



Standard Practice for Establishing Design Stresses for Round Timber Piles¹

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1. Scope

1.1 This practice covers basic principles for establishing recommended design stress values for round timber piles.

1.2 This practice is intended for use by associations, technical societies, and other groups responsible for establishing standards for design and use of round timber piles.

1.3 Stresses derived by this practice are applicable to pile quality described in Specification D 25.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

D 25 Specification for Round Timber Piles²

D 2555 Test Methods for Establishing Clear-Wood Strength Values²

3. Significance and Use

3.1 This practice is intended to establish design stresses (working stresses or allowable stresses) for timber pile material.

3.2 Safe and reliable design stresses are necessary in order to achieve economical and dependable designs, fully utilizing the physical properties of round timber piles. In using these stresses, the engineer must also consider other factors, such as the location of the critical section, the soil bearing capacity, the ability of the pile to withstand driving stresses, and service conditions which may affect the design of the pile system.

3.3 Maximum economy is achieved when all piles are stressed to the full allowable strength.

PRINCIPLES AFFECTING STRENGTH PROPERTIES

4. Clear Wood Strength

4.1 The strength of timber piles is dependent upon the

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This revision includes changes only to the design stresses for oak piles calculated from 14.1.1 and a change to 13.3 to make an exception for oak piles.

² *Annual Book of ASTM Standards*, Vol 04.10.

average clear wood strength. Values of clear wood strength are presented in Test Methods D 2555.

5. Variability

5.1 There is a variation in the strength of clear wood within each species resulting from the normal differences in the growth of individual trees. The variability of clear wood strength properties is composed of variations between trees, variations along the length of a tree, and variations between different locations within a cross section of a tree. Variability is presented in the form of standard deviations for clear wood strength of small specimens in Test Methods D 2555.

5.2 The variation in pile strength is mostly due to differences between trees. Thus, the standard deviations for pile strength are less than for clear wood strength of small specimens.

6. Density

6.1 The specific gravity of the solid wood substance of all clear wood is practically the same, regardless of species. Clear wood is porous and its strength depends upon the amount of wood substance present. Specific gravity provides an excellent index of the wood substance a piece of dry wood contains, and is therefore an index of its strength properties.

7. Decay

7.1 Ordinarily, the extent of decay in wood is difficult to determine, and its effect on strength and shock resistance is greater than visual observation would indicate. Decay in piles in any form is severely restricted or prohibited in accordance with Specification D 25.

8. Heartwood and Sapwood

8.1 Heartwood and sapwood have been found to be of equal strength and no requirement of heartwood need be made when strength alone is the governing factor.

9. Moisture Content

9.1 When timber is seasoned, the direct effect of the loss of moisture is the stiffening and strengthening of the wood fibers.

9.2 The effect of reduction of moisture content assumes importance only when piles protrude above ground for some distance, as in the case of piers and wharves or bridge construction. Piles are usually continuously wet for at least a major portion of their length.

10. Slope of Grain

10.1 Slope of grain in a timber pile is a spiraling of the grain, and is measured by the twist in the direction of the fibers with respect to the axis of the pile. Specification D 25 limits this characteristic so that its effect on strength is less than the effect due to allowable knots.

11. Knots

11.1 Knots reduce the strength of timber piles due to the distortion of grain around the knot. Their effect on bending strength is considerably greater than their effect on compression parallel to the grain. There is an increasing effect on strength with larger knots and closer grouping of knots. Limitations on size and spacing of knots for piles are given in Specification D 25.

12. Duration of Load

12.1 Both the elastic limit and ultimate strength of wood are greater under short-time loading than under long-time loading. Wood is able to absorb overloads of considerable magnitude for a short time or lesser overloads for a longer period. A factor must be applied to stress values obtained from laboratory testing to convert them to working stresses suitable for loading conditions in use.

13. Preservative Treatment

13.1 Preservative treatment by pressure process within the limits prescribed by the American Wood-Preservers' Association does not significantly affect strength. Conditioning of piles prior to treatment by processes that involve steaming or heating in liquids can have an effect on strength.

RECOMMENDED DERIVATION OF WORKING STRESSES

14. Bases for Design Stresses

14.1 The equations and adjustment factors herein incorporate results of pile and pole test data, design practice, and marketing practices. The source of basic strength information is Test Methods D 2555.

14.2 Adjustment factors used herein include an adjustment from short-time test conditions to normal duration of load conditions.

14.3 Except for oak piles, the weakest part of a timber pile is located toward the tip end. Adjustment factors used herein include an adjustment of Test Methods D 2555 strength values to the lower strength of the pile tip.

14.4 Timber pile strength is less variable than small clear strength due to using the tree as a whole. Adjustment factors used herein include an adjustment for this lower variability.

14.5 Adjustment factors used herein include a factor for growth and shape characteristic as specified in Specification D 25.

14.6 The equations in this practice give working stresses for untreated piles at a green moisture condition.

15. Calculation

15.1 Calculate compression parallel to the grain as follows:

$$C_{||} = (S - 1.645 SD)/1.88 \quad (1)$$

where:

$C_{||}$ = working stress in compression parallel to the grain for green untreated timber piles,

S = average small clear crushing strength from Test Methods D 2555, and

SD = standard deviation of small clear crushing strength from Test Methods D 2555.

15.1.1 For oak piles multiply the calculated compression parallel to grain $C_{||}$, by the factor 1.1.

15.2 Calculate extreme fiber in bending as follows:

$$f = (S - 1.645 SD)/2.04 \quad (2)$$

where:

f = working stress for extreme fiber in bending for green untreated timber piles,

S = average small clear bending strength from Test Methods D 2555, and

SD = standard deviation of small clear bending strength from Test Methods D 2555.

15.3 Calculate horizontal shears as follows:

$$\tau = (S - 1.645 SD)/5.47 \quad (3)$$

where:

τ = working stress in horizontal shear for green untreated timber piles,

S = average small clear shear strength from Test Methods D 2555, and

SD = standard deviation of small clear shear strength from Test Methods D 2555.

15.4 Calculate compression perpendicular to grain as follows:

$$C_{\perp} = S/1.5 \quad (4)$$

where:

C_{\perp} = working stress in compression perpendicular to the grain for green untreated timber piles, and

S = average proportional limit stress of small clear specimens from Test Methods D 2555.

15.5 The average small clear modulus of elasticity values from Test Methods D 2555 shall be taken as the values for green untreated timber piles.

ADDITIONAL FACTORS

16. Preservative Treatment

16.1 The values of working stress given by the equations in Section 15 shall be adjusted in accordance with the process of conditioning prior to treatment. The adjustment factors to be used are:

Air-dried	1.00
Boulton process	0.90
Steam conditioning	0.85

16.1.1 These factors shall apply to all strength properties. No adjustment is necessary for modulus of elasticity.

17. Increase in Compressive Strength of Piles from Tip to Butt

17.1 The working stresses obtained by the equations in Section 15 may be increased by the percentage obtained from the following equation:

$$P = 0.2L \quad (5)$$

where:

P = percentage increase for working stress and compression parallel to grain, and

L = distance (ft) from the tip end of the pile to the critical section.

17.2 This increase shall be applied to Southern Pine and Douglas Fir species only until data on other species becomes available.

DESIGN CONSIDERATIONS

18. Responsibility of Designer

18.1 The relation between design considerations and working stresses in particular cases, within limits set by building codes or other applicable regulations, is solely the responsibility of the designing engineer.

19. Factor of Safety

19.1 The combined effect of the reduction factors in 15.1 and 15.2 is to adjust clear wood strength values to design

values for piles. This is further explained in 19.1.1-19.1.4, and in Section 14. A formal factor of safety has not been included. If it is considered to be required, factors of 1.25 in compression parallel to grain and 1.30 in bending are recommended.

19.1.1 Minimum pile butt and tip diameters specified in Specification D 25 are the basis for design. Actually, the average pile may be larger than minimum specified at every point throughout the length of the pile.

19.1.2 The derivation of working stress is based on the weakest material in the pile, the tip section.

19.1.3 The full design load usually does not reach the tip of the pile because of the support by skin friction provided by the soil through which the pile is driven.

19.1.4 Pile foundations may establish some load sharing, but no factor for this is included.

20. Keywords

20.1 design; piles; stresses; timber

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