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Major Findings of Wood Tie and Fastener Performance Under Heavy Axle Loads at FAST 1988-1999

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Summary

The Wood Tie and Fastener Test has been an integral part of the Heavy Axle Load research program since its inception in 1988. Tests have been conducted at the Facility for Accelerated Service Testing (FAST), at the Federal Railroad Administration's Transportation Technology Center near Pueblo, Colorado. Test zones, located at FAST on the High Tonnage Loop (HTL), consist of various hardwood and softwood tie species with different fastening systems. In addition to measuring gage widening as a function of traffic, fastener stiffness is measured to determine gage spreading strength. General track geometry degradation is also monitored.

In addition to the traditional solid-sawn timber crossties, other wood-product ties in-test include dowel-laminated, glue-laminated, parallel-strand lumber and reconstituted ties.

Gage widening is the predominant failure mode or cause for maintenance on wood tie track at FAST. Due to dry climate, decay is not a significant factor in tie degradation. The dynamic loading of ties in curves at FAST is dependent on the rail profiles, lubrication, and truck types used. These factors affected the lateral loading and gage widening performance of all test ties.

Variation in truck suspension characteristics has been the largest single factor in tie performance during the HAL experiment. The use of premium suspension trucks with better steering capabilities has greatly improved the performance of all ties tested under 39-kip wheel loads. This has increased the projected gage widening life of hardwood and softwood ties by a factor of four, from 500 to 2,000 MGT, on the test ties in the HTL's unlubricated 5-degree curve.

In the 6-degree lubricated curve, under standard truck operations, hardwood ties with cut spikes had a gage widening life of about 500 MGT compared to 200-300 MGT for softwood ties. Under standard truck operations, use of elastic fasteners versus cut spikes decreased the loss of gage spreading strength by a factor of 5. The parallel-strand lumber ties currently in test in a 5-degree, 4-inch superelevation curve on the HTL have accumulated 212 MGT of 39-ton axle load traffic without gage-widening or gage-spreading strength problems.

This is a cooperative FRA/AAR program.

Authors' note: Supporting test results presented here will be published soon in a TTCI research report.

Suggested Distribution:

- ☐ Maintenance of Way
- ☐ Planning & Analysis
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- ☐ Safety

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INTRODUCTION

The Wood Tie and Fastener Test has been an integral part of Heavy Axle Load (HAL) research since the HAL program's inception in 1988. This research reports major findings that characterize the performance of crossties under HAL at the Facility for Accelerated Service Testing (FAST) during 11 years of testing.

The effects of heavy axle loads at FAST are examined by operating the HAL train on the 2.7 mile High Tonnage Loop (HTL). The HTL has three 5-degree curves with 4 inches of superelevation, one 6-degree curve with 5 inches of superelevation, and tangent sections. The train normally consists of 70 to 80 315,000 pound gondola and tank cars and operates four days per week, generating between 3 and 5 million gross tons (MGT) per week. The Wood Tie and Fastener Test zones are located in Sections 7 and 31, both 5-degree curves, in the 6-degree curve of Section 25, and the tangent of Section 33. At a steady 40 mph, the train runs at 1.7 inches overbalance speed in Sections 7 and 31, and at 1.6 inches overbalance speed in Section 25.

OBJECTIVES

The main objective of the Wood Tie and Fastener Test is to quantify the performance of different tie types and fastening systems under 39-ton axle load traffic. An additional objective is to compare the results gathered during the 460 MGT logged in Phases I and II of FAST/HAL operations under standard three-piece trucks, to the results of Phase III testing using vehicles equipped with improved-suspension trucks. The improved-suspension trucks provide the benefit of improved curving response with enhanced wheel-set steering and resistance to truck warp.

FAST LOAD ENVIRONMENT

The FAST load environment and operations are representative of a heavy haul railroad. With 39-kip wheel load cars, 40-mph operation and 100 to 150 MGT/yr traffic, the vertical load environment is more severe than most revenue service lines. Loads are applied in large concentrated doses of 100 to 130 trains all operating in the same direction on 4-minute headways (the ultimate in train fleeting).

The lateral loading is not necessarily more severe than that found in revenue service due to curvature and truck type. FAST has 5- and 6-degree curves versus a range of curves up to 14 degrees in revenue service. Also, for the last 450 MGT, premium steering trucks have been used in the train. These trucks have reduced the average and maximum lateral forces in the train by about 50 percent. Grade, lubrication, and rail profile also affect the lateral load environment. Each curve at FAST is unique due to its combination of these factors.

There is a smaller range of values on most operating and track maintenance variables with FAST than in revenue service. This is by design so that we can isolate the effects of specific test variables such as wheel load. However, another result is to eliminate or reduce the occurrence of infrequent

MAJOR FINDINGS

The findings listed below have been grouped into these categories: Effect of Truck Suspension, Failure Modes, Effect of Species/ Materials, Effect of Fasteners, FAST/Test Section

<u>Effect of Truck Suspension</u>

Truck suspension has been the largest single factor in tie performance during the HAL experiment. The use of premium suspension trucks with better steering capabilities has greatly improved the performance of all ties tested under 39-kip wheel loads.

- Improved-suspension trucks provided a reduction of about 50 percent in the average lateral loads as compared with standard threepiece trucks.
- The gage-widening rate of ties in the 5-degree curve was affected more by the reduced lateral load environment under the improved-suspension trucks during Phase III than by tie specie/type or fastening system.
- The projected gage-widening life of all ties in the 5-degree curve, based on a 1-inch limit, -increased from 500 MGT under standard-suspension trucks to 2,000 MGT under improvedsuspension trucks. Exhibit 1 shows the corresponding gage widening rates under each truck type.
- In the 6-degree curve, during standard-truck operations in Phase 11, two hem-fir and two southern yellow pine subzones reached 1 inch over standard gage after 200 MGT. Two Douglas fir subzones reached the same limit after 360 MGT. These subzones were fastened with cut spikes.
- The gage-spreading strength of softwood ties with e-clip and SAFELOKO fasteners under standard trucks was comparable to that of softwood ties with cut spikes under improved suspension trucks in Section 7 at 0.5 L/V static loads.

<u>Failure Modes</u>

Gage widening is the largest cause of wood tie maintenance at FAST. Lateral loading resulting in gage widening, tie splitting, and spike killing are all seen. Vertical loading problems have test section stiffness changes. The dry climate of southeastern Colorado prevents wood decay from being a significant factor.

- Tie-plate cutting has not been significant at FAST under improved trucks.
- Although cracks in ties have not been a major problem, most occur on the field side of high rails.
- The cracks originating at the high-side gage hold-down spikes on the majority of the Oak dowel-laminated ties have not affected track strength while in service for 470 MGT.

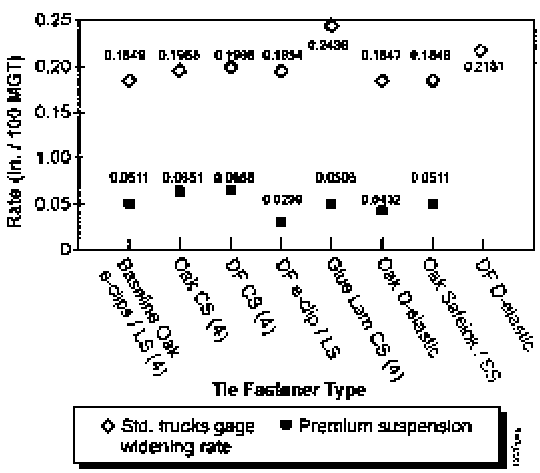

Exhibit 1. Calculated Gage Widening Rate in Section 7, 5-degree, 4-inch Superelevation Curve

<u>Effect of Species/ Materials</u>

Under the more severe load environment of standard trucks, Oak hardwood tie performance, in gage widening, was superior to the performance of softwood ties. Under the more benign load environment of premium trucks, the performance of hardwoods and softwoods was equally good. Both were markedly improved in gage widening performance. In addition, Azobe and various laminated wood ties performed well resisting gage widening under premium trucks.

- Ties in the 5-degree curve of Section 7 that have not required regaging during 920 MGT of service include:
  - Oak with cut spike, e-clip, and double elastic fasteners
  - Douglas Fir ties with cut spike and e-clip fasteners
- In the 6-degree curve, during standard truck operations in Phase 11, two hem-fir and two southern yellow pine subzones reached 1 inch over standard gage after 200 MGT. Two Douglas fir subzones reached the same limit after 360 MGT. These subzones were fastened with cut spikes.
- Although higher than in solid hardwood tie track, the gage-widening rate of the mixedspecie subzone, where three southern yellow pine ties were installed for every oak tie, was a low 0.07 inch per 100 MGT under improvedsuspension trucks.
- There has been no significant gage degradation in the Azobe cut-spike (520 MGT) and elastic-fastener subzones of the 5-degree curve in Section 31.
- During Phase III improved-truck operations, the parallel-strand lumber ties with e-clips and screw spikes, the dowel-laminated oak ties with cut spikes, and both the vertical and horizontal glue-laminated ties with cut spikes, performed comparably well in the 6-degree curve with an average gage-widening rate of about 0.02 inch per 100 MGT.
- Reconstituted ties, spaced at 19.5 inches and held down with four screw spikes, were removed after 178 MGT during standardtruck operations due to rail-seat cracks in 90 percent of the 6-degree curve installation. The installation in the tangent test zone, spaced at 24 inches and held down with four screw Spikes, remains in service after more than 400 MGT.

  Spruce ties, pre-drilled at 3/4 inch for screwspike hold-downs, were removed from service after 3 MGT due to a number of screw spikes working out.

<u>Effect of Fasteners</u>

Under standard truck operations, use of elastic fasteners generally improved the gage widening performance of most ties tested. The effect is larger for low-density species and ties. Under the premium suspension truck operations, many more ties provide acceptable gage widening performance.

The type of fastening system and the lateral load environment plays a greater role in determining the long-term degradation of gagespreading strength than tie type or specie. The gage-spreading degradation rate of both Oak and Douglas Fir ties fastened with cut spikes was nearly five times greater than that of track fastened with e-clips during standard-truck operations in Section 7.

The gage-spreadingstrengthperformance of softwood ties with e-clip and SAFELOKO fasteners under standard trucks was comparable to that of softwood ties with cut spikes under improved suspensions trucks in Section 7 at 0.5 L/V static loads.

- Under improved-suspension truck operations, the number of hold-down cut spikes in three southern yellow pine subzones, where all the ties were 7"x9"x8'5" and all had three rail spikes, did not affect the rate of gage widening.
- During standard truck operations, fastening system problems included loss of toe load, fractures of elastic fasteners and hold-down screw spikes working out, and fracturing below the tie surface.
- During improved truck operations, softwood ties screw spikes continued to work out and some fractured below the fie surface. One elastic fastener type fractured regularly at two rail joint locations.
- With the cut-spike fastening system, increasing gage-spreading loads resulted in further weakening of gage-spreading strength. On the other hand, the elastic fastening systems tested provided increasing gage-spreading strength as gage-spreading loads were increased.
- Refitting the softwood ties in Section 25 with e-clips (originally installed with cut spikes) improved gage retention after re-gaging. Maintenance of the badly split ties increased, however, due to screw spikes working up. The splits were caused by the numerous rail defects that were removed and replaced in that
- Although the condition did not affect track geometry or stability, tie skewing occurred in 19.5-inch tie-spaced track and in 24-inch tiespaced track where double elastic fasteners were used.

FAST/ Test Section Effects

The limited space available in curves for testing rail materials, rail maintenance policies, and crossties leads to an undesirable overlapping of component tests. The small size of the test sections in FAST and the lack of stiffness transition zones leave the tests vulnerable to the effects of uncontrolled variables such as rail breaks, bad

In the 5-degree test zone of Section 7, between 50 and 70 percent of the total gage widening measured was attributed to rail wear.

- Numerous rail changes, due to rail defects in the 6-degree curve, was the cause of all spikekilled ties during Phase 11 standard truck operation.

Out-of-face surfacing and alignment of the Wood Tie and Fastener test zones at FAST is generally required at 100 MGT+ intervals.

Due to the climatic, geologic, and operating conditions under which tests are conducted at FAST, including the use of improved-suspension trucks which significantly reduce the lateral load environment, the performance of the ties and fasteners tested may differ from revenue service.

FUTURE WORK

Future crosstie testing at FAST will emphasize new and unproven materials or materials/ fastener systems. The performance of existing materials and fastener systems has been shown for a variety of heavy haul operating conditions during the first three phases of HAL testing at FAST.

ACKNOWLEDGMENTS

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We also thank FRA for its support and the numerous manufacturers and suppliers for providing the railroad industry with new crosstie and fastener products and the opportunity to test them.

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A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, MAY BE AVAILABLE AT A LATER DATE THROUGH AAR/TTCI, PUBLICATIONS, P.O. Box 79780, BALTIMORE MD, 21279-0780.