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Standard Practice for Establishing Allowable Stresses for Round Timbers for Piles from Tests of Full-Size Material[1]

This standard is issued under the fixed designation D7381; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice contains procedures for establishing allowable compression parallel to grain and bending stresses for round timbers used for piling, based on results from full-size tests.

NOTE 1—Allowable stresses for compression perpendicular to grain and shear properties are established in accordance with the provisions of Practice D2899.

1.2 Stresses established under this practice are applicable to piles conforming to the size, quality, straightness, spiral grain, knot, shake and split provisions of Specification D25.

1.3 A commentary on the practice is available from ASTM International.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *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:*[2]

D25 Specification for Round Timber Piles
D198 Test Methods of Static Tests of Lumber in Structural Sizes
D245 Practice for Establishing Structural Grades and Related Allowable Properties for Visually Graded Lumber
D1036 Test Methods of Static Tests of Wood Poles
D1990 Practice for Establishing Allowable Properties for Visually-Graded Dimension Lumber from In-Grade Tests of Full-Size Specimens
D2555 Practice for Establishing Clear Wood Strength Values
D2899 Practice for Establishing Allowable Stresses for Round Timber Piles
D2915 Practice for Sampling and Data-Analysis for Structural Wood and Wood-Based Products
D4761 Test Methods for Mechanical Properties of Lumber and Wood-Base Structural Material
D6555 Guide for Evaluating System Effects in Repetitive-Member Wood Assemblies

3. Terminology

3.1 *Definitions:*

3.1.1 *allowable stress*—the numeric value of pile strength appropriate for use in design.

3.1.2 *end-bearing*—compression parallel to grain stress used in design when the pile load is not carried to the soil through skin friction.

3.1.3 *load sharing*—the distribution of load that occurs in two or more piles which are capped with a load-distributing element that assures the piles deform as a group. The load distributed to the piles in such a group is in proportion to the stiffness of each pile. This distribution of loads to the piles in the group reduces the effect of between pile variability and increases system reliability over that of piles which perform as single members.

3.1.4 *skin friction*—the interaction between the pile surface and the surrounding soil which serves to distribute load either away from or into a pile. A positive skin friction refers to pile loads distributed to the soil. Negative skin friction refers to loads being distributed into the pile as a result of soil subsidence or consolidation.

3.2 *Symbols:*

c = circumference of a round timber pile

C_{cp} = conditioning adjustment

C_{ds} = adjustment for duration of load and miscellaneous factor of safety

C_{ls} = load sharing adjustment

C_{oc}, C_{ob}, C_{oe}, C_{oeb}, = adjustments to F_c, F_b, E and $EMOE$ for pile oversizing relative to Specification D25 specified minimum circumferences

[1] This practice is under the jurisdiction of ASTM Committee D07 on Wood and is the direct responsibility of Subcommittee D07.04 on Pole and Pile Products.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

C_t = adjustment of allowable compression parallel to grain stress at pile tip to critical section location L

D = pile diameter

E_i = modulus of elasticity for individual member individual compression parallel to grain specimen

E_a = average modulus of elasticity of butt and tip compression parallel to grain specimens from the same pile

E' = sample mean modulus of elasticity in compression

E = allowable modulus of elasticity in compression

$EMOE_i$ = effective modulus of elasticity in bending for an individual pile

$EMOE'$ = sample mean effective modulus of elasticity in bending

$EMOE$ = allowable effective modulus of elasticity in bending

F_b = allowable stress in bending

F_c = allowable stress in compression parallel to grain

f_{cTL} = compression parallel to grain 5 % tolerance limit with 75 % confidence determined from test results for the tip specimen

f_{bTL} = bending 5 % tolerance limit with 75 % confidence determined from test results

L = distance from pile tip to critical section, ft

L_e = distance from top of butt compression parallel to grain test specimen to top of tip compression parallel to grain test specimen, ft

$MORBP$ = modulus of rupture at breakpoint

k = number of random variables used in random products simulation

n = number of piles in a species or species group selected for testing

p = exponent of L_e used to calculate pile length effect on compression strength

r = radius of gyration = $D/4$

UCS = ultimate compressive strength

z = number of piles in a cluster

4. Significance and Use

4.1 This practice is primarily intended for use by associations, third-party grading agencies, technical societies and other groups that develop national design standards and use recommendations for round timber piles.

4.2 This practice provides procedures for establishing compression parallel to grain and bending stresses for round timber piles including: sampling of material for testing; methods of test and property calculation procedures; distribution analysis of test data; procedures for determining adjustments for critical section location; pile oversize, load sharing and treatment; and procedures for deriving allowable stresses.

4.3 In using allowable stresses established under this practice, factors specific to each end use which may affect the performance of the pile system shall be considered by the designer. Such factors include the location of the critical section, the bearing capacity of the soil, the ability of the pile to withstand driving forces, the properties of the cap or load distributive element tying piles together and the loading and conditions of service.

5. Sampling Full-Size Round Timbers

5.1 The population to be sampled shall be round timbers of a particular species or species group meeting the provisions of Specification D25. Only those species groups that do not exceed the variability, as measured by the criteria of Section 5 of Practice D2555, of the major lumber species groups sampled in the In-Grade lumber testing program in the United States and Canada shall be considered as a single species for sampling and analysis purposes. For species groups exceeding these variability limits, the species composition should be changed such that the limits will be met by the remaining species in the group if sampling of the group as a single species is desired.

NOTE 2—See X9.1 of Practice D1990 for discussion of in-grade sampling of species groups. Major species groups sampled in the In-Grade lumber testing program are given in Note 3 of Practice D1990.

5.2 A representative sample (n) of all sizes (diameters) and lengths of timber piles as in Tables X1.2 or X1.3 and Tables X1.4 or X1.5 of Specification D25 shall be selected for the species or species group being evaluated. Sampling by size, length and class shall be in proportion to total production and shall be distributed across plants representative of the producing region.

NOTE 3—Specification D25 pile specifications provide for only one grade and quality level.

5.3 Individual piles selected as test material shall be green and randomly chosen from inventory in the yard at each plant.

5.4 Sample size shall be based on the principles of Practice D2915 and shall be sufficient to provide reliable estimates of the distributions of bending and compression parallel to grain strengths of timbers of the species or species group being evaluated. Each pile selected for test shall be evaluated for both bending and compression strength with compression specimens being cut from the butt and tip ends after the bending test is completed.

6. Test Methods and Calculation Procedures

6.1 All test members shall be maintained in a green condition prior to test.

6.2 Each member shall be tested in bending in accordance with the procedures of Test Methods D1036. Modulus of rupture at breakpoint (*MORBP*) and effective modulus of elasticity in bending (*EMOE*) shall be calculated in accordance with the formulas given in 19.4 of Test Methods D1036. If an alternative formula is used to calculate *EMOE*, its derivation and assumptions shall be documented.

NOTE 4—The cross-section of round timbers varies from butt to tip as a result of taper. A linear taper between butt and tip is assumed in the derivation of the *EMOE* equation. As tree tapers may not be linear but parabolic, the moment of inertia of the resisting cross-section is underestimated and the resulting bending *EMOE* value for the pile is typically substantially higher than the average E based on compression parallel to grain tests.

6.3 After completion of the bending test, compression test specimens shall be cut from the butt and tip ends of the member. These specimens shall be prepared and tested in accordance with Sections 12–19 of Test Methods D198. The same slenderness ratio, specimen length divided by the small end radius of gyration (r), shall be used for the butt and tip specimens but shall not exceed 17. Specific gravity disks shall be cut from the bottom and top of each pile, immediately above the small end of the compression test specimens.

6.4 To prevent excessive end crushing, the compression specimens shall be banded or the ends air-dried prior to testing. Load-deformation data shall be obtained for both specimens. In place of the testing speeds specified in section 17.3 of Test Methods D198, a rate of straining (in./in. per min) such that maximum load is obtained between 1 and 5 min shall be used and both butt and tip specimens shall be tested at the same rate.

NOTE 5—A range of 1 to 5 min in failure times is within the range of 10 s to 10 min specified for in-grade testing of lumber in section 34.4 of Test Methods D4761.

6.5 Ultimate compression strength (*UCS*) and modulus of elasticity (E_i) shall be calculated for both the butt and tip specimens using the area of the small end of each specimen. Values of E_i shall be based on the linear portion of the load-deformation curves with suitable adjustment made for any nonlinearity occurring at the beginning of the test. The average of the E_i values for the butt and tip specimens shall be calculated as the E_a of the pile.

7. Reporting Requirements for Sampling and Testing

7.1 The following information shall be reported:

7.1.1 The production volumes for the various sizes, lengths and classes of piles building poles used to develop the sampling plan for each species or species group evaluated.

7.1.2 The methods used to select the manufacturing facilities for sampling and the individual test piles from each facility.

7.1.3 A complete description of each test specimen including length, butt and tip circumference, rings per inch, percent summerwood, slope of spiral grain and the maximum individual knot size and the maximum sum of knot diameters in any one-foot of pile length.

7.1.4 The diameters of the small and large ends of the butt and tip compression parallel to grain test specimens selected from each pile and the maximum individual knot size and the maximum sum of knot diameters in any one-foot of length in each of these specimens.

7.1.5 Slenderness ratios, rate of load application, time to maximum load, section properties, specific gravity, formulas used to calculate strength and stiffness properties and other information as required by the provisions of Test Methods D198 and D1036.

7.1.6 A complete description of the analytical methods used to develop the statistics and factors described in Sections 8-11.

8. Analysis of Test Data

8.1 The average of the individual pile $EMOE_i$ and E_a values shall be calculated as the sample mean values (*EMOE'* and *E'*) for the species or species group evaluated.

8.2 The distributions of *UCS* values for the tip compression specimens and the *MORBP* values for the *n* piles in the sample shall be examined to determined what type of distribution (normal, lognormal or nonparametric) best describes each data set, particularly the lower strength values in the sample.

8.3 If a parametric distribution is to be used, the mean, standard deviation and 5 % tolerance limit with 75 % confidence (f_{cTL} or f_{bTL}) determined for the property and sample using the methods of sections 3.4.3.2, 4.5, and Table 1 of Practice D2915.

8.4 If a nonparametric distribution is to be used, the sample test values shall be arranged in ascending order and the *m*th order statistic selected as the sample 5 % tolerance limit with 75 % confidence (f_{cTL} or f_{bTL}) in accordance with 4.5.4, 4.5.5, and Table 2 of Practice D2915.

9. Critical Section Located Above the Pile Tip

9.1 Paired butt and tip compression parallel to grain *UCS* values shall be used to establish an equation for adjusting tip compression allowable design values (F_c) when the critical section is located above the tip as a result of skin friction.

9.2 For each test pile, the difference between butt and tip *UCS* values shall be normalized using the following calculation:

$$R_i = [(UCS_{butt} - UCS_{tip})/UCS_{tip}]/L_e^p \quad (1)$$

where:

R_i = normalized individual pile length effect on compression strength $p = 1.6$.

9.3 If the significance of the slope coefficient of the regression of R_i on L_e is not less than a probability of 25 %, the average of the R_i values for the sample (R_{avg}) shall be used to establish the following equation for determining C_l:

$$C_l = (R_{avg} \times 100)/L^p \quad (2)$$

where:

C_l = percentage increase in pile compression strength at distance L from the pile tip $p = 1.6$

9.4 If the significance of the slope coefficient is less than 25 %, the value of the exponent p shall be changed so as to meet this criterion. Individual R_i values based on a butt compression specimen containing a split that occurred during the bending test shall not be included in the regression analysis nor in the calculation of R_{avg} for the sample.

10. Effect of Pile Sizes Exceeding Specification D25 Size Class Minimums

10.1 Piles are marketed in accordance with circumference (diameter) and length specified in Specification D25. The actual diameters of piles qualifying for a particular circumference class generally exceed the minimum required, ranging from that minimum up to the minimum size defining the next larger class. The effect of this pile oversizing shall be determined through random product analysis using Monte Carlo simulation from normal or log normal distributions of *UCS* tip and *MORBP* test values and uniform distributions of section property values for representative pile circumference classes in Specification D25.

10.2 The ratio of the 5 % nonparmetric point estimate of the distribution of *k* products of individual random strength and section property values to the 5 % point estimate of the distribution of the *k* random strength values times the section property associated with the minimum size for the class shall be established as the oversize factor for the property, C_o.

NOTE 6—Random product analyses using a *k* of 10 000 have been found to provide consistent results.

10.3 The strength distribution of *UCS* tip and *MORBP* values used in the random product analysis shall have non-significant skewness. If a log normal distribution is used, the Monte Carlo simulation is made using the mean and coefficient of variation associated with the *ln* transformation and each randomly selected value is converted back to original units before multiplying by the section property variable. If a parametric distribution of acceptable skewness is not available for the strength property, the actual frequency distribution of test values in at least 20 classes shall be used for the Monte Carlo simulation.

10.4 For purposes of evaluating the oversize factor for *UCS* tip strength values, C_{oc}, the 8-in. tip class of 8.00 to 8.99 in. associated with cross-sectional areas (*A*) of 50.26 and 63.47 (normalized to 1.00 and 1.26) shall be used to define the uniform section property distribution for the random product analysis.

10.5 For purposes of evaluating the oversize factor for *MORBP* strength values, C_{ob}, the circumference of an 8-in. tip pile at 20 ft from the tip, or 28 in., and the circumference of an 9-in. tip member 20-ft from the tip, or 31 in., (Table X1.5, Specification D25) shall be used to establish a uniform section property distribution. The section moduli associated with these circumferences, 69.50 and 94.23 (for a *c* of 30.99 in.) (normalized to 1.00 and 1.33) define this distribution.

10.6 As the compression *E'* of the sample is a mean value and a uniform distribution of pile areas for a pile size class is being used, a random products analysis to determine an oversize factor for *E* is not required. Rather the mean area associated with the 8-in. tip class diameter limits of 8.00 to 8.99 in., or 1.131 (1+.2628/2) shall be used as the oversize factor, C_{oe}, to determine *E*.

10.7 Because test values of $EMOE_i$ are calculated assuming uniform taper and the resultant values are much larger than compression E_a values, an oversize factor (C_{oeb}) of 1.000 shall be used to establish *EMOE* values.

11. Load Sharing Analysis

11.1 Round timber foundation piles are generally used in clusters with the piles connected by a reinforced concrete cap or equivalent load distributive element that causes the piles in the cluster to deform by the same amount under load. Therefore the portion of the load carried by each pile in the cluster is proportional to its stiffness and the capacity of the cluster is generally not limited by the pile with the lowest strength but by the pile whose distributed load first exceeds its strength. This increase in load-carrying capacity of the cluster over that predicted using the pile design stress times the number of piles in the cluster is a function of the variation in individual pile strength values that is accounted for by variation in pile modulus of elasticity.

11.2 The increase in load-carrying capacity of piles acting as a group may be established using the principles of Guide D6555. Such methodology employs the regression of *UCS* or *MORBP* on E_a or $EMOE_i$, together with Monte Carlo sampling from the distribution of E_a or $EMOE_i$ test values and the associated variance about the regression to obtain paired stiffness and strength values for each pile in a cluster of *z* piles. The simulated strength of each pile in the cluster is divided by the ratio of its stiffness to the average stiffness of the *z* piles in the cluster to account for the proportion of the total load being carried by each pile. The lowest adjusted strength value for the *z* piles in the cluster is compared to the lowest unadjusted strength for any pile in the cluster to obtain a measure of the increase in capacity due to load sharing.

11.3 The procedure of 10.2 shall be repeated *k* times to obtain stable distributions of simulated pile cluster strength values and related unadjusted strengths of the weakest pile for the cluster population. The ratio of the 5 % nonparametric point estimate of the distribution of lowest adjusted strength values to the 5 % nonparametric point estimate of the distribution of lowest unadjusted strength values represents the load sharing factor, C_{ls}, for the cluster of *z* piles.

NOTE 7—Distributions using *k* equal to 10 000 have been found to provide reproducible results.

11.4 The procedures of 10.2 and 10.3 shall be repeated for each pile cluster size (z = 2,3,4, etc.) to develop a load sharing factor.

11.5 Distributions of E_a and $EMOE_i$ used for Monte Carlo simulation in 10.2 should test not significant for skewness. If a log normal distribution is used for these properties, the E_a and $EMOE_i$ values shall be selected in log normal units and then converted back to original units for entering the regression. If a parametric distribution of acceptable skewness is not available for the strength property, the actual frequency distribution of test values in at least 20 classes shall be used for the Monte Carlo simulation of E_a or $EMOE_i$ values. Regressions of *UCS* on *Ea* and *MORBP* on $EMOE_i$ used to estimate mean strength values shall be developed in original units. The error variance about the regression shall be assumed homogeneous and normal at each level of E_a or $EMOE_i$ when Monte Carlo simulation is used to determine the plus or minus error term applied to each regression estimate of strength.

12. Establishment of Allowable Stresses

12.1 *Adjustment of Test Values to a Design Use Basis*—Values determined in accordance with 8.1-8.4 shall be adjusted by the factors (C_{ds}) in Table 1 to obtain allowable stresses (*F*, *E*, *EMOE*) for use in design.

12.2 The factors for compression and bending strength in Table 1 include an adjustment for duration of loading and a miscellaneous factor of safety. The load duration adjustment

TABLE 1 Adjustment Factors Applied to Short-term Test Values

Property	C_{ds}	
	Softwoods	Hardwoods
Compression parallel to grain	1/1.9	1/2.1
Bending	1/2.1	1/2.3
Modulus of elasticity	1.00	1.00

reduces strength properties from a short-term test basis to a normal load duration basis. Normal load duration represents application of the load that fully stresses a member to its design stress for a cumulative duration of approximately 10 years.

12.3 When the cumulative duration of the full maximum load is less than or more than 10 years, pile allowable stresses (F_c, F_b) established in accordance with this practice shall be modified in accordance with the duration of load adjustments in Fig. 6 of Practice D245. Load duration adjustments greater than 1.6 shall not apply to piles treated with water-borne preservatives.

12.4 Duration of load factors are not applied to average modulus of elasticity values.

13. Moisture Content

13.1 Allowable stresses established by this practice apply to piles that are continuously wet or continuously exposed to the weather.

13.2 No increases in stresses for piles that are partially above ground and may be partially seasoned are recognized in this practice.

14. Treatment

14.1 Preservative treatments using approved processes and chemicals do not affect allowable stresses for round timber piles established under this practice. Conditioning prior to treatment does affect strength and must be considered.

14.2 Pile strength properties are affected by the conditioning of piles by kiln drying, steaming or boiling in liquids that is conducted before pressure treatment in order to facilitate penetration of preservative chemicals. Allowable stresses established by this practice shall be adjusted by the appropriate conditioning factor given in Table 2 which are based on compression parallel to grain tests of end-matched conditioned and unconditioned full-size pile sections.

14.3 Conditioning adjustments in Table 2 are applicable to F_c and F_b stresses. No adjustment is made in E and *EMOE* values for conditioning.

15. Derivation of Allowable Stresses

15.1 *Species*—Adjustment factors for oversizing, location of critical section and load sharing used with the allowable stresses for each species or species group shall be based on analysis of the test data for that species or group. If allowable stresses are being established for a number of species or groups under this practice, the smallest of the individual species values obtained for each factor may be applied to all species or groups for purposes of simplification.

TABLE 2 Adjustment Factors for Conditioning

Conditioning factor, C_{cp}				
Air drying	Kiln drying	Boulton drying	Steaming (normal)	Steaming (marine)
1.00	0.90	0.95	0.80	0.74

15.2 *Compression Parallel to Grain*—Calculate allowable stress in compression parallel to grain for the member tip by the following equation:

$$F_c = (f_{ctl}C_{ds})[C_o][C_{cp}][C_{ls}] \quad (3)$$

15.2.1 Where the critical section in compression parallel to the grain is located above the pile tip as a result of skin friction of the soil or other condition, F_c may be increased by the factor C_l as determined in accordance with 8.3.

15.3 *Extreme Fiber in Bending*—Calculate allowable stress in extreme fiber in bending by the following equation:

$$F_b = (f_{btl}C_{ds})[C_o][C_{cp}][C_{ls}] \quad (4)$$

15.4 *Modulus of Elasticity*—Calculate allowable modulus of elasticity in compression parallel to the grain as:

$$E = E'[C_o] \quad (5)$$

15.4.1 The allowable modulus of elasticity in bending is:

$$EMOE = EMOE' \quad (6)$$

15.5 *Rounding*—Allowable stresses shall be rounded after all adjustments to the following increments:

F_c, F_b	nearest 50 psi for values ≥ 1000 psi
	nearest 25 psi for values < 1000 psi
E, $EMOE$	nearest 100 000 psi

15.5.1 The rounding rules of Practice E380 shall be followed.

16. Design Considerations

16.1 *Pile Circumference and Diameter*—The minimum pile butt and tip circumferences (diameters) given in Specification D25 shall be used with the allowable stresses established by this practice to determine pile load-carrying capacity and stiffness. The actual size of individual piles generally will be larger than the minimum circumferences tabulated in Specification D25. The effect of this oversizing is accounted for by the C_{os} factor determined in accordance with section of this practice.

16.2 *Responsibility of the Designer*—It is the responsibility of the design engineer to relate allowable stresses to design assumptions, and to determine the appropriateness of load-sharing and other allowable stress adjustments provided in this practice to the specific conditions of end use.

17. Keywords

17.1 design; piles; stresses; timber

APPENDIX

(Nonmandatory Information)

X1. DEVELOPING STRESSES FOR ROUND TIMBER PILING BASED ON FULL-SCALE TESTS

X1.1 Currently, Practice D2899 provides the derivation method for developing allowable timber piling stresses. This procedure is based on tests of clear, straight grain samples and the adjustment factors necessary to derive allowable working stresses.

X1.2 This method is the historical method for developing stresses and virtually all other wood products now use methods derived from actual tests. Currently published allowable stresses are based on Practice D2899.

X1.3 The new Practice D7381 provides the derivation method for developing allowable stresses from full-scale tests. The Piling Subcommittee voted to separate the protocol for developing allowable stresses from full scale tests into a new Standard as full-scale testing is an entirely different approach from the historic method.

X1.4 Practice D7381 provides a more direct method for developing allowable working stresses for piles, and the methodology is the subject of this new ASTM Standard. The Standard provides the methods for developing primary piling stresses. Secondary stresses will continue to be developed under Practice D2899. This Standard emphasizes the importance of assuring that test samples are representative of production in terms of size and quality. It also describes the statistical analysis used to identify confidence values for bending and compression strength and the basis for design considerations such as load sharing.

X1.5 In actual service, loads placed on piles are transferred to the soil by a combination of "skin" friction at the pile-soil interface and end bearing force at the tip. Driving naturally tapered timber piles into the soil compresses it, thus increasing the confinement force and skin friction. Soils provide sufficient lateral restraint on the pile to permit the embedded portion to act as a short column without length/radius ratio adjustments.

X1.6 The load capacity of a timber pile foundation is most always governed by soil conditions as bearing and shear strengths of the soil are generally less than those of timber piling material.

X1.7 The most severe stresses encountered by piles of any type of material (wood, steel or concrete) occur during the driving process where actual stresses may be three times the allowable, a condition often referred to as, "a driven pile is a tested pile."

X1.8 In the late 1990's there was considerable ASTM Committee discussion on the use of Practice D2899 for developing allowable working stresses. Several committee members who voted for the re-approval of this standard in 1995 did so with the understanding that issues regarding this Standard would be addressed by the timber piling industry.

X1.9 The timber piling industry addressed these questions and funded full-scale tests for both Southern pine and Douglas fir piles. These tests were run by EDM International, an independent laboratory in Ft. Collins, CO, in 1999 and 2000.

X1.10 Because of questions raised by ASTM Committee members about the reliance on small-clear specimen test data and standing timber volume information, an unusual but not required, step in the testing process was included in the initial testing which was to survey the piling producers about where they obtained their whitewood materials and to use test specimens from those areas in the testing program.

X1.11 An associated result of the full scale tests is the ability to use the data in Reliability Based Design procedures. This procedure is used by non-wood piling materials and is the procedure commonly taught in university curriculum. Full-scale tests provide the basis for doing Reliability Based Design while the Practice D2899 protocol did not.

X1.12 The ASTM D07.04 Committee maintains several other standards dealing with timber piles and construction poles. These include:

(1) Specification D25, the oldest ASTM D standard still in use except D9 on wood terminology.
(2) Test Methods D1036 provides the procedure for bending strength evaluation of both poles and piling.
(3) Specification D3200 provides the derivation method for developing allowable stresses for construction poles.