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Consideration of Crib Ties for Improved Track Performance

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Summary

Transportation Technology Center, Inc. (TTCI) performed a preliminary study on the application of crib ties as an alternative design to improve track performance. Crib ties refer to short tie sections that are installed to support the rail in the ballast crib area between conventional ties. For this study, both concrete crib tie and wood crib tie test zones were established at the Facility for Accelerated Service Testing (FAST), Pueblo, Colo. TTCI compared the two crib tie test zones to their respective control zones, namely conventional wood and concrete tie zones without crib ties. This study performed preliminary performance tests and provided recommendations on potential crib tie applications.

Initial feasibility testing determined that crib ties can be installed without modification to existing conventional track structures and allows tamping with conventional split head tampers. The primary advantage of crib ties appears to be their flexibility and ease of installation, minimizing track out of service time. Results of performance testing conducted at FAST to characterize the crib tie zones indicated:

- Vertical track stiffness tests suggest that crib ties increase overall track stiffness, particularly under lower applied loads, likely due to their larger contact area with the supporting ballast.
- Track panel shift tests to characterize the lateral resistance were inconclusive. Lateral displacements were less than 0.1 inch under a 40,000-pound axle load and 40,000-pound lateral shift load.
- Static lateral track loading fixture (LTLF) gage strength testing did not show a significant difference between the crib tie test zones and the control zones,
- To date, the crib tie test zones have accumulated 273 MGT. No failures or other exceptions have been observed in either the crib tie test zones or their adjacent control zones.

Results suggest that crib ties represent a possible alternative to modify track vertical deflections and track modulus and may have applications at track stiffness transitions (bridge approaches, grade crossings, etc.), particularly in areas where only short track windows may be available for remediation. Further testing of the crib ties in these applications would be necessary.

The in-track testing was conducted in 2013 and 2014, as part of the Association of American Railroads' Strategic Research Initiatives Program to improve tie and fastener performance. Alternative track designs may be necessary when the demand increases for higher tonnage, higher reliability, and higher speed trains.



INTRODUCTION

With increasing demands on the North American rail network, conventional ballast track structures may not be optimal in more severe load environments such as high degree curves, transitions, or heavy axle load and high tonnage corridors. As part of the AAR's Strategic Research Initiatives Program, TTCI continues to study alternative tie and fastener designs and assess their performance and applicability for the railroad industry.

Recently, TTCI tested an alternative track design that incorporates crib ties; i.e., short tie sections installed in the crib area between two standard length ties beneath the rail. The concept appears to have originated in Austria with contributions from the Technical University of Graz and a test zone recently installed on the ÖBB-Austrian Federal Railways.¹ Figure 1 shows the crib tie test zone in Austria.



Figure 1. Crib Tie Test Zone on the ÖBB in Austria¹

The crib tie design was conceived to increase the area supporting the track under the otherwise unsupported rail in the crib. This concept presents itself in other alternative designs, notably the half-frame and full-frame ties (also being studied by TTCI). Performance test results of the half-frame tie have been addressed in a recent *Technology Digest*.²

Higher performing alternatives to conventional tie designs may have potential applications in higher demand situations with more severe loading environments such as track stiffness transitions (e.g., at bridge approaches), high degree curves, and heavy haul, high tonnage corridors. The goal of this study was to assess the feasibility, practicality, and possible performance benefits of the crib tie concept for the North American railroad industry.

INITIAL FEASIBILITY AND DESIGN

Both wood and concrete crib ties were considered, utilizing conventional rail fasteners.

The goal of this testing was to determine the shortest crib tie that could be cut to eliminate interference with modern tamping equipment. The shortest feasible crib tie would be one in which realistic lateral loads through the tie and fastener system would not blow out laterally the plate hold-down spikes of a wood tie system or the steel shoulder in a concrete tie system (i.e., a lateral bearing capacity failure). To quickly

determine the minimum length, a 10,000-pound gage widening load (approximated as a conservatively high lateral load an individual crib tie may carry) was applied to individual wood and concrete ties with various lengths cut off their ends, as Figure 2 shows. Observations were made to determine when lateral blowout of the plate hold-down spike or the concrete tie shoulder occurred.

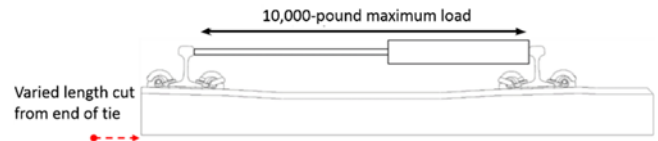


Figure 2. Setup for Initial Length Feasibility Testing

It was determined that the plate width would govern the required length of the wood crib ties. A widely used 16-inch rolled plate and elastic fastener system was selected. The wood ties were cut approximately to the width of the plate, leaving about 1½ inches of tie cover outside of the plate hold-down spikes. To minimize crib tie length, the plate hold-down screw spikes on the wood crib ties needed to be epoxied into place to prevent splitting of the tie during spiking. However, once spiked, they did hold the applied lateral load. Similarly for the concrete tie, about 2 inches of concrete cover was required to prevent blowout of the concrete tie shoulder under this load. The resulting design was a wood crib tie approximately 17 inches long and a concrete crib tie about 16 inches long. These lengths facilitate the use of conventional tamping equipment with split heads.

The feasibility of installation was also considered. It was determined that the crib ties would not require the removal of any existing fasteners. The only work required was to dig out enough crib ballast to install the crib tie and nip it up to the rail. For both the concrete and wood crib ties, an elastic fastener that could be easily driven on was chosen, as this allowed the clips to be driven on to the short, unstable crib tie during nipping. Nominal 20-inch spacing of wood ties provides approximately 1 inch of clearance on either side of the crib tie for installation of a standard rail anchor.

TEST SETUP AND INSTALLATION

Based on this preliminary testing and design, 20 concrete and 20 wood crib ties were cut out of full length ties. While purposely made concrete crib ties would be normally reinforced, the concrete crib ties cut for this study included the existing prestressed strands from the full length tie.

In May 2013, using these crib tie systems, two test zones were installed at FAST in Section 33, a tangent section of track. The wood crib tie zone consisted of 20 crib ties placed between 11 conventional full length wood ties nominally spaced at 20 inches on center. The concrete crib tie zone consisted of 20 crib ties placed between 11 conventional full length concrete ties nominally spaced at 24 inches on center. Additionally, control zones of wood and concrete ties were identified adjacent to the crib tie test zones. Figure 3 shows the installation of the wood crib ties. Figures 4 and 5 show the concrete and wood crib tie zones after installation.

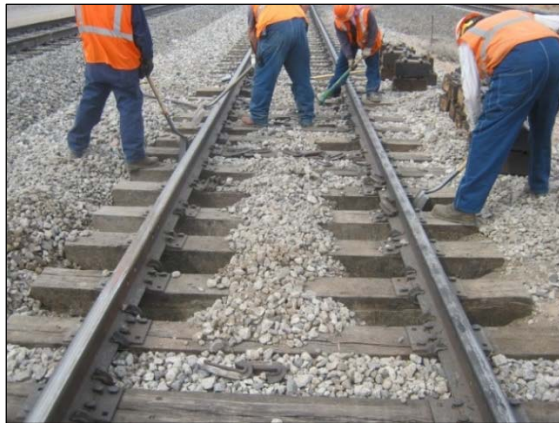


Figure 3. Installation of the Wood Crib Ties at FAST



Figure 4. (left) Concrete Crib Ties and (right) Wood Crib Ties at FAST

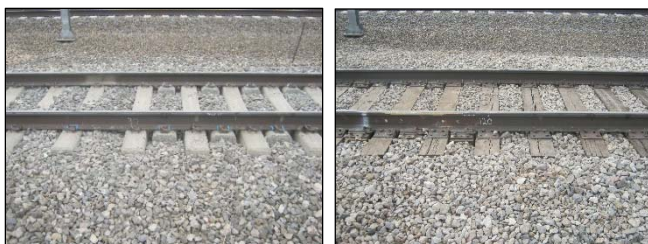


Figure 5. (left) Concrete Crib Ties and (right) Wood Crib Ties at FAST

VERTICAL TRACK STIFFNESS

To assess the effects of the crib ties on track stiffness, static track deflections were measured under an empty (8,344 pounds static wheel load) and loaded (39,713 pounds static wheel load) hopper car. Figure 6 shows the track deflections recorded at the applied loads for the crib tie zones and for the control zones. Measured track deflections were lower in each of the crib tie zones compared to their respective control zones. The effect of the crib ties on track stiffness is less clear.

A common measure of track stiffness for this type of test is represented by the slope of the line between the empty car and loaded car deflections. When comparing the track stiffness

between the empty and loaded car loads, the crib tie zones and their respective control zones showed similar stiffnesses.

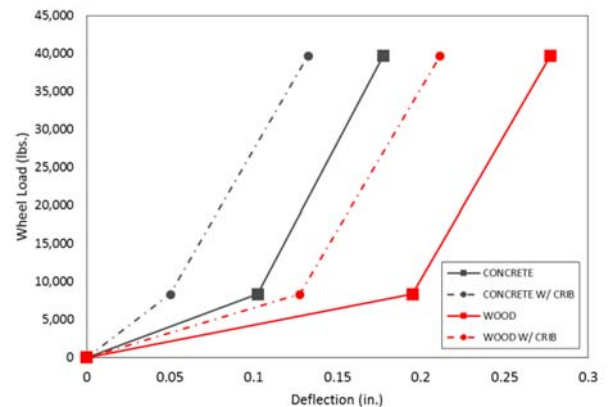


Figure 6. Track Deflections for the Crib Tie Test Zones

However, the crib tie zones limited the amount of initial “seating” deflection observed at the empty car load. This resulted in overall less track deflection in the wood and concrete crib tie zones compared to their respective control zones. A possible explanation for this result is that full length ties tend to govern track stiffness at higher applied loads, whereas the increased bearing area provided by the crib ties reduces track deflections and provides a slightly stiffer track when load is initially applied. This characteristic could make crib ties useful in reducing total track deflection in areas where abrupt stiffness transitions result in excessive track deflections and track surface deviations.

LATERAL TRACK STRENGTH

A hypothesized advantage of the crib tie system is an increase in lateral track stability. To assess these potential benefits, a preliminary panel shift test was conducted.

Panel shift testing was conducted using the AAR’s Track Loading Vehicle (TLV). A constant vertical load of 20,000 pounds was applied to each wheel as the lateral shift load was increased from zero to 40,000 pounds at a rate of 2,000 pounds per second. Figure 7 shows the TLV panel shift test setup.

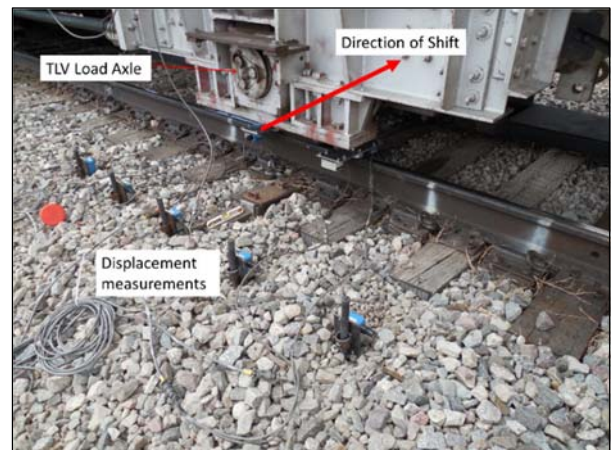


Figure 7. Panel Shift Test Setup Over Wood Crib Tie Zone

The results of the panel shift testing were inconclusive. No significant difference was observed between the crib tie test zones and their respective control zones. Total lateral displacement at the tie at which load was applied for all four zones was less than 0.1 inch. This indicates that the track was well consolidated and had high lateral stability. It is unclear how the crib ties would perform in less stable track.

GAGE STRENGTH

In order to assess the benefits of the crib ties system's effect on gage strength, in-track measurements were taken using the lateral track loading fixture (LTLF). The LTLF applies a gage widening load to the track. The outward displacement of each rail is recorded as gage widening load is increased. Two types of load are applied, one at the head and one at the web of the rail. Loads were applied directly over full length ties, in the crib tie test zones and in the control zones. For comparison, LTLF results collected for a variety of tie and fastener systems in a 6-degree curve on the High Tonnage Loop at FAST are covered in a separate TD.³ Figure 8 shows the LTLF results for the crib tie and control zones.

