# COMPOSITE CROSSTIE TEST
## CYCLIC LOAD

Letter Report No. P-09-003
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# Executive Summary

Transportation Technology Center, Inc. has completed a cyclic-load test on a composite crosstie manufactured by IntegriCo Composite, LLC. This test provides basic performance data, which can be used for comparison with existing wood tie performance data.

The tie was subjected to 2-million load cycles, which simulates about 9,000-train passes of a 110-car train. For fatigue purposes, loads produced by lead axles (two lead axles per car) are significant, as trailing axles produce little or no lateral load.

The lateral railhead displacements measured were low. There was no excessive workout of the cut spikes. There was minimal lateral tie plate movement. No excessive tie plate compression occurred. The tie material showed normal wear and abrasion in the tie plate area, and no cracks or anomalies developed.

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# 1.0 INTRODUCTION AND OBJECTIVE

Transportation Technology Center, Inc. has completed a cyclic-load test on a composite crosstie manufactured by IntegriCo Composite, LLC. This test provides basic tie and fastening system performance data, which can be used for comparison to existing wood tie performance data.

Crossties made of materials other than virgin wood or concrete have unknown performance characteristics and failure modes for which additional material-specific testing may be necessary before in-track testing can be considered. These laboratory tests are a prerequisite to in-track performance testing in the High Tonnage Loop (HTL) at the Facility for Accelerated Service Testing (FAST) located at the Transportation Technology Center, Pueblo, Colorado.

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.

*As an unofficial test, this test did not receive the pre-approval required for AAR certification purposes. Test results are not intended for AAR committee approval and should not be used for that purpose.*

# 2.0 CYCLIC LOAD TEST

## 2.1 Overview

The tie plates and rail sections were fastened to the tie using cut spikes, which will also be used in the in-track performance test. The load was applied to the railhead using two load arms. The load arms are set at an angle to apply both a vertical and lateral component to each rail seat. On the gage side, the 21,000 pounds applied through a load pin at an angle of 20.85 degrees resulted in a load distribution of 19,625 pounds for the vertical component and 7,474 pounds for the lateral component (L/V ratio = 0.38).

On the field side for the 21,000 pounds applied through the load pin at an angle of 10.32 degrees resulted in a load distribution of 20, 660 pounds for the vertical component and 3,762 pounds for the lateral component (L/V ratio = 0.18). Water and sand were added over the rail seat area to simulate an abrasive environment. Several measurements were taken throughout the test to document tie performance. The dynamic test was carried out for 2-million load cycles. Upon completion of the test, the rail seat assemblies were photographed and examined for any evidence of anomalies, failure, or damage.

## 2.2 Description of the Test Sample and Test Preparation

The test was performed on 1/2 of a composite crosstie, as received from IntegriCo, at an ambient temperature of 70°F. A 14-inch AREMA cut spike tie plate with a short section of rail designed for the test machine was attached to the rail seat end of the tie. Pilot holes measuring 9/16 inch x 5 inch deep were drilled for all five spikes. The spike pattern consisted of two diagonal plate hold-down spikes, two rail hold-down spikes on the gage side, and one rail hold-down spike on the field side. This is a typical spike pattern used in the HTL at FAST. See the appendix for pictures and drawing of tie setup. The test engineer noted that there was a buildup of tie material between the tie plate and the top of the tie after spiking causing a 5/32-inch gap that prevented the tie plate from lying flat on the tie. After several cycles, the tie plate pushed the material down and the plate was reasonably flat. See the appendix for pictures of tie material buildup.

The test sample was fastened to the tie wear machine, as Figure 1 shows. An angular load of 21,000 pounds was applied to the field side and unloaded. Next, an angular load of 21,000 pounds was applied to the gage side of the railhead and unloaded. These two loads represent one cycle. The test was conducted at a rate of approximately 220 cycles per minute. During the 2-million load cycle test, the rail seat area received a constant water drip on each side of the rail base. Per AREMA test requirements, locomotive sand was sprinkled on the entire rail base and tie plate once per day.

**Figure 1. Test Setup**

Several measurements were recorded to monitor tie performance. Measurements were taken at the start of the test with incremental measurements every 250,000 cycles until 2-million cycles were completed. The lateral displacement of the railhead relative to the tie was measured at a static load of 21,000 pounds from the gage side, released and measured again under 21,000 pounds from the field side. These measurements are taken to monitor the tie's ability to withstand the cyclic loading and maintain stiffness in the rail seat area. The heights of the five cut spikes were also measured, relative to the tie plate, to monitor spike workout. Lateral tie plate movement relative to the tie was also measured. Plate area compression resulting from gage and field side loading was documented, and, at the end of the test, the tie was removed and the tie-plate cutting depth was measured.

## 2.3 Test Results

### Lateral Railhead Displacement

The maximum lateral railhead displacements measured under gage-side loading was 0.156 inch and 0.062 inch from field-side loading. These maximum displacements are within gage-spreading limits. Table 1 lists railhead displacement and total displacement values.

**Table 1. Lateral Railhead Displacement**

| LATERAL RAIL HEAD DISPLACEMENT | | | |
|---|---|---|---|
| KILO CYCLES | FIELD LOADING | GAGE LOADING | TOTAL DISPLACEMENT |
| 0 | 2 | 3 | 5 |
| 250 | 2 | 5 | 7 |
| 500 | 2 | 3 | 5 |
| 750 | 2 | 4 | 6 |
| 1000 | 2 | 4 | 6 |
| 1250 | 2 | 2 | 4 |
| 1500 | 2 | 4 | 6 |
| 1750 | 2 | 5 | 7 |
| 2000 | 2 | 4 | 6 |
| MEASUREMENTS IN 32NDS OF IN. AT 21000 LBS. | | | |

### Cut Spike Workout

To establish a good baseline, initial spike heights were measured after several load cycles due to tie material buildup between tie plate and tie. This allowed for compaction of the tie material. There was no significant cut-spike workout. A 1/32-inch change occurred throughout the test for each spike except for spike 4, which realized a 1/16-inch workout. Table 2 lists the spike workout values recorded at each cycle interval.

**Table 2. Cut Spike Height**

| KILO CYCLES | SPIKE HEIGHT | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 0 | 12 | 14 | 15 | 8 | 19 |
| Load | 15 | 16 | 17 | 10 | 22 |
| 250 | 15 | 16 | 17 | 10 | 22 |
| 500 | 16 | 16 | 17 | 10 | 23 |
| 750 | 16 | 17 | 17 | 10 | 23 |
| 1000 | 16 | 17 | 18 | 10 | 23 |
| 1250 | 16 | 17 | 18 | 10 | 23 |
| 1500 | 16 | 17 | 18 | 10 | 23 |
| 1750 | 16 | 17 | 18 | 10 | 23 |
| 2000 | 16 | 17 | 18 | 11 | 24 |
| MEASUREMENTS IN 32NDS OF IN. | | | | | |

### Lateral Tie Plate Movement

The data indicates that there was a gradual gage spreading with a maximum displacement of 1/8 inch on the north side of the tie plate and a maximum of 3/32 inch on the south side of the tie plate. Table 3 lists the tie plate movement values. See Figure A-1 in the appendix for tie plate orientation.

**Table 3. Tie Plate Movement**

| KILO CYCLES | TIE PLATE TRAVEL | |
|---|---|---|
| | NORTH | SOUTH |
| 0 | 0 | 0 |
| Load | 1 | 1 |
| 250 | 2 | 2 |
| 500 | 3 | 2 |
| 750 | 2 | 3 |
| 1000 | 3 | 3 |
| 1250 | 3 | 3 |
| 1500 | 3 | 3 |
| 1750 | 3 | 3 |
| 2000 | 4 | 3 |
| MEASUREMENTS IN 32NDS OF IN. | | |

### Plate Area Compression

There was an initial compression caused by the relief of the buildup of tie material between the tie and tie plate. This buildup of tie material was produced when pilot holes were being drilled for spiking. Throughout the remainder of the test, there was no significant plate area compression under load. Table 4 lists the plate area compression values measured.

**Table 4. Plate Area Compression**

| KILO CYCLES | PLATE AREA COMPRESSION | |
|---|---|---|
| | GAGE LOADING | FIELD LOADING |
| Load | 3 | 2 |
| 250 | 1 | 0 |
| 500 | 1 | 1 |
| 750 | 1 | 1 |
| 1000 | 1 | 0 |
| 1250 | 1 | 1 |
| 1500 | 1 | 0 |
| 1750 | 2 | 1 |
| 2000 | 1 | 0 |
| MEASUREMENTS IN 32NDS OF IN. AT MAXIMUM LOAD | | |

**Tie Cutting**

The tie was labeled gage, field, north, and south. A straight edge was placed across tie plate area and the measurements were taken with a feeler gage, as Figure 2 shows. The maximum cutting depth was 0.153 inch at the center field location. All the tie cutting values measured are listed in Table 5. See the appendix for pictures of tie cutting.


**Figure 2. Tie Cutting Measurement Setup**

**Table 5. Tie Plate Cutting**

| TIE PLATE CUTTING | | | |
|---|---|---|---|
| | GAGE | MIDDLE | FIELD |
| NORTH | 0.068 | 0.101 | 0.101 |
| CENTER | 0.129 | 0.13 | 0.153 |
| SOUTH | 0.108 | 0.128 | 0.134 |
| *MEASURMENTS IN INCHES* | | | |

## 3.0 CONCLUSION

The IntegriCo tie was subjected to 2-million load cycles, which simulates about 9,000-train passes of a 110-car train. For fatigue purposes, only loads produced by lead axles (two lead axles per car) are significant, as trailing axles produce little or no lateral load. The lateral railhead displacements measured were low. There was no excessive workout of the cut spikes. There was minimal lateral tie plate movement. No excessive tie plate compression occurred. The tie material showed normal wear and abrasion in the tie plate area, and no cracks or anomalies developed.

# APPENDIX
## Tie Setup Drawing and Photographs

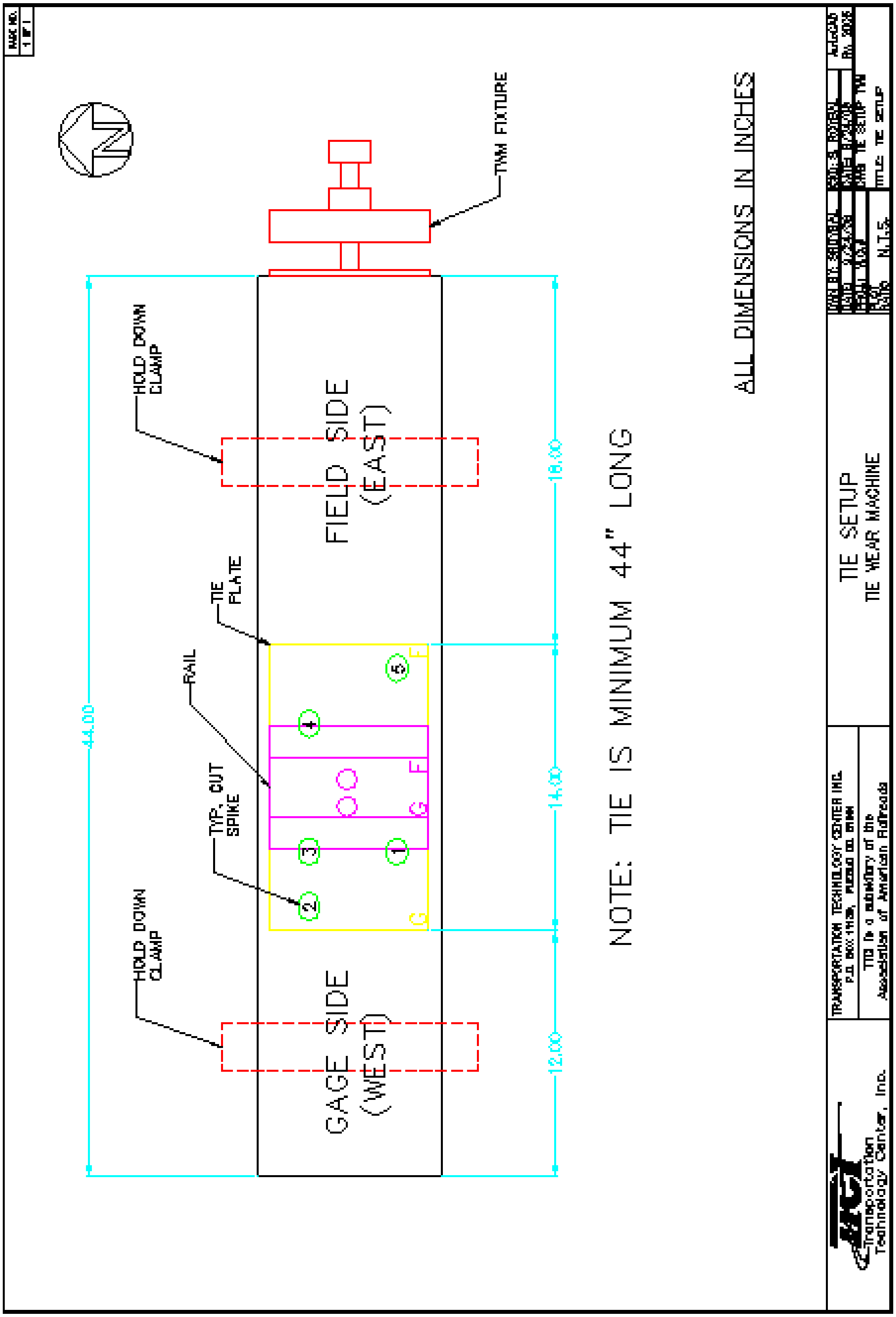


**Figure A-1. Tie Setup**

**Figure A-2. Predrilling Spike Holes**

**Figure A-3. Tie Plate and Rail Spiked to Tie**

**Figure A-4. Gap between Tie Plate and Tie**

**Figure A-5. Close-up Gap between Tie Plate and Tie**


**Figure A-6. Tie Plate Cutting**

**Figure A-7. Close-up tie Plate Cutting Gage Side**

**Figure A-8. Close-up Tie Plate Cutting Field Side**