RTA TieReport #5

Material Properties of Wood Crossties

Wood is an extremely versatile and effective material for use as a railroad track crosstie. However, the key properties of wood will vary with class of wood type. In order to allow for the potential use of a broad range of wood types, the wood tie properties presented here have been divided into six (6) categories of wood as presented in Table 1.

Tie Category
Oak
Northern Mixed Hardwoods
Southern Mixed Hardwoods
Southern Yellow Pine (SYP)
Softwoods
Douglas Fir (DF)

Table 1: Tie Life Factors

The material properties presented herein are based on a collection of material property data, to include data from standardized tests on small clear specimens and full tie test data (with adjustment to compensate for wood category differences) and are consistent with those presented in the Manual for Railway Engineering of the American Railway Engineering and Maintenance of way Association (AREMA) [Reference 1].

Table 2 presents the full set of wood property values as follows:

1. Dimensions are for a standard main line wood crosstie (in inches) and are based on the AREMA specification [1] that allows a 1/4 inch reduction in width and depth. Unit of measure is inches.

2. Volume is defined as the total amount of space occupied by the crosstie and is calculated based on the dimensions shown. Unit of measure is cubic feet.

3. Density is mass per unit volume and is derived from testing of small clear specimens of wood using ASTM procedure D-143 and U.S. Forest Service data. Actual whole tie values may differ [1]. Unit of measure is pounds per cubic foot.

4. Weight is the density multiplied by the volume. Unit of measure is pounds.

5. Moment of Inertia (MOI) is a measure of the rectangular shape of the crosstie and is calculated around its neutral axis calculated based on the defined dimensions and a rectangular cross-section. Unit of measure is inches^4.

6. Section modulus is a measure of the shape of the crosstie and is calculated by dividing the MOI by the greatest distance of the section from the neutral axis and is calculated from dimensions and rectangular cross-section. Unit of measure is inches^3.

7. Modulus of Elasticity (MOE) is the rate of change of unit stress with respect to unit strain under uniaxial loading within the proportional (or elastic) limits of the material. It is a measure of the stiffness of the crosstie, i.e. the relationship between load (stress) and deflection (strain). Values derived from testing of small clear specimens of wood using ASTM procedure D-143 and U.S. Forest Service data. Actual whole tie values may differ [1]. Unit of measure is pounds per square inch.

8. Modulus of Rupture (MOR) is a measure of the maximum load-carrying capacity or strength of the crosstie and is defined as the stress at which the material breaks or ruptures (based on the assumption that the material is elastic until rupture occurs). Values derived from testing of small clear specimens of wood using ASTM procedure D-143 and U.S. Forest Service data. Actual whole tie values may differ [1]. Unit of measure is pounds per square inch.

[1]*Eastern and Western Softwoods*

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9. Rail Seat Compression Test is a measure of the crushing strength or load-carrying capacity of the crosstie at the rail seat (under the tie plate) and is defined as load per unit area at which compression of the wood occurs. Values derived from testing of small clear specimens of wood using ASTM procedure D-143 and U.S. Forest Service data. Actual whole tie values may differ [1]. Unit of measure is pounds per square inch.

10. Material Surface Hardness (Janka Ball) Test is a measure of the surface hardness of the crosstie and is defined as load necessary to push a two-inch-diameter steel ball 0.25 inch into the tie surface. Values derived from testing of small clear specimens of wood using ASTM procedure D-143 and U.S. Forest Service data. Actual whole tie values may differ [1]. Unit of measure is pounds.

11. Static Bending Strength is a measure of the strength of the crosstie and is based on a load deflection test carried out to failure of the wood material (test similar to C-Stiffness Load/Deflection test, shown in 12 below). Unit of measure is inch-kips.

12. C-Stiffness Load Deflection is a measure of the flexibility of the crosstie and is based on a load deflection test in which a load of 10,000 lbs is applied to the center of the crosstie which is supported from below at two points 60 inches apart. The deflection is measured. Unit of measure is inches.

17. Single Tie Lateral Push Test is a measure of the lateral resistance of a single crosstie in ballasted track and is representative of the relative resistance of the track to lateral movement in the ballast. Values are based on field tests taken by U.S. Department of Transportation and are based on "minimum" value for consolidated track adjusted to account for differences in density (weight) of the different crosstie wood materials. Unit of measure is pounds.

Table 2: Material and Tie Strength Preliminary Values

		Oak	Northern Mixed Hardwoods	Southern Mixed Hardwoods	Southern Yellow Pine	Softwood	Douglas Fir
1. Dimensions	nominal						
Length (in)	102	102	102	102	102	102	102
Width (in)	9	8.75	8.75	8.75	8.75	8.75	8.75
Depth (in)	7	6.75	6.75	6.75	6.75	6.75	6.75
2. Volume (ft^3)		3.49	3.49	3.49	3.49	3.49	3.49
3. Density (pcf) [lbs/ft^3]		68.4	65.3	58.9	62.1	53.4	59.7
4. Weight (lbs)		238	227	205	216	186	208
5. Moment of Inertia (in^4)		224	224	224	224	224	224
6. Section Modulus (in^3)		66.4	66.4	66.4	66.4	66.4	66.4
7. Modulus of Elasticity (MOE)	10^6	1.22	1.28	0.95	1.49	1.07	1.60
8. Modulus of Rupture (MOR) in psi	72 F	8392	8893	6810	10508	7144	9299
9. Rail Seat Compression Test (psi)		670	418	523	632	430	594
10. Material Surface Hardness Test (pounds)	Janka Ball	883	690	587	565	371	556
11. Static Bending Strength (in-kips)		558	591	453	698	475	618
12. Stiffness; Load/Deflection (inches)		0.165	0.157	0.212	0.134	0.187	0.125
17. Single tie lateral push test (lbs)		1950	1900	1800	1850	1700	1800

[2] 50% lateral resistance was varied linearly as a function of the weight of the ties, using mixed hardwoods as the base reference. To account for the non-weight-related component of lateral resistance (due to side and end effects that do not change with weight) only 50% of the lateral resistance was varied with weight, with the remaining 50% held constant.

REFERENCES

1. American Railway Engineering and Maintenance of way Association (AREMA), Manual for Railway Engineering, 2007, Chapter 30, Section 30-A-1.