Verification of ANSI O5.1 Strength Values for Southern Pine Poles Through Current Full-Sized Destructive Testing

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Resource Testing Project

- Trend in the forestry community is faster and faster growth rates, with shorter and shorter rotation lengths.
Resource Testing Project

- Origin in Changes to SP Lumber Design Values by SPIB
- Visual Grading Rules for SP “Dense” Lumber and ANSI O5.1 Poles Are Similar
Resource Testing Project

- Difference Is No Juvenile Wood At the Pole Surface at the Groundline in Poles
- However, Still Market Questions Over “Juvenile” Wood and Rapid Growth Plantation Timber
- Project Organized and Funded by the Southern Pressure Treaters’ Association
Project Plan

- First, Develop Data on Growth Rates from Present Production
- Estimate Expected Outcome of Break Testing if Tested Sample Matched Observed Growth Rate
  - Develop from Historic Strength Test Results Sorted by Growth Rate
- Conduct Break Testing to Confirm
Growth Rate Study

- Sought Data on 2 Classes of Poles in Each Length from 30 Feet to 50 Feet
- Data Was Obtained from Over 1400 Poles from Throughout the SP Production Area
35' Poles - Pole Survey

Total Pole Count:
- 35 ft. Class 5: 200
- 35 ft. Class 3: 140

Percent of Poles in Data Set

Ring Count Outer 2''
45' Poles - Pole Survey (2'')

Total Pole Count: 200
45' Poles - Pole Survey (3"")

Total Pole Count: 180

Percent of Poles in Data Set

Ring Count Outer 3"
Results of Growth Rate Study

- Average Growth Rate Was More Rapid
- Larger Class Diameter Had Faster Growth in All Lengths
- Overall Average Growth Rate Showed Estimated MOR of 8870 psi, Which, Adjusted for Oversize and Conditioning, Is Above the ANSI O5.1 8000 psi MOR Value
Green Untreated Poles, 25'-45' in Length (Cantilever Loading)

Data Point Not From ANSI Data Set - Estimate Based on Limited Data

Estimated Weighted Average MOR (psi): 8874

Sample Size for Ring Count (poles): 1423
Specimen Selection

- Size Chosen Was 40 Foot Class 3, One of Largest Volume Sizes
- Expected More Rapid Growth than Smaller Classes
- 10 Pieces Each Were Randomly Selected from Green Inventory at 10 Different Production Facilities for a Total of 100 Pieces
- States Providing Specimens Were Arkansas, Texas, Louisiana, Mississippi, Alabama, Georgia, South Carolina, and North Carolina
Specimen Quality

- All Material Shipped to Test Facility at Baldwin Lighting, Inc. in Bay Minette, AL
- Material Was Measured and Inspected and Assigned a Test Specimen Number
- Eight Non-conforming Pieces Were Rejected for Growth Rate – Still Tested for Informational Purposes
- Average Growth Rate of Specimens Was Faster than that of 40 Foot Class 3’s in Growth Rate Survey – Therefore, Results Would Be Conservative
40' Class 3 Poles

Total Pole Count: 92

40 ft. Class 3 Break Test
40 ft. Class 3 Pole Survey

Percent of Poles in Data Set

Ring Count Outer 2"
Break Test Procedure

- Testing Followed ASTM D 1036 – Specified in ANSI O5.1
- Poles Tested in Green Condition
- Borings Were Taken for Moisture Content and Oven Dry Density Determination
- Cantilever Test Method Was Used Because More Representative of Actual Load Condition and Most Existing Data Based on This Method
Specific gravity numbers were calculated by Dr. Dan Seale and Dr. David Jones at the MSU Department of Forest Products

Average SG Was 0.5396  
Average MC Was 73.7%
Standard Test Methods of Static Tests of Wood Poles

This standard is issued under the fixed designation D 1036; 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.

INTRODUCTION

One of the important factors involved in the design and economical use of poles for the support of aerial communication and power lines is the value of the maximum fiber stress for the different species of timber used for poles. In order to gain information on this characteristic, mechanical tests on pole size specimens have been made by numerous investigators. These tests have been made in various manners, such as the use of a testing machine, holding the pole butt horizontally in a crib and applying the load at the tip, setting poles in the earth and applying the load at the tip, etc. The amount of seasoning the test poles have received and the type of preservative treatment applied to the poles are additional variables. The result is that it is difficult, if not impossible, to obtain sufficient information pertaining to the various tests to permit accurate comparisons.

It is the purpose of these test methods to cover testing procedures in sufficient detail so that the results of tests made in accordance with the test methods defined will be comparable. It is, of course, not intended that using other test methods that may be better adapted to a particular investigation should be discouraged. However, experience gained from tests of several hundred poles has indicated the test methods specified are entirely practicable.

The data forms presented have been found to be convenient for recording the test data and for making the calculations necessary for the proper analysis of the test results.

1. Scope
1.1 These test methods cover determination of the bending strength of wood poles in service.

2. Referenced Documents
2.1 ASTM Standards:
  D 143, Method of Testing Small Clear Specimens of The...
Break Test

• Break Testing Took Place Over 5 Days
• Poles Were Placed in a Fixture and Loaded with a Winch Until Failure Occurred
• Load Was Measured with a Calibrated Load Cell
• Measurements of Horizontal Deflection and Longitudinal Movement of Load Point Were Made
• Measured Pole Rotation in Test Fixture
Inserting a pole in the testing apparatus
Attaching deflection measurement tape
Force measurement – block and tackle double the measured force ex. 2130 is actually 4260 lbs of force
Just Before Failure
Break Test Data

- Data Was Gathered on Loads, Deflections, Failure Location and Failure Mode
- Most Failures Were Tension Failures Originating at or Near the Groundline, As Expected
- No Failures Were Associated with Defects Recognized and Limited by ANSI O5.1, Although Several Pieces Were Observed to Have Knots Near the Maximum Knot Limitations in the Standard
Data Analysis

- Computations of Modulus of Rupture and Modulus of Elasticity Were Made After Making Corrections for Geometry as Necessary
BUTT MOVEMENT HORIZONTAL DEFLECTION CORRECTION (not to scale)

Point of Load

Ground Line
Pivot Point
Upper Brace Measuring Point

Pole Loaded Position
Pole Unloaded Position
Lower Brace Measuring Point

Brace Width: 8"

Load to Groundline: 32'
Load to Pivot Point: 34' 1"

T: Tip Movement at Point of Load Due to Butt Movement
A: Angle of Rotation
U: Upper Butt Deflection Reading
L: Lower Butt Deflection Reading
POLE BENDING HORIZONTAL DEFLECTION CORRECTION (not to scale)

Fixed Horizontal Deflection Measuring Point

Ground Line

Pole Unloaded Position

Pole Loaded Position

Z : Zero Load Reading
D : Measured Horizontal Deflection Reading
$D_c$ : Corrected Horizontal Deflection Reading $D_c = (D^2 - L^2)^{0.5} - Z$
L : Longitudinal Deflection Measurement
Break Test Facts

- ANSI O5.1 Class 3 Load Is 3000 lb.
- Maximum Breaking Load Was 4960 lb., Minimum Was 2510 lb.
- Coefficient of Variation Was Only 0.13
- Average 6’ Dimension Was 37.06 Inches
- Load Point Circumferences 24.5 to 32.8 Inches
- For Non-conforming Poles Minimum Breaking Load Was 1790 lb., Max Was 3380 lb.
Development of ANSI O5.1 Strength Value

- For Distribution-sized Poles the ANSI O5.1 Equivalent Strength Is Based on Calculating the Groundline Stress at the Observed Breaking Load and It Is Based on Minimum ANSI Groundline Dimensions Since Pole Line Engineering Designs Are Based on Minimum ANSI Dimensions

- This Value Is Reduced by a Conditioning Factor of 0.85 for SP to Account for the Potential Strength Reduction Due to Steam Conditioning (Which Is Rarely Used Today)
Break Test Results

- The Average Green MOR at Groundline Was 8770 psi Based on Actual Groundline Dimensions
- When Adjusted to ANSI Minimum Dimensions This Became 9561 psi
- After Adjusting By the Worst-Case Conditioning Factor of 0.85 the Value Became 8127 psi
Break Test Results

● The Test Confirms that the 8000 psi MOR Value in ANSI O5.1 for SP Poles Is Still Valid

● The Average Effective MOE Value Was About 1.9 million psi
What Else Did We Learn?

• Many of the Previously Accepted “Truths” of Wood Pole Strength Properties Were Reaffirmed

• Generally, More Rings per Inch Equals More Strength

• Generally, Higher Summerwood Percentage Equals More Strength

• Generally, Higher Specific Gravity Equals More Strength
What Else Did We Learn?

● Following Charts Show Strength Versus Various Properties, and Selected Data Points Were Highlighted

● The 3 Lowest Strength Poles Are Yellow

● The Pole with the Highest Number of Growth Rings in the Outer 2 Inches Is Red

● The Highest Strength Pole that Met Only the Minimum Growth Rate Requirements Is Orange

● The Strongest Pole Is Violet
Groundline MOR Strength vs Tree Age

y = 49.596x + 7735.5

LEGEND
Lowest Strength
Highest Growth Rings
Highest Str @ Min Growth Rate
Highest Strength
Groundline MOR Strength vs Growth Rings in Outer 2 Inches

\[ y = 53.67x + 8829.1 \]

**Groundline MOR Strength vs Growth Rings in Outer 2 Inches**

**Legend**
- Lowest Strength
- Highest Growth Rings
- Highest Str @ Min Growth Rate
- Highest Strength

![Graph showing the relationship between Groundline MOR Strength and Growth Rings in Outer 2 Inches.](attachment:image.png)
y = 25.615x + 8039.7

Groundline MOR Strength vs Summerwood Percent

Legend:
- Lowest Strength
- Highest Growth Rings
- Highest Str @ Min Growth Rate
- Highest Strength
$y = 4409x + 7125.7$

**LEGEND**
- Lowest Strength
- Highest Growth Rings
- Highest Str @ Min Growth Rate
- Highest Strength
Groundline Strength (MOR) vs Modulus of Elasticity (MOE)

\[ y = 0.0021x + 5605.4 \]

LEGEND
- Lowest Strength
- Highest Growth Rings
- Highest Str @ Min Growth Rate
- Highest Strength
Summary

- Test Results Confirm the Validity of the ANSI O5.1 Table 1 Value of 8000 psi
- Care in Meeting the ANSI Growth Rate Requirement Is Critical to Providing Poles Meeting the Strength Requirement
- ANSI O5.1 Being Modified to Better Define How “Average” Rate of Growth Is Determined
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THE END

Questions?