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INTERNATIONAL CONCRETE CROSSTIE AND FASTENING SYSTEM SURVEY



SUMMARY

The International Concrete Crosstie and Fastening System Survey assesses the international railway industry's state of practice regarding concrete crossties and fastening system design, performance, and research needs. The Rail Transportation and Engineering Center (RailTEC) at the University of Illinois at Urbana-Champaign (UIUC) conducted the six-month long survey beginning September 2011. Participants included concrete crosstie and fastener experts around the world. The survey is part of a larger research program funded by the Federal Railroad Administration (FRA) to study crosstie and fastening systems and performance trends. The research objective is to improve the design and performance of concrete crossties and fastening systems for high-speed and mixed freight passenger service in the United States. The survey results provided useful insight into the potential causes and effects of various system failures. It also shed light on the research being conducted to mitigate these failure modes.

OBJECTIVES

The primary purpose of the International Concrete Crosstie and Fastening System Survey was to aid UIUC's research team in developing an understanding of some of the most common crosstie and fastening system failures, as well as the current state of practice relevant to the design and performance of these systems. This goal was accomplished by using the feedback gathered from polling the international railway community on the use and performance of concrete crossties and elastic fastening systems. In addition, the effort encouraged collaboration between railways, researchers, and manufacturers around the world, and enabled UIUC to establish valuable relationships.

METHODS

The International Survey was developed with extensive input from many of the experts in concrete crosstie and fastening system research, design, production, use, and maintenance.



The survey, which included questions regarding concrete crosstie and fastening system production and performance, was distributed to infrastructure owners, operators, or maintainers; academic, industry, or institutional researchers; and concrete crosstie manufacturers. A separate set of questions was addressed to fastening system manufacturers during personal conversations, allowing for more comprehensive answers about the fastening system landscape.

FINDINGS

The survey was distributed to 46 individuals and/or organizations worldwide with extensive knowledge of the performance and design of concrete crossties and fastening systems. Of those 46 individuals and/or organizations, 28 participated—a 61 percent response rate that the authors felt was adequate to provide meaningful results.

Survey responses were received from Asia (5 responses), Australia (5), Europe (8), and North America (10). Nine respondents were infrastructure owners, operators, or maintainers; twelve were academic, industrial, or institutional researchers; and seven were concrete crosstie manufacturers. Although there were no respondents from Africa or South America, the authors felt that the responses from both heavy haul and high-speed operating perspectives were representative of the international concrete crosstie and fastening system as a whole.

To better understand the complex loading conditions of the concrete crosstie and elastic fastening system, it is important to understand what types of loads are being applied to that system. A comparison of international and North American responses, as shown in **Table 1**, along with information gleaned from other load quantification methods, provides clarity about system design and insight into specific failures around the world.

	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 annual tonnage (per track)	38.7 million gross tons (35.1 million gross tonnes)	100.0 million gross tons (90.7 million gross tonnes)

Table 1. Survey Results – Loading Environment of Concrete Crosstie and Fastening System

When developing design recommendations, it is important to consider failure mechanisms. Identifying and analyzing the causes of failure may provide insight into ways in which the concrete crosstie and fastening system can be improved. As displayed in **Figure 1**, the most common failure causes, according to the survey responses, are fastening system wear and damage, tamping damage, and concrete deterioration beneath the rail (although many of the international researchers viewed this as the least critical failure cause).

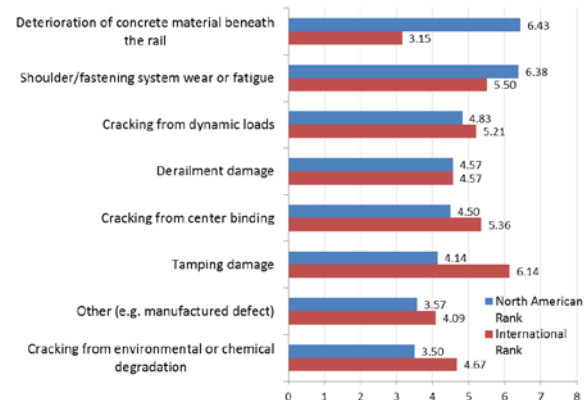


Figure 1. The most critical concrete crosstie and fastening system problems; ranked from 1 to 8, with 8 being the most critical



It should also be noted that structural failures are viewed as fairly critical problems by infrastructure owners and researchers, but are not considered to be very significant in comparison to other failures, according to crosstie manufacturers.

Wear and fatigue in the shoulder and in other component pieces of the fastening system were determined to be critical problems, according to both international and North American respondents. The international respondents identified tamping damage as their most critical problem, which could indicate that, comparatively, the other potential problems are not viewed as very critical. In North America, the most critical problem, according to the survey results, was rail seat deterioration (RSD). This was in sharp contrast to the international results, which ranked RSD as the least critical problem.

The problems identified by the survey results are clear areas for future research and development by both the international and North American railway communities (see **Figure 2**).

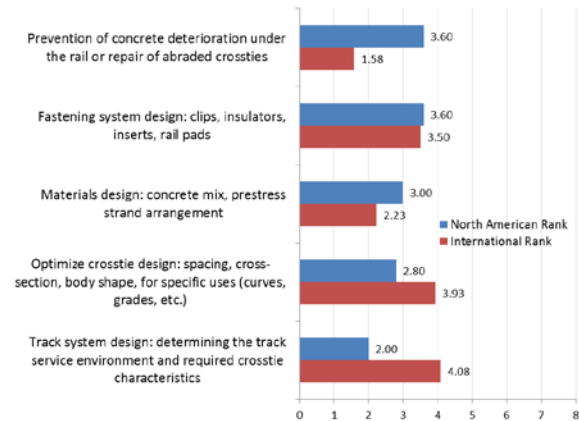


Figure 2. The most important concrete crosstie and fastening system research topics; ranked from 1 to 5, with 5 being the most important

Interestingly, whereas the international respondents indicated track system design and crosstie design optimization as the most critical research areas, the North American respondents placed a higher priority on rail seat deterioration (RSD) prevention and fastening system design. The North American research priorities align with the current research focus areas at the University of Illinois at Urbana-Champaign.



CONCLUSIONS

There are several important conclusions that can be drawn from the survey results. First, the North American and international responses seem to suggest that the differences in concrete tie manufacturing process may be the cause of the significantly different trends in concrete crosstie requirements and performance. The results also indicate that the most critical failure concerns in North America are related to wear or fatigue of the rail seat, rail pad, and shoulder, while the most critical failure concerns internationally are tamping damage, cracking from dynamic loads, and shoulder wear. The design of the concrete crosstie and fastening system must be considered comprehensively, with significant consideration given to component relationships and related performance. Survey data can be accessed through the UIUC Web site at http://ict.uiuc.edu/railroad/CEE/crossties/Deliverables/UIUC_International_Survey_Summary_FINAL.pdf.

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KEYWORDS

Concrete crossties, elastic fastening systems, state of practice, survey, concrete sleepers, international, research, failure, mechanisms

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