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EFFECT OF SAPSTAINING AND C.C.A. TREATMENT ON STRENGTH PROPERTIES OF RADIATA PINE POLES

D.J. Donnelly and G.R. Siemon
September 1989
W.U.R.C. Technical Report
Limited Distribution

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SUMMARY

Radiata pine (*Pinus radiata* D. Don) has potential as an alternative source of power transmission poles. Mean values of modulus of rupture and modulus of elasticity increased in the following ranking:

(i) poles tested untreated
(ii) sapstained poles
(iii) poles sprayed with Koppers NP-1 sapstain control chemical
(iv) sapstained/copper-chrome-arsenic (C.C.A.) pressure treated poles
(v) NP-1 sprayed/C.C.A. treated poles.

With modulus of rupture, grouped treatments (i) to (iii) were significantly less than treatments (iv) and (v), while treatment (i) was significantly less than grouped treatments (ii) to (v). Modulus of elasticity was not significantly different in the five treatments.

These results indicated that radiata pine poles, treated to minimise sapstain fungal attack and then pressure treated with C.C.A., have acceptable strength properties and will provide a long service life.

INTRODUCTION

Overhead power lines have traditionally been supported by wooden poles, which are preferred because of their low cost, ease of erection and replacement, and high electrical resistance.

In the past, native eucalypt species which had naturally durable heartwood (CSIRO Durability Classes 1 and 2) were used (Standards Association of Australia 1979). Consequently, poles were used untreated, but the width of the non-durable sapwood band was subtracted from the overall diameter in calculating design stresses. Supplies of poles of naturally durable eucalypts are dwindling, and the proportion of poles of less durable species, requiring treatment with chemical preservatives, is increasing.

In Western Australia the State Energy Commission (SECWA) has an annual requirement of about 20 000 wooden poles each year to maintain and extend the power grid in the State. Jarrah (*Eucalyptus marginata* Donn ex Sm.), a naturally durable species, has been most extensively used, with smaller volumes of West Australian blackbutt (*E. patens* Benth.) and wandoo (*E. wandoo* Blakely). The introduction of logging restrictions during winter to reduce the spread of jarrah dieback (caused by *Phytophthora cinnamomi* Rands), and decreases in the area available for timber production with large areas set aside for conservation, scientific and recreation purposes, has resulted in fewer jarrah poles being available. As availability decreased, the SECWA and the Department of Conservation and Land Management agreed that smaller diameter poles of these species, preservative-treated, could be used. The treated sapwood could therefore be included in design stress calculations. In addition other less durable species such as marri (*E. calophylla* R. Br.) could be used as poles after preservative treatment.

In the early 1960s, when SECWA was installing and extending rural power supplies, the need for long transmission poles could only be filled locally with the use of karri (*E. diversicolor* F. Muell.) which is Durability Class 3. These poles were pressure treated with creosote over the full length. This practice was extended to some distribution poles, using both karri and marri.

The use of creosote for pole treatment was discontinued by the early 1980s, because the use of creosote as a preservative was no longer acceptable to the unions involved. Creosote has not proved carcinogenic in over a hundred years of service, but the original formulation is dirty and protective clothing is needed.

Softwood species should be acceptable for use in SECWA power lines. Radiata pine (*Pinus radiata* D. Don) and maritime pine (*P. pinaster* Ait.) are available in increasing quantities, and after full length preservative treatment with copper-chrome-arsenic (C.C.A). were known to be a worthwhile option. Softwood power poles have been used and are still being used in many countries around the world.

In 1975 20 pine poles were placed in service at various locations around the State, and still appear to be performing well in 1989.

A commercial parcel of poles were prepared by CALM for SECWA in 1985/6. Unfortunately, after delivery, these poles did not receive correct storage treatment needed to ensure their performance, and were attacked not only by sapstaining fungi, but also by some wood destroying fungi. Consequently, after treatment with C.C.A. preservative, some poles broke during handling.

The SECWA requested further assessment of strength properties of pine, which resulted in the present trial. It was designed to compare bending strength properties (modulus of rupture and modulus of elasticity) of poles attacked by bluestain with those sprayed with an anti-sapstain fungicide, and subsequently either C.C.A.-treated or left untreated.

METHODS

The radiata pine poles used in the trial were harvested from compartments A22 and A23, Bussell Plantation, in the Collie district. Briefly, their silvicultural history is:

1966	planted at 1700 stems/ha (2.4 x 2.4 m spacing)
1971	low pruning (2.1 m) of 750 stems/ha and the remainder culled
1974	high pruning (6 m) of best 125 stems/ha
1978	first commercial thinning to 250 stems/ha (Compt A22)
1980/81	first commercial thinning to 300 stems/ha (Compt A23)
1981	remaining 175 stems in Compt A23 high pruned to 5 m.

Pole Sampling

The second thinning operation to provide poles for the trial was in 1989, using manual felling and log skidder for extraction. Eighty 11 m poles were delivered within 14 days to the Worsley pole preparation area for debarking by a modified Rosser head debarker and docking to length. All poles were numbered sequentially in the order of delivery.

Inspection was done using SECWA Specification ES/32/84. (This specification was subsequently modified to increase the required ground line circumferance for poles designed to carry specific loads. A pole description, including the groundline circumference, crown diameter, number of growth rings on the butt, and kN rating, is given in Appendix 1.

Fifty-eight poles were strength tested in the current trial. Thirty poles were subjected to sudden impact (drop) tests requested by SECWA (which will be reported separately), and eight of these were included in the strength tests.

The first 30 poles delivered were not treated after debarking, and deliberately left block stacked to encourage attack by sapstaining fungi. The next 50 poles were sprayed with a 1.0 per cent solution of Köppers NP-1 Sapstain Control Chemical (the active ingredient is didecyl dimethyl ammonium chloride) immediately after debarking to reduce the risk of sapstain fungi attack.

Sixty poles were then transported to Koppers Australia's yard at Picton, and 20 poles to the Wood Utilisation Research Centre at Harvey. The 30 unsprayed poles were again blockstacked at Koppers and covered with black plastic sheeting to further encourage sapstain fungal attack, and the balance were strip stacked to improve air drying before C.C.A. treatment.

After 14 days the first batch were heavily infected with sapstain, and were then strip stacked for air drying before C.C.A. treatment.

C.C.A. Treatment

The two groups of poles (sapstained and non-sapstained) were stored in Koppers yard until the moisture contents at 50 mm depth averaged 30 per cent. The poles were then treated in batches of twenty, using the standard full cell treatment method of initial vacuum, treatment to refusal at 1390 kPa pressure, and final vacuum (Wilkinson 1979).

Three sapstained poles had retention levels which were slightly below the SECWA specified values, but the non-sapstained poles had satisfactory retention.

Testing

The poles were allocated to five treatments for strength testing:

(i) green
(ii) sapstained
(iii) non-sapstained (i.e. NP-1 treated)
(iv) sapstained/C.C.A. treated
(v) non-sapstained/C.C.A. treated

All poles were tested at Harvey, using a cantilever test jig. The pivot point of the 11 m pole was the ground line position at 1.5 m from the butt. The load was applied by a winch, and measured using a standard load cell.

Deflection was measured using a tape attached at the loading point and in the same plane.

Modulus of rupture was calculated using the following equations:

$$M = w\,l$$

where
M = bending moment
w = maximum load (N)
l = distance from loading point to point of failure (mm)

and

$$M = fZ$$

where
f = modulus of rupture or maximum fibre stress (MPa)
Z = section modulus $\left(\frac{\Pi d^3}{32}\right)$

hence

$$f = \frac{M}{Z}$$

d = diameter at point of failure (mm)

Modulus of elasticity was calculated by:

$$E = \frac{64 W_1 L^3}{3 \Pi y d^4}$$

where
E = modulus of elasticity
W_1 = change in load (N)
L = distance from pivot point to loading point (mm)
y = change in deflection (mm)
d = diameter at pivot point (mm)

The data were analysed using analysis of variance.

RESULTS AND DISCUSSION

The mean values of modulus of rupture ranged from 45.7 MPa for the poles tested green to 56.4 MPa for the non-sapstained (or NP-1 treated) (Table 1). Standard deviation values were small, indicating a comparatively uniform strength over a range of pole sizes.

Modulus of elasticity values ranged from 6 475 MPa to 7 775 MPa for the treatments, with the same ranking as found with modulus of rupture data. The maximum load to failure and individual values of modulus of rupture and modulus of elasticity are also given in Appendix 1.

The analysis of variance indicated a significant difference in modulus of rupture between the green and non-sapstained (NP-1 sprayed), both C.C.A.-treated and untreated. The non-sapstained C.C.A.-treated and non-sapstained untreated poles had similar strength to the sapstained poles, both C.C.A.-treated and untreated. The comparatively small sample sizes in each treatment should explain most of the variation. Moisture content was above fibre saturation point in all poles, and presumably did not contribute to the variation.

Modulus of elasticity was similar in all five treatments (Table 1), indicating that attack by sapstain, anti sapstain treatment and C.C.A. preservative treatment did not affect elasticity.

Table 1

Modulus of rupture and modulus of elasticity of green, or sapstained or non-sapstained radiata pine poles, with or without C.C.A. preservative.

		MOR (MPa)*		MOE(MPa)*	
Treatment	**No.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Green	12	45.7	6.7	6475	890
Sapstained	9	49.9	6.2	6640	1140
Sapstained/ C.C.A. treated	15	51.2	6.5	6795	1090
Non-sapstained/ C.C.A. treated	15	55.1	9.2	6950	1550
Non-sapstained	7	56.4	5.2	7775	1620

* Values joined by the same vertical line are not significantly different at $p<0.01$

Pole sizes are estimated from their required load carrying capacity (kN). The maximum load values exceeded the design load multiplied by a safety factor of three in every pole, with the exception of pole No 14 (sapstained/C.C.A. treated), where the safety factor reduced to 2.9 (Appendix 1), which indicated that SECWA Specification ES/32/84 used for this trial provided satisfactory results before the revision increased the ground line circumference for a particular kN rating. The groundline circumference required could be re-evaluated, based on these test data, thereby increasing the pole availability if the circumference could be reduced.

The previous large scale trial showed that when sapstain fungal attack occurs, there is an increased risk of attack by wood destroying fungi. Any treatment to minimise sapstain attack is an advantage. Dipping is definitely more effective than spraying because it gives better penetration of the surface of the pole. Pressure treatment with C.C.A. preservative has been carried out for decades, and its efficiency is well proven.

The results of these strength tests indicate that radiata pine poles have adequate strength for their designed load, and correct treatment with anti-sapstain chemical and then C.C.A. treatment will provide acceptable life in service.

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Mr Matthew Williams of CALM did the statistical analysis.

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