TECHNOLOGY DIGEST

Timely Technology Transfer

"PERFORMANCE PREDICTION AND SPECIFICATION OF WOOD TIES FOR REVENUE SERVICE"

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Summary
To improve upon traditional wood crosstie service testing, which requires at least 5 to 10 years to reliably assess the technical and/or economic merits of products in their environments, the Association of American Railroads and the University of Illinois designed an accelerated test method. This method can "age" wood ties from new condition to 20 or 30.years equivalent in a few days. The strength properties of artificially weathered ties were compared with ties collected from revenue tracks across North America. From the field test data, we are able to construct a performance specification based on the current tie's strength vs age relationship. Candidate ties may be evaluated against this benchmark using the accelerated weathering technique developed. Test results, which have been used to calibrate the accelerated aging process reveal the following:

- Strength loss becomes significant as the crossties weather in track.
- Ties removed from revenue service had strength values as low as 50 percent of new tie strengths.
- New full-size crosstie strength values also differ from those published in the Wood Handbook, which presents values for small, clear specimens.
- A non-destructive test, such as plate area compression modulus, may be used to assess the acceptability of candidate ties.
- The weathering/artificial aging test may be used to evaluate the long-term durability of candidate ties.

Characterization of existing tie condition is essential to developing effective tie maintenance planning and policy. Rapid strength reduction in the field occurs during the crossties' first 5 to 15 years in service, after which, tie strength levels off to a lower stable value. The revenue track's climate index and rail traffic also contribute to tie deterioration. The effect, however, largely depends on the length of exposure to a given climate index and track traffic.

Suggested Distribution:
- ❑ Maintenance of Way
- 0 Research and Development
- ❑ Track Maintenance
- Cl Maintenance Planning

Association of American Railroads
Research and Test Department

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TIE PERFORMANCE IN REVENUE TRACKS

Results of statistical analysis showed that duration of exposure to a particular climate index and rail traffic tonnage is the main contributing factor to tie deterioration.

Exhibit 2 shows the compression modulus of elasticity (P_c) of the Red Oak crossties.

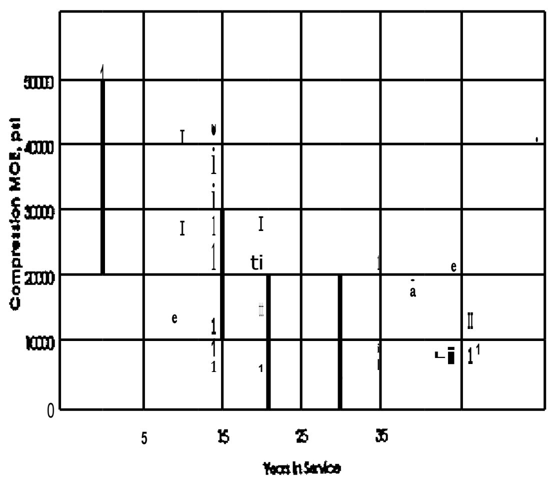

Exhibit 2. Compression MOE of Red Oak Crossties in **Revenue Tracks**

The best prediction equation derived was:

P_c = 35,700 - Age(9.57*CI t 13.2*Ton) (1)

where CI=Climate Index, Ton=Annual Tonnage (MGT/Yr).

The equation has a regression coefficient of R^2 = 0.66. A much simpler linear equation of compression modulus (P_c = 34,123 - 711*Age) is equally promising with a regression coefficient of R^2 = 0.60.

ARTIFICIAL AGING OF CROSSTIES

Exhibit 3 presents the artificial weathering cycle used to accelerate **crosstie aging** in the laboratory. Up to six iterations of this artificial weathering were employed and the crosstie properties were measured at the end of each aging cycle.

Exhibit 3. Weathering Schedule for the Artificial A In of Crossties

Activity	Duration	Conditions
Soaking under Vacuum	30 Minutes	25-inch
Soaking under Pressure	0 Minutes	170 psi
Freezing	3 Hours	0°F
Steaming	**10.5** Hours	250°F and 15 psi
Oven Drying	9.5 Hours	220°F
Conditioning	22 Hours	70°F and 90 RH

Exhibit 4 shows the compression modulus of elasticity of aged Red Oak crossties. The compression modulus of naturally aged and artificially weathered ties are correlated, as also evident from the similarity in trends shown in Exhibits 2 and 4. For artificially aged ties, compression modulus declines rapidly during the first three cycles and levels off after the third cycle. As a result of this correlation, the service age equivalent of the number of artificial weathering cycles was established as follows:

Service years = 5.484 + 2.75 x (Cycles) (2)

PERFORMANCE PREDICTION OF NEW TIES

Exhibit 5 shows the strength retention of oak crossties after several years of exposure in railroad tracks. It appears that compression modulus in the plate area decreases more rapidly than the other properties as the ties age in service. The figure could provide a benchmark for how much crosstie strength is retained after several years, relative to its **strength when new.**

INTRODUCTION AND CONCLUSION

To **improve** upon traditional wood crosstie service testing, the Association of American Railroads and the University of Illinois designed an accelerated test method. In doing so, they also developed an artificial crosstie aging technique which is being used to compare strength-age-traffic relationships in wood ties collected from revenue tracks across North America.

Performance comparisons of the artificially "aged" ties with actual revenue service ties showed that a relationship between the two can be developed for some strength properties, in particular the compression modulus in the plate area.

Physical property tests on field ties showed that moisture content was generally higher (greater than 30 percent) 1 inch or more inside the materials. Mechanical tests further revealed that rapid strength loss in field ties occurred during the first 15 years of service.

Strength properties tested include:

- bending modulus of elasticity,
- modulus of rupture,
- compression modulus perpendicular to the gram,
- face hardness and
- spike load resistance

Trends in the compression modulus of artificially weathered ties are consistent with those of revenue service. Rapid strength reduction occurred during the first three cycles of artificial weathering before gradually leveling off.

The results of this study can be used to predict crosstie performance, and to develop specifications for new ties for various track environments. The accelerated aging test **could** be used to qualify new ties by determining their long-term performance and the durability of treatments.

Sample crossties were collected from various test sites, as shown in Exhibit 1. The corresponding climate index, a measure of the potential for wood decay, is also listed for each site. The index is based on the number of days exhibiting warm moist conditions necessary for decay. The annual tonnage rate at each site and the number of ties used in the study are also indicated in the exhibit.

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1	71	5-40	HW	47	15
2	24	20	1-IW	52	25
3	41	21	HW	45	45
4	39	34	SW	15	14
5	27	10-40	HW	115	10
6	20	10-40	HW	26	35
6	19	10-40	SW	26	35
7	49	21	HW	50	45
8	30	14	Mixed	41	57
9	28	20-50	HW	64	4
10	13	20-50	HW	s4	4

Exhibit 1. Test Specimen Collection Sites

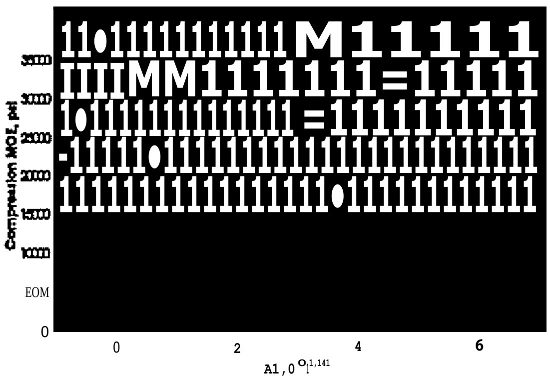

Exhibit 4. Compression MOE of Artificially Aged Oak Crossties

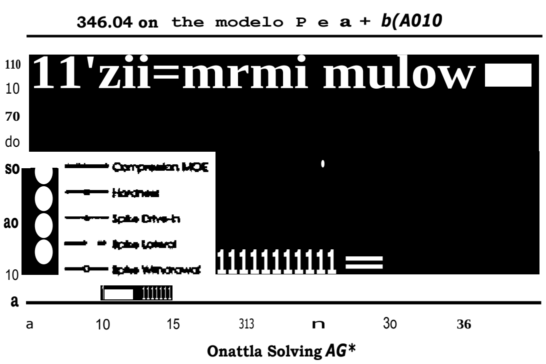

Exhibit 5. Strength Retention of Red Oak Crossties

Some of the prediction models developed in the study could be utilized to assess the property of a new crosstie for a given age-climate-traffic tonnage scenario. For bending modulus and compression modulus of elasticity, the following form of prediction equation could be used:

$$P_y = P_. - Age\ (b * CI + c * Ton) \qquad (3)$$

where b and c are the appropriate constants in Equation 1, P_y is the predicted property after y years of service, and P. is the property of a new crosstie.

The artificial weathering test could also be used to estimate the property of a crosstie after some aging cycles. To establish the long-term performance of crossties, three aging cycles are sufficient

STRENGTH SPECIFICATIONS OF NEW CROSSTIES

Among the goals of this project was the development of a performance specification for new crossties. Choosing the appropriate tests may depend on the location and load environment where the ties will be installed. A non-destructive test, such as the compression modulus in the plate area, should be conducted to assess the acceptability of candidate ties. Testing can be performed quickly and easily without destroying the test specimen.

Exhibit 6 provides a sample specification for the compression modulus test. Additionally, the weathering/artificial aging test can be used to assess long term durability of new ties. Test results will serve as indicator of wood quality and the durability of treatment.

Exhibit 6. Sample Crosstie Specification for Compression Modulus

Test Property:	Compression Modulus*
Species:	Oak
Sample Size:	15
New Tie Strength:	Average must meet . or exceed 38,000 psi
Threecycle Aging btrength:	" Average must meet or exceed 24,009 psi (63% of new tie strength)
* Loadinmust be applied as specified in AAR Report R-702. " Accelerated Aging Testto be Performed in Accordance with AAR Report R-702.	

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