Performance of alternative tie material under heavy-axle-load traffic
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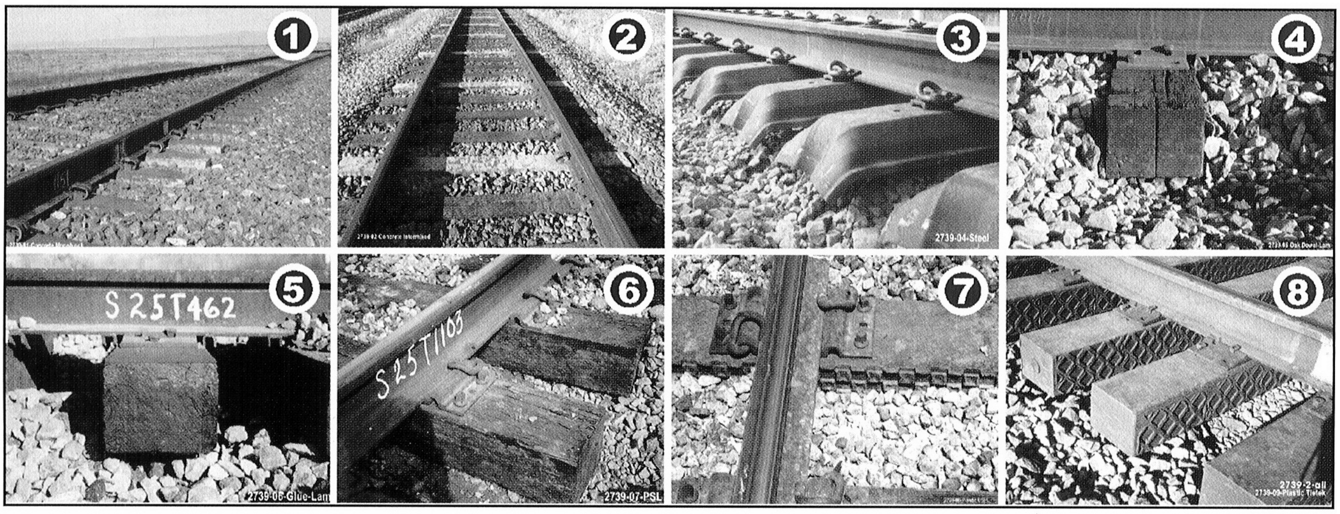

TTCI provided manufacturers of alternative tie materials a place to test their newly-designed products and found some promising results.

Some of the crosstie and fastener issues that the railroads face include: gauge strength, longitudinal rail restraint, lateral and vertical track stability, tie skewing, cut spike and screw spike uplift, spike-kill conditions, tie plate and hold-down-fastener fractures, tie plate cutting into the tie, tie checks and splits, effects of moisture and cost.

In 2001, the U.S. Class 1 railroads spent $911 million in capital expenditures on crossties and $26.5 million on repair and maintenance of existing crossties.[1]

In 2003, the track engineering programs of seven major railroads and four regional/shortline railroads in North America called for the installation of approximately 15.3 million ties. Of that total, about 94 percent were new solid-sawn wood ties and about 1.5 percent were relay ties. The remainder was made up of almost five percent concrete, less than 0.1 percent steel and almost 0.4 percent plastic and alternative ties.[2]

Although the number of alternative material ties called for is still relatively small, manufacturers continue to develop and improve their designs. Transportation Technology Center, Inc., has tested the performance of various types of ties on the High Tonnage Loop at the U.S. Federal Railroad Administration's Facility for Accelerated Service Testing near Pueblo, Colo. Most of the results summarized here are from tests conducted with the 39-ton heavy-axle-load train at FAST. Information from revenue-service testing is included in the concrete tie section.

Plastic composite ties

The first plastic composite ties installed were from TieTek, Inc., and U.S. Plastic Lumber. They have been in track as part of the FAST/HAL program since 1997, where some have been subjected to more than 790 mgt. To date, the ties have been able to withstand heavy axle loads. There have been some screw spike and slight cut spike uplifts in some of the ties. Cracks that occurred during installation in some of the ties, due to small screw spike pilot holes, have not grown significantly. Neither condition has resulted in any ties being removed from track. Resistance to lateral movement is about 60 percent higher for rough-sided ties and 40 percent lower for the smooth-sided ties from both manufacturers, as compared to wood ties after 10 mgt.

Although TTCI laboratory tests show that the average force required to extract cut spikes from plastic ties is significantly lower (3,500 pound) than in new oak ties (9,300 pound), cut spike uplift has not been a problem.

Figure 1 shows monoblock concrete ties. Figure 2 shows monoblock concrete ties designed for intermixing. Figure 3 shows steel ties in track. Figure 4 shows dowel-laminated ties. Figure 5 shows glue-laminated ties. Figure 6 shows parallel strand lumber ties. Figures 7 and 8 show plastic composite ties.

The two primary plastic composite tie test zones are located in the six-degree curve of the HTL. One of the test zones is designed to evaluate the performance of plastic composite ties intermixed in wood tie track. That test zone consists of 174 ties (about 284 track feet) where 30 percent are plastic composite ties, which have accumulated 310 mgt. Both the plastic composite ties and the wood ties in this test zone are fitted with elastic fasteners and screw spikes. Some screw spikes have worked out in both tie types, but have been reinserted with wood plugs.

The second test zone consists of 100 out-of-face (consecutive) cut spiked plastic composite ties, which were fitted with 14-inch AREMA tie plates and cut spikes in 3/8-inch pilot holes.[3] The cut spike pattern used on both rails in this test zone is typical of that used in curves; that is, two diagonally-opposed hold-down spikes, two rail

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spikes on the gauge side and one rail spike on the field side. There is some slight tie plate cutting under the ends of the plates. Soon after the HAL train began operations on the newly-installed test zone, the majority of spikes in the hold-down and rail positions began to work upward. After 410 mgt, cut spike uplift is between 3/8 inch and 1/2 inch, slightly more than usual in wood ties.

A preliminary evaluation of the effect of temperature on the vertical stiffness and the gauge-spreading strength of plastic composite tie track was conducted at TTCI.[4] Laboratory results indicate that the material tested can be expected to experience a 0.24-inch change in length in 60 inches for a 100-degree change in temperature compared to 0.016 inch in an oak tie.

The FRA-funded vertical stiffness tests were performed in the 100-tie out-of-face plastic composite test zone and in the adjacent oak tie test zone of the same configuration. The results of those tests indicate that there was no major difference in vertical track stiffness between the plastic composite tie track and the oak tie track.

In the static tests, the vertical stiffness of the plastic composite tie track and the oak tie track was between 3,160 pounds per inch per inch and 3,430 pounds per inch per inch (within a 270-pound per inch per inch range) during an 88-degree change in tie-center temperature.

The dynamic measurements, taken with TTCI's Track Loading Vehicle, show similar results. In the strong track support conditions characterized by the silty sand subgrade and clean ballast, there was no significant change in vertical track stiffness that can be attributed to the change in plastic composite tie temperature within the range evaluated.

The gauge-spreading strength tests were performed statically using TTCI's Lateral Track Loading Fixture and dynamically using the TLV. The results indicate that there was no evidence of major temperature effect on the gauge-spreading strength of the plastic composite tie track within the range evaluated.

A preliminary evaluation of tie-center deformation under load has been in place since October 2002, where a plastic composite tie is simply supported using nine-inch-wide supports and a 60-inch span on a flat concrete surface. A load of about 270 pounds of rail sections is in place over 18 inches in the center of the tie. During the time that the tie has been monitored, the ambient temperature has varied between minus 10 degrees and 109 degrees. To date, there has been no significant permanent deformation.

In addition to being the same size and approximate weight as wood ties and accepting both cut spikes and elastic fasteners, the plastic composite ties in the six-degree curve at FAST survived a wheel-off derailment with the same degree of minor wheel-flange-type damage as the adjacent oak ties. The intermixed zone and the out-of-face zone have performed as well as wood tie track with regard to surface and alignment retention and ballast condition.

TTCI recently installed plastic composite ties in a No. 10 spring frog on the HTL. The ties range from 12 feet to 16 feet.

Concrete ties

Tests at FAST and in revenue service have shown that increased axle loads can result in increased lateral forces. TLV tests at FAST and in revenue service show that concrete ties with elastic fasteners provide much greater and more uniform rail restraint capability than cut spikes (premium fasteners on wood ties in good condition also provide much greater resistance to gauge widening than cut spike).[5,6] This comparison also indicated higher hold-down strength and resistance to rail rollover for the concrete ties and fasteners tested. The concrete ties tested also showed higher individual strength compared to the timber ties and more uniform rail restraint. In these tests, which involved a good ballast layer, the concrete ties held surface and alignment well.

Higher center bending strains have been measured on concrete ties under heavier axle loads, but none of the loads measured during testing exceeded the calculated design cracking strain.[7]

Abrasion of the concrete in the rail seat area has been a problem on some railroads, especially in moist conditions. Methods such as "sandwich pads" (sealant, steel plate and resilient material) have been shown to reduce rail seat abrasion.[8] There have been no axle-load-related problems with concrete ties at FAST over 1,300 mgt of HAL operations.

Concrete ties intermixed with wood

A proprietary test was performed at TTCI with monoblock concrete ties designed for intermixing in wood tie track.[9] According to Rocla Concrete Tie, Inc., the pre-stressing forces in these specially-designed ties are positioned to maximize the bending strength needed for the unique loading conditions that exist when intermixing concrete ties in wood tie track and the tie profile matches that of wood ties. The 100-tie test zone was installed in tangent track on the HTL. Twenty-five of the elastic-fastened concrete Maintenance Replacement Ties (MRT™), designed-for-intermixing, were installed at a rate of one for every four existing cut spiked wood ties.

Tie strain was measured at both rail seats and at the tie center of four concrete ties in the test zone under dynamic loading of the HAL train during the 100-mgt test. The manufacturer used the loaded strain data to help validate the tie design.

Although the period of performance of this proprietary test specified that inspections and measurements be taken during the 100 mgt of traffic, the ties are still in track and have accumulated just over 200 mgt. To date, the intermixed test zone has performed as intended. After some initial ballast settlement along the length of the intermixed concrete ties, no additional settlement has occurred and no additional ballast has been required. The test zone has held surface and alignment without additional maintenance since installation and there have been no fastener-system problems on the elastic-fastened concrete ties or on the cut spiked wood ties.

Wood composite ties

The cut spiked, oak, dowel-laminated ties performed as intended during 475 mgt in the relatively-benign lateral load environment (average 9.1 kip) under the HAL train with improved suspension trucks. When standard suspension trucks, which increased the average lateral loads applied in the test zone to about 12.6 kip, were reinstalled in the train, the majority of the ties developed splits that originated at the hold-down spikes. After 200 mgt of train operations with standard trucks, tie splits and cut spike uplift reached the point that gauge widening became a significant problem and additional spikes were added and gauge rods were installed. After about 290 mgt under standard truck operations, the majority of the ties were removed due to derailment damage. The derailment did not initiate in the test zone.

Glue-laminated yellow pine ties

The 100-tie test zone, which consists of 50 vertically-laminated and 50 horizontally-laminated cut spiked ties, performed similarly to an adjacent 100-tie test zone of solid-sawn southern yellow pine ties during 475 mgt under improved suspension truck operations in the six-degree curve.

After 200 mgt of service under standard suspension trucks, the loaded (18 kip lateral/33 kip vertical) track gauge in the test zone approached 57.5 inches. As a result, all the ties were regauged.

Parallel strand lumber ties

TTCI has been monitoring the performance of Parallam® parallel strand lumber ties during more than 770 mgt of service under HAL traffic—more than 550 mgt during standard suspension truck operations. The two test zones are located in five- and six-degree curves and the ties are fitted with elastic fasteners and screw spikes. Aside from some longitudinal cracks and swelling between the rails and some very minor tie plate cutting, the ties are performing as intended in the semi-arid environment of the HTL. To date, there have been no problems with screw spikes working up, gauge widening, or track geometry.

Steel ties

Steel tie track and typical wood tie track test zones did not perform the same in a six-degree curve under HAL traffic at FAST. The steel tie track required frequent maintenance. The ties demonstrated poor dynamic performance under load that resulted in track geometry and ballast degradation. The major part of the test was concluded after about 170 mgt, but 50 ties had accumulated 360 mgt. There was no significant wear or failure of any of the elastic-fastening-system components. The steel ties provided better restraint to gauge widening than wood ties fastened with cut spikes or elastic fasteners.[10]

Future work

TTCI will continue to work with manufacturers, providing them a test bed to try out their newly-designed ties under confidential and proprietary conditions. Additionally, TTCI will continue to monitor and report on the performance of existing and newly-developed ties tested under the FRA/AAR-funded FAST/HAL program.

Mention of the proprietary intermixed Rocla MRT concrete tie test is made with the permission of the manufacturer.□

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