EFFECT OF SIZE ON TENSION PERPENDICULAR-TO-GRAIN STRENGTH OF DOUGLAS-FIR

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ABSTRACT

The strength of wood in tension perpendicular-to-grain has been studied by several authors and found to depend on specimen geometry. In this paper, the weakest-link concept has been applied to predict the relationship between specimen volume and load-carrying capacity for Douglas-fir specimens loaded in uniform tension perpendicular-to-grain. The theory allowed the prediction that logarithm of maximum strength should decrease linearly with logarithm of volume. Experimental data taken from the literature were used to evaluate the theoretical model and agreement was found to be high ($R^2 \geqslant 0.85$). Average strength of a unit volume is approximately 460 psi, whereas the predicted strength of a 10- × 10- × 20-inch specimen (2000 inches^3) is approximately 100 psi. The magnitude of the size effect may depend on the quality of material in the specimens, but certainly any rational development of working stresses for tension perpendicular-to-grain must consider effects of specimen (or structural component) size.

Additional keywords: Pseudotsuga menziesii, size effects, tension, Weibull distribution, strength, duration of load, glued-laminated beams, pitched-tapered beams, design of structures.

SYMBOLS

- B risk of rupture
- D beam depth
- F cumulative distribution function giving probability of failure
- f frequency distribution
- g_1, g_2 function of volume
- k shape parameter of Weibull distribution
- n an integer
- P probability indicator
- S cumulative distribution function giving probability of survival
- s size effect parameter
- V volume
- X a generalized strength value
- x stress parameter
- x_l a lower limit on strength (location parameter of Weibull distribution)
- x_0 scale parameter of Weibull distribution
- β stress-volume coefficient
- Γ gamma function
- ψ a variable
- ξ stress distribution coefficient
- σ a generalized stress
- σ_0 scale parameter
- ρ a parameter

INTRODUCTION

The relationship between structure load-carrying capacity and the size, shape, and stress distribution within members has been documented for many materials, including wood (Weibull 1939a,b; Pierce 1926; Tucker 1927, 1941; Frankel 1948; Epstein 1948; Bohannen 1966; Johnson 1971; Leicester 1973; Keenan and Selby 1973; Schniewind and Lyon 1973). The size, shape, and stress distribution effects observed in materials are a manifestation of material strength as defined classically. In the classical theory of strength, as embodied in the maximum-stress theory, for example, it is assumed that strength is controlled by a combination of stress components, with failure occurring when this generalized stress reaches a maximum value. This strength concept makes use of the mean strength obtained from a number of geometrically similar tests as the measure of material strength. The implications of natural variability observed in tests of similar specimens are often neglected and it is this variability that gives rise to various "statistical" effects that influence load-carrying capacity (Weibull 1952).