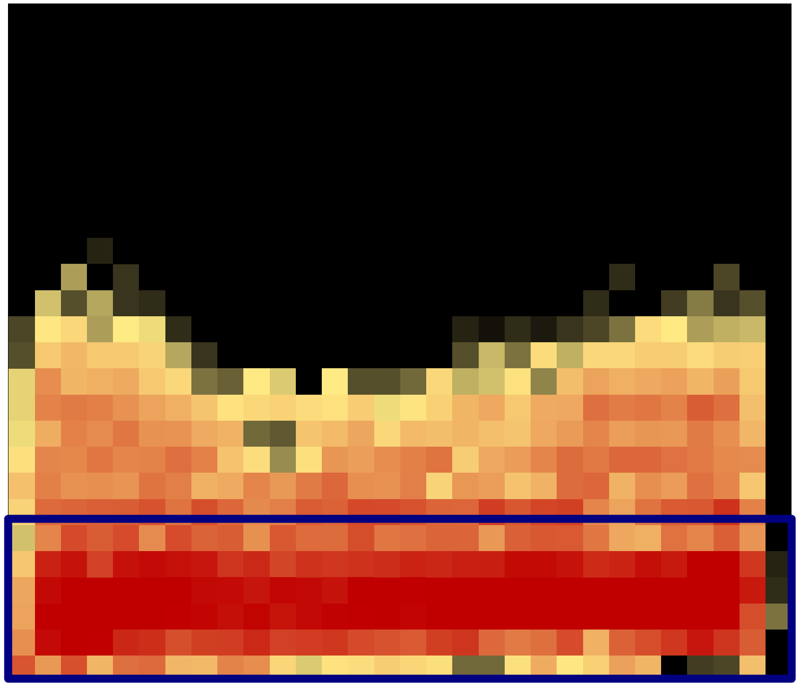
Rail seat interface

- Reduced risk of rail seat deterioration (RSD)
  - **21% larger bearing area**, pressure decreased by 17%, assuming 6” uniform distribution (tangent track)
  - **25% larger bearing area**, pressure decreased by 20%, assuming 1” concentrated field side distribution (high-degree curve)



UIUC Rail Seat Load Index (RSLI)

- A quantifiable design value which describes the sensitivity of the rail seat load distribution to changes in the L/V force ratio
- Rail Seat Load Index (RSLI) is defined as the percent of total rail seat load imparted onto a critical region of the rail seat, defined as the area of the rail seat not more than 1 inch (25.4 mm) from the field side shoulder, normalized to a theoretical, uniform distribution.



$$RSI = \frac{\frac{[Load\ in\ Critical\ Area]}{[Total\ Rail\ Seat\ Load]}}{\frac{1}{6}} = 6 * \frac{[Load\ in\ Critical\ Area]}{[Total\ Rail\ Seat\ Load]}$$

Greve, M.J., M.S. Dersch, J.R. Edwards and C.P.L. Barkan. 2015. Evaluation of Laboratory and Field Experimentation Characterizing Concrete Crosstie Rail Seat Load Distributions. In: *Proceedings of the 2015 Joint Rail Conference*, San Jose, CA, March 2015.

Vision for reduced-risk design

- Reduce Stress
  - Rail Seat Interface
  - Wire-Concrete Interface
  - Tie-Ballast Interface
  - Dowel-Concrete Interface

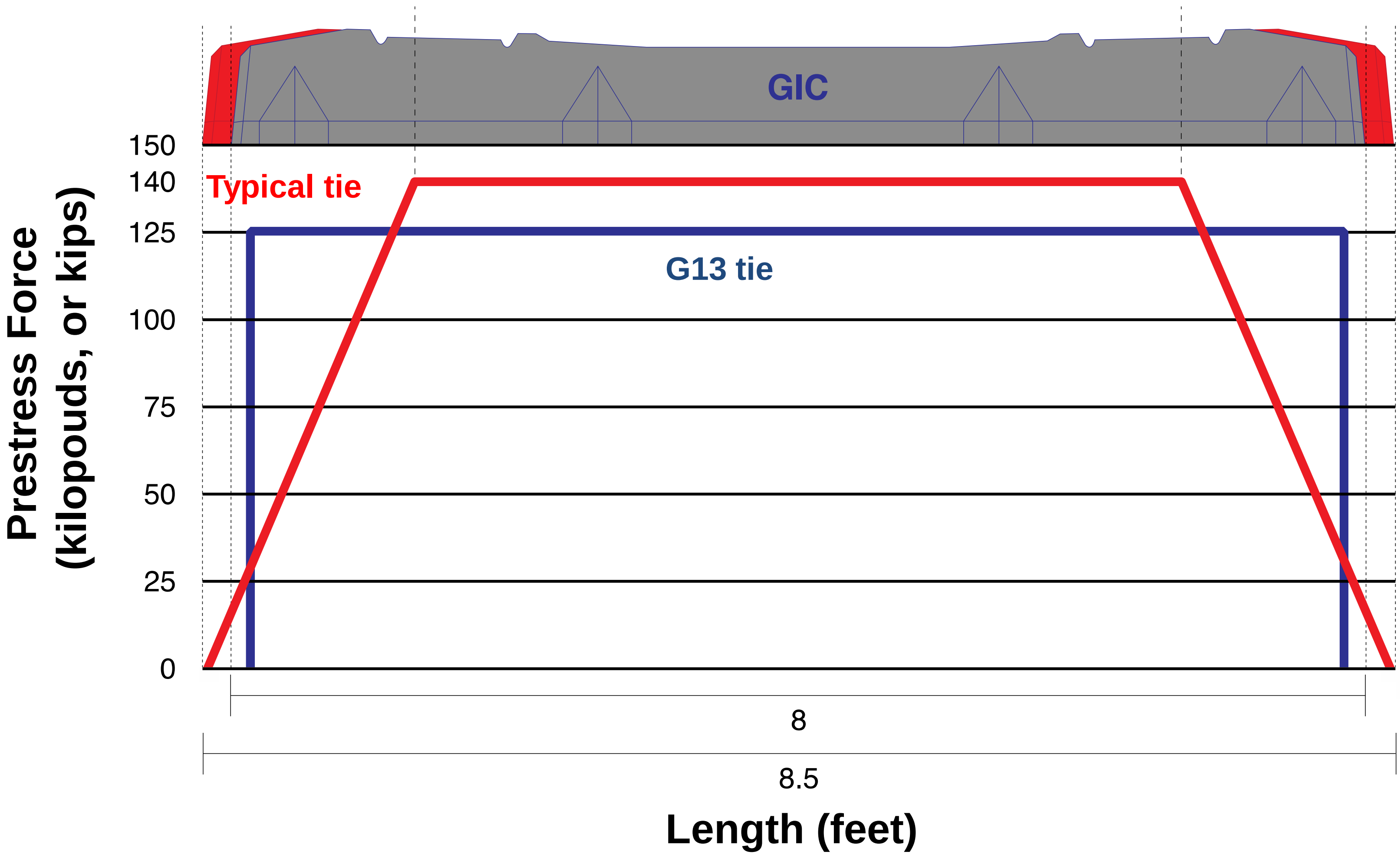
Wire-concrete interface

- Eliminated risk of end splitting and longitudinal cracking using pretensioned load transfer plate system
  - Provides compression beginning at the crosstie ends
    - Reduces radial stress along wires
      - Results in a more uniform distribution of prestress forces
      - Less prestress force, reduced stress in concrete

Wire-concrete interface

Less force along wire

- Smaller force, less concrete and steel needed to support heavy-haul loads



Wire-concrete interface

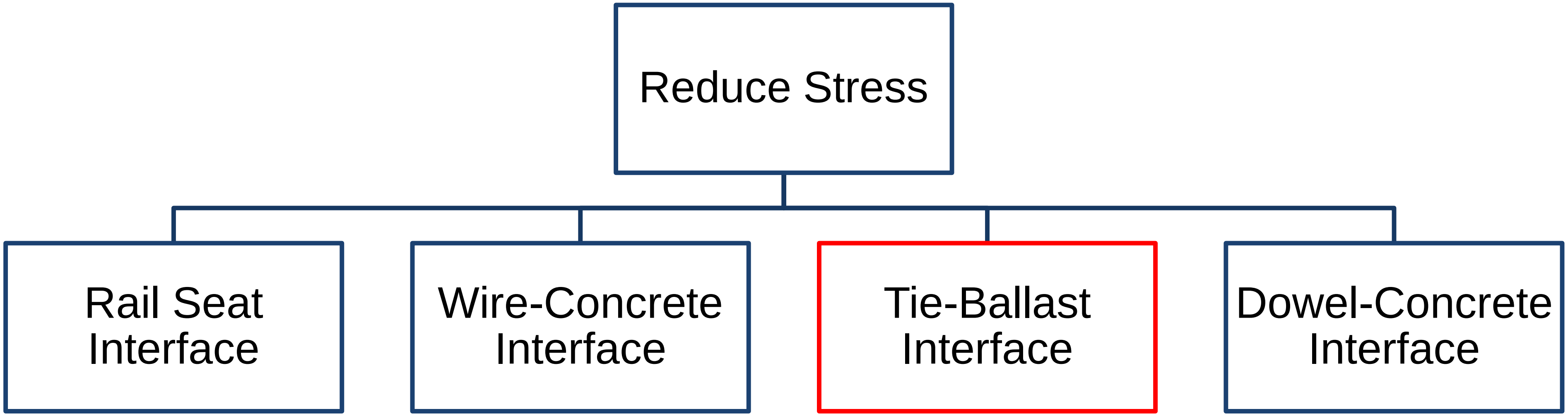
Heavy-haul structural capacity

- G13 passed 100% of AREMA design qualification tests

<u>AREMA Ch. 30 Section 4.9.1.1 – Crosstie Flexural Strength</u>

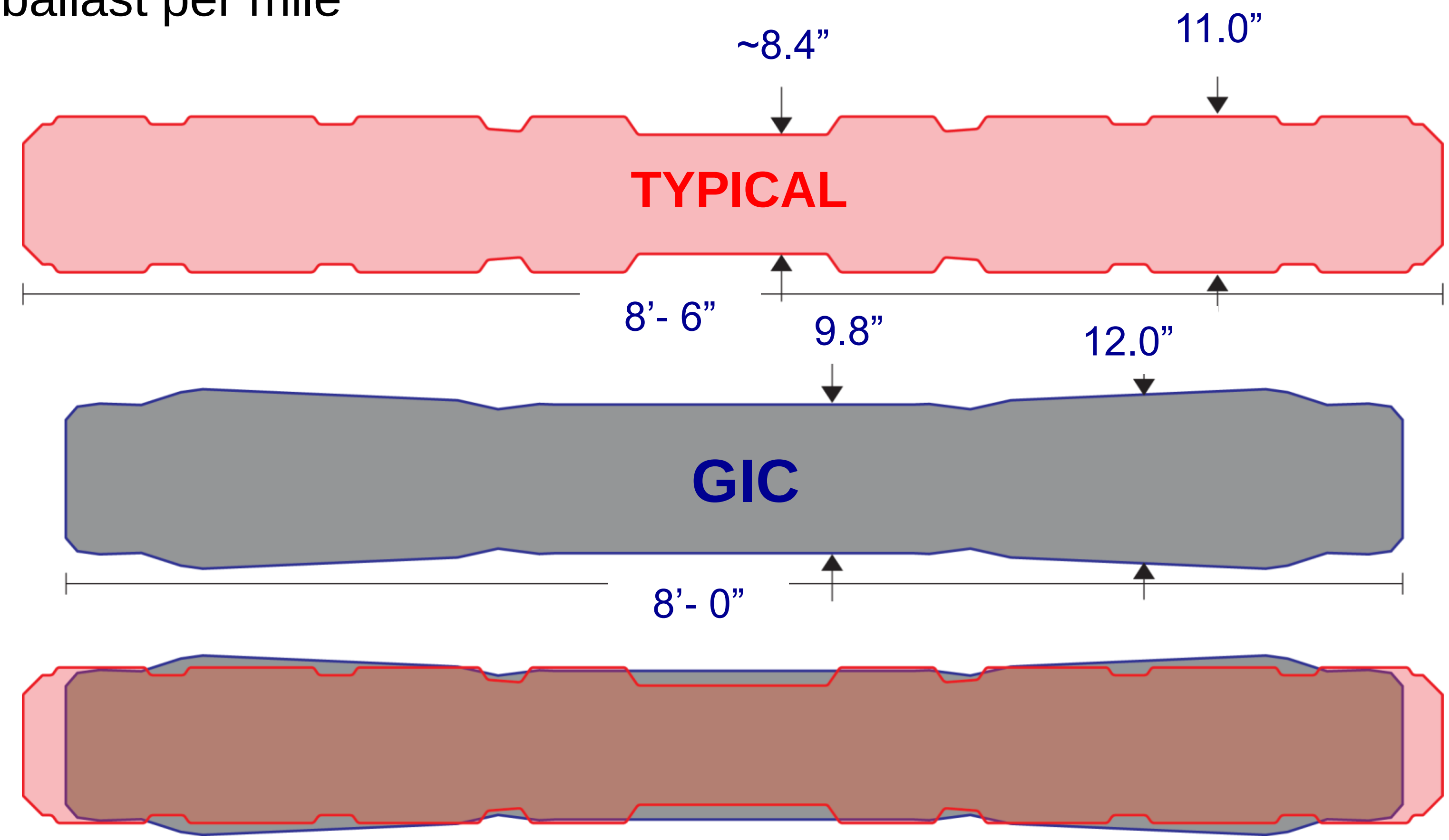
Test	Load (kips)	Crosstie G13-1	Crosstie G13-2
RS- A	32	Pass	Pass
RS+ A	64	Pass	Pass
Ce-	17	Pass	Pass
Ce+	13	Pass	Pass
RS- B	32	Pass	Pass
RS+ B	64	Pass	Pass
RS+ B	(1st crack)	77 kips	79 kips
Ce-	(1st crack)	22 kips	24 kips

Vision for reduced-risk design

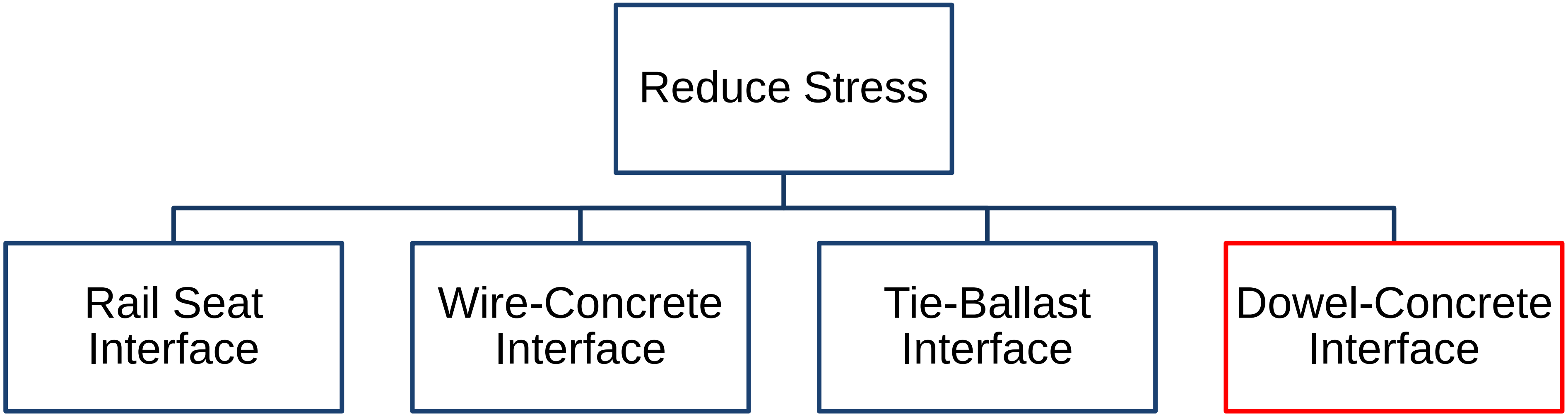


Tie-ballast interface

- Approximately **16% more bearing area** in 24” tamping zone
  - Pressure decreased by 14% assuming uniform distribution
- Shorter crosstie length reduces track width by 6” – saving 94 tons of ballast per mile

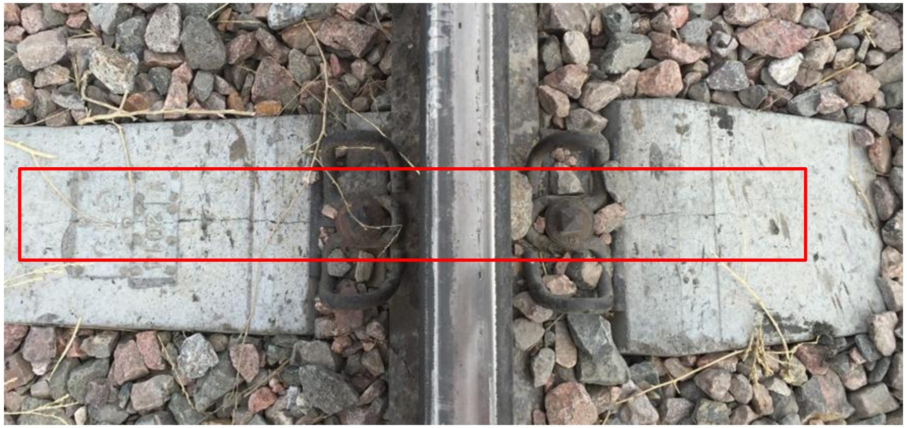


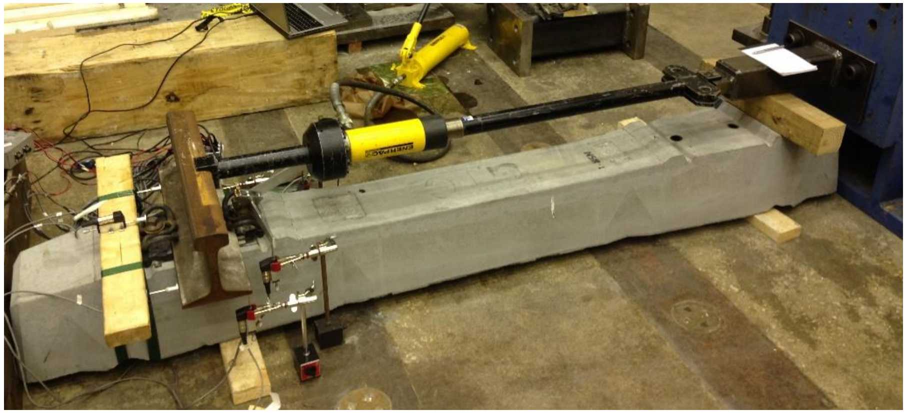
Vision for reduced-risk design



Dowel-concrete interface

- Dowel-based fastening system needs reinforcement and/or revised dowel design to prevent transverse stress perpendicular to dowel hole
- Steel spiral reinforcement around the dowel is effective





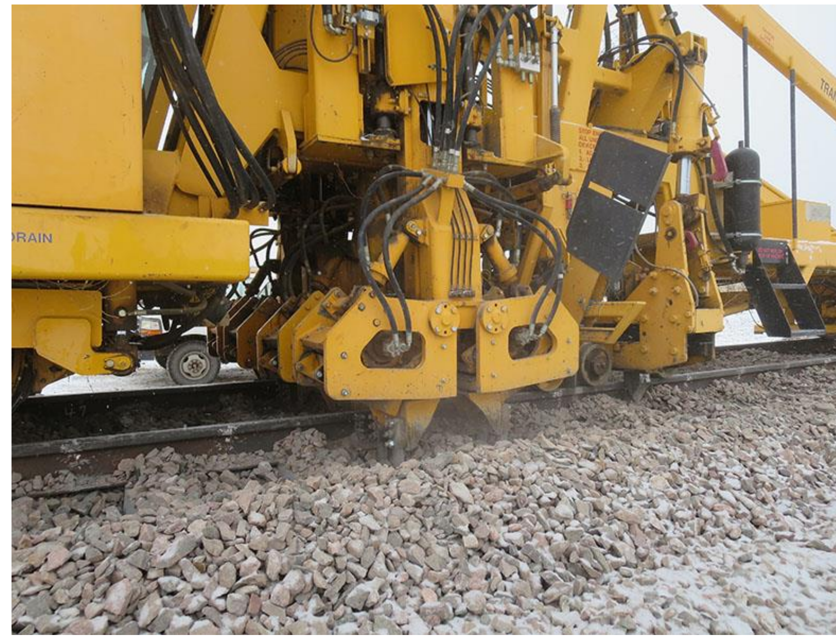
BNSF Installation of G13

Low tonnage TLM trial – July 2015

BNSF Installation of G13

BNSF site visit March 2016

TTCI installation of G13



Installed November 2014

TTCI installation of G13

29 MGT

51 MGT

Test Duration: November 2014 – April 2015

TRE installation of G13

Trinity Railway Express – Installed May 2016

TRE installation of G13

Path forward

- Lead strongly in concrete crosstie market
- Continue to prove reduced-risk design though field performance
- Increase availability for high-performance concrete crossties in several geographical regions in USA and Canada
- Drive market innovation through development of advanced technologies and reduced-risk design

Comments & Questions

Tie-ballast interface

Lateral resistance

AREMA Section 2.9 Test 8 – Single Tie Push (STP)