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Vertical Track Modulus in Plastic Composite Tie Test Zones at FAST

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13. ABSTRACT
Transportation Technology Center, Inc. (TTCI) conducted vertical track modulus (stiffness) tests on existing plastic composite tie test zones on the High Tonnage Loop (HTL) at the Federal Railroad Administration’s (FRA) Facility for Accelerated Service Testing (FAST), Pueblo, Colorado. Warm- and cold-weather tests were performed during the late summer and winter of 2002 to document the effect of temperature on the stiffness of track fitted with plastic ties. An adjacent solid-sawn oak-wood-tie test zone was used as a control zone.

The static measurement results indicated that the vertical track modulus of plastic-tie track in the 6-degree curve of the HTL was comparable to oak-wood-tie track in the same curve during a 57-degree change in ambient temperature and concurrent 88-degree change in center-of-tie temperature.

The dynamic measurements provided a relative comparison of the low rail vertical stiffness in plastic-tie track and the low-rail stiffness of wood-tie track throughout the 6-degree curve. The results of the dynamic measurements agree with those of the static measurements in the comparability of plastic-tie track and wood-tie track.

Results of this test indicate that there was no significant change in the vertical track stiffness that can be attributed to the change in plastic-tie temperature within the range evaluated.

Due to climatic conditions, temperature during testing, type of subgrade, and maintenance standards under which tests are conducted at FAST, the performance of plastic tie track may differ in revenue service. Neither TTCI nor the AAR endorses any specific manufacturer’s product or service.

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EXECUTIVE SUMMARY

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1.0 INTRODUCTION

Transportation Technology Center, Inc. (TTCI) conducted vertical track modulus (stiffness) tests on existing plastic composite tie test zones on the High Tonnage Loop (HTL) at the Federal Railroad Administration's (FRA) Facility for Accelerated Service Testing (FAST) in Pueblo, Colorado. Warm- and cold-weather tests were performed during the late summer and winter of 2002 to document the effect of temperature on the stiffness of track fitted with plastic ties. An adjacent solid-sawn oak-wood-tie test zone was used as control zone.

The original statement of work specified warm- and cold-weather ambient temperature ranges within which to conduct the tests. The warm-weather ambient temperature was specified as 90-degrees Fahrenheit for at least 2 hours prior to testing and the cold-weather range was specified between 30- and 50-degrees Fahrenheit. Due to a delay in contract signing, the warm-weather tests, which were scheduled first, were not done until late August when higher ambient temperatures were less likely. As a result, and with concurrence from the U.S. Army Corp of Engineers, the warm-weather specification was lowered to 80-degrees Fahrenheit.

2.0 OBJECTIVE

The tests were conducted to quantify the effect of temperature on the vertical stiffness of plastic-tie track and to compare to the stiffness of wood-tie track.

3.0 PROCEDURE

Vertical track modulus tests were performed over adjacent test zones in the 6-degree, 5-inch superelevation curve of the HTL, Section 25. The TieTek® plastic-tie test zone and the solid-sawn oak-tie control zone, about 326 total track-feet, consist of 100 ties each, spaced at 19.5-inch centers. The ties are all box-anchored and fitted with AREMA 14-inch tie plates and cut spikes.

A plastic-tie test zone, about 115-track feet, located in the 5-degree, 4-inch superelevation curve of the HTL, Section 7, was also tested. The test zone consists of 20 box anchored TieTek® plastic ties fastened with cut spikes and 50 box anchored USPL® plastic ties fitted with screw spikes and elastic fasteners.

The ballast section in the 6- and 5-degree curve test zones consists of nominal 18-inch-deep AREMA 4A granite with 15-inch shoulders. The subgrade under the HTL is generally silty sand.

Figure 1 shows the two plastic tie test zones.

Figure 1. (Left side) USPLâ Plastic Tie Test Zone with Elastic Fasteners in the 5-degree Curve; (Right side) TieTekâ Plastic Tie Test Zone in the 6-degree Curve with Cut Spikes

3.1 Static Measurements

Vertical track deflection was measured every five ties throughout the test and control zones under vertical loads up to 40 kips in 10-kip increments. Track modulus was calculated using the track deflection between the single point loads of 10 and 40 kips to remove non-linearity in the stiffness curve due to slack in the track structure. The measurements at 20 and 30 kips were used for verification.

The temperature of a plastic tie was measured during track modulus testing using a thermocouple installed inside the center of one tie at the neutral axis and another one on the top surface at the center of the same tie. One tie at mid-test zone was instrumented as

shown in Figure 2.

Figure 2. Plastic Tie Instrumented with Thermocouples to Measure Internal and Surface Temperature during Testing

Two static measurement cycles were performed in the plastic-tie test zone and in the wood-tie control zones of the 6-degree curve, as well as in the plastic-tie test zone of the 5-degree curve. One set of measurements was taken when the ambient temperature had been higher than 80 degrees Fahrenheit for more than 2 hours; the other set was taken when the ambient temperature was between 26 and 53 degrees Fahrenheit.

Although the ambient temperature reached 53-degrees Fahrenheit during the last three measurements of the cold-weather measurement cycle, those ties were not likely affected under the shade of the rail force calibration car. The tie instrumented with thermocouples, located in the center of the test zone, however, did show the effect of solar heat with higher top-of-tie and center-of-tie temperatures. Tables 1 and 2 show the ambient top-of-tie and center-of-tie temperatures during testing.

The vertical loads used to measure track deflection were applied using TTCI's rail force calibration 605 Car shown in Figure 3.

Figure 3. TTCI's Rail Force Calibration 605 Car Deploying its Hydraulic System

3.2 Dynamic Measurements

Dynamic vertical deflection of the low rail was measured using TTCI's Track Loading Vehicle (TLV) shown in Figure 4. The dynamic measurements, taken at 10 mph, provide a relative comparison of the low-rail stiffness in plastic-tie track with the low-rail stiffness of wood-tie track. The plastic-tie test zone and the wood-tie control zone are located in the same 6-degree curve on the HTL, Section 25, where ties and fasteners are tested under the Association of American Railroads (AAR) and FRA jointly funded Heavy Axle Load (HAL) Research Program. This allowed for a comparison with numerous wood-tie test zones of different species and fastening systems in addition to the control zone comparison.

Figure 4. TTCI's Track Loading Vehicle (TLV), Test Car, and Locomotive Consist. (The TLV measures gage strength, lateral track stability, and vertical track stiffness on the move.)

As with the static measurements, to remove non-linearity in the stiffness curve due to slack in the track structure, the modulus was calculated using the results from a 10-kip vertical load run and a 40-kip vertical load run.

Two dynamic vertical rail modulus tests were performed: One when the ambient temperature was about 25 degrees Fahrenheit, and one when the ambient temperature had been higher than 80 degrees for at least 2 hours.

4.0 RESULTS

4.1 Static Measurements

Nineteen vertical deflection measurements each were taken in the plastic-tie test zone and in the wood-tie (oak) control zone of the 6-degree curve. Ten vertical deflection measurements were taken in the plastic-tie test zone of the 5-degree curve. Table 1 lists the average calculated vertical track modulus (low and high rails) under the warm- and cold-weather test conditions. Also given are the test dates, the time of day when the measurements were taken, and the ambient top-of-tie and center-of-tie temperatures at the start and end of each measurement cycle.

Table 1. Average Static Vertical Track Modulus of Plastic-Tie and Wood-Tie Track in Warm- and Cold-Weather Conditions

	Test Date	Time - start wood/start plastic/end plastic	Ambient Temp (F) start wood/start plastic/end plastic	Top-of-Tie Temp (F) start plastic/end plastic	Center-of-Tie Temp (F) start plastic/end plastic	Track	Avg. Track Modulus (lb/in/in)
6-Deg. Curve Warm Weather Test	8/21/02	1300/1445/ 1640	87°/93°/ 93°	126° / 133°	118° / 123°	Plastic Tie Track (Test)	3190
				NA	NA	Wood Tie Track (Control)	3160
6-Deg. Curve Cold Weather Test	11/27/02	0800/1100/ 1410	20°/30°/53°	46°/70°	30°/36°	Plastic Tie Track (Test)	3430
				NA	NA	Wood Tie Track (Control)	3240
5-Deg. Curve Warm Weather Test	8/22/02	NA/1400/ 1530	NA/90°/ 88°	140° / 115°	108° / 115°	Plastic Tie Track (Test)	4460
5-Deg. Curve Cold Weather Test	12/3/02	NA/0800/ 1320	NA/26°/ 27°	27° / 27°	27° / 27°	Plastic Tie Track (Test)	5130

The average track modulus calculated from the measured static vertical track deflections in the test zone and the control zone of the 6-degree curve, and in the test zone of the 5-degree curve are shown in Figure 5.

Figure 5 shows that with a 57-degree average reduction in ambient temperature and concurrent 88-degree average reduction in center-of-tie temperature (the difference between the labeled Warm-Weather and Cold-Weather measurement cycles), there was an average increase in vertical track modulus of about 7.5 percent in the plastic-tie track of the 6-degree curve during cold weather. By comparison, the vertical stiffness of the oak-wood-tie track-control zone, during the same change in ambient temperature, was about 2.5 percent higher during the cold-weather measurement cycle.

In the 6-degree curve during warm- and cold-weather measurements, the vertical stiffness of the plastic-tie test zone was comparable to the stiffness of the control zone with a range between 3,200 lb/in/in and 3,400 lb/in/in.

The highest increase in track stiffness was measured in the plastic-tie test zone of the 5-degree curve, where for a 62-degree average reduction in ambient temperature and concurrent 85-degree average reduction in center-of-tie temperature, there was an average increase in stiffness of about 15 percent to about 5,100 lb/in/in.

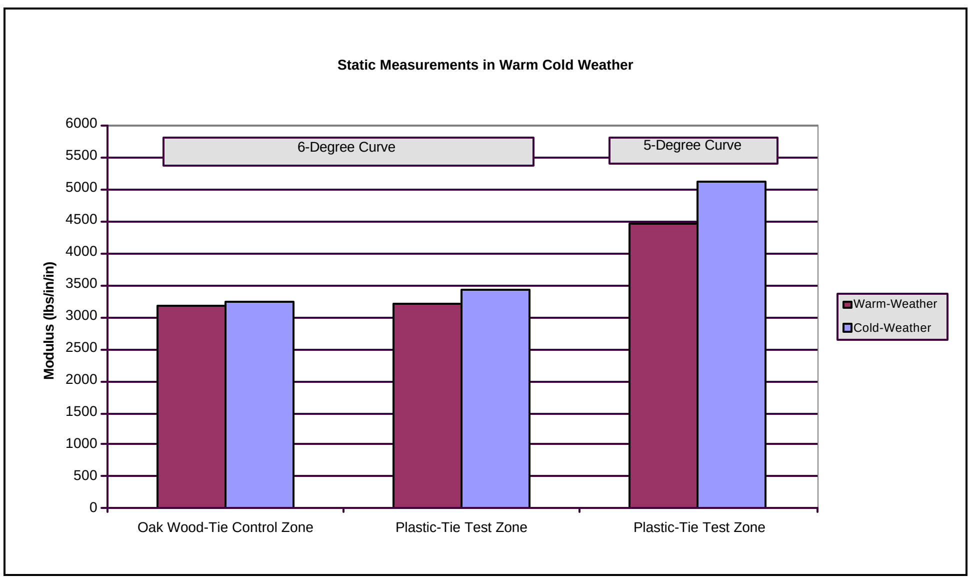

Figure 5. Average Vertical Track Modulus of Plastic-Tie and Wood-Tie (Oak) Track in the 6-degree Curve and Plastic-Tie Track in the 5-degree Curve of the HTL

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4.2 Dynamic Measurements

Table 2 lists the average vertical modulus calculated from the dynamic low rail deflections measured in the test zone and in the control zone of the 6-degree curve under warm- and cold-weather test conditions.

Table 2. Average Low Rail Vertical Modulus of Plastic-Tie and Wood-Tie Track in Warm- and Cold-Weather Conditions from Dynamic Measurements.

	Test Date	Time start wood/end plastic	Ambient Temp (F) start wood/end plastic	Top-of-Tie Temp (F) start wood/end plastic	Center-of-Tie Temp (F) start wood/end plastic	Track	Avg. Low Rail Modulus (lb/in/in)
6-Deg. Curve Warm Weather Test	9/20/02	1400 / 1600	80° / 82°	137° / 132°	113° / 110°	Plastic Tie Track (Test)	2590
				NA	NA	Wood Tie Track (Control)	3000
6-Deg. Curve Cold Weather Test	11/25/02	1025 / 1230	24° / 25°	8° / 33°	40° / 40°	Plastic Tie Track (Test)	3060
				NA	NA	Wood Tie Track (Control)	3160

Figure 6 shows the warm- and cold-weather stiffness of the low rail in the 6-degree curve of the HTL. The limits of the different tie specie and fastening system in the curve are indicated with vertical lines. The left half of Figure 6 consists of wood-tie track with cut spikes. The plastic-tie test zone, located near the center of the curve, is identified. The right half shows the stiffness of wood-tie track with elastic fasteners. A test zone of plastic ties intermixed with wood ties, where 30 percent of the ties are plastic, is also shown.

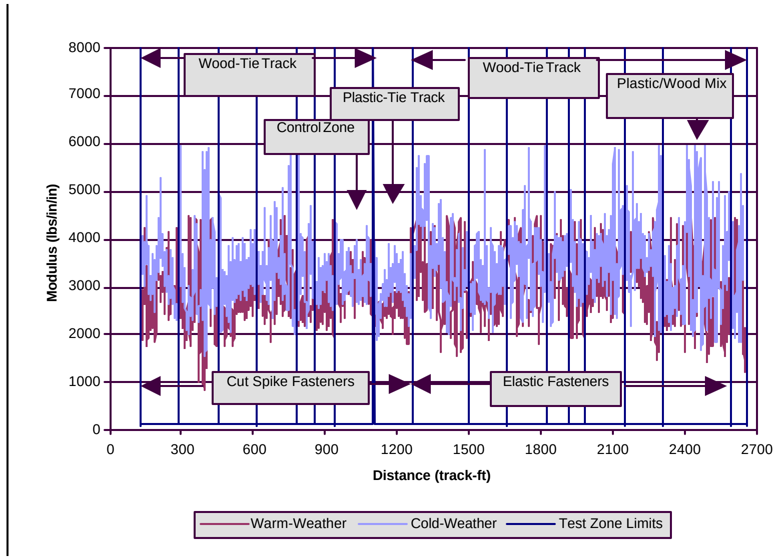
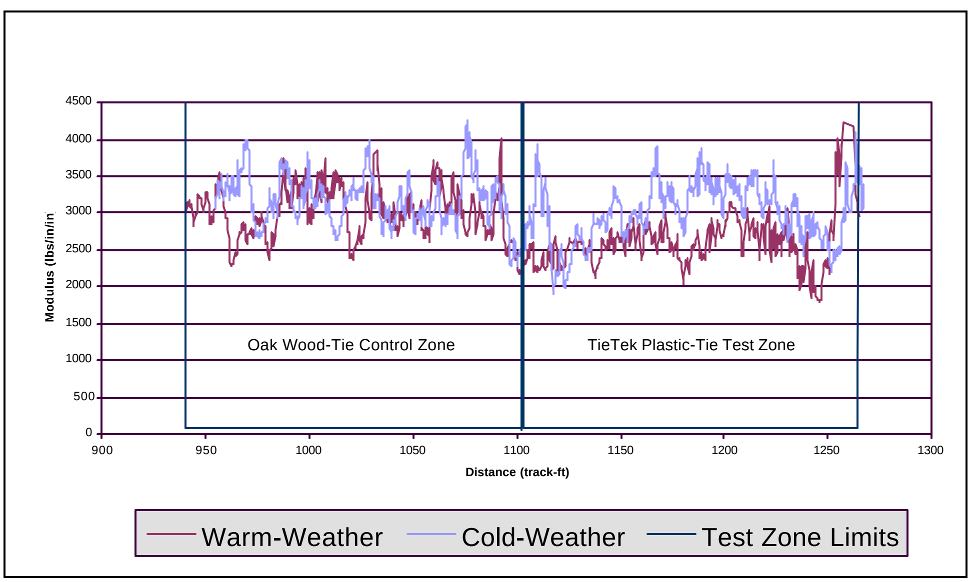


Figure 6. Warm- and Cold-Weather Vertical Modulus of the Low Rail in the 6-degree Curve of the HTL from Dynamic Measurements

The warm- and cold-weather stiffness curves of the plastic-tie test zone and the wood-tie control zone were extracted from Figure 6 and the scales were expanded for a closer look



in Figure 7.

Figure 7. Warm- and Cold Weather Vertical Modulus of the Low Rail in the Plastic-Tie Test Zone and the Wood-Tie Control Zone in the 6-Degree Curve from Dynamic Measurements

Figure 8 shows the average low-rail stiffness calculated for all the tie and fastener combinations located in the 6-degree curve of the HTL. The dynamic test is intended to provide a relative comparison of the stiffness of track fitted with plastic ties with that of track fitted with other tie types. That relative comparison, shown more clearly in Figure 8, indicates that there was no significant difference between the cold- and warm-weather measurements in the plastic-tie test zone and the cold- and warm-weather measurements taken in the rest of the curve. Generally, for the temperature range during which the dynamic measurements were taken, the low-rail stiffness throughout the curve, including the plastic-tie test zone, was between 2,600 lbs/in/in and 3,700 lbs/in/in.

Frozen ballast conditions did not exist during any of the cold-weather testing.

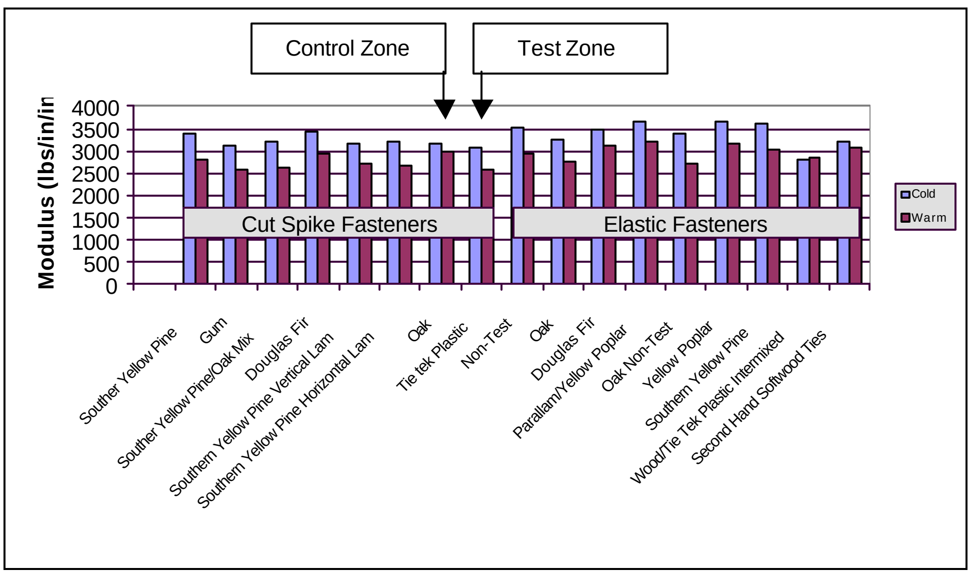


Figure 8. Average Low Rail Modulus in the 6-degree Curve of the HTL from Dynamic Measurements

5.0 CONCLUSIONS

The static measurement results indicate that the vertical track modulus of plastic-tie track was comparable to oak-wood-tie track in the 6-degree curve of the HTL at FAST during a 57-degree change in ambient temperature and concurrent 88-degree change in center-of-tie temperature.

The dynamic measurements provided a relative comparison of the low-rail vertical stiffness in plastic-tie track and the low-rail stiffness of wood-tie track throughout the 6-degree curve. The results of the dynamic measurements agree with those of the static measurements in the comparability of plastic-tie and wood-tie tracks.

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