TECHNOLOGY DIGEST

Timely Technology Transfer

"PERFORMANCE EVALUATION OF TIE PLUGGING REMEDIAL TREATMENTS"

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TD 97-003

Summary

The Association of American Railroads and the University of Illinois performed a series of spike resistance tests on selected tie specimens to evaluate current tie plugging remedial treatments and to further develop performance requirements. Maximum spike drive-in force, maximum spike withdrawal force, and maximum lateral displacement resistance were recorded for each 7″×9″×18″ specimen. Analysis of the test results show:

- Remedial treatments increase tie strength in the spike lateral and spike pull-out tests.
- Treatments restore the strength in 20 to 25-year old crossties to half the strength or more of a new tie in the spike pull-out and spike drive-in tests.
- Using a new hole in the tie plate area provides higher resistance than plugging existing spike holes.
- Hardwood plugs provide higher strengths in the spike pull-out tests than other plug materials tested.
- Polyurethane and phenolic foams provide initial strengths equal to hardwood plugs in the spike lateral and drive-in tests; long term performance remains to be determined.

Spike resistance tests used 79 oak cross ties removed from revenue service and donated by Illinois Central, Conrail, and Burlington Northern Santa Fe. Tie plugging materials tested included two polyurethane foams, a phenolic foam, an epoxy, and hardwood plugs. For comparison, two control spike holes, a new hole and an old hole, were tested without any remedial treatment to serve as best and worst case scenarios, respectively.

Suggested Distribution:

- ❑ Maintenance of Way
- ❑ Maintenance Planning
- ❑ Track Maintenance
- ❑ Research and Development/Test Dept.

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INTRODUCTION AND CONCLUSIONS

The Association of American Railroads (AAR) and University of Illinois (UI) conducted a study to examine tie plugging remedial treatments currently in use and to further develop performance requirements for a new remedial treatment. The objective is to extend the service life of cross ties by improving the spike holding strength of ties when rail has been replaced. Spike resistance tests, used to indicate rail gage and rollover restraint capacity, were employed on used oak cross ties. Various remedial treatments were tested on 18-inch rail seat sections of each tie.

Results indicate that a new hole provided the best results; i.e., highest resistance. As expected, an old hole almost always yielded the lowest resistance, except in the case of the IC ties, where the old hole performed equal to or better than remedial treatments on all tests. Thus, adding a remedial treatment to a spike hole will not necessarily make a difference if a tie is old, structurally degraded, or a combination of both.

The polyurethane foams and phenolic foams provided initial strengths equal to the hardwood plug in the spike lateral resistance and spike pull-out tests. All results reported are statistically significant at a 95 percent confidence level.

TEST PROGRAM

Testing consisted of three spike resistance tests. Maximum spike drive-in force, maximum spike withdrawal force, and the maximum load produced by displacing the cut spike head laterally by .20 inch were recorded for each rail seat area tested. New standard cut spikes (measuring 5/8″×5/8″×6 ½″) were used.

Cut spikes were driven into the spike hole at a rate of 2 inches/minute then displaced laterally at a rate of .1 inch/minute and lastly, pulled out at a rate of .3 inch/minute. The cross tie specimens were conditioned to constant weight and moisture content in a climate chamber for 10 days before testing. A relative humidity of 90 ± 5 percent at a temperature of 68 ± 5°F were the conditions maintained in the chamber. Tests were performed on six to eight spike holes per specimen.

Tests were conducted on 38 Burlington Northern Santa Fe (BNSF) ties that were removed from service during a concrete tie program. The BNSF ties were between 20 and 25 years old. Illinois Central (IC) donated twenty 30-year old ties, while the 21 ties donated by Conrail were 25 years of age. Both the IC and Conrail ties were removed from track for selective replacement as part of program renewals.

Exhibit 1 lists the products used on the three sets of ties. Not every treatment was used on each group of ties due to the limited quantity of treatment material. Additionally, two baseline spike tests were conducted on the ties using one old hole and one new hole. The old hole spike property tests were conducted by driving a spike into an existing spike hole without any treatment. In the new hole tests, a new spike hole was created in the tie plate area; again, without any treatments. The new hole and old hole served as upper and lower limits of strength resistance for each tie.

Exhibit 1. Tie Plugging Matrix

Railroad	Products Tested	Spike Holes Tested
BNSF	Poly Foam B Hardwood Plug	75 38
IC	Poly Foam A Phenolic Foam Epoxy Hardwood Plug	16 8 20 18
Conrail	Poly Foam A Phenolic Foam Hardwood Plug	42 8 21

TEST RESULTS

Each set of tests exhibited unique results in the three spike property tests. Spike resistance forces appeared the lowest for the IC ties. The younger, more structurally sound Conrail and BNSF ties provided higher and similar values. Exhibits 2, 3, and 4 represent average spike insertion, spike lateral, and spike withdrawal forces; respectively. Included in each plot is data collected from an AAR/UI study conducted from 1985 to 1991 in which spike resistance tests were performed on new oak cross ties. Additionally, predicted values based on field data collected from a previous study (TD 96-010) are included in the graphs.[1] The following empirical models were used to predict those values:

- Spike Drive-In (lbs.): P= 9098 - [133.98 × age]
- Spike Lateral Resistance (lbs. at 0.2 inch): P= 2923.4 - [54 × age]
- Spike Withdrawal (lbs.): P= 7871 - [158.71 × age]

The age value used is 25 years.

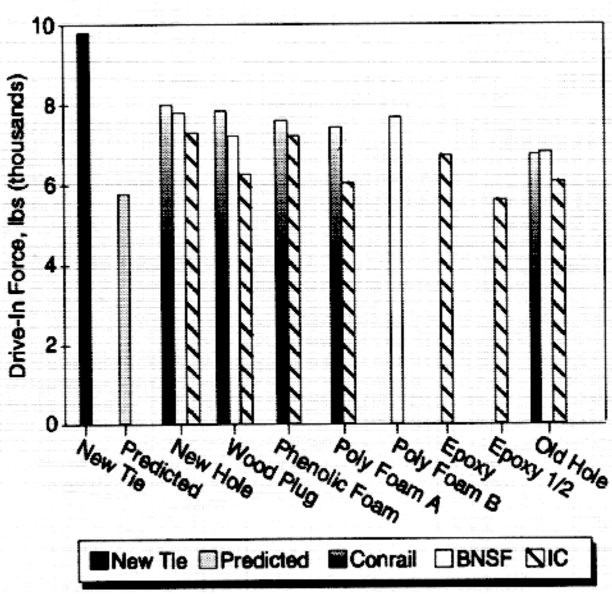
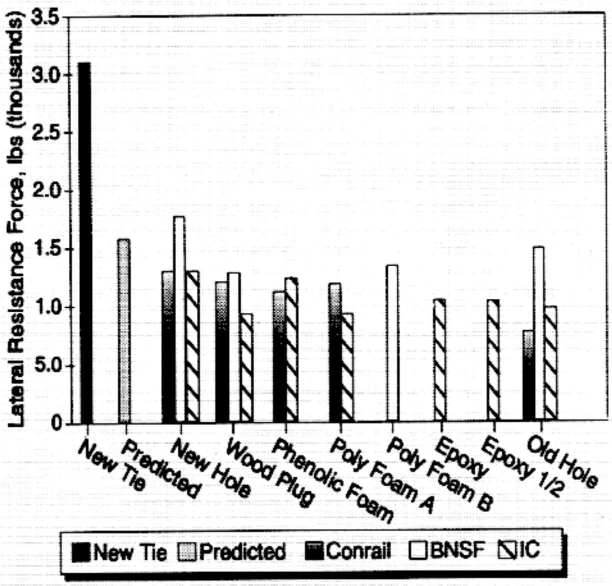


Exhibit 2. Spike Drive-In Force



Note: The epoxy treatment was cured prior to testing. The epoxy ½, however, was not cured beforehand and only filled half of the spike hole.

Exhibit 3. Spike Lateral Resistance

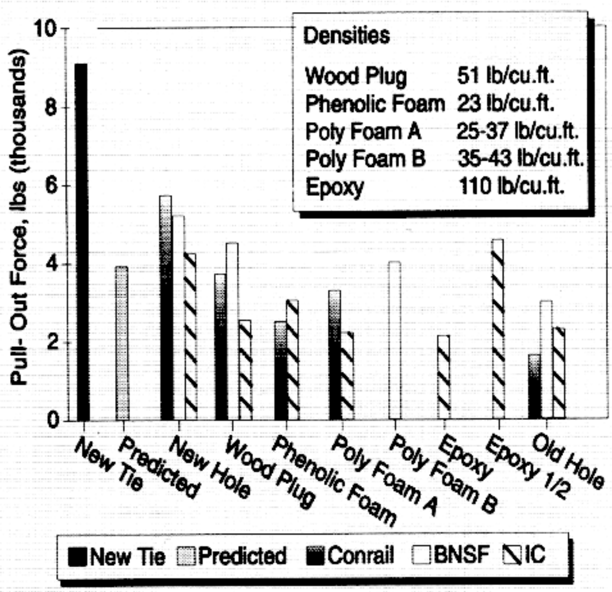


Exhibit 4. Spike Pull-Out Resistance

After the spike resistance tests, the ties were cut through the tie plate area to observe how the remedial treatments interacted with the wood and spike. Cut spikes withdrawn from the polyurethane and phenolic foams exhibited oily surfaces indicating a lack of bonding. Spikes inserted in the epoxy treatment did not bond; however, spikes inserted with in the epoxy ½ treatment showed better bonding at the wood-to-spike interface. The hardwood plugs were either crushed or squeezed during the spike insertion test resulting in frequent splitting of the spike holes.

PERFORMANCE REQUIREMENTS FOR REMEDIAL TREATMENTS

One of the objectives of this study was to develop performance requirements for tie plugging treatments. Listed below are initial requirements that should be considered a starting point. More laboratory testing, such as an accelerated weathering test, would provide further insight into the performance of remedial treatments. Based on these tests and prior cross tie research, suggestions for remedial treatments are listed below.

Remedial treatments must:

- Serve as a filler material or a wedge in the spike hole
- Allow spike removal with minimal damage to the tie plate area
- Out-perform "old hole" vertical and lateral spike resistance tests
- "Set" in 10 minutes
- Be easily applicable to facilitate smooth rail gang operation
- Be non-toxic and require no licensing or disposal permits
- Remain stable over -40° to +150° F
- Remain stable in saturated wood
- Be non-corrosive to cut spikes
- Retain strength with load and weathering cycles

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REFERENCES

1. Davis, D. D., P. Chow, and R. Meimban, "Performance Prediction and Specification of Wood Ties for Revenue Service," Technology Digest 96-010, Association of American Railroads, April 1996.

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