

# COMPOSITE CROSSTIE TESTING

Fastener Electrical Impedance Test & Bending – Center Negative Test

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Prepared for Dynamic Composite, LLC

by Sirius Roybal, Transportation Technology Center, Inc.



*... a subsidiary of the Association of American Railroads*

*P. O. Box 11130, Pueblo, Colorado 81001 USA November 30, 2009*

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## Executive Summary

Transportation Technology Center, Inc. (TTCI) has completed a fastener electrical impedance test and a bending center negative test on composite cross-ties manufactured by Dynamic Composite, LLC.

These tests will provide basic data that can be compared to past data, existing wood tie performance data, and to the recommended criteria of the American Railway Engineering and Maintenance of Way Association (AREMA), Chapter 30, Sections 2.2 and 2.8.

### Test Results

Test 7: Fastener Electrical Impedance Test

- 10,000 ohms – AREMA’s minimum recommended impedance
- 81,566 ohms – Dynamic Composite impedance test results

Test 1C: Bending – Center Negative

- 170,000 psi – AREMA’s minimum recommended Modulus of Elasticity (MOE)
- 515,064 psi – Dynamic Composite MOE test results
- 2,000 psi – AREMA’s minimum recommended Modulus of Rupture (MOR)
- 5,688 psi – Dynamic Composite MOR test results

The Dynamic Composite ties provided to TTCI successfully met AREMA requirements for the two tests performed. The Dynamic Composite tie met AREMA requirements for Test 1C: Bending – Center Negative, as stated in AREMA Chapter 30, and it passed Test 7: Fastener Electrical Impedance Test, as stated in AREMA Chapter 30.

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## **1.0 INTRODUCTION**

Transportation Technology Center, Inc. (TTCI) has completed a fastener electrical impedance test and a bending center negative test on composite crossties manufactured by Dynamic Composite, LLC.

These tests will provide basic data that can be compared to past data, existing wood tie performance data, and to the recommended criteria of the American Railway Engineering and Maintenance of Way Association (AREMA), Chapter 30, Sections 2.2 and 2.8.

These laboratory tests are two of several prerequisite tests needed for in-track performance testing in the High Tonnage Loop (HTL) at the Facility for Accelerated Service Testing (FAST), Pueblo, Colorado.

Crossties made of materials other than virgin wood or concrete have unknown performance characteristics and failure modes; therefore, additional material-specific testing may be necessary before in-track testing can be considered.

Although the tests will not provide comprehensive performance data under the likely range of environmental conditions found in North American railroads, the results will indicate relative characteristics under similar test conditions.

## 2.0 FASTENER ELECTRICAL IMPEDANCE TEST

### 2.1 Overview

For the electrical impedance test, the following AREMA specification test procedures found in Chapter 30, Part 2 Section 2.8, were followed:

- Two short pieces of rail are affixed at each rail seat area of a full size tie with the selected fastening system.
- The complete tie and rail assembly are immersed in water for a minimum of 6 hours.
- The contact points on each rail are cleaned and test cables are attached.
- 10 volts AC 60 hertz will be applied between the two running rails for a period of 15 minutes.
- The current flow between the two rails will be measured.
- The impedance value is calculated – AREMA requires a minimum impedance value of 10,000 ohms.

### 2.2 Description of the Test Sample and Test Preparation

A 14-inch AREMA cut spike tie plate was installed on each rail seat using five cut spikes using the following spike configuration: two diagonally opposed tie plate hold-down spikes, two gage-side rail spikes, and one field-side rail spike. This is the same pattern used in curves on the HTL. Spike pilot holes, 9/16-inch diameter by 5 inches deep, were drilled for all holes before spike insertion. Short sections of 136-pound rail were attached to the tie plates. After soaking for 6 hours, the tie was removed from the water bath, and the leads were connected to the flanges of the rails, as Figure 1 shows. The voltage was applied with a variable power source and monitored with a multimeter. Also, the amperage was monitored using a multimeter. Figure 2 shows the setup.



**Figure 1. Electrical Impedance Tie Setup**

### 2.3 Test Results

The current flow between the two rails before soaking was 0.0038 milliamps (mA). Dividing the applied 10 volts by this amperage in amperes resulted in approximately 2.6 megohms. After soaking the tie for 6 hours and applying the voltage for 15 minutes, the current flow increased to a value of 0.1226 mA. This calculates out to 81,566 ohms, which meets the AREMA specification of a minimum impedance of 10,000 ohms.



Figure 2. Electrical Impedance Electrical Setup


<b>Company Name:</b>		Dynamic Composites, LLC. 11/10/09			
Electrical Impedance Test					
Time	V (AC)	mA	A	ohms	MEETS/DNM
Pre Soak	10	0.0038	3.8E-06	2,631,579	MEETS
Post Soak @ 15 min.	10	0.1226	0.00012	81,566	MEETS
MEETS: Meets 10,000 ohm minimum criteria					
DNM: Does not meet 10,000 ohm minimum criteria					
					

Figure 3. Electrical Impedance Results

### 3.0 BENDING – CENTER NEGATIVE TEST

#### 3.1 Overview

For the Negative Center Bending Test, the tie was supported upside down on two supports 60 inches apart longitudinally (30 inches each side of the centerline of the tie). The tie was then loaded at the longitudinal centerline at a rate of 5-inches per minute. The tie was tested to failure. The force and deflection at the tie center were recorded and plotted on a graph. The modulus of elasticity (MOE) and modulus of rupture (MOR) were calculated using this data.

#### 3.2 Description of the Test Sample and Test Preparation

The test was performed on one full-size composite crosstie, as received from Dynamic Composite, at an ambient temperature of 70°F. The test sample was set up in the three-post load frame, as Figure 4 shows. The centerline of the tie was marked to align with the load head. The tie measured 8.5 inches wide and 6.75 inches high; these measurements were used in MOE and MOR calculations.



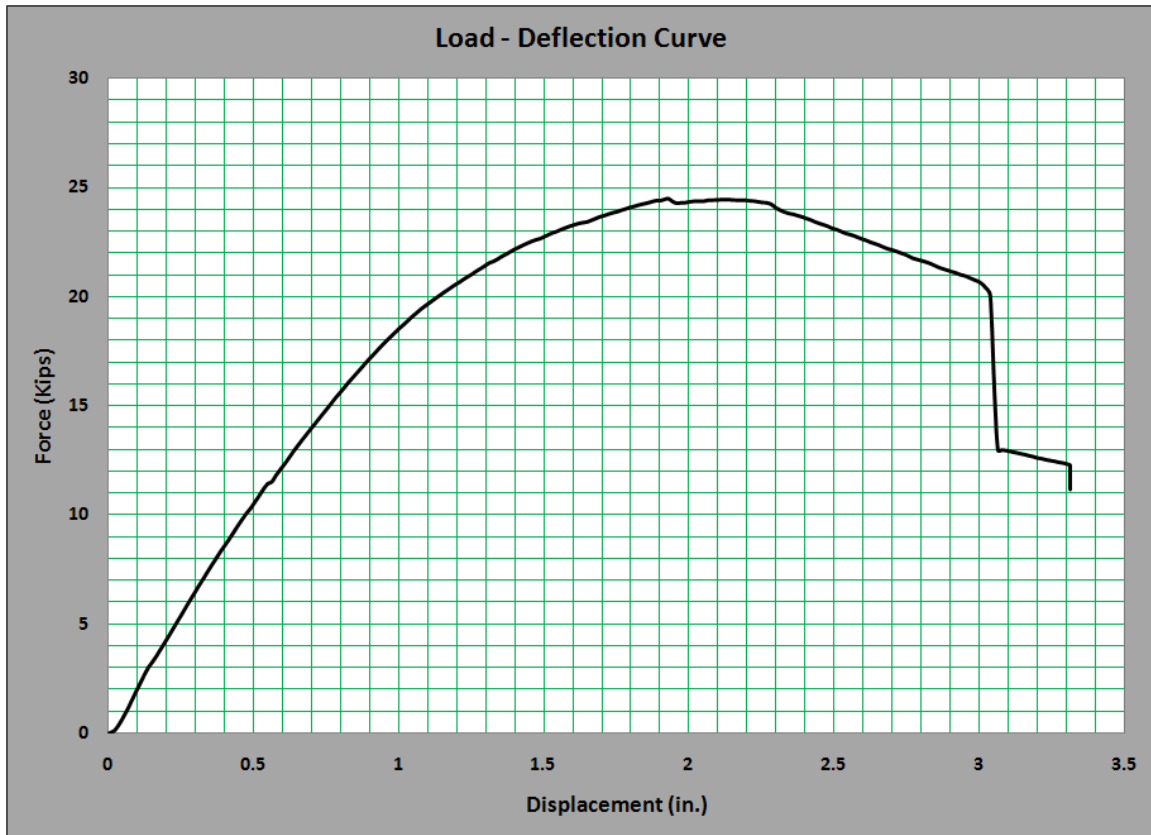
Figure 4. Negative Center Bending Setup

#### 3.3 Test Results

The tie was loaded to failure, as Figure 5 shows. The load at failure was 24,475 pounds. This load value was used in the calculation of the MOR. Additional pictures of the failure are shown in the attachment. Figure 6 shows the load/deflection curve generated from the three-point bending. The slope of this curve is used to calculate the MOE.



Figure 5. Tie Loaded to Failure



**Figure 6. Load-Deflection Curve Negative Center Bending**

MOE and MOR are calculated using the following formulas seen in AREMA Chapter 30 Part 2 Section 2.2 Article 2.2.3:

*Modulus of Elasticity:*

$$MOE = \frac{mL^3}{48I}$$

where:

m = slope of the load-deflection curve (pounds/inch)

L = loading span (inches)

I = 1/12 (bd<sup>3</sup>)

b = tie width (inches)

d = tie height (inches)

*Modulus of Rupture:*

$$MOR = \frac{3LP}{2bd^2}$$

where:

P = the applied load at break (lbf)

L = loading span (inches)

b = tie width (inches)

d = tie height (inches)

Using the slope of the load-deflection curve, figured as the straight line from the origin (corrected for toe effect) to the load generating approximately 600 pounds per square inch (psi) stress, the MOE calculated for a full-size Dynamic Composite tie was 515,064 psi. The AREMA MOE specification for a polymer composite tie is a minimum of 170,000 psi.

The MOR calculated for the same Dynamic Composite tie was 5,688 psi using the applied load at break of 24,475 pounds. The AREMA MOR specification is a minimum of 2,000 psi.

#### **4.0 CONCLUSION**

The Dynamic Composite ties provided to TTCI successfully met AREMA requirements for the two tests performed. The Dynamic Composite tie met AREMA requirements for Test 1C: Bending – Center Negative, as stated in AREMA Chapter 30, and it passed Test 7: Fastener Electrical Impedance Test, as stated in AREMA Chapter 30.

## **Attachment Photographs**



**Figure 7. Tie Loaded to Failure**



**Figure 8. Tie Load Area**



**Figure 9. Tie Failure (1)**



**Figure 10. Tie Failure (2)**