SRI LANKA STANDARD 848 : PART 4 : 1989

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SPECIFICATION FOR

WOOD POLES FOR OVERHEAD POWER AND TELECOMMUNICATION LINES

PART 4 - DETERMINATION OF MECHANICAL AND PHYSICAL PROPERTIES OF POLES

SRI LANKA STANDARDS INSTITUTION

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PART 4 : DETERMINATION OF MECHANICAL AND PHYSICAL PROPERTIES OF POLES

SLS 848 : Part 4 : 1989

Gr.11

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SRI LANKA STANDARD

SPECIFICATION FOR WOOD POLES FOR OVERHEAD POWER AND TELECOMMUNICATION LINES

PART 4 : DETERMINATION OF MECHANICAL AND PHYSICAL PROPERTIES OF POLES

FOREWORD

This Sri Lanka Standard was authorized for adoption and publication by the Council of the Sri Lanka Standards Institution on 89.09.07, after the draft, finalized by the drafting committee on Wood Poles for Overhead Power and Telecommunication Lines, had been approved by the Electrical Engineering Divisional Committee.

The formulation of a standard on wood poles was felt necessary to achieve the following objetives.

a) Maintain quality and uniformity of production.
b) Ensure that poles are used according to their load capabilities.
c) Encourage the production of poles by the proper classification of all usable locally grown species.

This standard is in four parts, namely; Part 1 Terminology of wood poles; Part 2 Selection and preparation of wood poles for treatment; Part 3 Design data and pole classes; and Part 4 Determination of mechanical and physical properties of poles;

All values in this specification are given in SI units.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or an analysis shall be rounded off in accordance with CS 102. The number of significant figures to be retained in the rounded off value shall be the same as that of the specified value in this standard.

The assistance derived from the publications of the American National Standards Institution and British Standards Institution, in the preparation of this standard is gratefully acknowledged.

1 SCOPE

This part of the standard specifies tests to determine the fibre stress in bending, modulus of elasticity, rate of growth, relative density, and density of tapered solid wood poles.

2 REFERENCES

BS 1990 Wood poles for overhead power and telecommunication lines Part 1 Specification for soft wood poles
CS 102 Presentation of numerical values
SLS 848 wood poles for overhead power and telecommunication -lines
Part 1 Terminology of wood poles
Part 3 Design data and pole classes.

3 DEFINITIONS

The definitions given in SLS 848 : Part 1, shall apply for the purpose of this standard.

4 TEST TO DETERMINE MECHANICAL PROPERTIES OF POLE SPECIES

4.1 General

Two methods of test are available for the determination of the bending strength and modulus of elasticity of round, tapered solid wood poles. Either method may be adopted for the test.

The poles for test shall be selected by someone qualified to identify the species.

For each species under investigation it is desirable that a minimum of 50 specimens be selected for test. The poles shall be carefully chosen as representative of the commercial product being supplied.

Poles to be tested should be debarked, trimmed, notched, conditioned, and if so specified preservative treated, to simulate their usual service condition. The moisture content of the poles to be tested should be at or above their fibre saturation point.

For the duration of the test programme, untested poles should be stored under cover and clear off the ground. Before testing, each specimen should be assigned an identification number or mark.

Poles selected for tests shall satisfy the requirements of clause 11.5.3 of SLS 848 : Part 2 : 1989. To facilitate selection of poles for testing and also to record observed defects, sample data sheet (Table 2) in Appendix A shall be used.

When tests to determine mechanical properties are to be conducted for acceptance of a batch of poles, number of poles shall be determined in accordance with clause 11.4.3 of SLS 848 : Part 2 : 1989. Selection of these poles shall be carried out in accordance with clause 11.3.2 and clause 11.4.3 of SLS 848 : Part 2 : 1989.

4.2 Conditioning of specimens for testing species
All poles to be tested shall be selected in the green condition and shall be tested before any seasoning has taken place. If there is any delay in testing which would result in seasoning, this shall be prevented by proper storage, preferably by full-length immersion in water. If other methods of maintaining the green condition are employed, care shall be exercised to prevent the development of stain or decay. Special moisture content determinations of the test poles are not required prior to test.

4.3 Cantilever method of testing
4.3.1 *Initial measurements*
Before placing a pole in the testing apparatus, a record shall be made of the following:
a) Weight (kg);
b) Length (mm);
c) Class;
d) Circumference at butt, at tip, and at the ground line (mm). (In this specification, the location for ground line for various lengths of poles is indicated in Table 3 to Table 7 and Table 8 to Table 12 of Part 3 of this standard.);
e) Diameter of each knot over 12 mm in diameter and its location on the surface of the pole relative to the butt and to the longitudinal centre line of the face of the pole; and
f) Any possible strength reducing defects observed other than knots, such as sweep, crook, checks, shakes, spiral grain, insect damage, etc.

4.3.2 *Apparatus*
A schematic drawing of the testing apparatus and field layout for conducting the tests is shown in Figure 1. For convenience of reference, the principal feature of the layout are denoted on the drawing by capital letters. The pole to be tested shall be held securely from the butt to the ground line in the crib(A). The crib shall be built in such a manner that there will be no significant movement of the pole butt during the test. The design of the crib and holding devices shall be such that all vertical and rotational motion of the pole shall be prevented.

A support(B) shall be provided at a point about three quarters of the distance from the ground line to the point of load application to minimize vertical movement at that point and reduce the stress from the weight of the pole. This support shall be such that any friction associated with the deflection of the pole under load shall not be a significant portion of the measured load on the pole.

The pole should be supported in its natural fall position to minimize any tendency for the pole to rotate when the load is applied. This should be located before test by gently rolling the pole on the butt and tip support positions before tightening the butt support.

The pole shall be shifted longitudinally until its ground line coincides with the front face of the crib, and then it shall be secured firmly in place. A wooden saddle (C), Figure 1 with a concave surface on the pole side and rounded edges, shall be placed against the pole to prevent injury to the ground line section. This saddle shall be made of wood at least as soft as the pole under test and shall have dimensions as shown in Figure 2.
The details of crib support (B) and saddle (C) in Figure 1 and Figure 2 may be altered suitably, provided that the pole under test behaves in a manner similar to that specified in this clause.

4.3.3 *Load*
The load shall be applied at a point 600 mm from the tip of the pole by a power winch or other means, of sufficient capacity and capable of pulling at a constant rate of speed. The pulling line shall be kept level between the winch position (see Figure 1), or alternatively the lower pulley on the loading rig (see Figure 3) and the point where the load is applied to the pole. The load shall be applied in increments (see 4.3.8) such that the pole fails at 900 + 300 s.

4.3.4 *Pulling line*
The pulling line shall be secured around the pole at the load point. The load measuring device shall be placed in series with the pulling line and the line to the winch with a free running swivel on each side of it.
Alternatively the pulling line shall be secured around the pole at the load point and passed through a system of pulleys in the loading rig (see D of Figure 3) and secured to the loading pan.

4.3.5 *Winch or loading rig positions*
The winch (C of Figure 1) or the loading rig (see Figure 3), shall be set far enough away from the pole to make the angle between the initial and final positions of the pulling line small so that the error in assuming that the pull is always perpendicular to the original direction of the pole axis will be negligible. The winch or loading rig shall be located at the positions given in Table 1.

TABLE 1 - Winch Positions

Pole length (m)	Distance M from pole axis (m)	Distance N from Ground Line (m)
6.1	30.5	4.1
6.7	33.5	4.7
7.6	38.1	5.3
9.1	45.7	6.7
10.7	53.3	8.1
12.2	61.0	9.4
13.7	68.6	10.8
15.2	76.2	12.2
16.8	83.8	13.6
18.3	91.4	14.9

NOTE
See Figure 1 and Figure 3 for location of distances M and N.

4.3.6 *Load measurement*
Load shall be measured by a suitable measuring device placed in series in the pulling line. The recommended method is a calibrated metal tension bar fitted with calibrated electric-type strain gauges, suitably wrapped or housed for protection against shock when the pole breaks. This method permits remote reading of loads and minimizes the possibility of personal injury during test. Alternatively, where electric-type strain gauging equipment is not available, load may be measured by a dynamometer of suitable capacity graduated in 200 N divisions. Calibration of the dynamometer shall be checked at frequent intervals during the tests. The load-measuring device shall be supported on a sled or cradle moving on a suitable platform or level space. The sled or cradle and the surface on which it moves shall be such that the force required to pull it shall not add materially to the measured load on the pole.

Loading may also be carried out with suitable dead weights on a pan attached to the pulling line. The dead weights shall be calibrated at frequent intervals by an approved authority. Load measurement shall be made to an accuracy of 2 per cent.

4.3.7 *Deflections*
The deflection of the pole at the point of load shall be measured at such intervals of load as to provide not less than 15 simultaneous readings of load and deflection. A greater number of readings (25 to 40) is preferred. The measurement of the deflection of the load point shall be made in a direction perpendicular to the unloaded position of the pole axis. A measurement of the movement of the load point towards the butt resulting from the deflection shall also be made at each increment of load.

A second datum line shall be established at F, Figure 1 from which movement of the ground line shall be measured. Deflection measurement shall be made to an accuracy of 2 per cent.

NOTE
These measurements may be facilitated if a piece of plywood (datum board) E, Figure 1 is ruled with lines perpendicular to the unloaded side of the pole and spaced 25 mm apart. The edge of the plywood board away from the pole may be used as the datum line from which the deflection is measured. Then as the pole is deflected under load, the tape with which the deflection is measured is kept parallel to the ruled lines and its motion towards the butt may be measured by noting the line the tape is parallel to when the deflection is measured.

4.3.8 *Procedure*
Before any load is applied to the pole, take zero readings for the following and enter in the appropriate columns of Table 3 (Data Sheet 2) :

a) On the tape which measures the deflection of the load point to the edge of the datum board, t;

b) On the datum board the line to which the tape of a) is parallel, s ; and

c) On the tape for measuring ground line movement, g.

Make the following measurement or observations and record them in the appropriate place in Table 3. (Data sheet 2) ;

A) actual distance (mm) from the butt of test pole to ground line (that is, point of support) ;

b) the distance from the ground line to point of load (mm) ;

c) circumference at point of load (mm) ;

d) species of timber ;

e) source of pole ;

f) preservative treatment, if any ; and

g) test number ;

The difference between the zero and any subsequent, "t" readings, measures the movement of the point of load in a direction perpendicular to the unloaded position of the pole axis. Similarly, the difference between the zero and subsequent "s" readings, measures the movement of the point of load towards the pole butt in a direction parallel to the unloaded position of the pole axis. The data relative to the ground line movement, "g" readings, will be needed only for correction of the deflection readings and for calculation of the modulus of elasticity.

Apply the load incrementally and at a uniform rate. At each increment in the load, make simultaneous readings of t, s, and g and record them in Table 3 (data Sheet 2) until the pole fails (see 4.3.3). Record the load at failure and the circumference at the point of break. After failure estimate the break location. Measure and record the distance from this location to the point of load, and the circumference at the point of break.

4.3.9 *Test results*

4.3.9.1 Load correction
Record the corrected load reading in the appropriate column of Table 4 (Data Sheet 3). Determine these corrected readings from calibration curves of the load measuring device. If dead weights are used, their weights shall be verified against a standard such as a calibrated balance.

4.3.9.2 Lever arm correction
The difference between the "t" and "s" readings and the zero readings made during each test are, respectively, measures of the movement of the point of load in a direction perpendicular to and parallel to, the unloaded position of the pole axis. Calculate difference between the zero reading and final "s" reading. Deduct this difference from the distance from point of load to ground line to obtain the true lever arm for the calculation of the maximum fibre stress at the ground line. Also deduct the above difference from the distance from point of load to point of break to obtain the true lever arm for the calculation of maximum fibre stress at break point.

4.3.9.3 Load deflection curve
Plot a load-deflection curve for each pole tested.

4.3.9.4 Calculations
Calculate the maximum fibre stress at the ground line as follows :

$$F = \frac{32 \times \pi^2 \times P \times a}{C^3}$$

where,
F is the maximum fibre stress at ground line (N/mm^2);
P is the load (N) at failure (see **4.3.9.1**) ;
a is the distance (mm) from ground line to point of load (see **4.3.9.2**) and
C is the circumference at ground line (mm).

If the maximum fibre stress at break is desired, calculate it as follows :

$$F_b = \frac{32 \times \pi^2 \times P \times a}{(C_a)^3}$$

where,
F_b is the maximum fibre stress at point of break (N/mm^2);
P is the load (N) at failure ;
a is the distance from point of break to point of load (mm); and
C_a is the circumference at point of break (mm).
The modulus of elasticity may be calculated as follows :

$$E = \frac{64 \times a^3 \times \pi^3}{3 \times C^3 \times B} \times \frac{dP}{d\delta}$$

where,
E is the modulus of elasticity (N/mm^2);
a is the true lever arm of the loading point (mm);
C is the circumference at ground line (mm);
B is the circumference of the pole at the point of load application (mm)

$\frac{dP}{d\delta}$ is slope of the load deflection curve (N/mm) at the initially straight portion.

NOTE
Since shear deformation makes a negligible contribution to the deflection of the pole in test, the modulus of elasticity calculated by the formula will correspond more nearly to the true (compression) modulus of elasticity of the wood than to the apparent (bending) modulus in the standard test of a small clear specimen.

4.3.9.5 Mode of failure
Take a photograph or make a sketch of each pole failure as a portion of the permanent record of tests.

4.5 Simply supported method of testing
Alternatively the test method given in Appendix D of **BS 1990 :Part 1 : 1984** may be used for the determination of strength characteristics of poles.

5 TEST TO DETERMINE PHYSICAL PROPERTIES OF WOOD POLES.
5.1 General
Tests described below define the relevant physical properties of a pole. Test given in 4 should be carried out in addition to these tests.

5.2 Rate of growth
Immediately after completion of the strength test an approximately 30 mm thick cross-sectional disc shall be cut from the vicinity of the fracture. The disc should be free from knots, resin pockets and other abnormal features.

In species of timber where growth rings are visible, the average rate of growth should be taken as the number of rings per 25 mm, between 75 mm and 100 mm from centre.
The total number of rings (i.e. the approximate age of the tree should also be recorded.)

5.3 Moisture content
Moisture content should be determined in accordance with **SLS 848 : Part 2** using the timber disc (see 5.2)

5.4 Relative density (specific gravity)
The specimen extracted for determination of moisture content (or a similar specimen cut from the same disc) should be used for the determination of relative density in accordance with SLS *...
The calculation of relative density is based on the oven dry mass and wet volume of the specimen.

5.5 Density

The pole should be considered as three longitudinally adjacent frustums of cones joined at the ground line and the point of load application. The density (in kg/m^3) should be calculated from the following expression :

$$\rho = \frac{12\pi m}{\sum_{i=1}^{i=3} h_i\{(C_{t,i})^2 + (C_{b,i})^2 + C_{t,i}C_{b,i})\}}$$

where,

C_b is the larger circumference (mm) of the frustum under consideration;

C_t is the smaller circumference (mm) of the frustum under consideration;

h is the height of the frustum under consideration; and

m is the mass of the pole (kg).

6 TEST REPORT

The test report shall contain the following information :

a) species ;
b) length (mm) ;
c) mass (kg)
d) butt circumference (mm) ;
e) circumference at ground line (mm) ;
f) circumference of point of load application (mm) ;
g) tip circumference (mm) ;
h) circumference at break (mm) ;
j) table of load and various deformations ;
k) graph of load versus deflection ;
l) maximum load applied (N) ;
m) maximum ground line stress (N/mm^2)
n) modulus of elasticity (N/mm^2)
o) density (kg/m^3) ;
p) the percentage moisture content ;
q) relative density (kg/m^3) ;
r) rate (s) of growth (Rings per 25 mm) ; if measurable ;
s) age (years), if measurable or from records ;
t) mode of failure ;
u) any other relevant information that may influence the use of the results, for example the strength reducing characteristics.

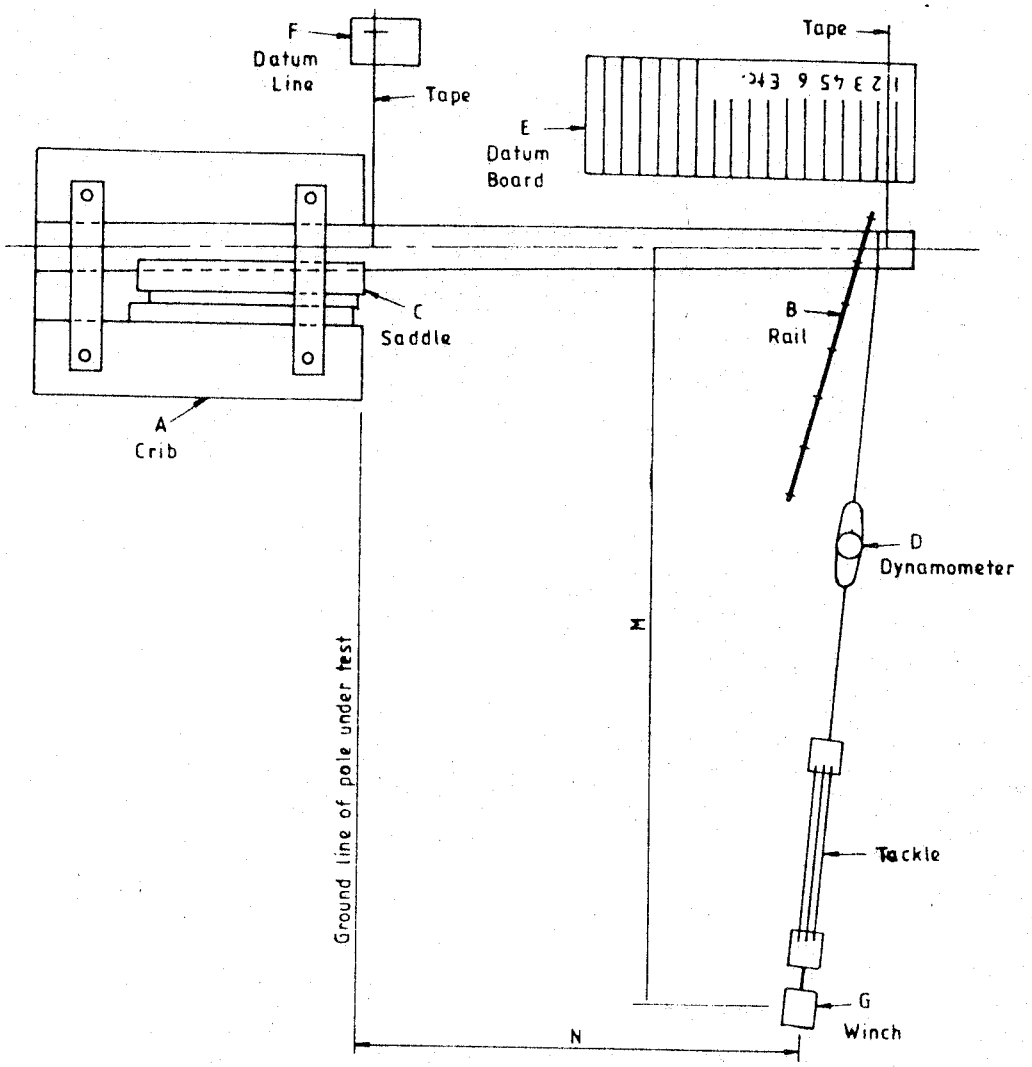
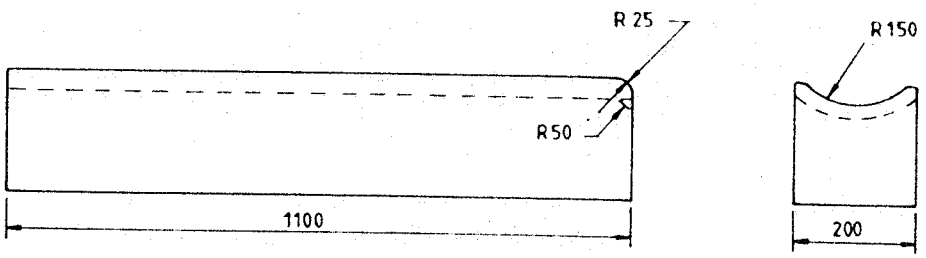
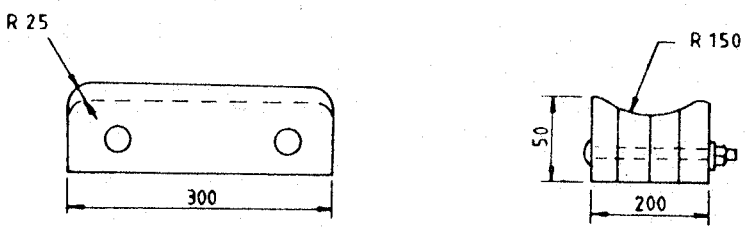


FIGURE 1 - Schematic diagram of a wood pole under test



(a) Wooden saddle



(b) Wooden cradle

dimensions in millimetres

FIGURE 2 - Saddle and cradle

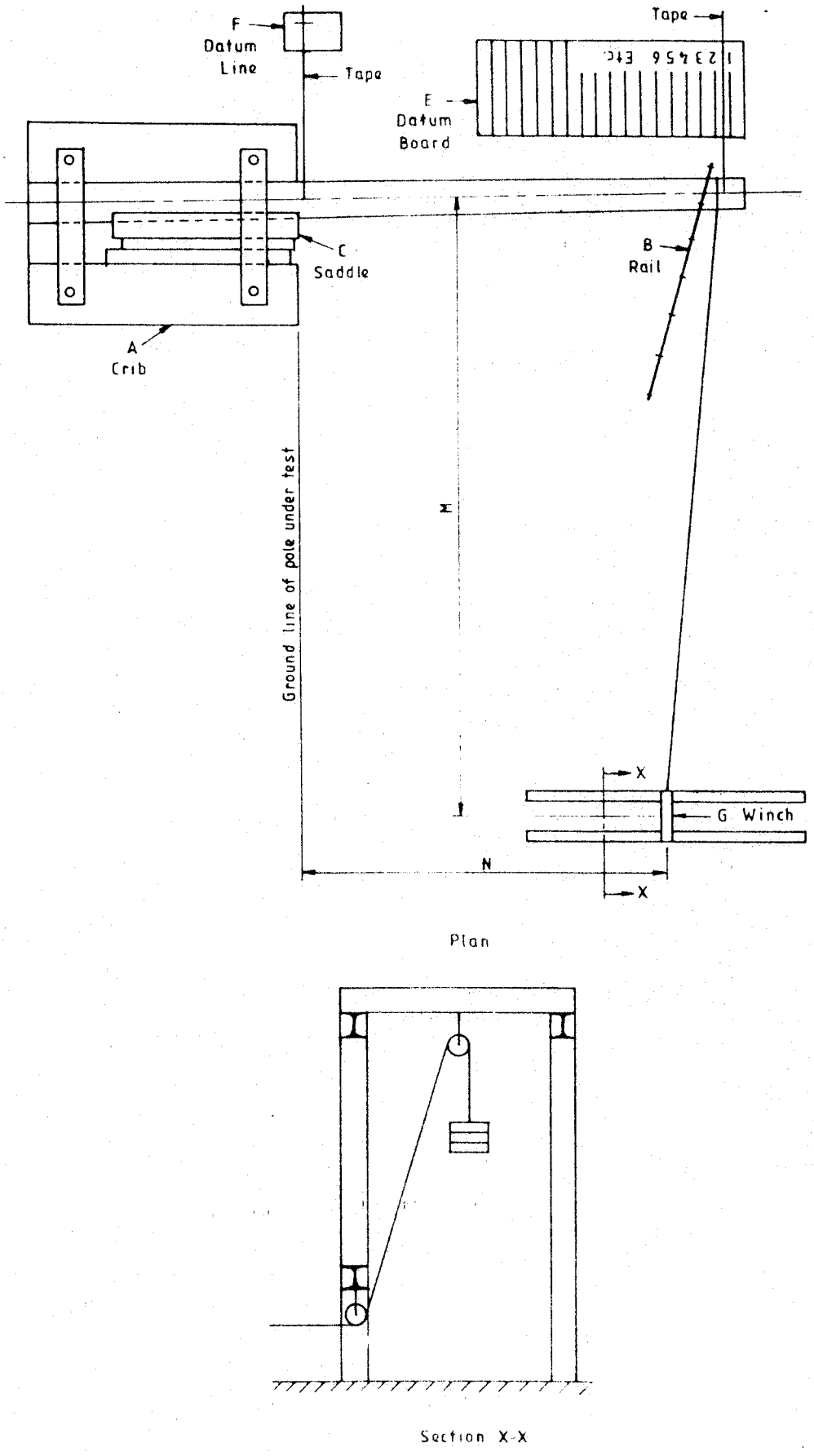


FIGURE 3 - Schematic diagram of a wood pole under test loaded with dead weights

TABLE 2 Sample data sheet 1

No.	A record of observed defects		Acceptance or rejection Acceptance criteria
1	Depth of bark inclusions :	..mm	Bark inclusions not more than 50 mm in
2	Largest depth of visible compression wood on either end :	..mm	Outer 25 mm free from compression wood
3	Number of cross breaks :		No cross breaks
4	Number of dead streaks	..mm	No dead streaks
5	Largest extent of decay :	..mm	No decay (also see item 11)
6	Hollow bt area (due to splinter pulling only) as a percentage of butt area	%	Area of hollow butt (due to splinter pulling only) less than 10 per cent of butt area
7	Largest hole diameter :	..mm	No holes (except plugged holes done for test purposes)
8	Diameter of hollow butt : Diameter of hollow top :	..mm	No hollow butts or tops (also see item 6)
9	Diameter of hollow pith centre at top : Diameter of hollow pith centre at butt :	..mm ..mm	Hollow pith centre of any size at butt or top

Table 2 continued

No.	A record of observed defects		Acceptance or rejection
			Acceptance criteria
10	Diameter of largest insect damaged hole: External surface scoring : Extent of channelling :	..mm ..mm ..mm	Insect damage of holes 2 mm or less in diameter, surface scoring or channelling
11	i) Diameter of the largest single knot. ii) Presence of a cluster of knots, in any 300 mm length of pole, where sum of diameters of all knots, greater than 13 mm exceeds 200 mm.	..mm Yes/No	i) Diameter of every knot less than 75 mm. ii) sum of diameters of all knots greater than 13 mm, in any 300 mm length of pole less than of equal to 200 mm. iii) Type II decayed knots subjected to limits in (i) and(ii) above
12	Largest diameter of marine borer damage :	..mm	No marine borer damage
13	Number of nails, spikes, and other metals :		No nails, spikes and other metals
14	Number of sap stain patches with softening or decay :		Sap stain without softening or decay

Table 2 Continued

No	A record of observed defects	Acceptance of rejection
		Acceptance criteria
15	Number of scars (or turpentine cat face) located with 600 mm of the ground line (see Table)	i) No scars (or turpentine cat face) within 600 mm ground line
	Number of other scars : (sound scars)	ii) Other sound trimmed scars between butt and 600 mm below ground line where circumference at the section containing a scar not less than the minimum
	circumference specified	at 1.5 m from the butt
	iii) Depth of trimmed	scars equal to or less than 50 mm where diameter is 250 mm or less
		iv) Depth of trimmed scars not more than 1/5 diameter at the location of the scars, where the diameter is equal to or less than 250 mm.
16	Number of turpentine acid face scars :	Turpentine acid face scars allowed only in the casde of pinus

Table 2 Continued

No	A record of oberved defects		Acceptance or rejection
			Acceptance criteria
17	i) Distance of each shake from the side surface at the butt end : ii) Depth of each shake at butt end : iii) Largest distance of shakes from the side surface at the top end :	..mm ..mm ..mm	i) Shakes in the butt end not closer than 50 mm to the side surface of the pole and which do not extend to the ground line ii) Shakes or a combination of connected shakes closer than 50 mm to side surface and which do not extend further than 600 mm from butt end, and not wider than 3 mm iii) Shakes in the top end with diameter of shakes not greater than 1/2 the diameter of the pole at the top end.
18	Distance in which one complete twist is formed due to spiral grain	..mm	i) 9 m length and under 1 complete twist in any 3 m
			ii) over 9 m length and under 15 m :1 complete twist in any 4.5 m
			iii) 15 m length and over : 1 complete twist in any 6 m

TABLE 3 - SAMPLE DATA SHEET 2

Pole strength Tests at : State Timber Corporation Orugodawatta				Test Pole No : 26
Species : Pinus	Class :	Length : 8500 mm	Weight : 2564 kg	
Circumference (in mm) Butt :	Ground Line :	Break point :	Load point :	Tip
Butt to ground Line	Length 9in mm) Ground line to load point		Load point to break point	
Applied loade in N	t* mm	s* mm	g+ mm	Remarks
0	3218.8	125	0	
1 000	3312.5	141	0	
2 000	3396.9	156	-1.6	
3 000	3531.3	156	+1.6	
4 000	↓	↓	↓	
5 000				
6 000				
7 000				
8 000				
9 000				
10 000	4485.0	250	+ 10.0	
11 000	-	-	-	Failure, Heaartwood of the pole was found to be wet

*t = perpendicular distance from top datum to load point
**s = distance load point moves toward butt
+g = distance pole moves at ground line

Initials of Recorder :
Date : 87-05-09

TABLE 4 - SAMPLE DATA SHEET 3

Pole Strength Tests at : State Timber Corporation Orugodawatta				Test Pole No. : 26	
Applied load in N		Deflection in mm		calculation of maximum fibre stress at ground line and break point N/mm^2	calculation of Modulus of Elasticity N/mm^2
Observed	corrected*	Observed	Corrected**		
0	0	0	0	Formula : $F = \frac{32\pi^2 Pa}{C^3}$	Formula : $E = \frac{64 a^3 \pi^3 (\frac{dP}{d\delta})}{3 C^3 B}$
1 000	995	93.7	93.7		
2 000	1990	178.1	179.7	$F = \frac{32\pi^2 Pa}{C_a^3}$	For notation see **C.4.9.4**
3 000	2985	312.5	310.9		
4 000					
5 000					
6 000					
7 000					
8 000					
9 000					
10 000	9950	1266.2	1256.2		
				Calculation of a and a^1	Calculation $\frac{dP}{d\delta}$
				load point to ground line† total S^1 = mm = 125 mm a =	$\frac{dP}{d\delta}$ = N/mm from the graph of corrected load versus corrected deflection)
				Load point to break† = mm Total s^1 = mm a^1 † mm	Other factors a = mm C = mm B = mm
				Other factors: P = N C = mm C_a = mm	Modulus of Elasticity = N/mm^2
				Fibre stress : F = N/mm^2 F_b = N/mm^2	

* *corrections are based on calibration curve*

** *corrected deflection = Difference between the t value of Table 2* (data sheet 1) For any load and zero load - (difference between the g values of Table 2 (Data Sheet 1) for any load and zero load).

† Table 3 (Data sheet 2)

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