TEST REPORT

ON

MECHANICAL PROPERTIES

WITH EIGHT INTEGRICO COMPOSITE CROSSTIES

FOR

Mr. Ryan. Nielson, Vice President, Railroad Operations
IntegriCo Composites
4310 Lucius McClvey Drive
Temple, TX 76504

Test Conducted

By

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OBJECTIVES

To determine some mechanical properties of eight new IntegriCo composite crossties made from plastics and oak. The test methods are described in "Proposed Strength Properties Tests for Wood Crossties", pages 22-24, Jan./Feb. issue, 1995 in *Crossties Journal*. A comparison will also be made between the test results of the bending modulus of elasticity (MOE), modulus of rupture (MOR), and the spike pullout and those derived from polymer composite crossties listed in Table 30-5-1, Part 5: Engineered Composite Ties, Chapter 30: TIES, Manual for Railway Engineering, American Railway Engineering and Maintenance-of Way Association (AREMA), 2005.

EXPERIMENT

I. Material

On January 22, 2007, a shipment of eight new composite crossties (7" x 9" x 8-1/2') made from the composite plastics and oak by IntegriCo Composites, Temple, Texas was delivered to the Wood Engineering Laboratory at the University of Illinois, Urbana, Illinois.

II. Mechanical Tests

All 8-1/2-foot IntegriCo composite crosstie specimens were subjected at first to a static bending test. This test indicated the structural capacity or the breakage of the tie and is important for track load capacity, deformation and surfacing.

A. Static bending test (Center Point Flexure Test)

1. Loading Span and Supports: Center loading and a span length of 60 inches were used to simulate a "center-bound" tie. The tie specimen was supported by two bearing plates (6" x 14") to prevent damage to the tie at the point of contact between tie and reaction support.

2. Loading Bearing: A 12" long steel pipe (6" diameter) was used for applying the load.

3. Speed of Testing: The load was applied continuously throughout the test at a rate of motion of the movable crosshead of 0.10 inch per minute until failure.

4. Load-Deflection Curve: After a 200-pound pre-loading, load-deflection curve was taken to the maximum load; deflections of the neutral plane at the center of the length were taken. The maximum bending load was recorded when the loading created a center deflection of 2 inches.

5. Calculations:

    a. Calculate the maximum bending stress or the modulus of rupture (MOR) for each specimen by the following equation:

$$\text{MOR (Psi)} = 3\ PL/2bd^2$$

    b. Calculate the modulus of elasticity (MOE) for each specimen by the following equation:

$$\text{MOE (Psi)} = \frac{P_1L^3}{4bd^3y_1}$$

where

b = width of specimen, inches
d = thickness (depth of specimen, inches)
L = length of span (60”), inches
P = maximum load, pounds
P_1 = load at proportional limit, pounds
y_1 = center deflection at proportional load, inches

After the static bending test, one 18-inch section was cut from each of the eight 8-1/2-foot crossties. The following tests were conducted on each sample after their weight, and dimension had been determined.

B. Compression perpendicular to grain load (24,000 lbs.)

The test determines the crushing capacity for the crosstie in the critical plate areas.

1. Loading: A 24,000 lbs. load was applied through a movable crosshead and carried through a short section of 115 RE rail to a 7.75 by 13-inch tie plate in turn to the upper surface of the crosstie samples at equal distances from the ends and at right angles to the length.

2. Speed of Testing: The load was applied continuously throughout the test at a rate of motion of the movable crosshead of 0.024-inch per minute.

3. Load-Compression Curves: It was taken for all specimens up to 24,000 lbs. Load after which the test was discontinued.

4. Calculation: The modulus of elasticity in compression (MOE) was calculated using the following equation:

E (psi) = Compression stress (psi)/Strain (in/in)

Compressive Stress (psi) = P_1/A

$$\text{Compressive Strain (in/in)} = Y_1/d$$

Where:

P_1 = load at proportional limit, pounds

A = net plate area, square inches

Y_1 = compression at proportional limit, inches

d = thickness or depth of tie specimens, inches

C. Surface Hardness Test

This test defines the plate cutting resistance and surface hardness of the tie specimen in the critical plate areas:

1. Specimen Size: The test was made near the tie-plate area of the 18" long samples.

2. Loading: A steel ball "2-inch" in diameter was used as a loading head.

3. Speed of Testing: The test was conducted at a speed of 0.25 inches of crosshead deflection per minute.

4. Calculations: The maximum load required to embed the "ball" to 0.25 inches into samples is the measure of surface hardness (lbs.).

D. Spike Resistance Tests

These tests were used to indicate the rail gage and rollover restraint capacity of the ties. The spike drive-in force, the lateral spike resistance; and spike withdrawal resistance were tested. The 5/8" square and 6 l/2" long cut-spikes were inserted into a 3/8-inch pre-drilled pilot hole on the plate area of the tie samples, so the resistance to spike push-in and spike withdrawal in plane normal to the tie surface can be measured.

1. Speed of Testing: a) A cut spike was driven into the tie plate surface at a speed of 2 inches per minute; b) the lateral spike resistance test was made at the speed of 0.1 inches per minute; c) the direct withdrawal test was made at a speed of 0.3 inches per minute.

2. Load was recorded for the tests at the spike head is being bent or displaced 0.2 inches laterally (90° angle) in the lateral spike resistance test.

RESULTS

1. Table 1 lists the weight, dimension, density and specific gravity of all IntegriCo composite crosstie specimens. The proportional limit load and deflection derived

from the static bending test, the maximum bending load, maximum bending stress (Modulus of Rupture or MOR), and Modulus of Elasticity (MOE) in bending of eight IntegriCo composite crosstie specimens. All eight IntegriCo specimens did not break into two pieces prior to reaching their center deflection of 2 inches. For comparison purposes, both the AREMA-30 specified minimum values of bending MOR and MOE for polymer composite crossties, and the average tested values of the commercial creosote treated oak crossties are provided in Tables 1 and 2.

2. The compressive modulus of elasticity (MOE) and the maximum surface hardness values for all eight IntegriCoTie samples and the creosote treated oak (7" x 9" x 18") are shown in Tables 3.

3. Table 4 shows three spike resistance properties using 3/8-inch bit for making pre-bored pilot holes on all IntegriCo composite crosstie samples. Table 4 also shows the AREMA-30 minimum required value of spike direct pullout or withdrawal property for polymer composite crossties.

OBSERVATIONS

This report contains the results of a study that examined the performance of the IntegriCo composite crossties made from the industrial plastics and oak. The experiment looked at the static bending properties, compressive MOE, surface hardness, and three spike resistance properties.

The following observations can be made based on the test results.

1. These IntegriCo composite crossties showed uniform surface appearance and measurement in dimension in thickness and width. The weight of each IntegriCo specimen meets or falls within the required dimension and weight-range specified for polymer composite crossties in AREMA-30 standard. On the average, the IntegriCo specimens are about twenty-five percent heavier than the commercial creosote treated oak crossties (Table 1).

2. The eight specimens made from the plastics and oak obtained both average test values of MOR and MOE exceeding the AREMA-30 required minimum bending (MOR) and modulus of elasticity (MOE) properties for polymer composite crossties. All specimens were quite flexible in bending, and were not broken into two pieces in brash failure prior to reaching their center deflection of 2 inches in the static bending test.

3. In the compressive MOE (perpendicular to plate area) test, the IntegriCo crossties obtained about 81 percent average values of those of the creosote treated oak crossties The average surface hardness value of the IntegriCo composite plastic crosstie samples obtained about 117 percent of those of the commercial treated oak crossties.

4. In the spike withdrawal or pullout tests conducted on the pre-bored holes using 3/8-inch bit, the IntegriCo composite crossties meet the minimum required value of 1,900 pounds specified for polymer composite ties in AREMA-30 standard (Table 4).

TABLE 1. Dimension, Density and Specific Gravity of New IntegriCo Composite Railroad Crosstie Specimens

IntegriCo-Code	Weight (lbs.)	Length (in.)	Thickness (in.)	Width (in.)	Density (lbs/cu.ft.)	Specific Gravity
1	269	104-5/16	7-3/16	9-1/16	68.50	1.10
2	270	104-5/16	7-1/4	9	68.55	1.10
3	290	104-7/16	7-3/16	9	74.17	1.19
4	275	104-3/16	7-1/4	9	69.90	1.12
5	289	104-5/16	7-1/4	9	73.37	1.18
6	278	104-5/16	7-3/16	9	67.13	1.14
7	272	104-3/8	7-3/16	9-1//16	69.14	1.11
8	259	104-1/4	7-1/8	8-15/16	67.13	1.08
Average ($\bar{x}$)	**275**	**104-5/16**	**7-3/16**	**9**	**69.74**	**1.13**
Polymer Composites	**185 to 320 (AREMA-30)**	**102-108**	**7.000**	**9.000**	**50 to-86**	**0.80 to 1.38**
Treated Oak (52 crossties)	**220.0**	**102.000**	**7.000**	**9.000**	**56.40**	**0.904**

TABLE 2. Static Bending Modulus of Elasticity (MOE) and Modulus of Rupture (MOR) of New Full-Length IntegriCo Composite Crossties

I. IntegriCo II. Code	IV. Load at Prop. Limit **(lbs.)**	V. Deflection **(in.)**	**Maximum Load (lbs.)**	**MOR (psi)**	**MOE (psi)**
1	9,600	0.544	17,707	3,404	285,160
2	14,400	0.676	22,402	4,262	335,390
3	6,600	0.488	14,346	2,777	218,550
4	7,200	0.547	16,975	3,230	207,240
5	8,400	0.475	17,593	3,347	278,430
6	9,600	0.530	17,879	3,461	292,690
7	9,600	0.422	19,200	3,690	363,310
8	10,200	0.505	19,780	3,907	335,980
Average (x)	**9,450**	**0.523**	**18,235**	**3,510**	**289,600**
Polymer Composites (AREMA-30)	**--**	**--**	**--**	**2,000**	**170,000**
Treated Oaks 52 Commercial Ties	**20,000**	**0.365**	**38,220**	**7,810**	**960,000**

TABLE 3. Plate-Area Compressive Modulus of Elasticity (Perpendicular to face) and Surface Hardness of IntegriCo Composite Crossties

IntegriCo Code	Compressive Modulus of Elasticity (Psi)			2-inch Steel Ball Surface Hardness (Pounds)				
1		36,291			5,396			
2		22,855			5,240			
3		33,011			4,486			
4		34,473			5,697			
5		29,457			4,662			
6		22,000			4,432			
7		27,825			4,997			
8		23,000			4,697			
Average		**28,614**			**4,950**			
Creosote Treated Oak Ties (84 air dried)		**35,330**			**4,225**			

TABLE 4. Average Spike Resistance Properties of IntegriCo Composite Crossties (Pre-bored using 3/8" bit)[a]

IntegriCo Code	Spike Drive-In Force (Pounds)		Spike Direct Withdrawal (Pounds)		Lateral Resistance (0.2" Displacement)	
1 (83)	8,042		4,627		2,266	
2 (82)	7,230		4,141		2,938	
3 (76)	8,068		4,963		2,287	
4 (77)	9,185		5,066		2,604	
5 (79)	6,213		2,513		2,359	
6 (78)	6,786		2,955		2,646	
7 (72)	5,525		2,497		2,475	
8 (75)	6,043		3,144		2,500	
Average	**7,136**		**3,738**		**2,509**	
Composite Ties	**--**		**1,900**		**--**	
Oaks[c]	**9,300**		**8,000**		**3,100**	

[a]Each value is an average for two tests.
[c]Average test values of 84 oak crossties.